Q.1. Explain the journey of automotive with the help of flow chart from the beginning of 18th century to the 21st century and give brief description on the following milestones in the automotive.

1769 : Nicolas-Josefih Cugnot (French) built world's first automobile capable of human transportation. He built a steam-powered automobile called the 'fardier à vapeur' (steam dray).

1807 : Isaac de Rivaz (Franco-Swiss) built the world's first vehicle to be powered by an ICE. The 'de Rivaz engine' was developed by him in 1804. It used hydrogen gas as fuel.

a) 1827 : Anyos Jedlik (Hungarian) built the world's first electric motor. He created a tiny model car powered by this motor.

1884 : First production electric car was built by Thomas Parker (England), using his own specially designed high-capacity rechargeable batteries. He electrified the 'London Underground', overhead tramways in Liverpool and Birmingham, and the smokeless fuel coalite were his inventions.

1885 : Carl Benz (German) built the first practical automobile run on ICE, and first car put into series production.

1890 : William Morrison (Scottish) built the first practical electric automobile in USA.

b) 1890s - 1900s : Golden Era of EV.

c) Electric vehicles were dominated by gasoline vehicles from 1910s. This was due to the advances in ~~electric~~ ICE. The electric starter was invented in 1903, and installed first on vehicle on 1912 on a Cadillac. Ford Motor Company produced the first automobile to be mass produced on a moving assembly line. Worldwide discoveries of large

Petroleum reseeves led to availability of affordable gasoline. The greater range, quicker refuelling time, and growing Petroleum infrastructure led to a decline in the use of EVs, especially during the WWI.

d) 1952 : Great Smog of London from 5 Dec - 9 Dec.

1990s : California Air Resource Board (CARB) began to push for lowese-emissions vehicles.

2008 : Tesla Motors delivereed the Tesla Roadstere to customeres.

2010 : Nissan Leaf became the first modern all-electric, affordable, zero emission five door family hatchback to be produced for the mass market from a major manufacturer.

The concerns overe environmental impact of gasoline cars, higher gasoline prices, improvement in battery technology, and oil depletion have brought the renewed interest in electric cars, which are more environment friendly and cheapere to maintain and run, despite high initial cost.

e) After CARB first adopted the Low-Emission Vehicle (LEV) program in 1990 (covering automobiles from 1994 to 2003) leading to Chrysler, Toyota, and a group of GM dealers sueing CARB in ~~for~~ Federal court, they had to cancel the Zero-Emission Vehicle (ZEV) mandate. Hence LEV II was adopted in 1999 (covering vehicles from 2004 to 2014) The following were the categories under the LEV program which encouraged HEVs:-

- LEV (Low-Emission Vehicle) : The least strict emission standard for all new vehicles sold in California after 2004.
- ULEV (Ultra Low Emission Vehicle) : 50% cleaner than average 2003 model vehicle.
- SULEV (Super Ultra Low Emission Vehicle) : 90% cleaner than 2003 model vehicle.

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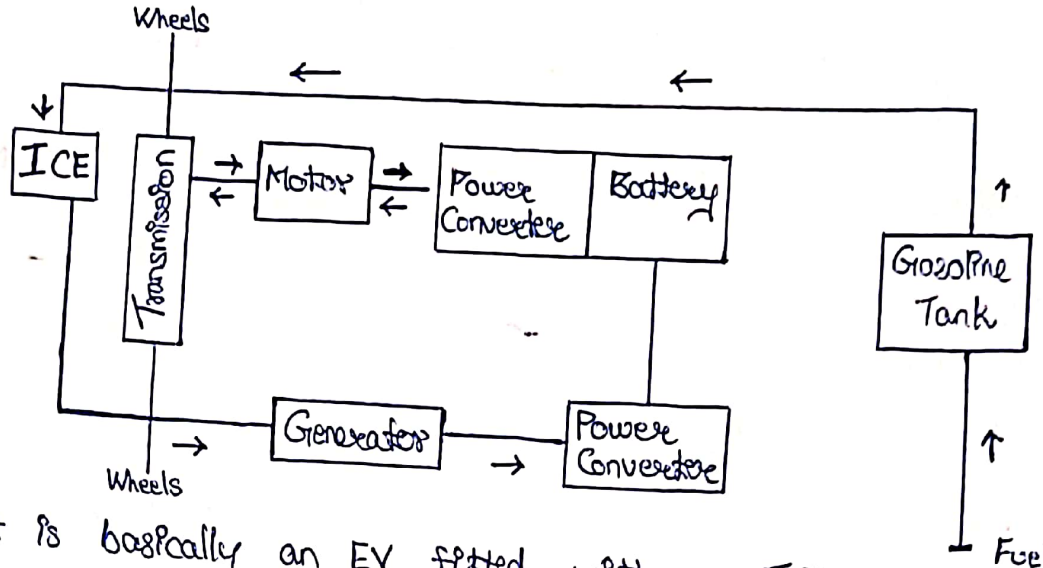
Q.2. Explain and draw the layout of following HEVs with their two advantages, disadvantages and industrial application in automotive segment.

a) Series HEV:



It is basically an EV fitted with an ICE to recharge the battery pack. Here the motor is the primary source, and hence more powerful than the ICE. Hence the battery pack will be large in size.

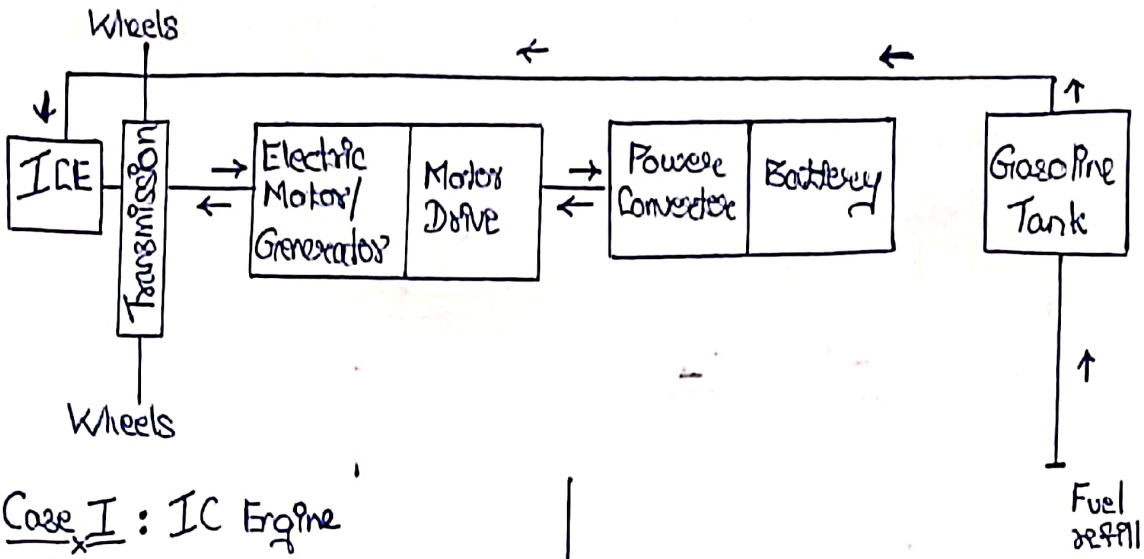
Advantages:

- Since ICE is the secondary source, smaller engines are required, reducing the pollution.
- Mechanical decoupling between the ICE and driven wheels allow the ICE operating at its very narrow optimal range.
- Nearly ideal torque-speed characteristics of electric motor make multi-gear transmission unnecessary.

Disadvantages:

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

b) Parallel HEV :



Case I : IC Engine
Motor → Charging
IC Engine → Performing Drive

Case II : Electric Drive
Motor → Performing Drive
IC Engine → Rest Condition

Case III : Hybrid Mode
Motor → Performing Drive
IC Engine → Performing Drive

Case IV : Low Battery
Engine → Charging and Drive Mode

Case V : Regenerative Braking
Motor → Generator, Power stored in battery.
IC Engine → Rest Condition.

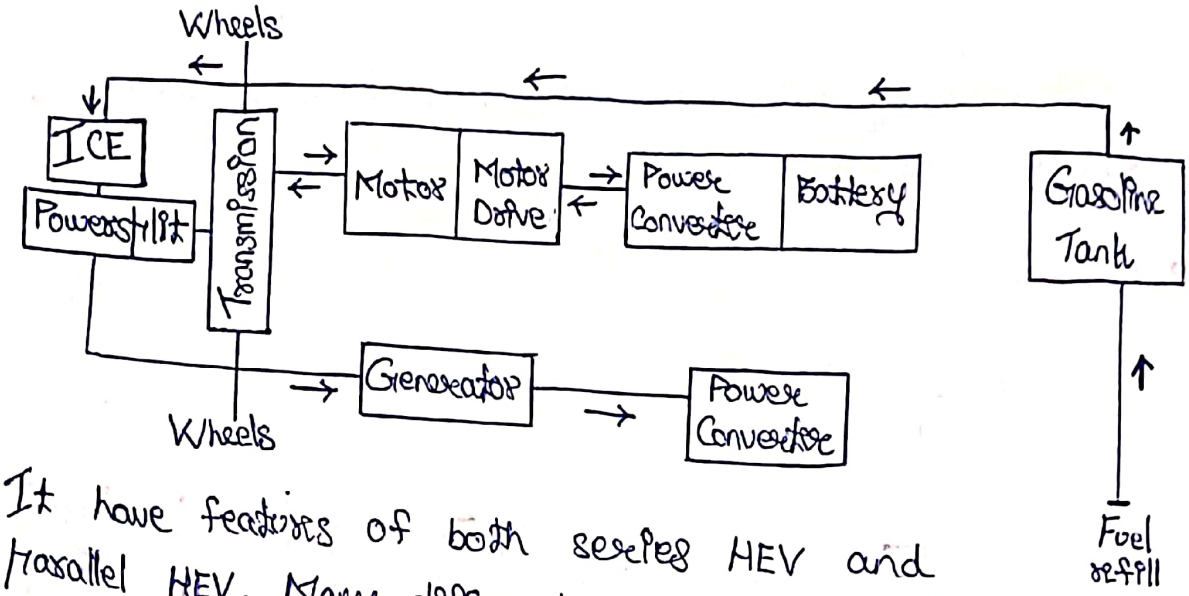
Advantages :

- 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 the generator and smaller traction motor.

Disadvantages :

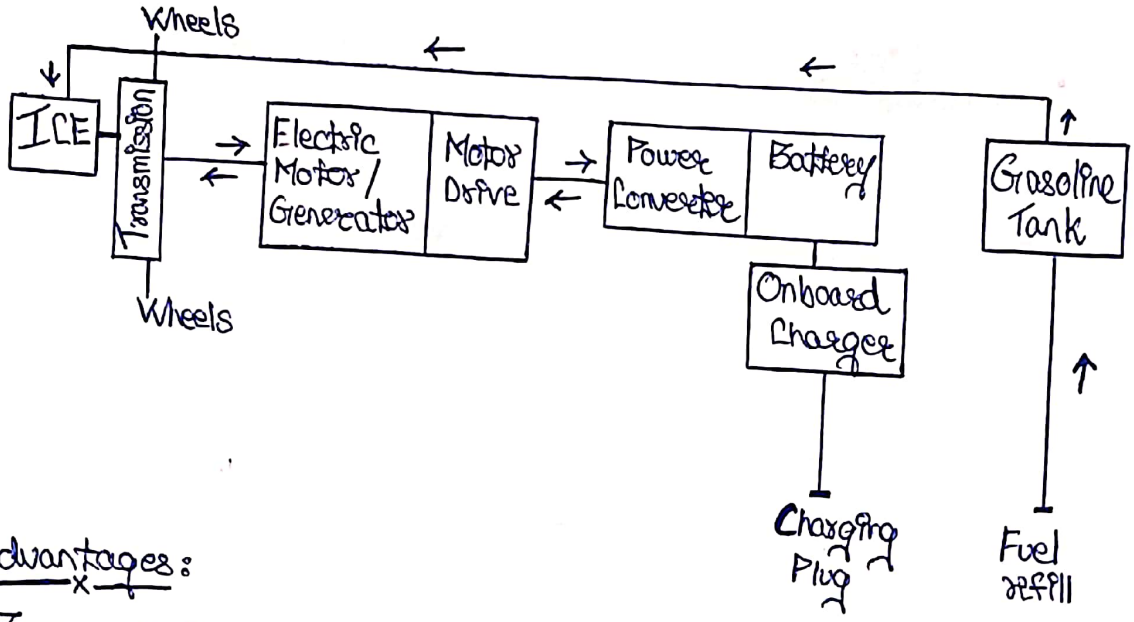
- Mechanical coupling between the engine, motor and driven wheels, thus the engine operating points cannot be fixed in a narrow speed region.
- The mechanical configuration and the control strategy are complex compared to series hybrid drivetrain.

c) Series Parallel HEV:



It have features of both series HEV and Parallel HEV. Many different modes of driving is possible under ICE dominant hybrid vehicle and under motor dominant drive mode. The first model used in a vehicle was on the Toyota Prius on 1997. The drawback of the setup was that it was very bulky.

d) Plug-in Hybrid EV (PHEV):



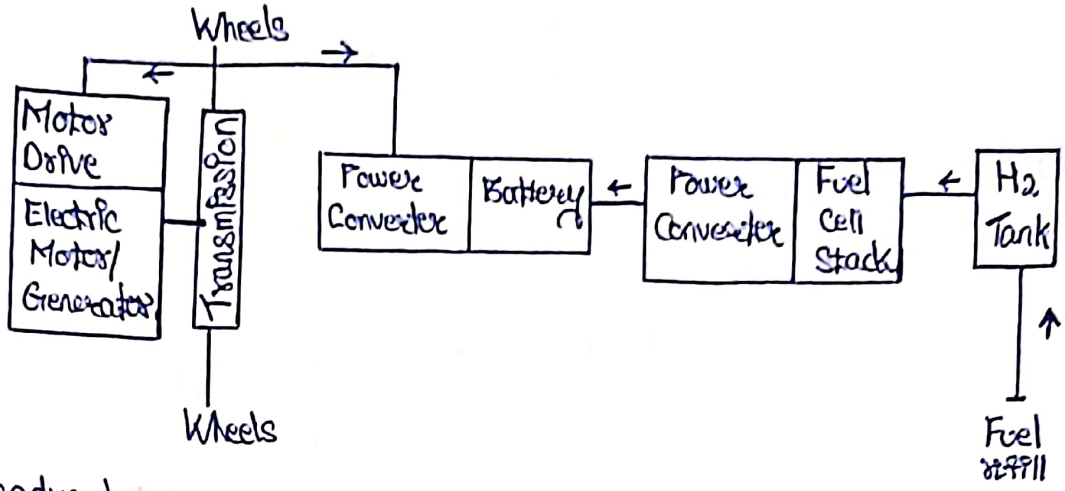
Advantages:

- Zero emission when driving on batteries.
- Fuel efficient in traffic.
- Easy to drive.
- Cheap to run if doing regular 10/15 mile commutes.

Disadvantages:

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

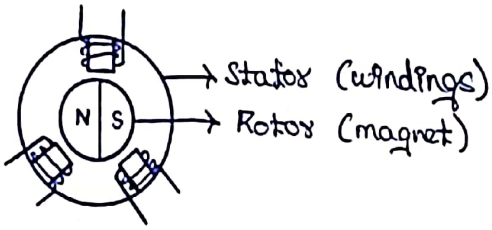
e) Fuel Cell EV (FCEV):



Disadvantages:

- Difficulty to handle hydrogen fuel.
- Hydrogen tanks occupy space leaving less space for the batteries.
- Hydrogen fuel is costly.

Q.3. Explain with diagram the construction and working principle of BLDC.



The BLDC motor uses a permanent magnet as the rotor. The coils that carry the current are fixed on the stator. When you pass current through the # coils, the resultant magnetic current attracts or deflects the permanent magnet, which in the case is the rotor itself. By adjusting the magnitude and direction of the current into the coils using a controller, the direction and speed of the rotor's rotation can be controlled (unlike the brushed DC motor which uses brushes and commutator).

The BLDC motor works on the main principle similar to conventional DC motors, that is, the Lorentz force which states that whenever a current carrying conductor placed in a magnetic field it experiences a force.

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