III

Electric Vehicles

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Electric propulsion & Dynamics

choice of electric propulsion :-

⇒ Electric propulsion is the heart of EV

⇒ Electric propulsion is the main reason to move the vehicle by taking the current as input from the motor and motor gives mechanical energy to move the wheels

⇒ The main job of the electric propulsion is to interface batteries with vehicle wheels, transferring energy in either direction as required, with higher efficiency, under control of the driver at all times

⇒ The electric propulsion for HEV's mainly depends on three factors

1. driver expectation
2. vehicle constraint
3. energy source

⇒ there are three basic types of electric propulsion systems

1. Electrothermal
2. Electrostatic

⇒ From the functional part of view, an electric propulsion system can be divided into two parts

- Electrical
- Mechanical

⇒ The electric part consists of the subsystems of electric motor, power converter, electronic Controller

⇒ whereas the mechanical part includes the subsystems of mechanical transmissions, wheels.

⇒ The boundary between the electrical and mechanical part is the air-gap of the motor, where electromechanical energy conversion is takes place

⇒ The electronic controller is further divided into three functional

- units - sensor
- interface circuitry
- processor

⇒ The sensor is used to translate the measurable quantities, such as current, voltage, temperature, speed, torque, flux, into electronic signals

⇒ The interface circuitry, these signals are conditioned to the appropriate level before being fed into the processor

⇒ The processor output signals are usually amplified via the interface circuitry to drive power semiconductor devices of the power converter

⇒ The convertor acts as the regulates the power flow between the energy source and the electric motor for motoring and Regenerating

⇒ Finally, the motor interfaces with the vehicle wheels via the Mechinical transmission.

⇒ The transmission is optional because the electric motor can directly drive the wheels as in the case of in-wheel drives

⇒ The choice of electric propulsion is mainly depend on three factors

- Driver Expectation
- Vehicle Constraint
- Energy source

⇒ The driver Expectation is defined by a driving profile which includes

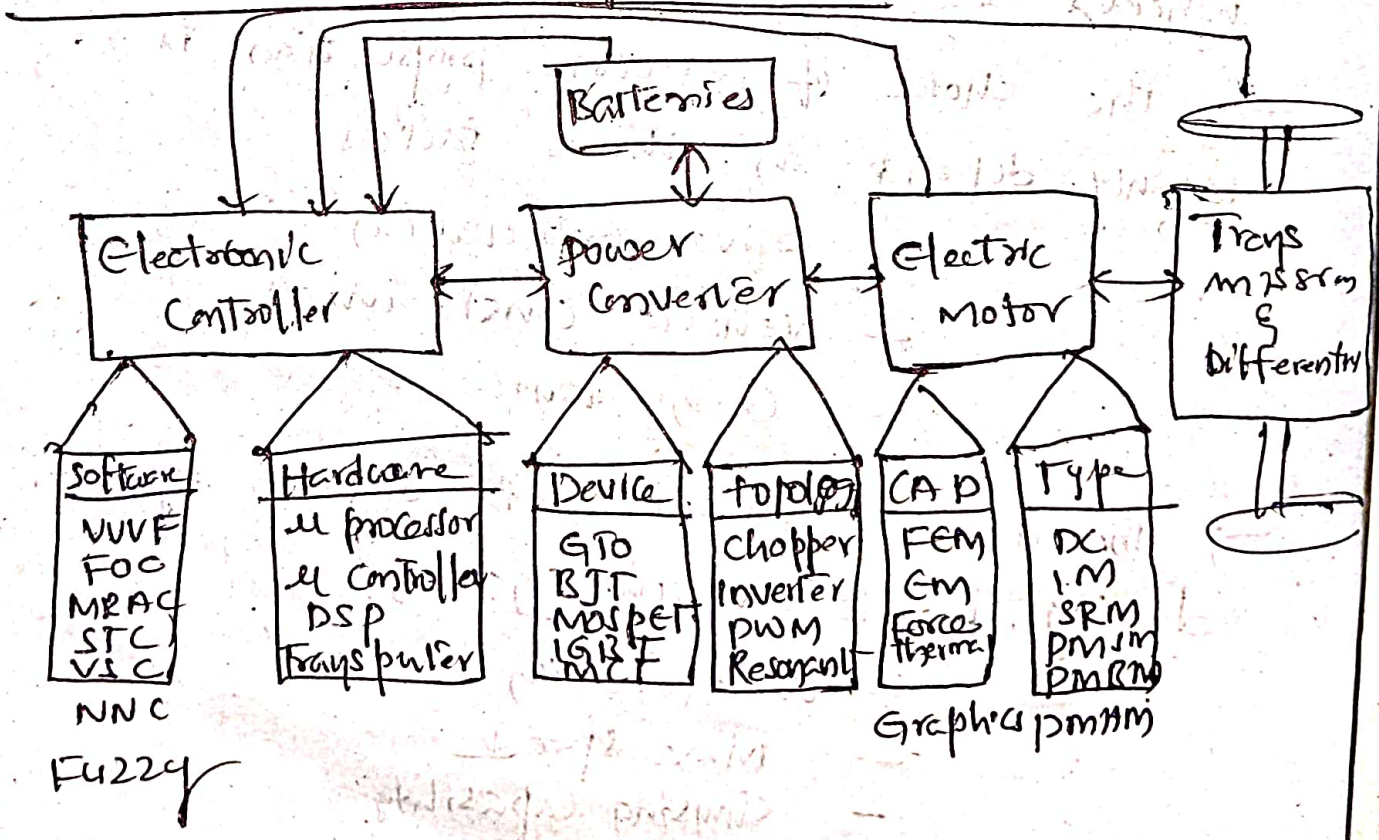
- acceleration
- Max speed
- Climbing capability
- braking and Range

⇒ The vehicle constraint depends on the
- vehicle type
- vehicle weight
- payload

⇒ The energy source relates with batteries, fuelcells, capacitors, flywheels and various hybrid sources.

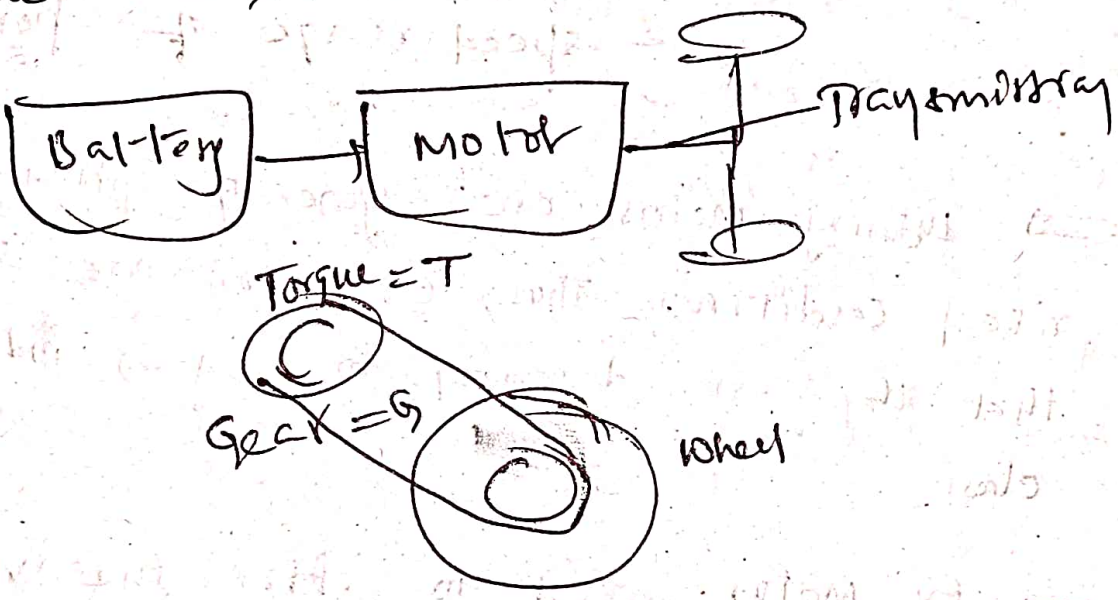
⇒ The development of electric propulsion systems has been based on the growth of various technologies,
- electric motors
- power electronics
- control strategies

Functional / Block diagram of EV :-



Concept of EV motors :-

⇒ The main concept of the EV motor is to take electricity supply from the battery and applied to stator which cause the rotor to turn, and subsequently provide mechanical energy to turn the car's gears. once the gears are rotating, the wheels turn too



⇒ An Electric motor is an Electric Machine which converts the Electrical Energy into Machincal Energy

⇒ Most Electric motor operate through the interaction between the motor's Magnetic field and Electric current in a wire winding to generate force in the form of torque applied on the motor's shaft.

⇒ EV motor frequently require
- start-/stop
- High rate of acceleration/deacceleration
- High-torque low speed hill climbing,
- low torque high speed cruising
- speed range of operation

⇒ Industry Motors are generally optimized at rated conditions. Thus, EV Motors are so unique that they are deserved to form as individual class

⇒ EV motor need to offer the Maximum torque that is four to five times of the rated torque for temporary acceleration and hill-climbing,
Industry motor generally offers the max torque that is twice of the rated torque for overload operation

⇒ EV motor need to achive four to five times of the based speed in highway cruising

⇒ EV motors should be designed according to the vehicle driving profiles and drivers habits.

⇒ EV motor demand both high power density and good efficiency map (high efficiency over wide speed and torque ranges) for the reduction of total vehicle weight and the extension of driving ranges.

⇒ EV motors desire high controllability, high steady state accuracy and good dynamic performance for multiple-motor coordination.

⇒ EV motors need to be installed in mobile vehicles with harsh operating conditions such as high temperatures, bad whether and frequent vibrations.

⇒ EV motors also dependent on the designed of the technologies

1. Electro static
2. Electro thermal
3. Electro magnetic

Single motor / Multi motor configuration :-

Single motor	Multi motor
⇒ Single motor is used to propel the driving wheels	⇒ Multi motors permanently coupled to individual driving wheels.
⇒ Single motor has the merit of using only one motor which can minimize the corresponding size, weight and cost	⇒ Uses one wheel one motor which can maximize the size, weight and cost
⇒ single motor is used to balance the speed of two wheels	⇒ Size of motor is evenly distributed to each wheel. and weight also
⇒ Here $\frac{\text{power}}{\text{current}}$ ratios are high	⇒ To reduce $\frac{\text{power}}{\text{current}}$ ratios multimotor are induced.
⇒ Main need is differential	⇒ Main need is an additional precautions to allow for fault tolerance during the electronic differential action.
	⇒ Each motor have its own controller which is connected to master controller

→ Single motor configuration is adopted in the GM EV 1	→ Dual motor configuration has been adopted in the NIO ES Evolve
→ The usage of single motor is high still	→ The usage of Multimotor is comparatively less than single motor

Steps to select the Best Motor :-

step 1 :- Determine torque and Revolutions per minute

step 2 :- Analysing the production Environment

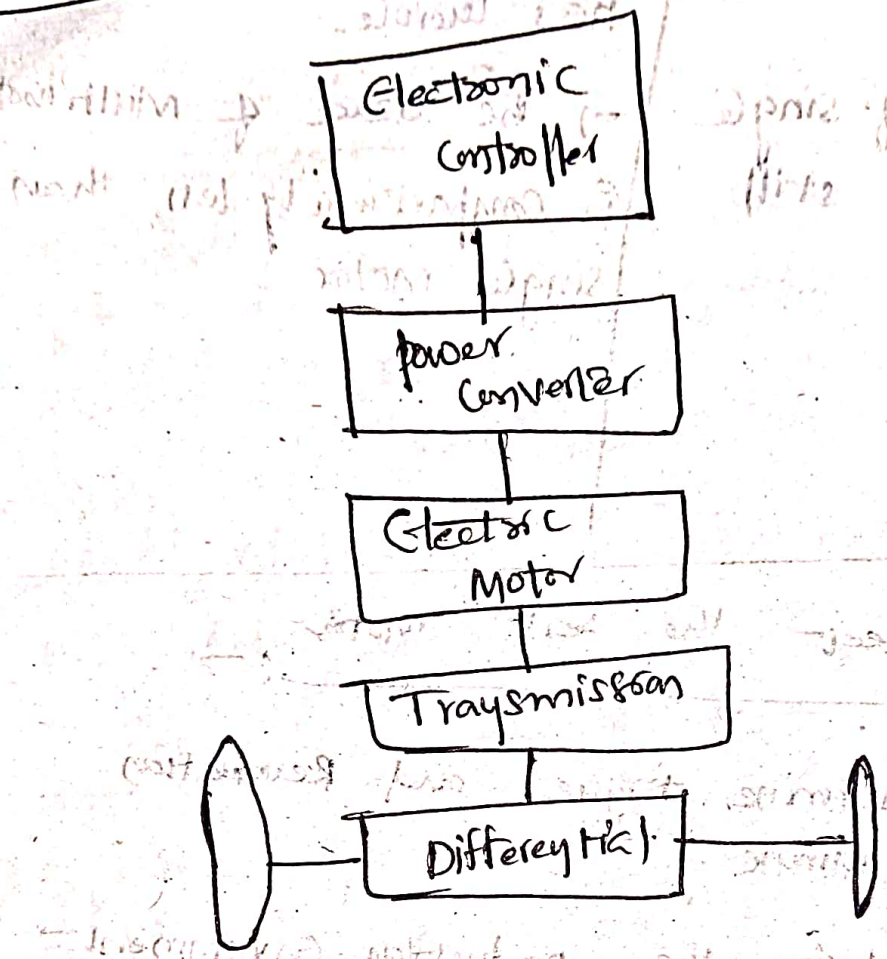
step 3 :- Installation space

step 4 :- Determine the frequency of movement in relation to life span

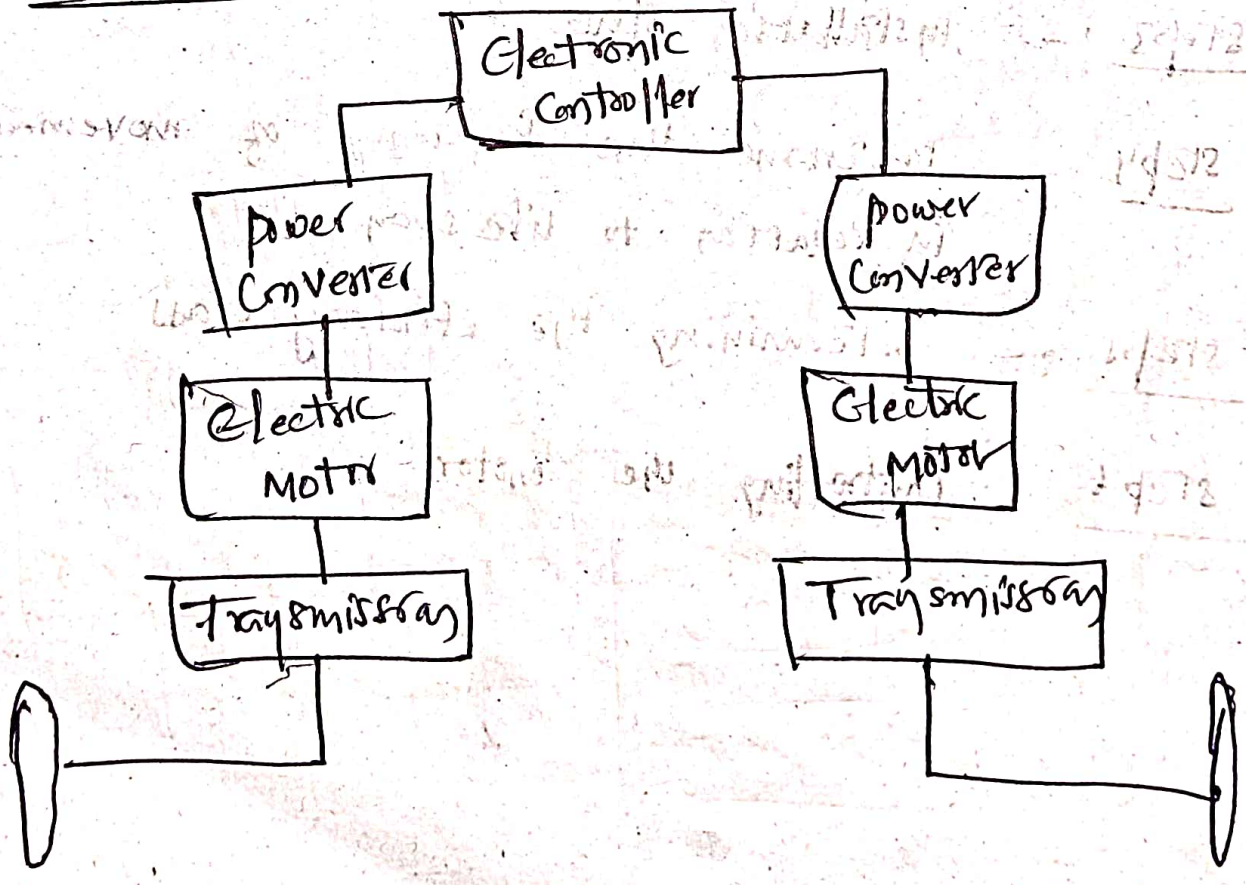
step 5 :- Determining the efficiency class

step 6 :- Controlling the motor

Single motor :-



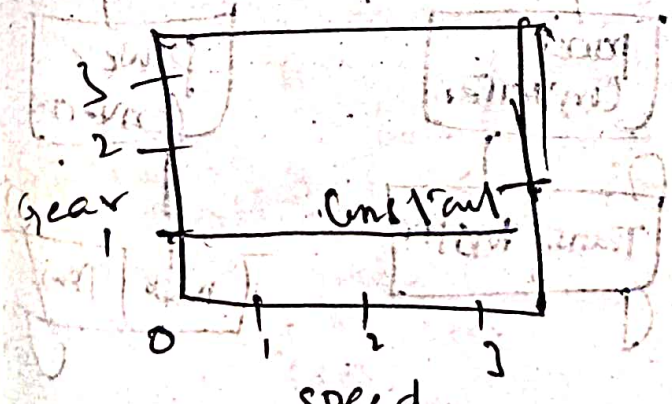
Dual-Motor :-

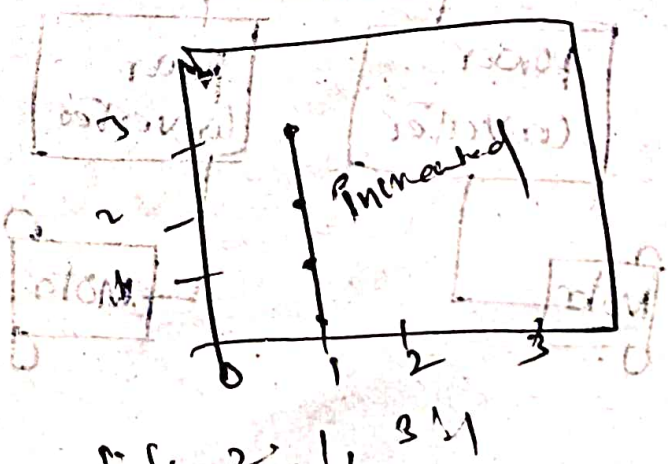


	Single Motor	Dual-motor
Cost	Lower	Higher
Size	Lumped	Distributed
weight	Lumped	Distributed
Efficiency	Lower	Higher
Differential	Mechanical	Electronic

Fixed / variable variable gearing transmissions

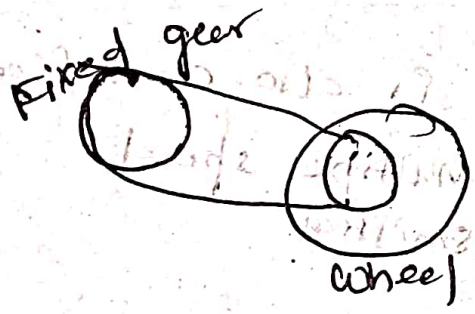
Fixed	Variable
⇒ It is also classified as single speed	⇒ It is also classified as multiple speed transmissions
⇒ The speed of the vehicle is kept constant of the fixed gear	⇒ The gear ratio between the Follower (F) and Base (B) is steadily increased from (1:1) to 2:1

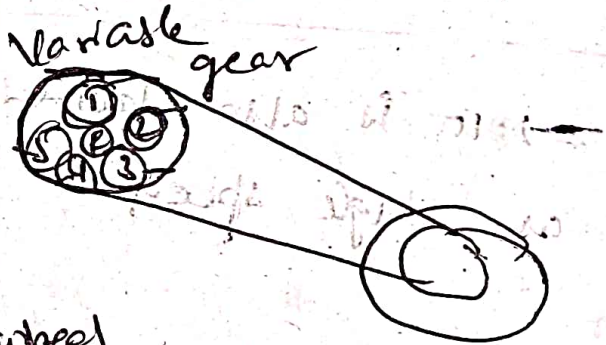




1:1, 2:1, 3:1

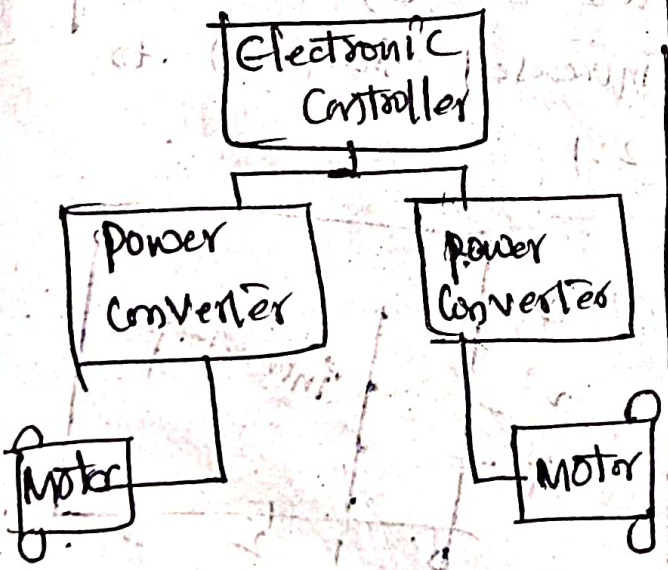
⇒ Motor rating is High	⇒ low
⇒ Inverter rating is High	⇒ low
⇒ cost is low	⇒ High
⇒ size is small	⇒ large
⇒ weight is low	⇒ Higher
⇒ Efficiency is Higher	⇒ Lower
⇒ Reliability is Higher	⇒ lower



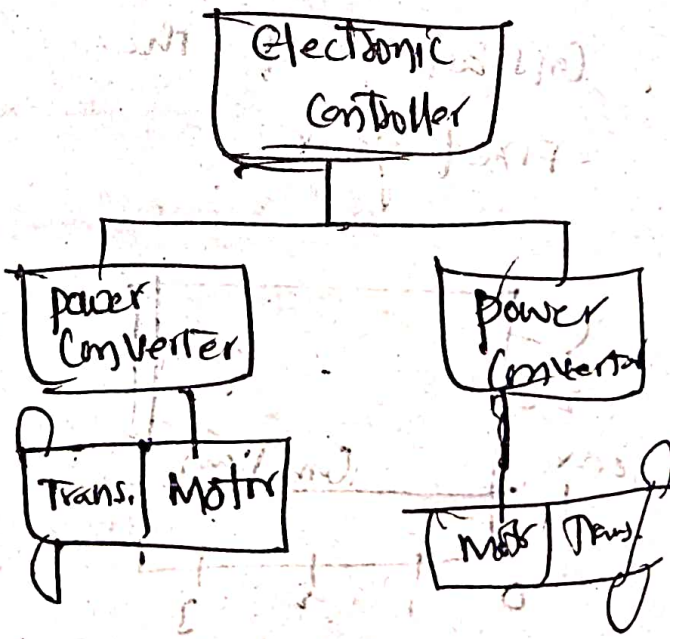


Inwheel motor configuration

⇒ Gearless motor



⇒ Geared motor

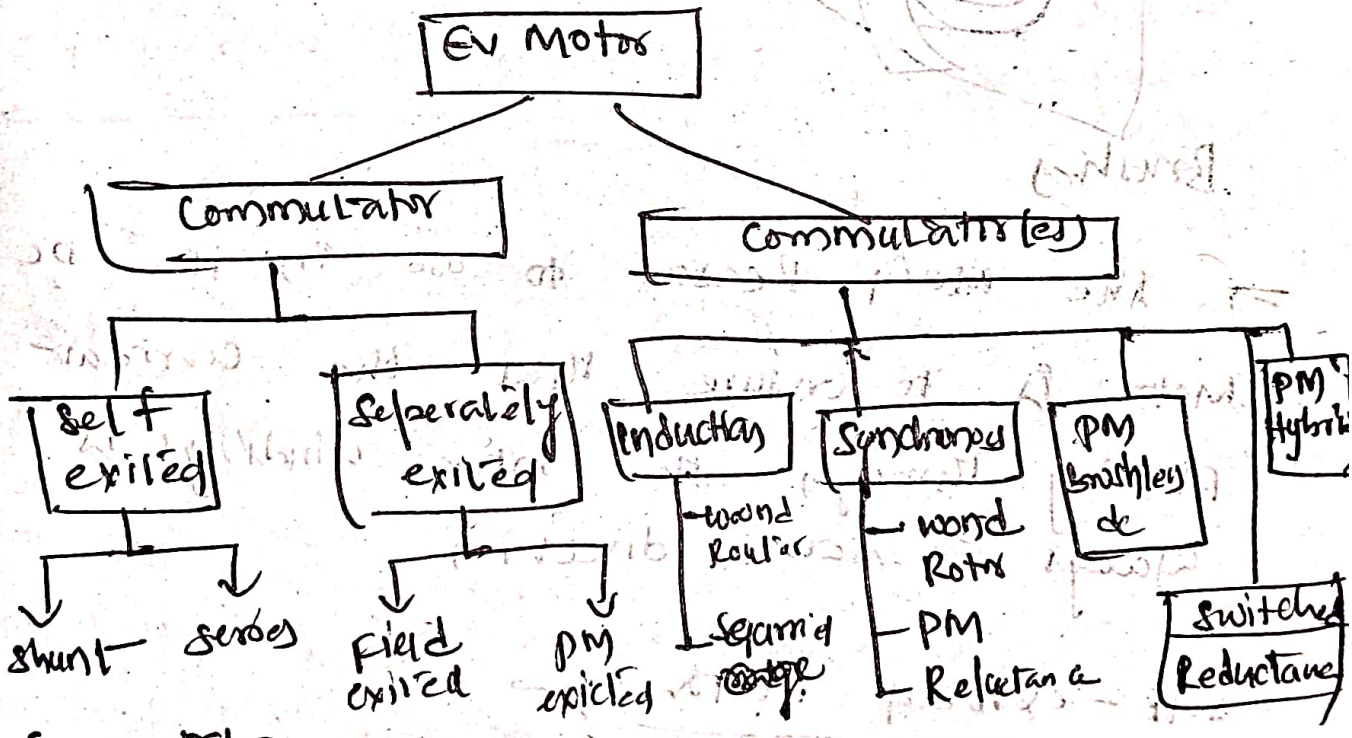


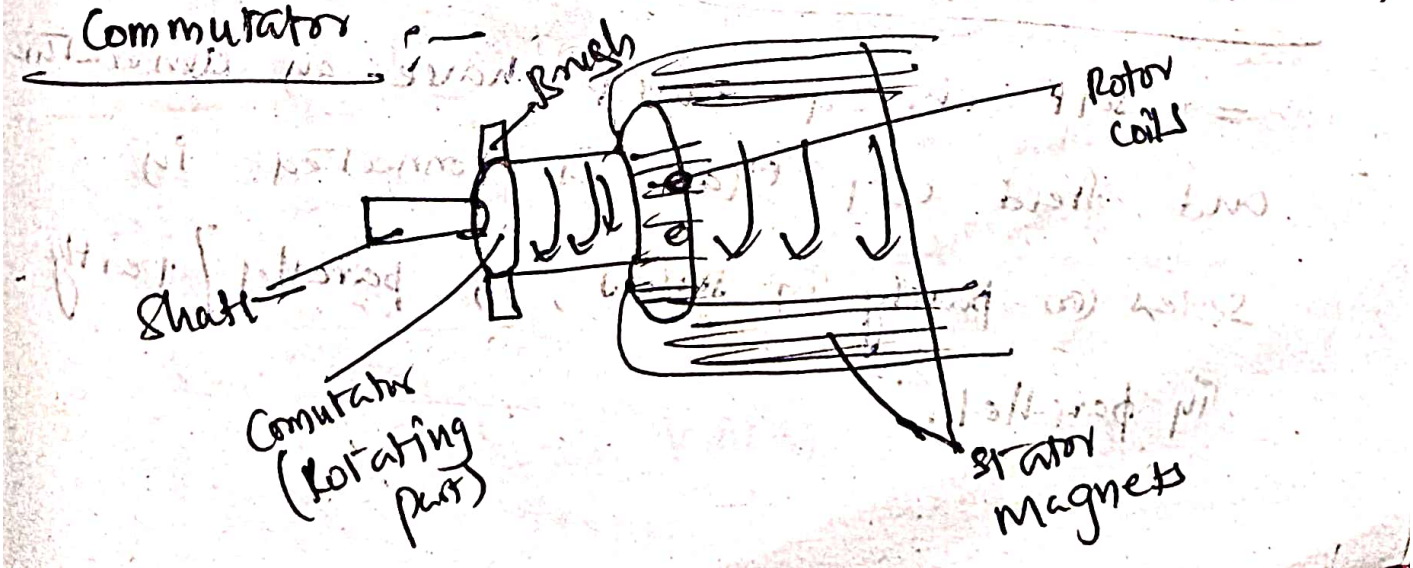
classification of ev motors :-

⇒) the development of EVs are continually fueled by new materials, sophisticated topologies powerful computer-aided-design (CAD) as well as modern power electronics and microelectronics

⇒ the classification of electric motors are two

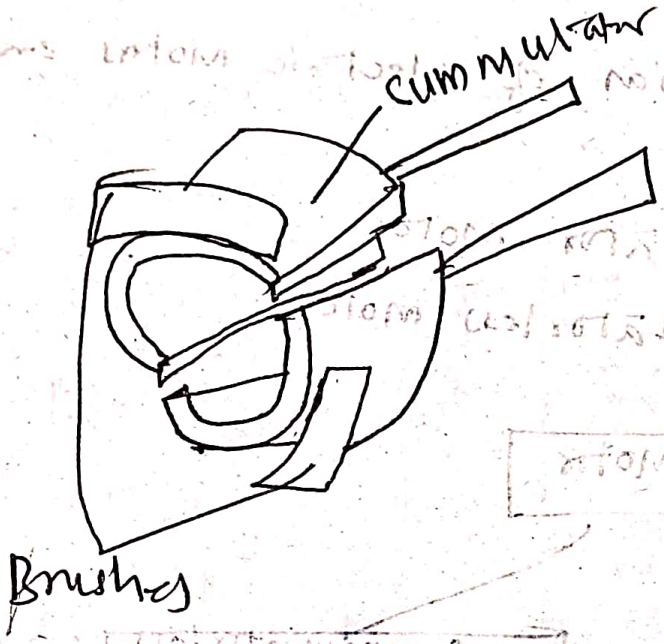
1. Commutator Motors
2. Commutatorless motors.





⇒ commutators are used in DC Machines (DC Motors and DC Generators) universal Motors

⇒ In a Motor, a commutator applies an electric current to the winding



⇒ The main Reason to use in the DC Motor is to ensure that the current flowing through the rotor windings is always in same direction

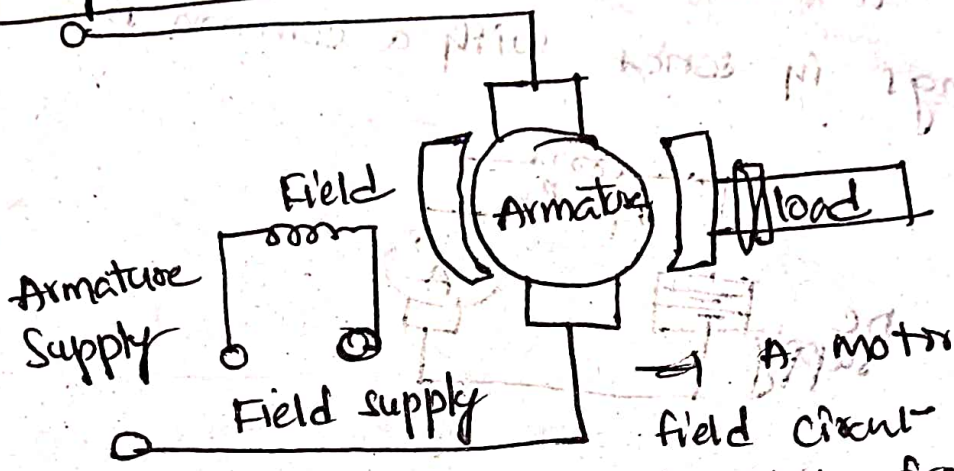
Self-excited motors :-

⇒ self-excited motor have an armature and field coil that is connected in series (or) partly in series, in parallel / partly in parallel.

⇒ They also have a single source of power

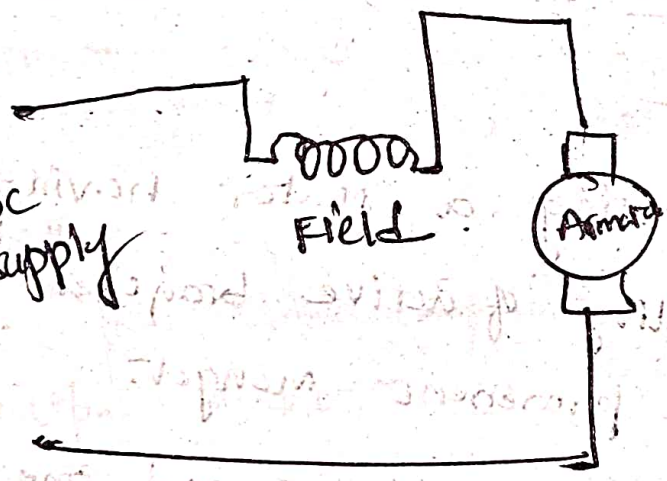
⇒ There are two types of self exited motors they are series, shunt motors

Seperately - Exited :- →



⇒ A motor whose field circuit is supplied from a seperate constant voltage power supply

self - exited (Diagram) :-



Self - exited

Self - exited motor :-

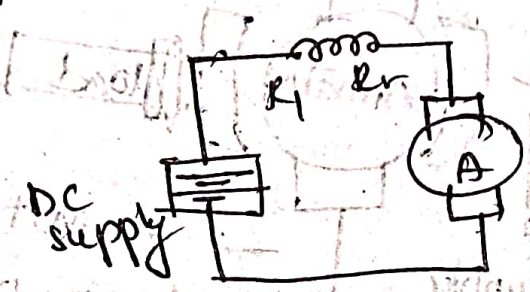
1. shunt motor :- A direct current motor whose two windings are in parallel, with the same voltage across each.

⇒ Here induced voltage & speed, torque & armature current

⇒ designed to run at practically constant speed, regardless to the load.

Series Motor :-

⇒ Connects the armature and field windings in series with a common D.C. power source



~~Self excited~~ :-

1. Field excited :-

Commutatorless :-

⇒ Comprising a stator having a coil with a plurality of active branches and a rotor having a permenent magnet.

⇒ active branches are arranged one after another essentially without gaps.

⇒ The permenent magnet has magnetic segments that overlap all the active branches.

1. Induction :-

At present, induction motor drives are the most mature technology among various commutatorless motor drives.

There are two types of induction machines. 1. The wond - rotor

2. Squirrel cage

The wound-rotor :- It guaranteed a safe communication of the load-commutated inverter under any condition of operation
→ There are no starting problems

Squarrel cage :-

The motor is named because of its shape of their rotor,

→ The inner component connected to the output shaft - look like cage

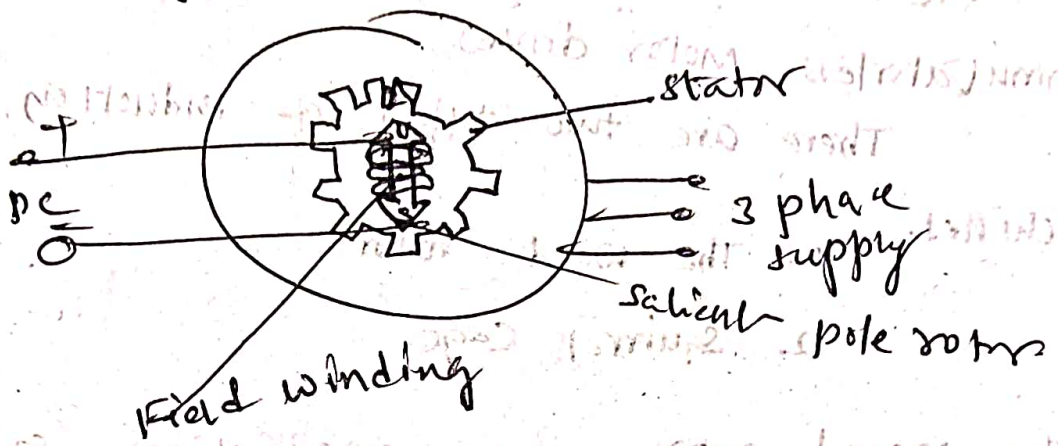
→ It harness electromagnetism to generate motion.

2. Synchronous :-

An synchronous is an AC electric motor in which at steady state, the rotation of the shaft is synchronized with the

frequency of the supply current

⇒ The rotation period is exactly equal to an integral number of AC cycles



Permenent magnet motor :-

⇒ It is a type of electric motor that uses permenant magnet for the field excitation and wound armature

⇒ It may be stationary / rotating

Reluctance motor :-

⇒ It has permenent magnet

⇒ It is a motor that induces non-permenent magnet poles on the ferro magnetic rotor

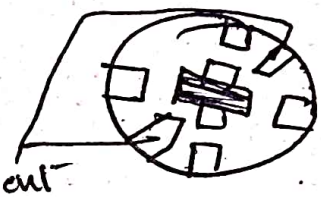
⇒ The rotor donot have any winding

PM brushless motor :-

It uses an electronic controller to switch DC currents to the motor windings producing magnetic fields that effectively rotate in space and which the permanent magnet rotor follows.

Switched Reluctance :-

→ It is double salient - pole motor,
→ It means the magnetic field projects outwards from the stator and the rotor.
→ The rotor in the SRM does not contain permanent magnet / windings



Salient pole

PM Hybrid :-

→ It is the combination of variable reluctance and permanent magnet type motors.

Applications of EV Motors :-

~~Industrial~~	
Mazda Bongo	shunt-dc motor
Suzuki Senior Tricycle	pm dc motor
GM EV1	induction motor
Toyota RAV4	pm synchronous motor
Honda Ev plus	PM synchronous motor
NISAN Altra	pm synchronous

Vehicle load Factors

⇒ the measurement of the weight (or) mass of a vehicle relative to its designed or rated capacity

⇒ these factors are important for various reasons, including safety, efficiency, and compliance with Regulations

1. Gross Vehicle weight Rating (GVWR) :-

⇒ weight of the vehicle + weight of passagenes + laugage + other weight

2 Curb weight :-

⇒ weight of the vehicle + Fuel only

⇒ no passagner weight

3. payload :- Gross weight Rating

— Curb weight

4. Axle load :-

The weight borne by a single axle of the vehicle.

⇒ Exceeding the specific axle load limits can cause damage to roads and Results in Fine.

5. Tire load Rating :-

Each tire has a load Rating that specifies the maximum load it can carry safely.

all tyre load value < axle load

6. Legal load limits :-

Over load cause road damage.

7. Weight Distribution :-

It is crucial for stability and control. if unbalanced causes handling issues

8. Overloading :-

⇒ Reduced breaking system