DEPARTMENT OF ELECTRICAL ENGINEERING

SOLUTION & MARKING SCHEME

(Semester 1, 2011/12)

SUBJECT (Code & Title) : EE512 Electric Vehicles

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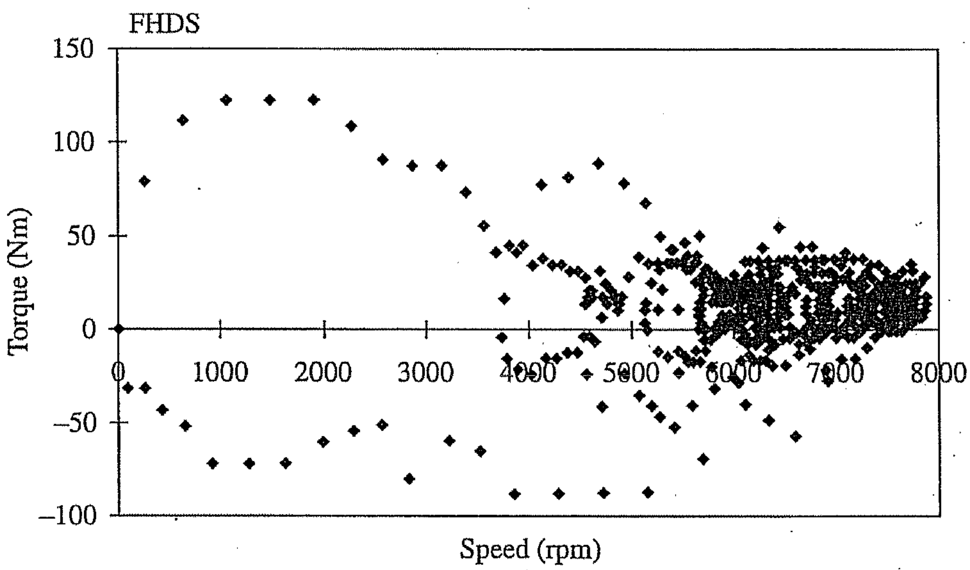
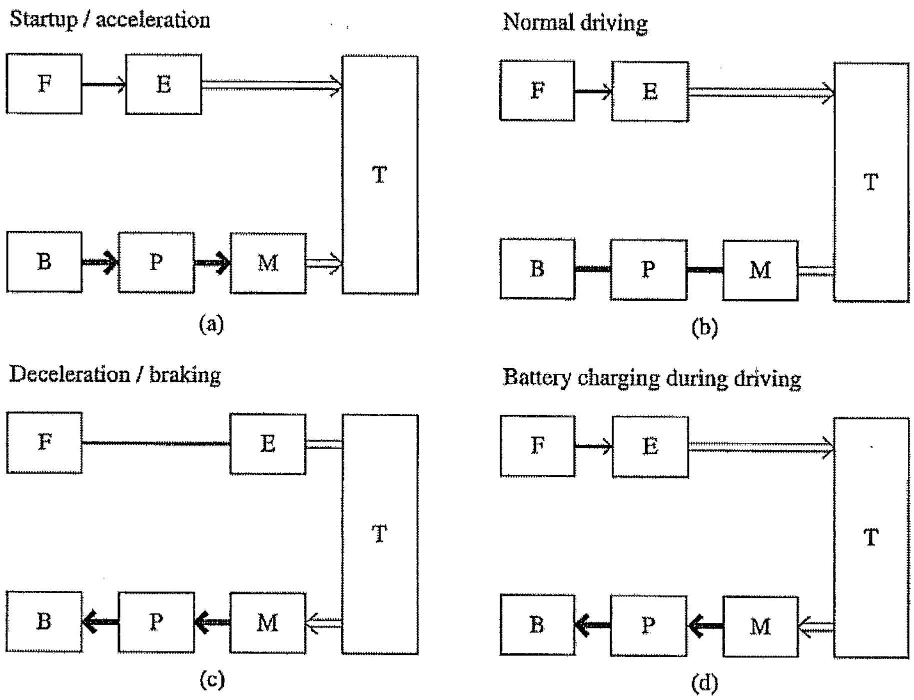
QUESTION NO. ( )	SOLUTION	MARKS
Q1		
(a)	Zone A – Vehicle is accelerating from rest or from a low speed.	2
	Zone B – Vehicle is moving at low speed.	2
	Zone C – Vehicle is cruising at high speed on a horizontal plane.	2
	Zone D - Vehicle is braking to a standstill.	2
(b)	Vehicle is driving in the urban area, because	
	1. It has frequent start stops.	2
	2. Most of the time, the vehicle is spent in medium to low speeds.	2
	3. It seldom reaches maximum speed.	2
(c)	(b)	6

QUESTION NO. ( )	SOLUTION	MARKS
Q2	Motor Size & Weight – Given the some power output, Low speed direct drive motor in (b) is much larger and higher in weight and size than high speed motor in (a); however, high speed motor requires gear box reduction, and this will add extra weight to the whole system.	3
	System and Control – In (b) the overall hardware structure is simpler. However, the control software is more complex, due to torque sharing and speed synchronization of the two wheels for straight line path and cornering.	3
	Reliability and Safety - In (b), there are less components that can go wrong, therefore in is more reliability than (a). However, it has serious safety concern, anything malfunction in one of the motor may prohibit the car to travel along a straight path, or set the car spinning.	3
		8
	Add explanation to each of the case.	3

QUESTION NO. ( )	SOLUTION	MARKS

Br referring to the circuit diagram below:

Q3

(a) 4

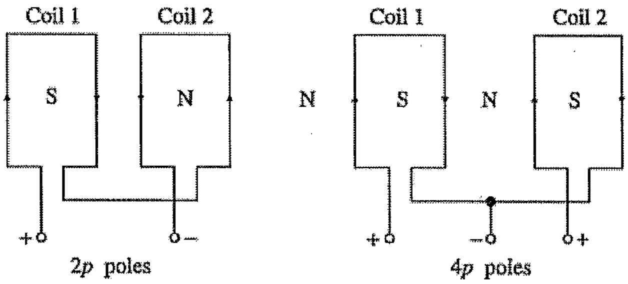
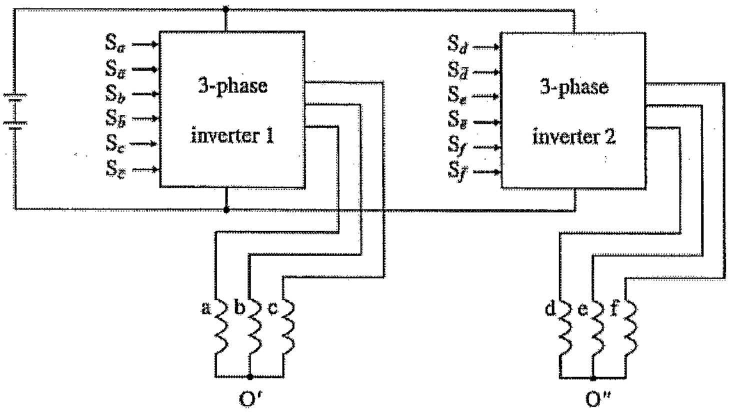


Fig. 5.37. Principle of pole-changing control.



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By using a centre tapped connection, 2p poles can be changed to 4 p poles (as circuit above). The lower diagram shows a dual inverter six-phase pole changing inverter motor drive that can offer 4 pole and 8 pole operation.

Constant Torque Region – to provide maximum torque to the EV for high acceleration during start-up from rest.

(b) Constant Power region – When the vehicle needs high acceleration at medium to high speed.

1

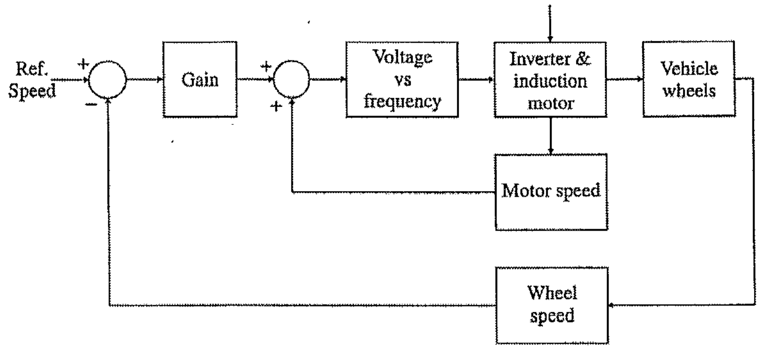
High Speed – When the vehicle needs to cruise at extra high speed, but the motor load is light.

1

1

5

(c)

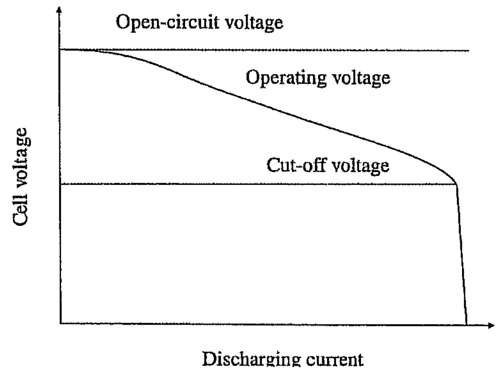
QUESTION NO. ( )	SOLUTION	MARKS
	 Constant torque – increase V, while keeping slip constant (at a low value) Constant power – increase slip frequency, while keeping V, I constant Higher Speed – Reduce the I, while keeping other constant.	4

QUESTION NO. ( )	SOLUTION	MARKS

Q4

(a)

Cut Off Voltage - The point during the discharge of the battery, when it experience a sudden voltage drop. 2



Coulometric capacity – The current capacity of the battery (in AH) and is defined as:

$$CC = \int_0^t i(t)dt.$$ 2

Depth of Discharge - The percentage of discharge of the battery, from fully charged (100%), to the cut off voltage (0%). 2

State of Discharge - Ratio of present capacity over fully charge capacity 2

Life Cycle – The number of charge and discharge cycles of a battery. Usually quoted in relation of the DOD (e.g. 400 at 100% DOD; 1000 at 70% DOD) 2

(b)

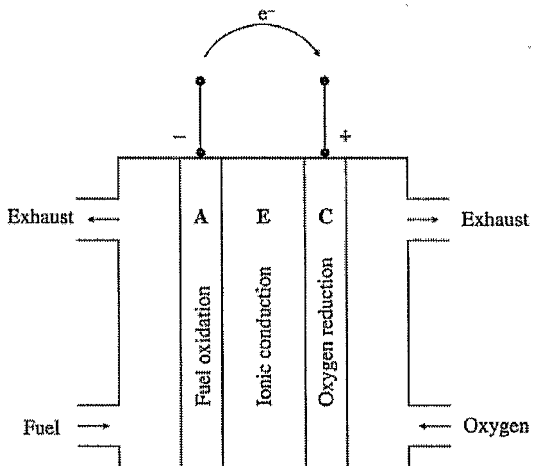


Fig. 6.4. Basic principle of fuel cells.

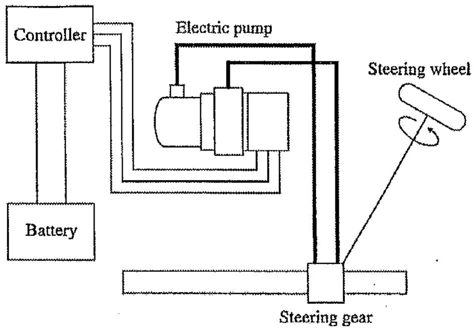
Add some explanation to the fuel cell diagram 5

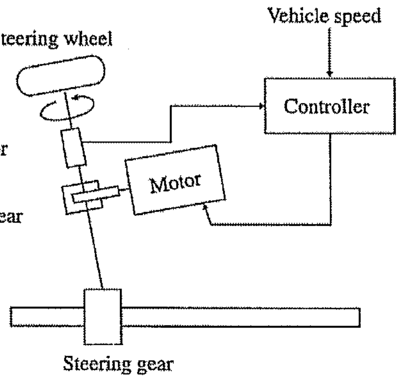
The key advantage of fuel cells over batteries is that a fuel cell powered EV can give a driving range comparable to an ICEV because its range is determined only by the amount of fuel available in the fuel tank, and is independent of the size of fuel cells. Actually, the size of fuel cells is only governed by the required power level of EVs. Other major advantages of fuel cells are that their reactant feeding time is generally much shorter than the recharging time of batteries (except for those mechanically rechargeable ones), their lifetime is generally much longer than that of batteries, and they generally require less maintenance than batteries. 5

QUESTION NO. ( )	SOLUTION	MARKS

Q5

(a)





A: Electro-hydraulic Power Steering B: Full Electric Power Steering

8

Comparisons:
1. Electro-hydraulic steering has a more complicated setup than the full electric power steering.

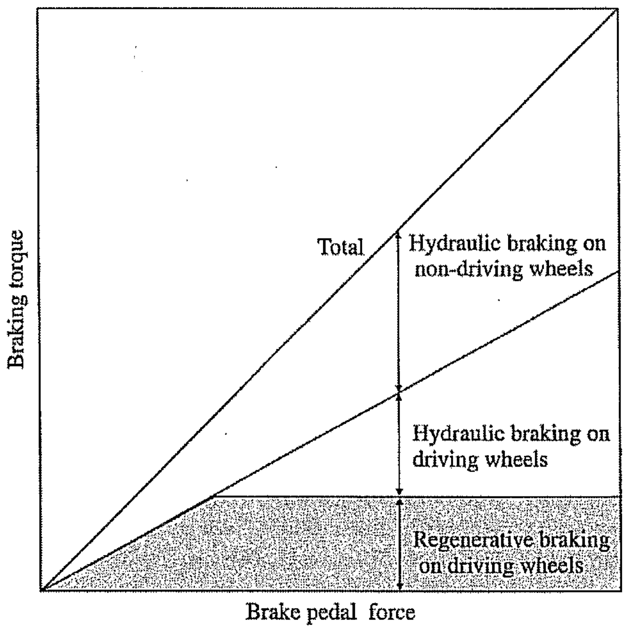
2. Electro-hydraulic and it needs more energy, because the hydraulic pump needs to be on all the time.

3. Full electric power steering needs to have an ultra reliable torque sensor, otherwise the sensor will send the wrong command signal to the steering motor and steering wheel. 4

(b)

Because (i) the motor/generator rating is not high enough to convert all the energy into electricity; and (ii) the battery cannot be charged up with such a high energy within such a short duration.

2



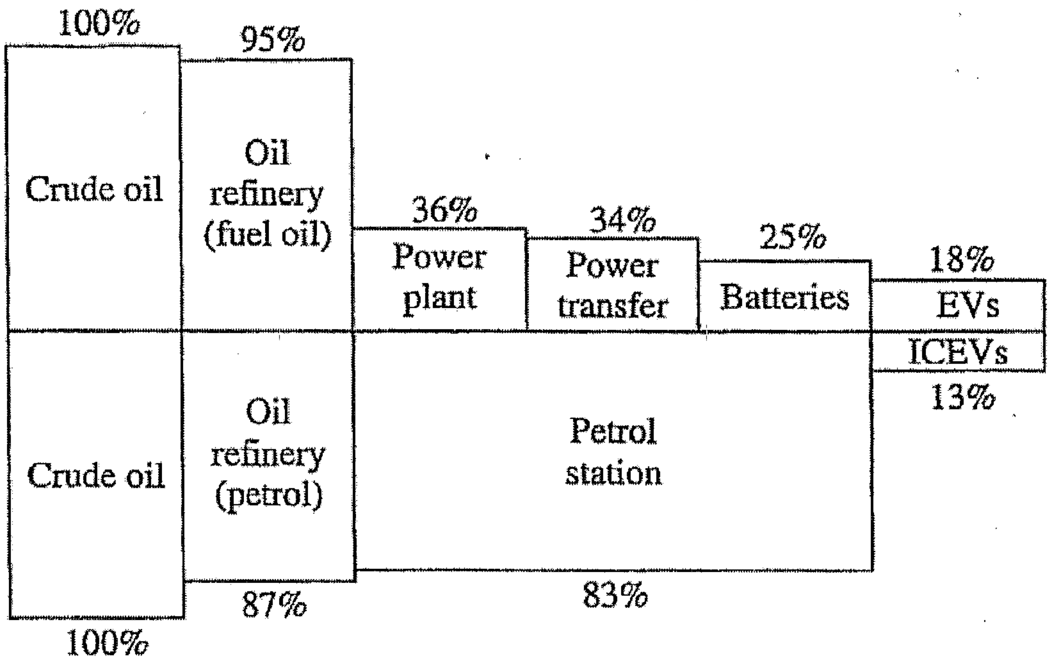
6

Suggest to install a pair of normal size hydraulic brakes on the normal driving wheels and a pair of reduced size hydraulic brakes on the driving wheels. The remaining energy generated on the driving wheels during braking will be absorbed by regenerative braking, as shown in the diagram above.

QUESTION NO. ( )	SOLUTION	MARKS

Q6 — 10

(a)



Add explanation to the above figure

(b)

1. Electricity can be generated from other energy sources (e.g. coal, gas), whereas, ICEV relies solely on petroleum. In future petroleum is too precious to be used as vehicle fuel.

2. If renewable energy source are used to generate electricity in a large scale, the overall consumption of energy will go down. Pollution and green house effect will go down. — 2

3. ICEV is a mature technology; room for improvement is very small. However, EV technologies are just the beginning. Therefore the cost and performance of EV will continue to improve. It will be more and more attractive to consumers. — 2

4. The construction of a EV is much simpler than an ICEV, and it does not have noise and vibration problems. Future EV can use more light weight material to build the chassis and other mechanical parts. — 2

5. Noise and air pollution in urban areas will improve drastically. — 2

6. Any other valid reasons….. — 2