

- 1768 - 1st vehicle by Nicholas Cugnot (Steam Engine)
- 1806 - Issac de Rivas (1st IC Engine)
- 1826 - Anyoz zedlike (Electric motor for car)
- 1886 - Thomas Parker 1st Electric Vehicle
- 1884 - Carl Benz - IC Engine
- 1890 - William Morrison invented Morrison's carriage
 - Speed - 20 mph
 - Motor - 4HP
3kW
 - Battery - 58kW
112AH $\approx$ 6496 watt hr
 - 4 speed control - 12V, 24V, 48V, 86V

1906 - Golden Era of EV

IC Engine - 20%

Steam Engine - 48%

Electric Vehicle - 32%

Reason for popularity of EV are

- Easy start
- No emission
- Efficient
- Low cost.

1910 - End of Golden Era

1912 - Decline of EV

- Reason for Decline are :
- Assembly line production by Henry Ford
 - World war, oil lobby

1929 - The great US depression
(oil lobbies)

1950(s) - New era in EV

• The great smog (5-9 Dec 1950)
12000 death

1960 - Pollution and death in California

1970 - California Air Resource board formed (CARB)

1991 - LEV I (Low emission vehicle)

- all manufacturer to provide EV alternative
- ZEV zero emission vehicle

lease agreement resulted in failure of LEV I

1996 - Filed case against CARB

1999 - companies won

2003 - LEV II

LEV - 10 - 15% less emission

ULEV - 70 - 80% less emission

P2EV - 0% emission

2004 - Emission Regulation in India

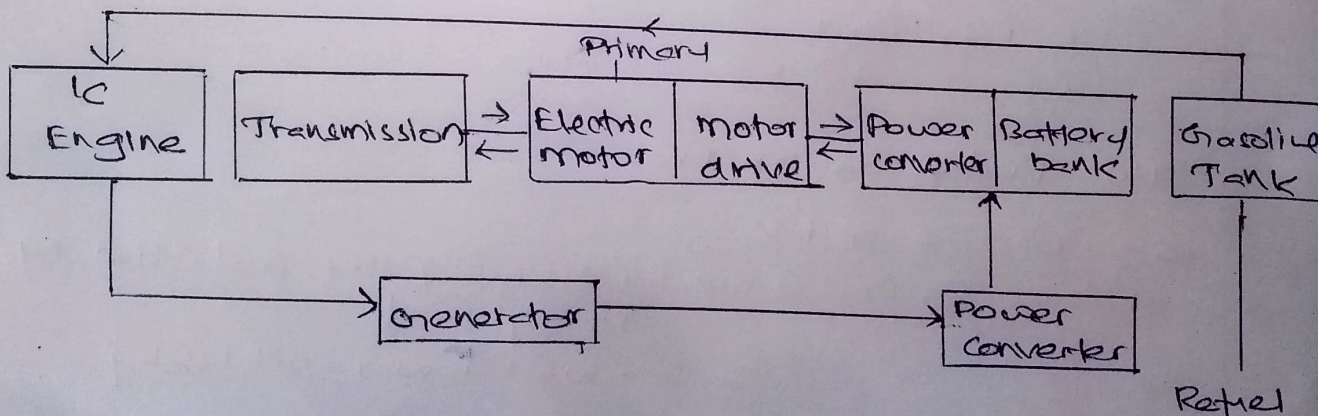
2006 - Santa Monica Auto Expo

Tesla Roadster was presented. It had capacity
of 180-200 mi/hr

2010 - Nissan Leaf (1st affordable 5 door hatch back EV)

2.

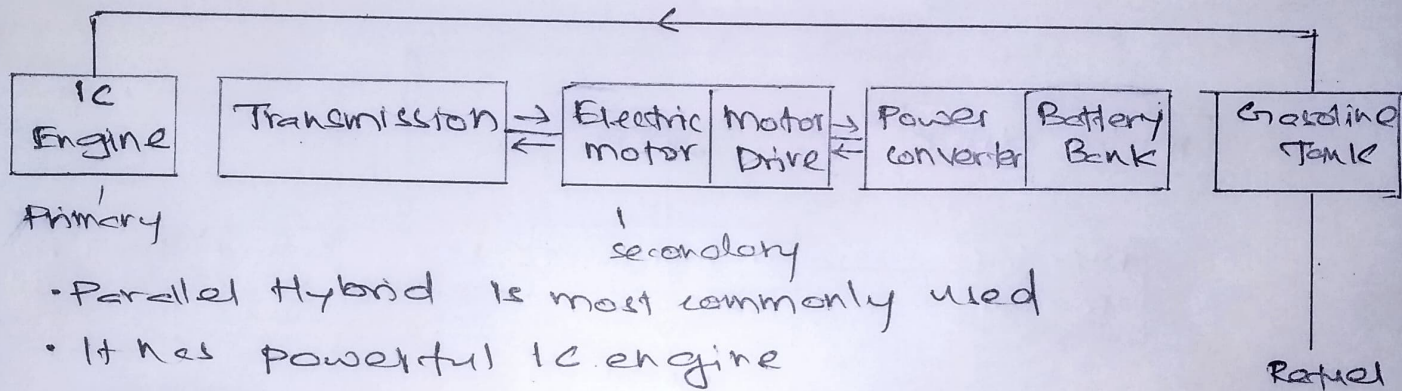
(a) Series hybrid EV



- IC engine recharge Battery Bank
- Powerful electric motor
- Larger Battery pack
- Motor at back
- Has range extender
- Rarely used

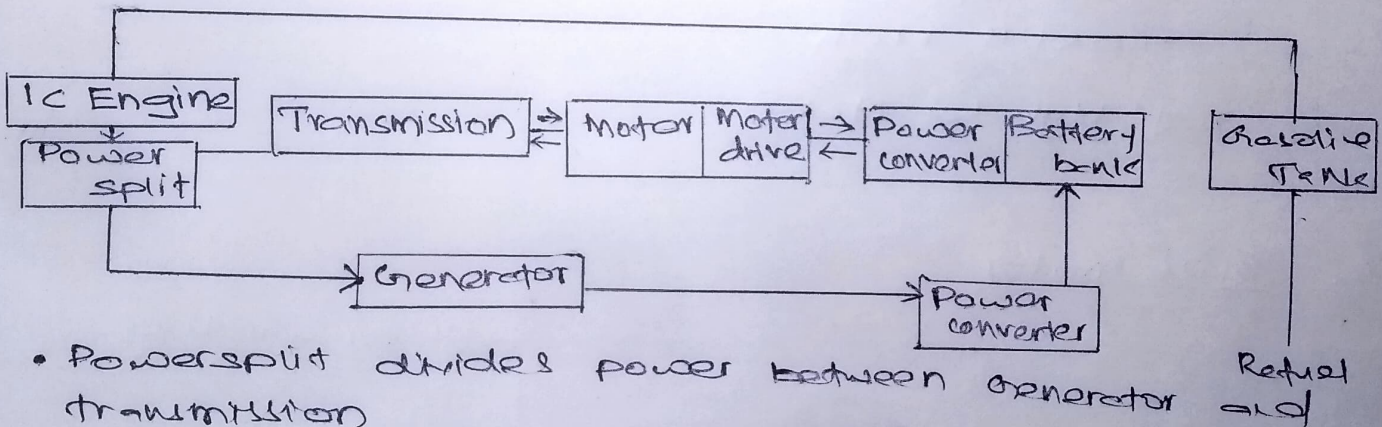
eg: BMW i3

(b) Parallel Hybrid



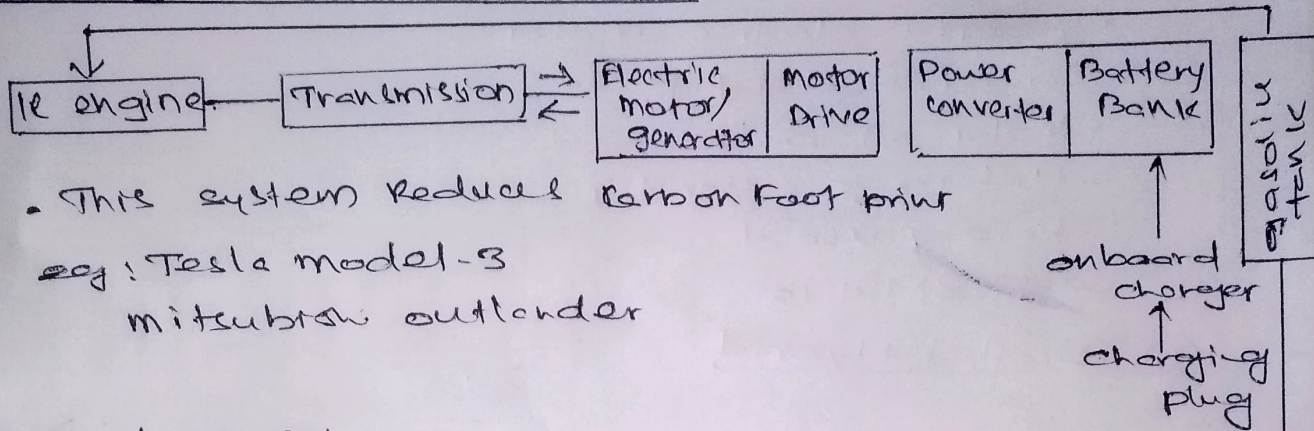
- Parallel Hybrid is most commonly used
- It has powerful IC engine
- small battery pack
- eg: BMW i8

(c) Series-Parallel Hybrid

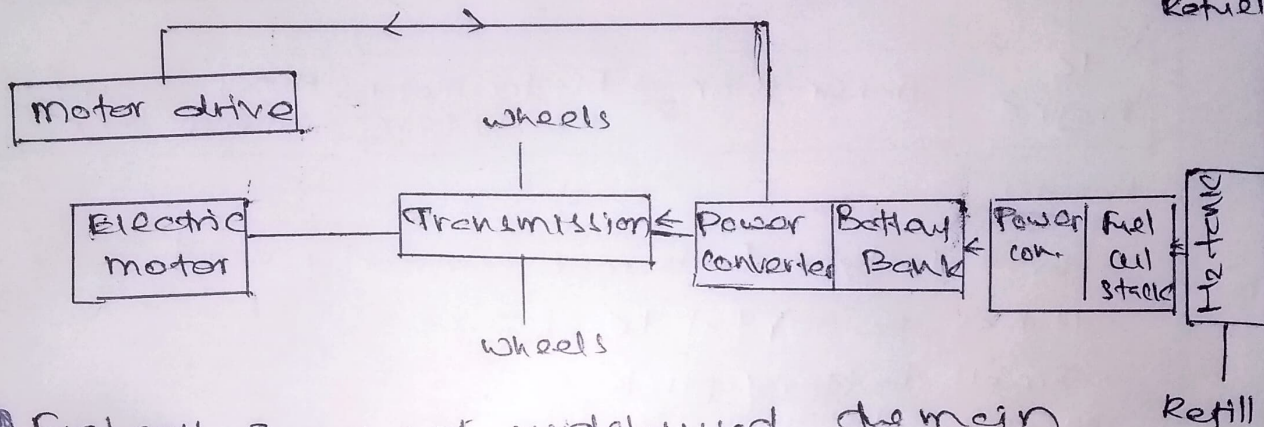


- Powersplit divides power between generator and transmission
- Heavy setup - draw back
- Motor connected to Ring gear
- IC engine connected to ~~ring~~^{sun} gear
- Back disc - gearbox
- Small rotor - generator
- Toyota Prius - eg
- Only one vehicle is introduced.

① Plug-in hybrid EV (PHEV)



② Fuel cell EV

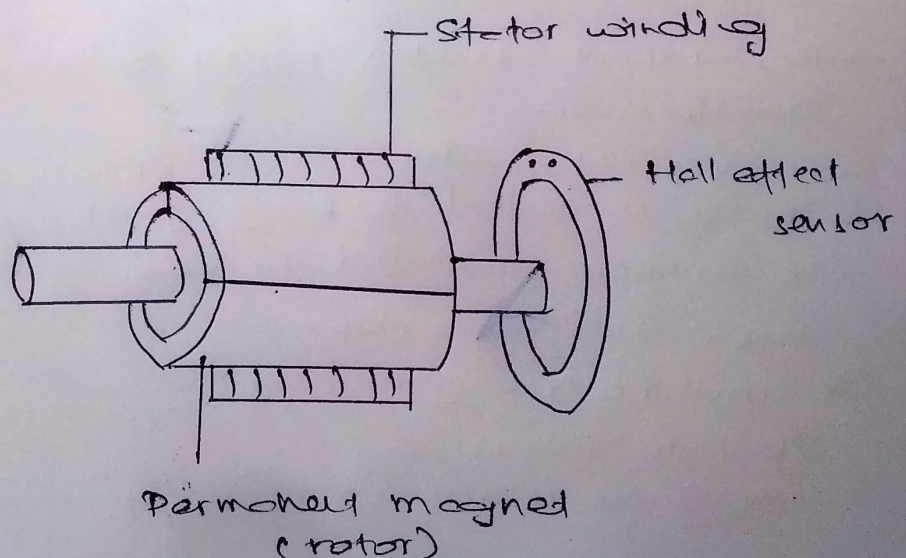


● Fuel cell EV was not widely used, the main reason was, it was difficult to handle H_2

- more space is required
- cost is high

eg: Hyundai Nexo

3. BLDC motor



Working principle

Lorentz Force Law:

It states that whenever a current carrying conductor is placed in a magnetic field, it experiences a force as a consequence, the magnet will experience an equal and opposite force. In BLDC motor, conductor windings are stator and magnet is rotor.

- Radial flux BLDC

- Axial flux BLDC: Better flux density
Rotating according to axis

$$\eta_{\max} = 95\%$$

$$\eta_{\min} = 35\%$$

Applications are in 2-wheeler vehicle & 3-wheeler vehicle.

Peak power: maximum power motor can deliver.

$t = 10 \text{ sec} \Rightarrow$ motor cannot operate in max. power for more than 10 sec.

Rated Power: max. power deliver for continuous operation

$$t = 30 \text{ min}$$

Peak torque: max. torque delivered by motor

~~aka~~ peak torque = initial torque.

Rated torque: torque delivered at rated RPM/power

we can manipulate torque by controlling v_i
strong magnet field means strong torque.