BT OC - Before + dead centre

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Chapter - 1

Automotive Systems, Design Cycles & Automotive Industry Overview.

Vidio - 1

Introduction: Overview of Automotive Industry

- The tot. anual output of more than 85 million vehicles.
- Revenues of more than U.S $2.8 billion (2013)
- Primary activity:

1) Development - duvelopment of various automotive subsystems in order to realize various user friendly activities which are necessary in ordr to help the user / driver to reduce the stress related to driving activities & promote safety & othr standrs

2) Manufacturing - of various subsystem / component - which is done by original manufacturers (OEM)

3) Distributn - of various s/w components & parts

4) Service of transportatn vehicles - Insurance of vehicles are part & parcel of pr. activity in automotive industry.

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Product categories
- Passenger cars
- Small SUV
- Trucks
- Agricultral vehicles

Overview of Automotive Industry
Automotive Industry Players:
- OEM (Original Equipment Manufacturer)
The makers of cars, light trucks, and motorbikes.
Ex: TATA

- Tiered suppliers: deal of supply of different H/w as well as S/w compon
Ex: Delphi, JCL, Visteon.

- Vendors: Intermediate ppl bet industry suppliers & distributors
- Both H/w & S/w are handled by vendors.

- Service Providers:- Include maintenance carried on H/w, IC also Include Insurance

- Customers: We

Automotive supply chain management system

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1) Sourcing - of raw materials & other components required for manufacture of H/w or S/w or vehicle

2) Material management & manufacturing - Actual manufacture of vehicle, H/w or S/w takes place

3) Finished Goods Management & Distribution
All vendors & showroom ppl comes here

- Under sourcing we have 2 supplier categories who provide with raw material accessories.

1) Domestic supplies - Those whose reside in our own country

2) Foreign supplies - Out of our country

- In Intermediate sector we have compo-
→ nent & sub-component manufacturing in terms of H/w & S/w

- Under last one, we have domestic OEMs
→ foreign OEMs, vendors

Automotive component manufacturers.
- certain components are readily not available so they have to manufactured or imported from out.

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Key factors promote growth of Automotive Industry

1) Government : different acts, rules & regulations imposed by gov.
   - TREAD Act
   - Disposal
   - Reconciliation
   - Safety & environmental legislations.

These promote the research & dvelopm of AI

2) International Trade - Imp for growth & sustainable of AI
   - Exchange rate
   - Trade acts / tariff

3) Suppliers - various suppliers
   - global presence
   - Emerge of low cost destination
   - Increasing tiers.

4) Competition - essentially required for any company to sustain
   - healthy push for develop activities
   - competing on cost / features
   - globalized.

5) OEM - have requirements of day to day in manufacturing unit
   - consolidation
   - overcapacity

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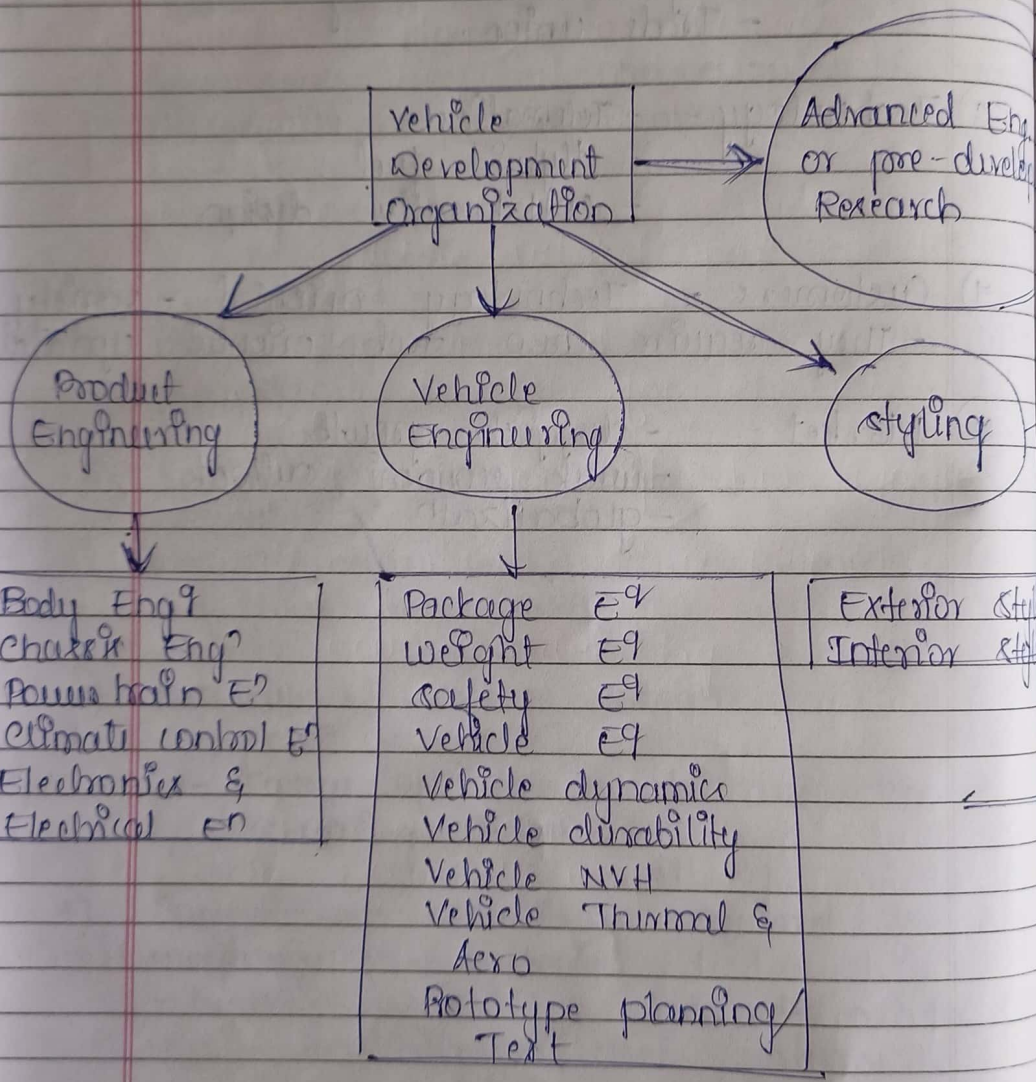
- distributed operation
- high FG inventory
- Trade union.

6) Technology - - Telematics
- Hybrid fuel
- collaborative design

7) Customers - Technology oriented - variety
- They require new tech oriented updated

8) Market - - sluggish growth
- weak economic outlook
- globalizath

Various Engineering domains in AI



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Video - 2

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- Dawn: E

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Video - 2

Evolution of Automotive Electronics

- Dawn: Early 1970. The radio, the alternator (Diodes) & the voltage regulator to manage charging of batteries
  - 99% mechanical
  - Late 1970's: Electronics for engine control
  - 1980's: Antilock braking introduced (ABS)
  - Early 1990's: Airbags become standard
  - Late 1990's: Rapid expansion of body electronics
    i.e, Automatic control of headlight opening of doors.

- Sub-domains.
  - Early 2000's to date: Infotainment, GPS and mapping capabilities, satellite radio.
  - Late 2000's: Steer-by-wire, wireless connectivity
  - Trends 2020: connected cars & autonomous vehicles.

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Domains: Advanced Eng. or pre-development Research; styling

Exterior Styling
Interior Styling

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NOW → 10% mech & 90% elect°/electron°
[ECU - electronic control unit]

Electrical system of automobile
And 1960 - only headlights & spark plugs are electrical & no electronic component involved.

Recently, VW Phaeton:
- 11,136 electrical parts in tot
communicatn:
- 61 ECUs in total
- external diagonsis for 31 ECUs via serial communicatn
- optical bus for high bw infotain° data
- sub networks based on proprietary serial bus
- 35 ECUs connected by 3 CAN buses

sharing
- appx. 2500 signals
- in 250 CAN msgs.

safety

1)
2)
3)
4)

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active safety — active — vehicle guidance

- collision avoidance
- automatic parking
- ACC stop+go
- active parking aid
- lane-keeping assistant
- ACC

safety ← → comfort

- pedestrain object recognition
- precrash
- accidince warning
- dead angle detection
- lane departure warning
- night-vision support

passive safety — passive — driver assistance

Problems and challenges:

1) little standardization for automotive elelmonics & software existing.
2) Availability of hardware components cycle of advancement of semiconductor industry is less as compared to automotive
3) service personnel not qualified for elechnik or s/w based sys^m.
4) Embedded sys^m with mostly hard real time requirements
   - drive train → order of 100 µs
   - chasis → order of ... ms
   - body → order of 10 --- 100 ms

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Design Issues: Automotive sector

1) layout and packaging within the vehicle
- existance of such a huge amt of sensors & huge amt of data which is passing every now & then over the network it is difficult to get a layout for all communicatn lines

2) Electrical (hard/software) & mech/hydraulic/pneumatic partitioning of system hrs.
- In EVs it's difficult to classify signal & power lines.
- optimal at large voltages.

3) safety concept (fault tolerance, redundant decisions, ...).

5) Information processing architecture
- design constraint.

6) Functional architecture (hierarchical functional control with standardized vehicle fn oriented interfaces).

7) Communicatn network protocol selectn & standardizatn.

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Video - 3

Automotive Electronics - Automotive development methodology

- conventional vehicle development
- Design & testing of mechanical & electro-mechanical components.
- cars have become complex systems of E/E sys, electronics / s/w due to user expectations w.r.t time
- Difficult to design, test and deploy the subsystems into vehicles with better confidence.
- upto 40% of vehicles cost are determined by electronics & s/w deployed
- 50% - 70% of the development cost for an ECU are related to s/w

Goals

- complexity can be handled by dividing the design task among various teams
- Infotainment
- power train
- Body electronics
- Chassis & driver assistance
- safety sys
- sys engineering - Approach
  - System engineering - (lot of technical process goes on)
  - Management processes - (progm, prj managm, risk managem)

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Systems Engineering Approach.

Systems engineering
→ Requirement engineering / management
→ System validation
→ system architecture & design
→ Sys^m Integration & verification
→ Subsys^m / component engineering
Technical processes

Management processes
→ program / project management
→ Risk management
→ configuration management

1) Requirement engineering / management
- capturing requirements of OEMs & managing them

2) System architecture & design
- evaluate various feasibility ~~test~~ of various architecture & design method/ black box approach in order to realise given sys^m

3) Sub-system Engineering
- Various sub-system modules designed are integrated @ subsystem level or component level & all engineering aspects are tested & verified

4) System Integration & verification
- various sub-system developed are

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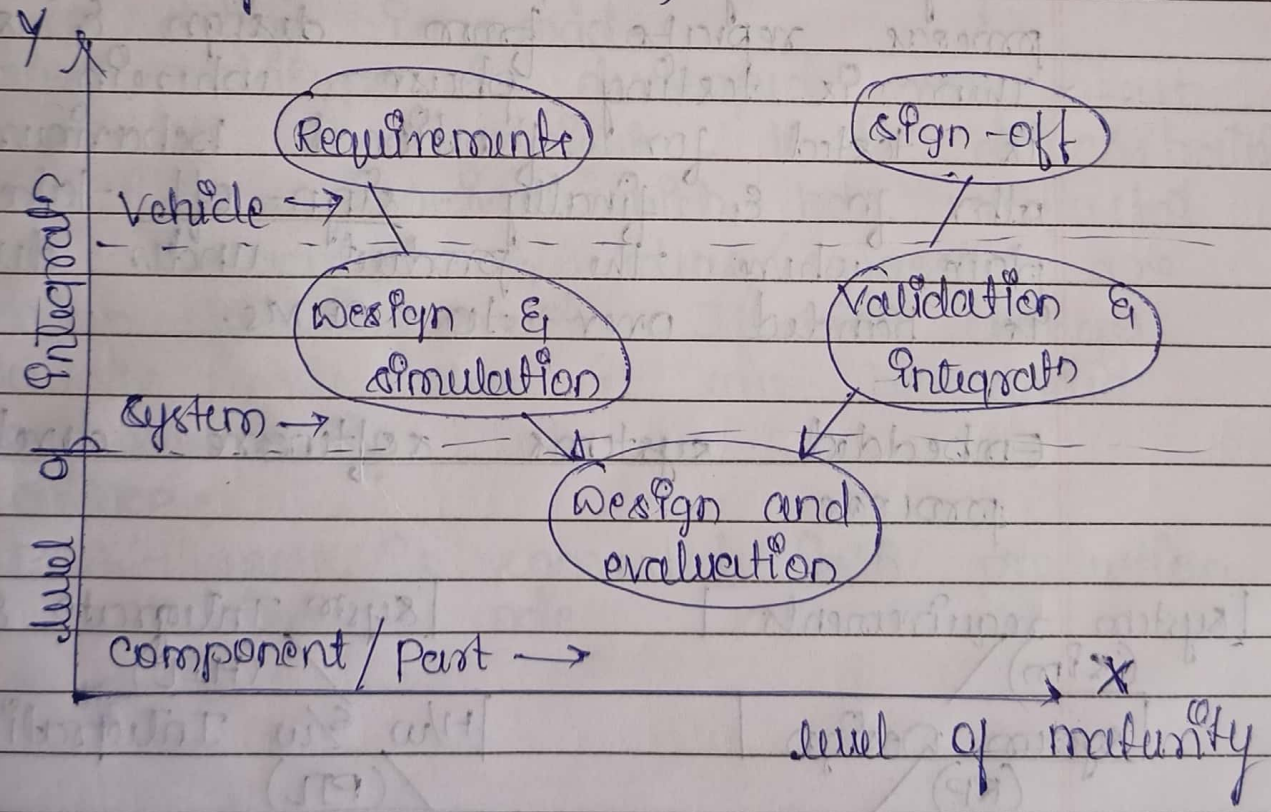
integrated & verified for functional correctness & other parameters.

e) System validation :
- functional requirements are validated by OEMs & final sign-off of sys/component takes place.
- Vehicle is handled over real OEM.

Models
1) classical V-model of development :-
(commonly used model)



→ 1st phase of model is requirement phase where OEMs conceive or plan where in as to how the subsystm / product / s/w under develop looks like.

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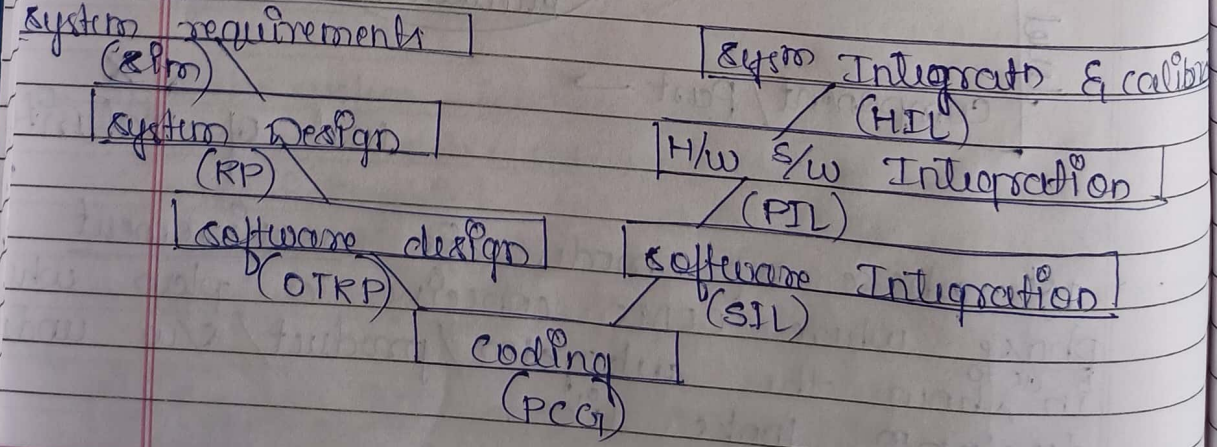
→ Under design & simulation, it makes sure that the requirements that are facilitated in requirements docs are complete. to calm needs of design & simulation

→ In evaluation phase, design is evaluated for its flexibility, cost effectiveness & other related strategies.

→ In validation & integration phase, the design developed in earlier stages including simulation the H/w, S/w are integrated & tested together. So these may bring many loop holes the agn the process replate from design & simulation

→ Then is testing phase, wherein vehicle is tested for functional behaviour & other fr & finally sign-off takes place where the product under development is handed over to OEMs.

Embedded systems software development process



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Sim - simulatn
RP - Rapid prototyping
OTRP - On target rapid prototyping
PCG - Producth code generatn
SIL - Software-in-the-loop Testing
PIL - Processor-in-the-loop Testing
HIL - Hardware-in-the-loop Testing.

1) Sysm requirements - requirements regarding embedded sysm are gathered & documented
- Thro' sim we come across sysm design.
2) Sysm design - using various eng. aspects sysm design is made
- RP: prototype is developed very fast in span of fortnight. It is demonstrated to customer / OEM which has requested for development & ideas / suggestns are taken for improvement. If any changes to be made then it can be added
3) Software design
- OTRP:
PCG - code is converted into production domain code

Vehicle Functional Domains

1) - Infotainment
2) - Body electronics
3) - power train
4) - safety systems
5) - chassis & driver assistance

1) Infotainment subsystems -
   - Navigation
   - Telematics
   - Dashboard controls
   - In-car multimedia
   - GSM, Bluetooth

2) Body electronics -
   - Interior lighting and control
   - Heating, Ventilation, HVAC
   - seat and door operations
   - power windows
   - Keyless Entry.

3) Power Train (engine to differential)
   - engine control
   - Transmission control
   - Starter / Alternator control
   - Emission control
   - Exhaust Recirculation control

4) safety systems
   - ABS
   - Airbags
   - Power steering
   - Tire pressr monitor
   - driver assistance sysm (DAS)

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8) Chassis & Automotive Mechanical systems :

Engine and Transmission -

a) Engine :

- heart of vehicle wherein torque is generated
- convert energy from fuel into useful mechanical motion
- External & Internal combustion engine
- diesel engine, petrol engine, CNG engine, LPG engines.
- Air cooled engines, liquid cooled eng.
- Inline, opposed, rotary, V- engines & W- engine.

- Basically engine works in 4 stokes intake, compression, power, exhaust.

1) Intake :

- During intake stroke, the inlet valve opens and as piston moves from top dead centre (TDC) to bottom dead centre (BDC), fuel & air are sucked into the cylinder.

2) Compression :

- During compression stroke, the piston moves from BDC to TDC, and the air & fuel mixture is compressed.

3) Power :

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- During power stroke the spark from spark plug ignites the compressed air & fuel mixture & gases of combustn undrgo rapid expansion thereby pushing the piston outwards towards BDC so this creats torque on crank shaft which is connected to piston & therefore the linear motion of piston is converted to rotational.

4) Exhaust :-
- During exhaust stroke, the outlet valve opens & the combustion gases are pushed out by the piston moving from BDC to TDC

* A 4-stroke engine produces power once every 4 stroke only (1 power stroke & 3 idial stroke)
- Energy for idial stroke come from stored energy resource present in flywheel

b) Transmission ? (Gear box)
- It is the technique of providing different gear or drive ration between the engine & drive wheels of an automotive vehicle
- principle -
  → drop in speed, increase in torque
  → A transmission provides variable speed, variable torque o/p at the wheels
- operation (max)
  manual / automatic / semi-automatic

24

Braking and suspension systems.

Braking systems -
- It is responsible for slowing & stopping the vehicle
- It converts kinetic energy of vehicle to heat dissipation
- Types : Drum, disk
  Drum - internally expanding (rear wheel)
  Disk - externally expanding (front wheel)

Suspension system -
- It is a mechanism which connects the wheels with vehicle body.
- suspension is combination of spring & damper which supports & weight of car
  a) Sprung mass
  b) Unsprung mass.

a) Sprung mass - The mass of vehicle that rests on spring or hanging on spring

b) Unsprung mass - The mass of vehicle hanging below the spring.

Shock - absorber (damper) - damps oscillations which are occuring due to spring & mass action.
- To obtain best results, the system shld be critically damped.

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Steering and Ignition Systems.

- We have a steering wheel which is coupled to wheel of vehicle thro' rack & pinion gear. This sys is called steering system.
- These are assisted with hydraulic or electric boosts.

→ Steering system
- helps the driver to turn the vehicle
- control the directn of motion of vehicle (purpose)
- steering angle: The angle by which wheels change their alignment w.r.t the plane of vehicle.
- No of rotatn ∝ Angle of steering.

→ Ignition System
- generate sparks that will ignite the air-fuel mixture.
- spark plug - produces sparks which ignite mixture
- distributor - which distributes spark to various cylinders
- The proper & efficient operatn of engine is greatly associated with spark plug.
- The spark shld be produced at right moment. This is known as spark advance.
- If spark advance is controlled properly then engine achieves better efficiency.
- Maintain spark advance

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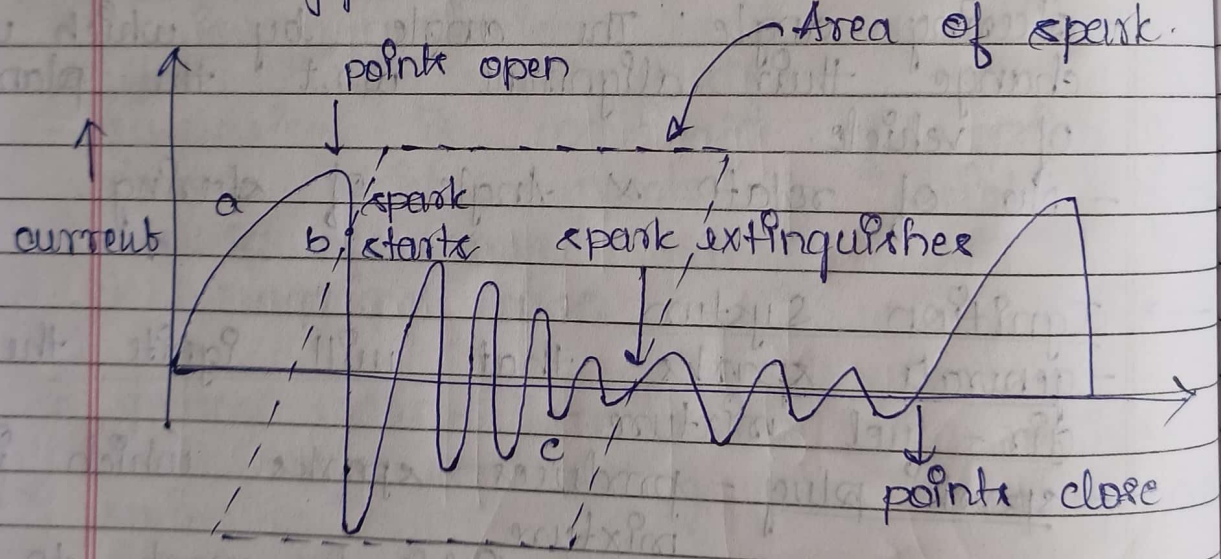
Spark advance -
The angle before the TDC at which the spark should be triggered in spark plug.

→ Principle : When voltage larger than Ionisation voltage of air gap present in spark gap. The air in spark gap can ignite provided the potential difference bet the E-ve terminal is larger than dielectric strength of air which is pres in air gap.



potential : 20 - 25 kV / mm of area gap

- Ionization of air in the electrode space
- Di-electric strength of air is 25 kV/m

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Hybrid Electric Vehicle

- Any vehicle which combines two or more sources of power ↓
- Diseal - electric
- Nuclear - electric
- Gasoline - electric

- classification - series / parallel hybrid.

a) Typical parallel hybrid

- Energy from the engine is combined with the energy from electric motor

4 cylinder engine → Electric Motor → Transmission → wheels

- Both engine & motor generate power @ same time. This power is converted using torque converter box & supplied to wheels.

b) Typical series hybrid

- Electric motor drives the engine at the same time we have generator coupled to A cylinder motor
- Diseal / petrol engine act as prime mover to drive generator
- Generator generates electrical energy
- This energy is either used to charge the battery packs or power electric motor
- Electric motor directly propels vehicle

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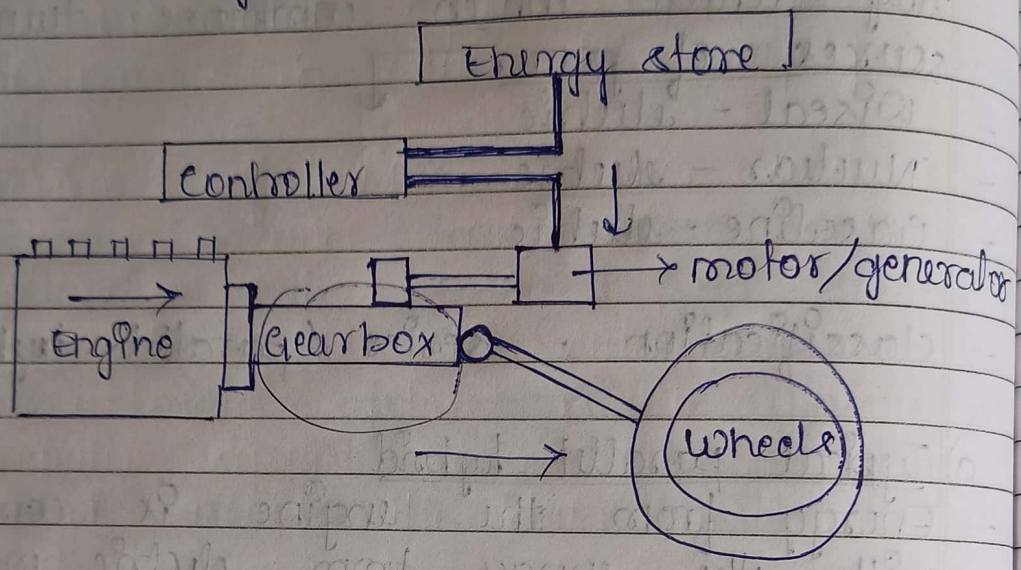
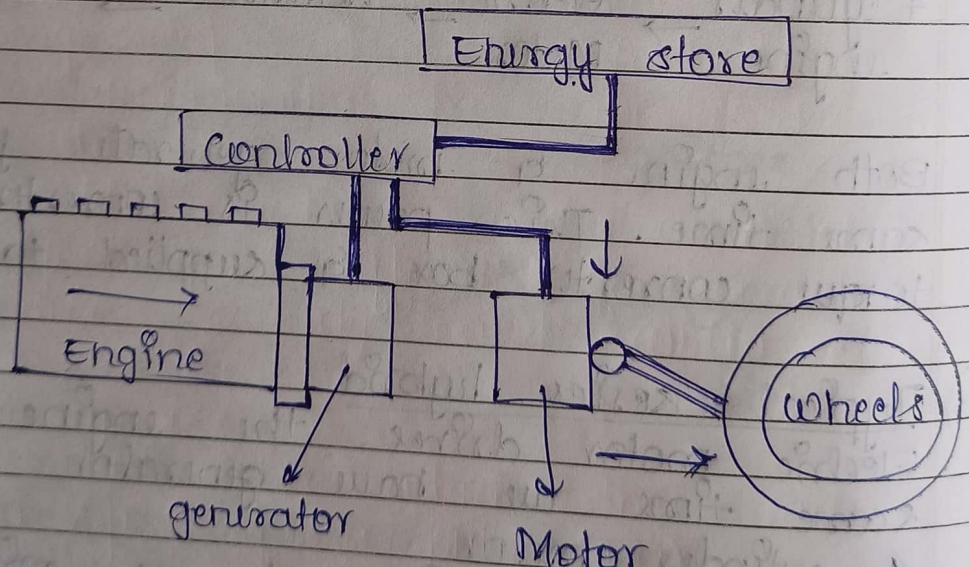
Parallel hybrid



Series hybrid



→ Based on battery & power rating classification - further

a) Micro hybrid : start and stop (12 V / 3 KW)

b) Mild hybrid : 48 V to 160 V, 15 KW

c) Full hybrid : 200 V to 300 V, 50 KW

d) PHEV : 300 V to 400 V, 100 KW
(Plug-in hybrid Electric vehicle)
- powerful EV.

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