CMR
INSTITUTE OF
TECHNOLOGY

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Internal Assesment Test - III

Sub:	Utilization of Electrical Power							Code:	15EE742
Date:	19/11/2018	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch:	EEE
Answer Any FIVE FULL Questions									

		Marks	OBE CO	OBE RBT
1	A tram car is equipped with two motors that are operating in parallel, the resistance in parallel. The resistance of each motor is 0.5 Ω. Calculate the current drawn from the supply mains at 450 V when the car is running at a steady-state speed of 45 kmph and each motor is developing a tractive effort of 1,000 N. The friction, windage, and other losses may be assumed as 3,000 W per motor.	[10]	CO3	L3
2	A 300-ton motor coach having four motors each developing 6,000 N-m torque during acceleration, starts from rest. If the gradient is 40 in 1,000, gear ration is 4, gear transmission efficiency is 87%, wheel radius is 40 cm, train resistance is 50 N/ton, the addition of rotational inertia is 12%. Calculate the time taken to attain a speed of 50 kmph. If the line voltage is 3,000-V DC and the efficiency of motors is 85%. Find the current during notching period.	[10]	CO3	L3
3	With neat sketch explain rheostatic braking in DC series motor.	[10]	CO4	L3
4	Explain the following in DC series motor (i) Plugging (ii) Regenerative braking	[10]	CO4	L3
5	A 500 ton electric train has its speed reduced by regenerative braking from 60 to 40 km/h over a distance of 2km along down gradient of 1.5 percent. Assuming specific train resistance as 50N/t, rotational inertia effect of 10% and conversion efficiency of the system is 75%. Calculate Electrical energy returned to the line and Average power returned to the line.	[10]	CO4	L3
6	A 400 ton train travels down a gradient of 1 in 70 for 120 secs during which period its speed is reduced from 80km/h to 50km/ by regenerative braking. Find the energy returned to lines if the tractive resistance is 49 N/ton and allowance for rotational inertia is 7.5 percent. Over efficiency of the motor is 80 percent.	[10]	CO4	L3
7a	Write the advantages and disadvantages of electrical vehicle with respect to IC Engine vehicles.	[5]	CO5	L2
7b	With block diagram, explain the various functions of different sub systems in an electrical vehicle.	[5]	CO5	L2
8	Discuss the hybrid electric vehicle working principle and its types with relevant block diagrams.	[10]	CO5	L2

Course Outcomes		Modules covered	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	To acquire knowledge about the electric heating, welding, electrolysis, extraction and refining of metals and electro deposition.	1	3	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO2	To Impart the knowledge on the concepts of illumination, working of electric lamps, different types of lamps and its fittings.	2	3	3	2	-	-	-	-	-	-	-	-	-	-	1	-
CO3	To introduce the working of electrical traction system, speed time curves, mechanics of train movement and control of motors.	3	3	3	1	-	-	-	-	-	-	-	-	-	-	1	-
CO4	To discuss braking of electric motors, different types of traction systems and its power supply.	4	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO5	To create awareness of the technology of electric and hybrid electric vehicles.	5	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-

Cognitive level	KEYWORDS
L1	List, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where, etc.
L2	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend
L3	Apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover.
L4	Analyze, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer.
L5	Assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize.

PO1 - *Engineering knowledge*; PO2 - *Problem analysis*; PO3 - *Design/development of solutions*; PO4 - *Conduct investigations of complex problems*; PO5 - *Modern tool usage*; PO6 - *The Engineer and society*; PO7- *Environment and sustainability*; PO8 – *Ethics*; PO9 - *Individual and team work*; PO10 - *Communication*; PO11 - *Project management and finance*; PO12 - *Life-long learning*

Answer Key

1. Solution

The resistance of each motor = 0.5 Ω.

Voltage across each motor V = 450 V.

Tractive effort F_t = 1,600 N.

Maximum speed V_m = 45 kmph.

Losses per motor = 3,000 W.

$$\text{The power output of each motor} = \frac{F_t \times V_m}{3,600}$$
$$= \frac{1,600 \times 45 \times 10^3}{3,600}$$
$$= 20,000 \text{ W.}$$

Copper losses = $I^2R_m = I^2 \times 0.5$

Motor input = motor output + constant loss + copper losses

$450 \times I = 20,000 + 3,000 + 0.5I^2$

$0.5\,I^2 - 450I + 23,000 = 0.$

After solving, we get I = 54.39 A.

Total current drawn from supply mains = 2 × 54.39

= 108.78 A.

--**[10Marks]**

2.

The weight of train $W = 250$ ton.

Parentage gradient $G = \frac{40}{1,000} \times 100 = 4\%$.

Gear ratio $r = 4$.

Wheel diameter $D = 2 \times 40 = 80$ cm.

Or, $D = 0.8$ m.

Train resistance $r = 50$ N/ton.

Rotational inertia = 12%.

Accelerating weight of the train $W_e = 1.10 \times 250 = 275$ ton.

Total torque developed $T = 4 \times 6,000 = 24,000$ Nm.

$$\text{Tractive effort } F_t = \frac{\eta T 2r}{D}$$
$$= \frac{0.87 \times 24,000 \times 2 \times 4}{0.8} = 208,800 \text{ N}.$$

But,

$F_t = 277.8\ W_e \alpha + 98.1\ WG + Wr$

$208,800 = 277.8 \times 275\ \alpha + 98.1 \times 250 \times 4 + 250 \times 50$

$\therefore\ \alpha = 1.285$ kmphps.

The time taken for the train to attain the speed of 50 kmph:

$$t = \frac{V_m}{\alpha}$$
$$= \frac{50}{1.285} = 38.89\text{s}.$$

Power output from the driving axles:

$$= \frac{F_t \times V_m}{3,600} = \frac{208,800 \times 50}{3,600}$$
$$= 2,900 \text{ kW}.$$

$$\text{Power input} = \frac{\text{power output}}{\eta_m}$$
$$= \frac{2,900}{0.85} = 3,411.76 \text{ kW}.$$

$$\text{Total current drawn} = \frac{\text{power input}}{V}$$
$$= \frac{3,411.76 \times 10^3}{3,000} = 1,137.25 \text{ A}.$$

$$\text{Current drawn by the each motor} = \frac{1,137.25}{4} = 284.31 \text{ A}.$$

---**[10Marks]**

3.

Rheostatic or dynamic braking

In this method of braking, the electric motor is disconnected from the supply during the braking period and is reconnected across same electrical resistance. But field winding is continuously excited from the supply in the same direction. Thus, during the starts working as generator during the braking period and all the kinetic energy of the rotating parts is converted into electric energy and is dissipated across the external resistance.

One of the main advantages of the rehostatic braking is electrical energy is not drawn by the motor during braking period compared to plugging. The rehostatic braking can be applied to various DC and AC motors.

The rheostatic braking can be applied to both DC shunt and DC series motors, by disconnecting the armature from the supply and reconnecting it across and external resistance. This is required to dissipate the kinetic energy of all rotating parts thereby brining the motor to rest.

In case of DC series motor, both the field and armature windings are connected across the resistance after disconnecting the same from the supply; current directions of both the field and armatures are reversed. This results in the production of torque in same direction as before. So, in order to produce the braking torque only the direction of current in the armature has to be reversed. The connection diagram of DC series is shown in Fig. 9.11.

If more than one motor has to be used as in electric traction. All motors can be connected in equalizer connection as shown in Fig. 9.12. In this connection, one machine is excited by the armature current of another machine.

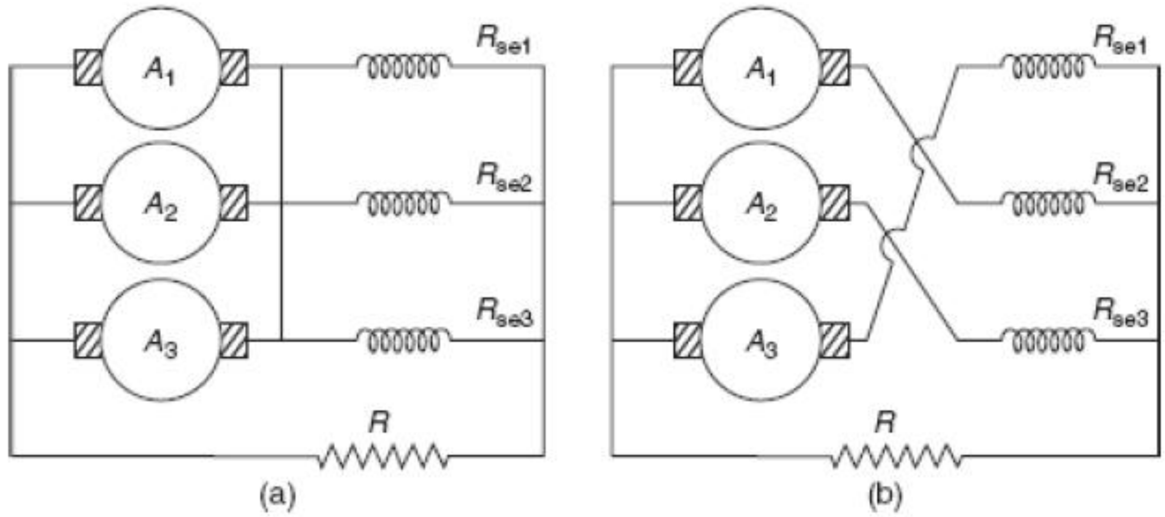


Fig. Equalizer connection

---**[10Marks]**

4 (i)

Plugging

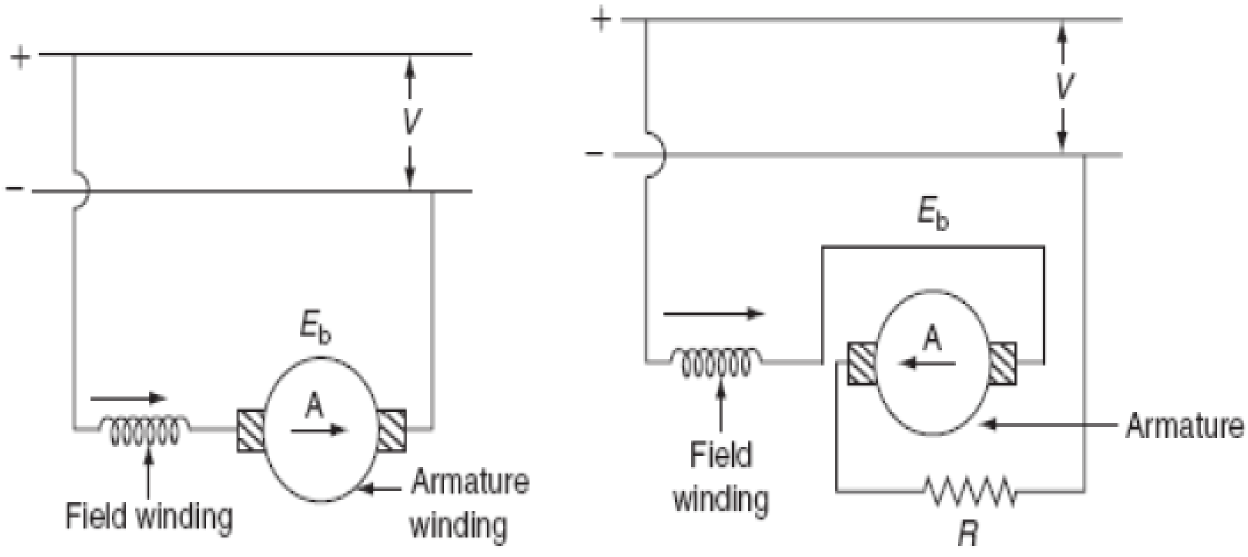
In this method of braking, the electric motor is reconnected to the supply in such a way that it has to develop a torque in opposite direction to the movement of the rotor. Now, the motor will decelerates until zero speed is zero and then accelerates in opposite direction. Immediately, it is necessary to disconnect the motor from the supply as soon as system comes to rest.

The main disadvantage of this method is that the kinetic energy of the rotating parts of the motor is wasted and an additional amount of energy from the supply is required to develop the torque in reverse direction, i.e., in this method, the motor should be connected to the supply during braking. This method can be applied to both DC and AC motors.

Plugging applied to DC motors

Pulling is nothing but reverse current braking. This method of braking can be applied to both DC shunt and DC series motors by reversing either the current through armature or the field winding in order to produce the torque in apposite direction, but not both. The connection diagrams for both DC shunt and DC series motors during normal and braking periods are given as follows.

The connection diagram for normal running conditions of both DC shunt and DC series motors are shown in Figs. 9.4 (a) and 9.5 (a). The back emf developed by the motor is equal in magnitude and same as to the direction of terminal or supply voltage. During the braking, the armatures of both shunt and series motors are reversed as shown in Fig. 9.4 (b) and Fig. 9.5 (b). Now, the back emf developed by the motor direction of terminal voltage. A high resistance '*R*' is connected in series with the armature to limit high-starting current during the braking period.



(a) During normal run period (b) During braking period

Fig. 9.5 Plugging of DC series motor

--**[5Marks]**

(ii)

DC series motor

In case of DC series motor, it is not easy to apply regenerative braking as of DC shunt motor. The main reasons of the difficulty of applying regenerative braking to DC series motor are:

1. During the braking period, the motor acts as generator by reversing the direction of current flowing through the armature, but at the same time, the current flowing through the field winding is also reversed; hence, there is no retarding torque. And, a short-circuit condition will set up both back emf and supply voltage will be added together. So that, during the braking period, it is necessary to reverse the terminals of field winding.
2. Some sort of compensating equipment must be incorporated to take care of large change in supply voltage.

On doing some modifications during the braking period, the regenerative braking can be applied to DC series motor. Any one of the following methods is used.

Method-I (French method)

If one or more series motors are running in parallel, during the braking period, the field windings, of all series motors, are connected across the supply in series with suitable resistance. Thereby converting all series machines in shunt machines as shown in Fig. 9.15.

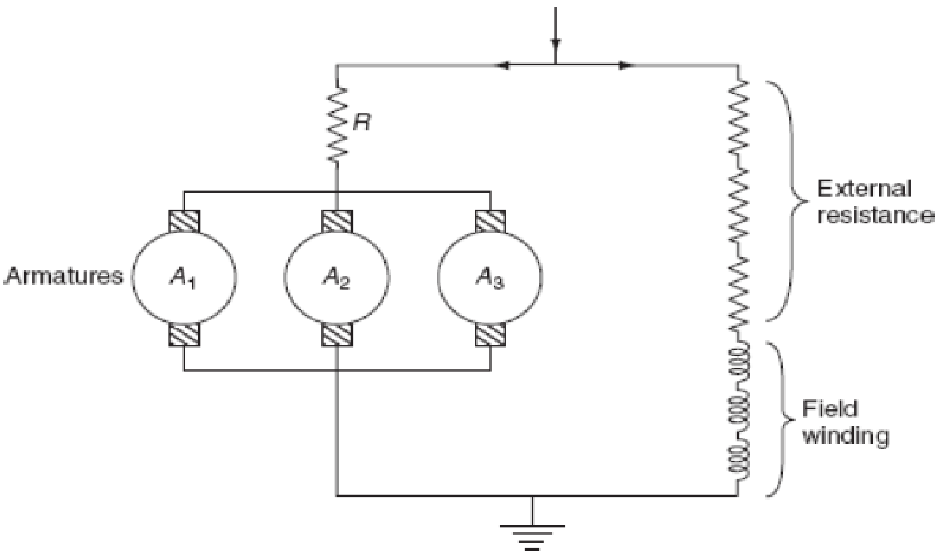


Fig. Regenerative braking of DC series motor

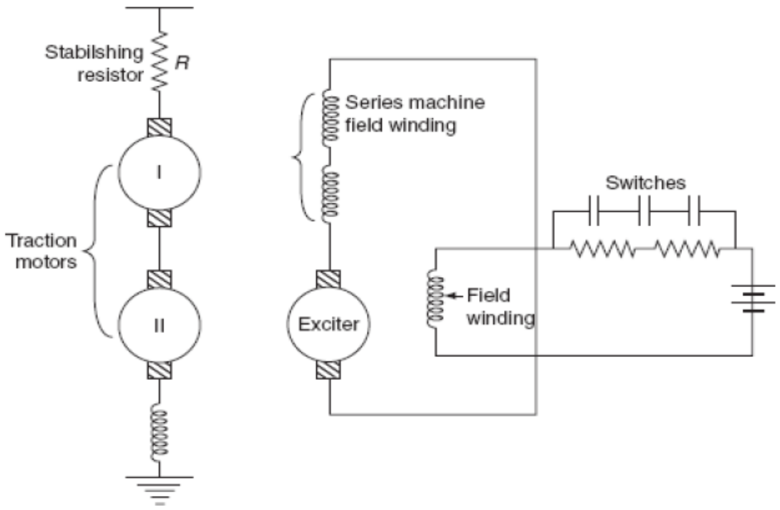
The main advantage of this method is, all armatures are connected in parallel and current supplied to one machine is sufficient to excite the field windings of all the machines, and the energy supplied by remaining all the machines is fed back to the supply system, during the braking period.

Method-II

In this method, the exciter is provided to excite the field windings of the series machine during the regenerative braking period. This is necessary to avoid the dissipation of energy or the loss of power in the external resistance.

Whenever the excitation of field winding is adjusted to increase the rotational emf more than the supply voltage, then the energy is supplied to the supply system. At that time, the field winding of the series machine is connected across an excited being driven by motor operated from an auxiliary supply. Now, during the braking period, the series machine acts as separately excited DC generator which supplies

energy to the main lines. A stabilizing resistance is used to control the braking torque (Figs. 9.16 and 9.17).



--[5Marks]

5.

(*i*) *Electrical energy returned to the line.* **(Bombay University)**

(*ii*) *Ave -age power returned to the line.*

Solution. *Given* : $M = 400$ tonnes ; $V_1 = 60$ km/h ; $V_2 = 40$ km/h ; $S = 2$ km ; $G = 1.5\%$;

$$r = 50 \text{ N/tonne} ; \frac{M_e}{M} = 1.1 ; \eta = 75\%.$$

(*i*) **Electrical energy returned to the line :**

Electrical energy returned to the line

$$= \eta \left[0.01072 \frac{M_e}{M} (V_1^2 - V_2^2) + S\,(27.25\,G - 0.2778\,r)\right] \text{Wh/tonne}$$

$$= 0.75\,[0.01072 \times 1.1(60^2 - 40^2) + 2(27.25 \times 1.5 - 0.2778 \times 50)] \text{ Wh/tonne}$$

$$= 58.16 \text{ Wh/tonne} = 58.16 \times 400 \times 10^{-3} = \mathbf{23.26\ kWh.} \quad \textbf{(Ans.)}$$

(*ii*) **Average power returned to the line :**

$$\text{Average speed} = \frac{60 + 40}{2} = 50 \text{ km/h}$$

$$\therefore \quad \text{Time taken} = \frac{\text{Distance(s)}}{\text{Average speed}} = \frac{2}{50} = 0.04 \text{ h}$$

$$\text{Hence, power returned} = \frac{23.26}{0.04} = \mathbf{581.5\ kW.} \quad \textbf{(Ans.)}$$

...ting 400 tonnes is going down a gradient of 20 in 1000. It is ... regenerative braking. If the tractive resistance is ... of 75 percent, calculate the power fed into **(A.M.I.E.)**

--**[10Marks]**

6.

Solution. *Given* : $M = 500$ tonnes ; $G = \frac{1}{70} \times 100 = \frac{100}{70}\%$; $t = 120$ s ; $V_1 = 80$ km/h ;

$$V_2 = 50 \text{ km/h} ; r = 49 \text{ N/tonne} ; \frac{M_e}{M} = 1.075 ; \eta = 80\%.$$

Energy retu...

$$= \eta\left[0.01072\,\frac{M_e}{M}\,(V_1^2 - V_2^2) + S\,(27.25\,G - 0.2778\,r)\right]\text{ Wh/tonne}$$

$$= 0.8\left[0.01072 \times 1.075\,(80^2 - 50^2) + 2.167\left(27.25 \times \frac{100}{70} - 0.2778 \times 49\right)\right]\text{ Wh/tonne}$$

...Eqn. (8.9)

$$= 0.8\,[44.94 + 54.86) = \mathbf{79.84\ Wh/tonne} \qquad \left[\because\ S = \left(\frac{V_1 + V_2}{2}\right) \times t = \left(\frac{80 + 50}{2}\right) \times \frac{120}{3600} = 2.167\right]$$

$\therefore$ **Total energy returned to the line during regenerative braking**

$= 500 \times 79.4 = 39700$ Wh or **39.7 kWh. (Ans.)**

--[10Marks]

7 (a) Advantages of Electrical vehicle

- **Reduce dependences on oil and gasoline.**
- **Pollutants and noise free.**
- **Recyclable batteries.**
- **No fire hazards.**
- **Low maintenance and operation cost.**

Disadvantages of Electrical vehicle

- **High price, Tesla modal costs around $50,000.**
- **High recharge time.**
- **Silence may be fatal.**
- **Range lies between 25-30 miles only.**

--[5Marks]

7 b.

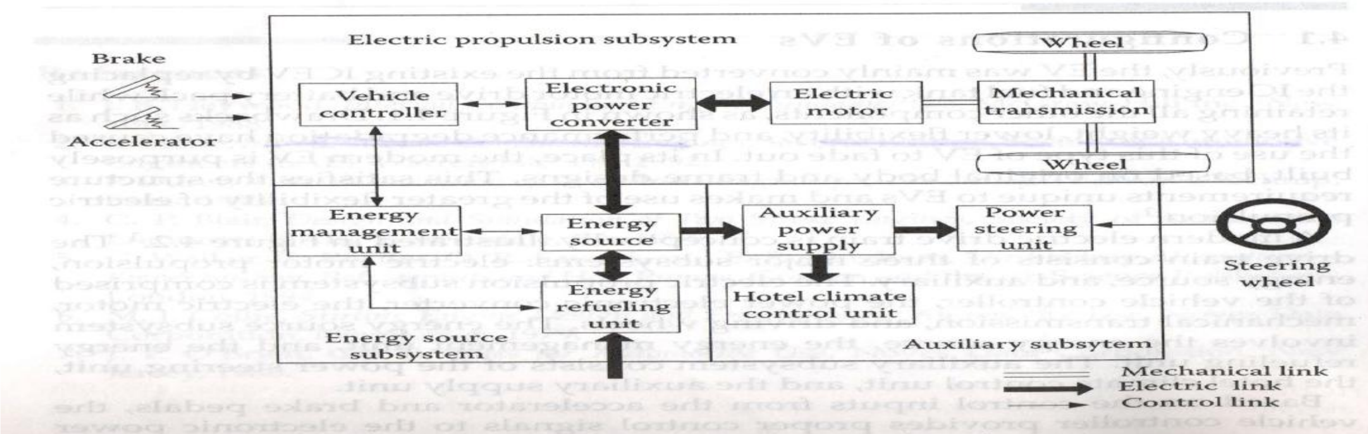


FIGURE 4.2 Conceptual illustration of a general EV configuration.[1]

8. --[5Marks]

- A hybrid car is any car that uses both electricity and fuel injection in order to run.

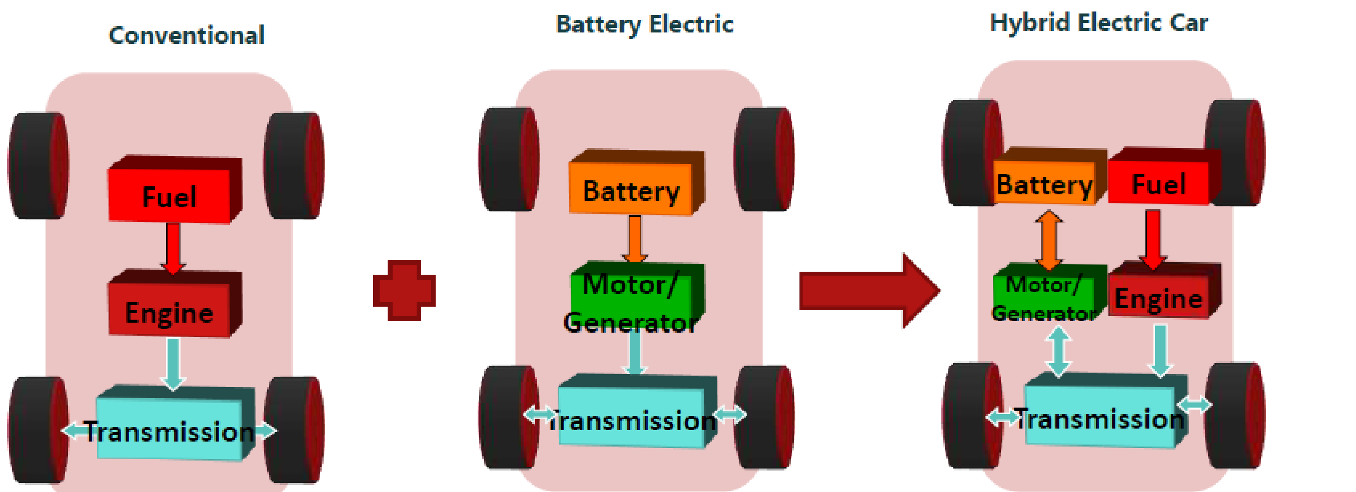


Fig: Hybrid Vehicle Mean

Image Source: (

1. MILD / Micro Hybridization

- They feature idle-stop function
- Regenerative braking
- Are not capable of using the electric motor to propel the vehicle
- These systems are usually 42 volts or less

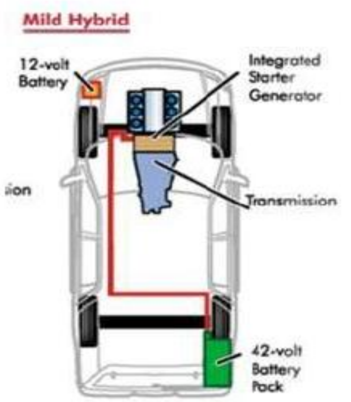


Fig: Mild Hybridization

2. Parallel Hybrid

- Has a fuel tank that supplies gas to the engine like a regular car.
- It also has a set of batteries that run an electric motor.
- Both the engine and electric motor can turn the transmission at the same time.

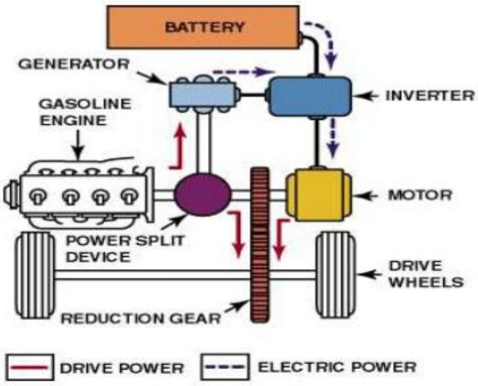


Fig: Parallel Hybrid

3. Electrical Motor

- It's power the vehicle at low speed and assist the gasoline engine when additional power is needed.
- Most of the electric machines used in hybrid vehicles are brushless DC motors (BLDC).


Fig: Electrical Motor

--[10Marks]