ASSIGNMENT 1 : ELECTRIC VEHICLE DESIGN

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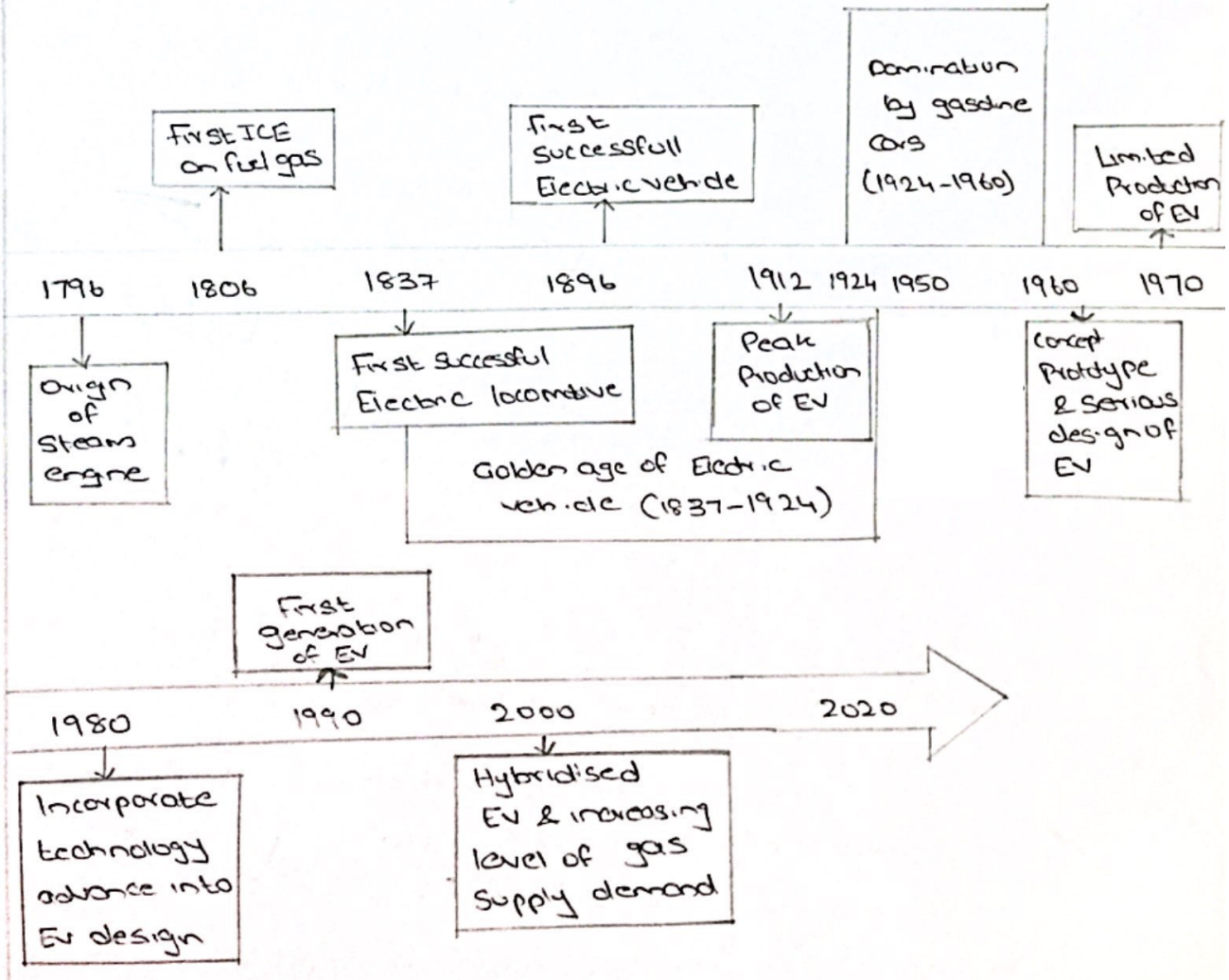
Q1. Explain the journey of Automotive with the help of flowchart from the beginning of 18th century to 21st Century & give brief description on the following milestones in the automotive.

Journey :

a) Invention of electric motor
b) Gaden era of EV
c) Domination of Electric Vehicle by Gasoline Cars
d) Coming of new era in EV
e) Introduction to hybrid electric vehicles.

a)



- The first steam engine developed was by Nicholas Cugnot in 1768. It was mainly used by French military but was decommissioned due to its limitations, mainly speed. In 1796, James Watt developed steam engine into a more prime mover capable of providing energy to run machines.
- First IC engine vehicle was made by Isaac de Revaz in 1806. The fuel used for running the vehicle was hydrogen.
- The first known electric locomotive was built in 1837, in Scotland by chemist Robert Davidson of Aberden. This invention lead to improvement in battery technology in France (1881).
- The first successful Electric vehicle was built in 1896, in US by William Morrison. It was designed as passenger carriage driven by driver with 2 passenger carrying capacity.
- In beginning of 1900, electric vehicles shared a market of 38% along with 40% by steam engine and 22% by petrol. From 1837-1924 is called as the golden era of EV.
- From 1924-1960, the market was dominated by gasoline cars. Henry Ford's Assembly line production was able to reduce the cost of IC engine vehicles & In 1912, Charles Kettering came up with self start mechanism and easy refueling made IC engine vehicles more reliable.

- Due to the great smog in London and as several new diseases came out due to pollution in California. US based California Air Resources Board (CARB) released emission regulation in 1970's Since 1970's to 2000's they reduced pollution by 80%. Every 10 years they also released new regulations.
- In 1991 they came up with Low Emission vehicle (LEV 1). In US every Car companies needed to launch atleast One EV option. and they called it as Zero Emission Vehicle (ZEV).
- Due to the pressure from Car companies and as they won the case against CARB. CARB. pulled out certain aspects of LEV 1 and introduced LEV 2 in 2003, which include LEV (Low Emission vehicle) with 10%15% less emission, ULEV (Ultra low Emission Vehicle) with 70% - 80% less emission. & PZEV (Pure Zero Emission Vehicle) with 0% emission.
- In 2006, Santa Monica auto expo, Tesla Roadster was displayed, gained attention from people due to its performance & features.
- In 2010 - Nissan leaf was introduced. It was the first affordable hatchback EV. It has a range of 100-110 miles and a maximum speed of 130kmph.

a) Invention of Electric Motor.

- In 1828, the Hungarian inventor Anyos Jedlik invented World's first Electric Motor, and created a small model car powered by Electric Motor.

b) Golden era of EV

From 1837 - 1924 is marked as the golden era of electric vehicles. In 1906, Electric vehicles were very advanced. In single charge it could go up to 100 miles with a speed of 45 to 50 kmph. The world market also had 38% of Electrical vehicles. Electric cars were popular because of its no emission, efficiency, low cost & easy start.

c) Domination of Electric vehicles by gasoline cars

- In 1912, Petrol powered cars became easier to drive due to invention of Charles kettering and his electric starter. Henry Ford introduced Assembly line produced which in turn reduced cost of IC engine vehicles. Electric cars slowly began to lose their position in market and EV was dominated by gasoline cars from 1924-1960

d) Coming of new era in EV.

Due to great Smog & diseases stated coming up due to pollution. In USA CARB put some regulations on emission. This lead to introduction LEV I in 1991 & LEV 2 in 2003, ULEV, & PZEV. Government started giving Subsidies. They also introduced greencredit for promoting the sales of EV.

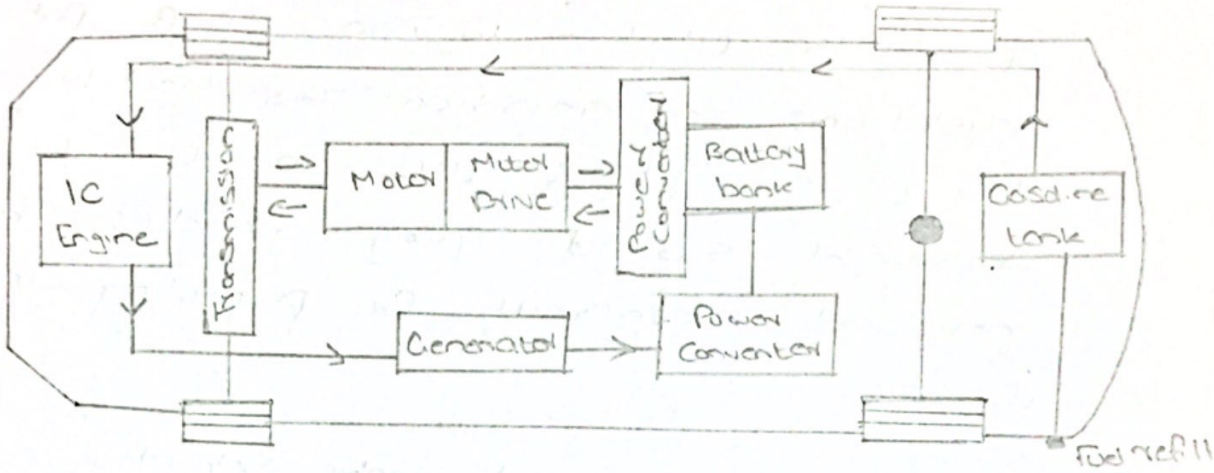
e) Introduction to hybrid electric vehicles

Hybrid electric vehicles combines a conventional internal combustion engine system with an electric propulsion system. The presence of electric motor achieve either better fuel economy than a conventional fuel vehicle. They are categorized into two types based on Hybrid architecture which include series, parallel & series parallel types and based on degree of hybridisation which include micro, mild & full types of hybrid vehicles.

Q2. Explain and draw the layouts of following Hybrid Electric vehicles with their two advantages, disadvantages and industrial application in automotive segment?

a) Series Hybrid Electric Vehicles
b) Parallel Hybrid Electric Vehicles
c) Series Parallel Hybrid Vehicle
d) Plug in Hybrid Electric Vehicle
e) Fuel Cell Electric Vehicle.

c) Series Hybrid Electric Vehicle



- Electric motor is connected to transmission & IC engine is connected to generator. The generator charges the battery pack from the energy of IC engine and motor will drive the vehicle. Power Converters provided will convert the AC to DC.

Advantages

- Mechanical decoupling between ICE & driven wheels allow the IC engine operating at its narrow optimal region.
- Nearly Ideal torque - speed characteristics of electric motor make multi-gear transmission unnecessary.

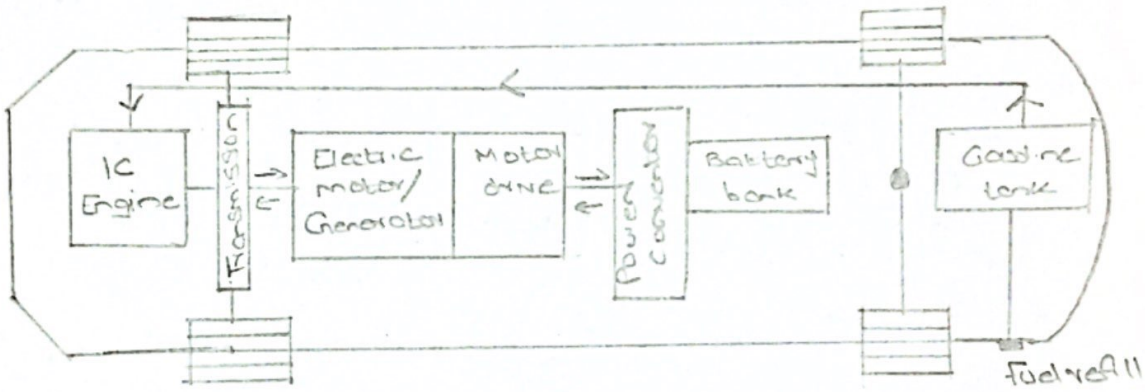
Disadvantages

- The energy is converted twice (mechanical to electrical & then to mechanical) and this reduces overall efficiency.
- Two electric machines are needed and a big traction motor is required because it is only the torque source of its driven wheels.

Industrial application

BMW i3 is a series hybrid electric vehicle equped with a range extender. Another example of it is Fisker Karma.

b) Parallel Hybrid Electric Vehicle



- This is the most common configuration
- Ic engine is the primary machine & motor is playing a secondary role.
- Ic engine is responsible for running the vehicle & once in a while motor can take over.

Case 1
Ic engine drive :→ Ic engine running
Motor will be off

Case 2
Electric drive :→ Ic engine will be off
Motor is running

Case 3
Hybrid mode → Both engine & motor will be running

Case IV

If battery is low :-> IC engine runs & vehicle & charges battery.

Case V

Regenerative braking :-> IC engine will be off & motor act as generator inorder to utilise inertia. It act as a generator and recharge battery pack while vehicle slows down.

Advantages

- Both engine and electric motor directly supply torques to the driven wheels and no energy form conversion occurs, hence energy loss is less.
- Compactness due to no need of generator & smaller traction motor.

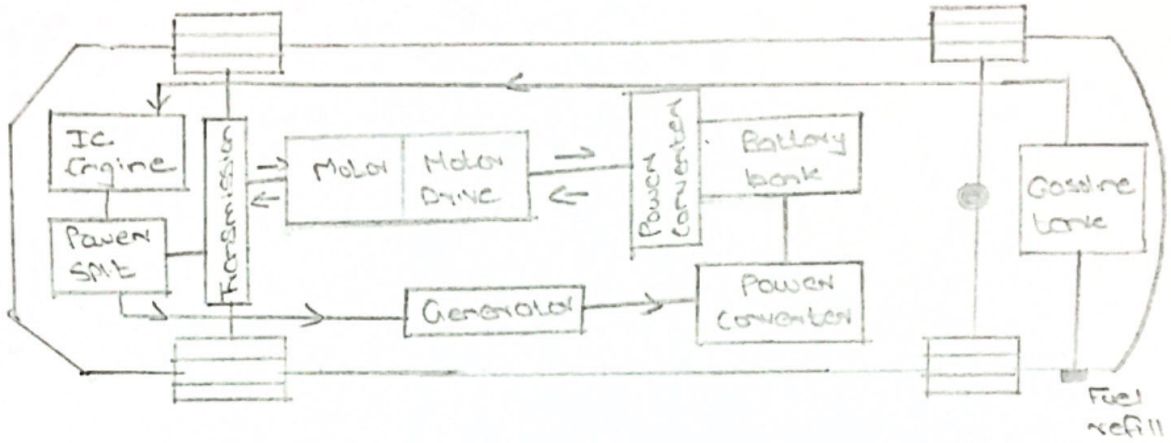
Disadvantages

- Mechanical coupling between the engines & driven wheels, thus the engine operating points cannot be fixed in a narrow speed region
- The mechanical configuration and control strategy are complex compared to series hybrid drivetrain.

Industrial application

Vehicles using parallel hybrid configurations are Honda Civic hybrid, Mercedez Benz S400 blue hybrid

c) Series Parallel hybrid Vehicle



- Have feature of both Series & parallel hybrid
- Many different modes of driving are possible under ICE dominant hybrid vehicle and under motor dominant drive mode.
- Engine is connected to powersplit. When battery is low powersplit directs power to generator. If battery is recharged fully it directs power to the transmission

Advantages

- Have both the features of Series & parallel Combination.

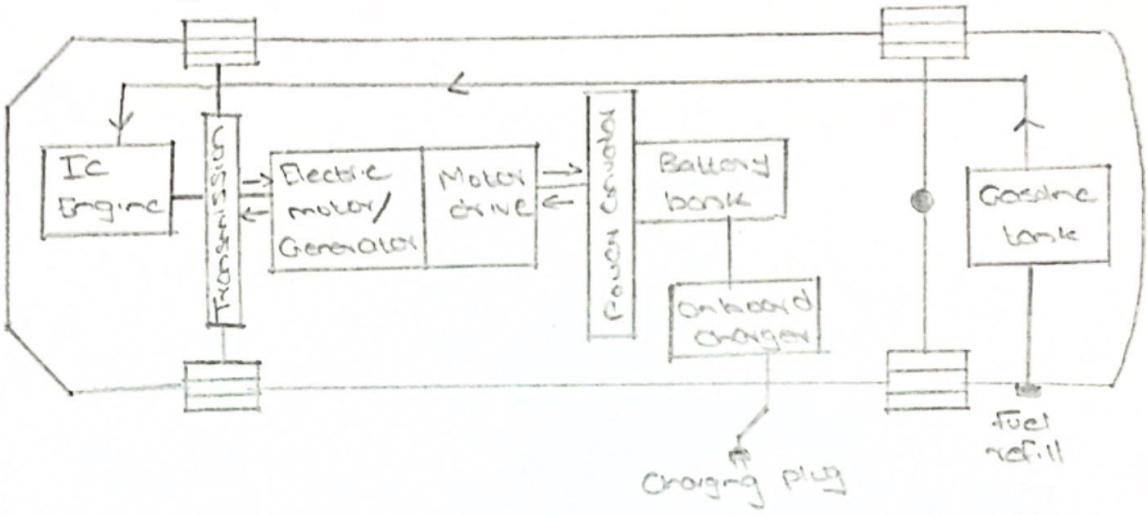
Disadvantages

- It has a really heavy setup
- Most Costly design & Complicated Control.

Industrial application

- Only used in Toyota Prius (1995)

d) Plug in hybrid Electric Vehicle



- Plug in hybrid electric vehicle has the same concept of parallel hybrid electric vehicle. In addition it has an onboard charger.
- Batteries power the electric motor & gasoline power IC engine. Batteries can be charged by using a wall outlet or charging equipment, by ICE or through regenerative braking. The vehicle typically runs on electric power until the battery is nearly depleted and then can automatically switches to ICE.

Advantages

- Zero emission while driving on batteries
- Fuel efficient in traffic
- Easy to drive

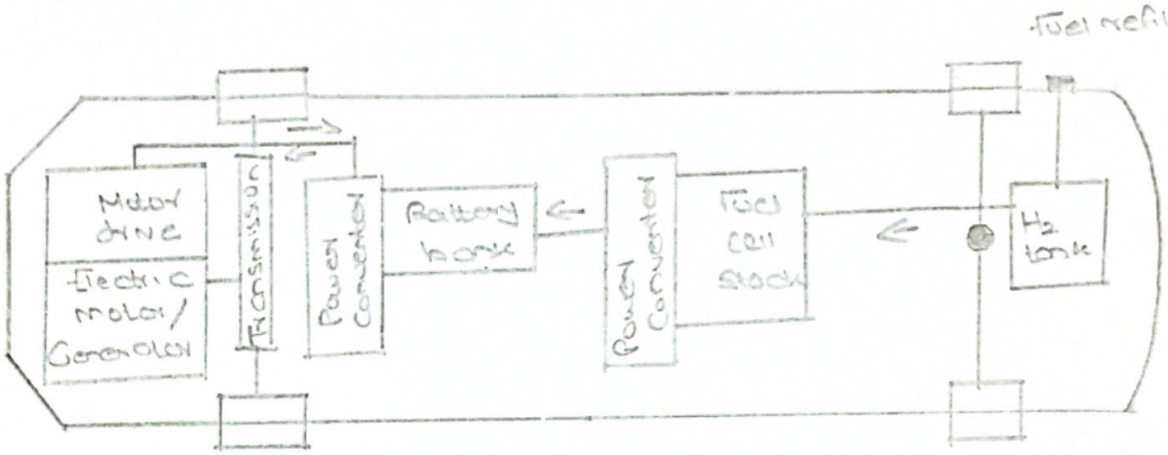
Disadvantages

- Relatively expensive and complex to maintain
- Fuel economy not very good on motorway journeys
- Battery life concerns.

Industrial application

- BMW I8 uses a parallel setup with an onboard charger
- Tesla Model 3 also uses a plug in hybrid setup.

e) Fuel Cell Electric Vehicle



- Fuel cell electric vehicle uses hydrogen as fuel.
- Concept of fuel cell electric vehicle is similar to that of series hybrid vehicle.
- Hydrogen from tank moves to fuel cell stack where it release ions. Hydrogen mixes with Oxygen & releases electrons, which will be delivered to battery pack to recharge the battery.

Advantage

- More efficient than conventional IC engines.
- No tailpipe emissions

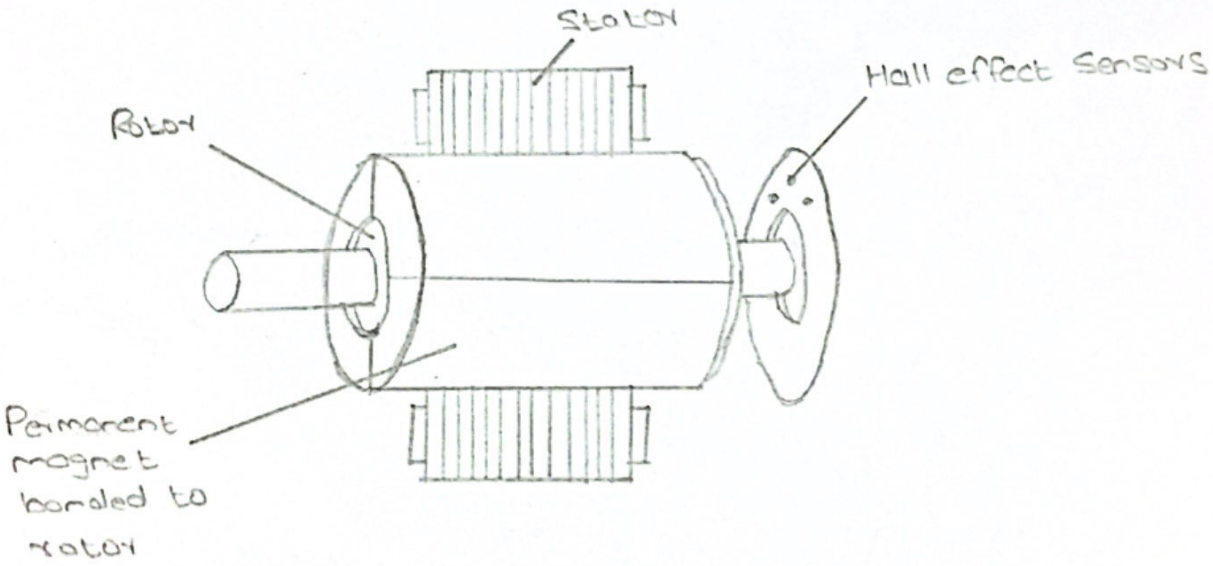
Disadvantages

- Hydrogen fuel is costly.
- Difficult to handle hydrogen fuel

Industrial application

- Toyota Mirai in 2014
- Hyundai Nexo in 2018

Q3: Explain with diagram the construction & working principle of BLDC?



- A brushless DC motor is driven by direct current (DC) electricity and it accomplishes electronically controlled commutation system instead of a mechanical commutation system. It is also referred to as trapezoidal Permanent magnet motors.

Construction

- BLDC motors can be constructed in different physical configurations. Depending on stator windings, these can be configured as single phase, two phase or three phase motors. However three phase BLDC motors are commonly used.

Stator

- The stator of a BLDC motor is made up of stacked steel laminations to carry the windings. These windings are placed in slots which are axially cut along the inner periphery of stator. These windings can be arranged either in star or delta. Most use star connected stator. Each winding is constructed with numerous interconnected coils, where one or more coils are placed in each slot. In order to form a no. of poles, each of these windings is distributed over the stator periphery. The stator must be chosen with correct rating of voltage depending on power supply capability.

Rotor

BLDC incorporates a permanent magnet in rotor. The no of poles in rotor can vary from 2 to 8 with alternate north & south poles. In order to achieve maximum torque flux density should be higher. A proper magnetic material for the rotor is needed to produce required magnetic field density.

Hall sensors

- Hall sensors provide information to synchronize stator armature excitation with rotor position. As commutation of BLDC is controlled electronically the stator windings should be energized in sequence in order to rotate the motor. Before energizing a particular stator winding, acknowledgement of rotor position is necessary. So the Hall effect sensor embedded in stator ~~enhances~~ senses the rotor position. Each sensor generates low & high signals however the rotor poles pass near to it. The exact commutation sequence to stator winding can be determined based on combination of these sensor's response.

Working principle

- BLDC motor works on principle similar to that of a conventional DC motor i.e Lorentz force law which states that whenever a current carrying conductor placed in a magnetic field it experiences a force. As a consequence of reaction force, the magnet will experience an equal & opposite force. In case of BLDC motor, the current carrying conductor is stationary while permanent magnet moves.

when the stator coils are electrically switched by a supply source. It becomes electromagnet and starts producing uniform field in air gap. Though the source of supply is DC, switching makes to generate or AC voltage waveform with trapezoidal shape. Due to the force of interaction between electromagnet stator and permanent magnet rotor, the rotor continues to rotate.