THE HONG KONG POLYTECHNIC UNIVERSITY

DEPARTMENT OF ELECTRICAL ENGINEERING

Subject Code : EE543

Subject Title : HYBRID AND ELECTRIC CAR TECHNOLOGY

Session : Semester 2, 2013/14 **Venue** : P305

Date : 13 May 2014 **Time** : 08:45 – 11:45

Time Allowed : 3 Hours **Subject Examiner** : Prof. E.Cheng and Dr. N.Cheung

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This question paper has a total of 6 pages (attachments included).

Instructions to Candidates :

Attempt any five questions. All questions carry equal marks

Physical Constants : N/A

Other Attachments : N/A

Available from Invigilator : N/A

DO NOT TURN OVER THE PAGE UNTIL YOU ARE TOLD TO DO SO.

Question 1

Compare the energy and environment issues between Internal Combustion Engine Vehicle and Electric Vehicle, according to the following aspects:

(a) Flexibility on the use of different energy sources (7 marks)

(b) Energy Efficiency (7 marks)

(c) Urban pollution and overall pollution (6 marks)

Limit your answer to 3 pages maximum. Substantiate your answer with facts, figures, and graphs.

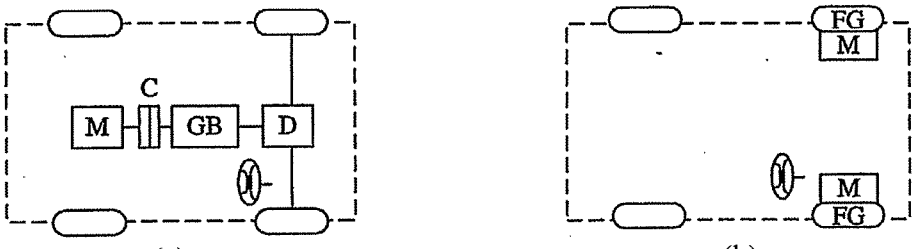
Question 2

Fig. Q2 shows two possible configurations of constructing an electric vehicle.

(a) What are the improvements of configuration (a) over configuration (b)? (6 marks)

(b) What are the concerns and disadvantages of configuration (b) over configuration (a)? (6 marks)

(c) Describe in more detail the motor drive mechanism in configuration (b). (8 marks)



(a) (b)

C : Clutch
D : Differential
FG : Fixed gearing
GB : Gearbox
M : Electric motor

Fig. Q2

Question 3

(a) Fig. Q3a shows the configuration of a series hybrid vehicle. Explain how the energy flow when the series hybrid vehicle is (i) starting up and normal driving, (ii) driving at light load, (iii) decelerating; and (iv) charging at standstill.

(8 marks)

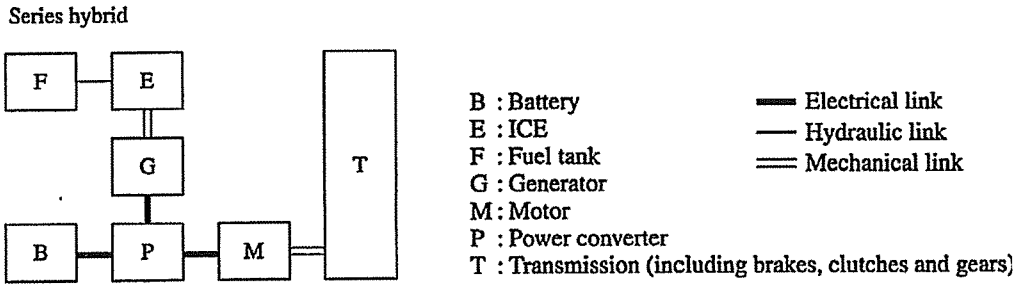


Fig. Q3a

(b) Fig. Q3b shows the braking system of an electric vehicle.

(i) Explain why a hydraulic braking system is still needed in an EV. (2 marks)

(ii) Explain why the mechanical brakes are still needed in an EV. (2 marks)

(iii) Describe how the braking power is shared out between the mechanical brakes and the motor regenerative brakes. (8 marks)

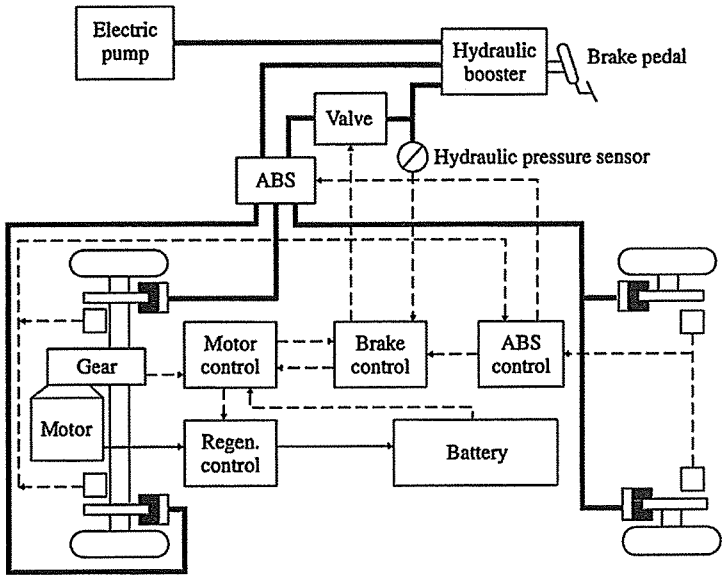


Fig. Q3b

Question 4

(a) An electric vehicle or a hybrid electric vehicle should have a DC bus to supply power to all equipment. Sketch a schematic diagram for the DC distribution in a vehicle. (4 marks)

(b) For high power application of DC-DC conversion in a vehicle, the H-bridge converter is used. Sketch the converter and explain briefly the principle of operation. (4 marks)

(c) The flyback converter is usually applied for lower power operation, rather than using H-bridge converter for main traction motor. Sketch the circuit and briefly explain the operation including transistor on and off states. (4 marks)

(d) The battery balance circuit requires energy conversion from one battery to another battery. Propose a circuit using flyback converter or buck-boost converter to provide batteries connected in series in order to perform battery voltage balancing. (4 marks)

(e) Describe in 200 words the current trend and applications of power converter for electric or hybrid electric vehicles. (4 marks)

Question 5

(a) Discuss the difference between the battery energy content in hybrid electric vehicle and pure electric vehicle. In order to calculate the State of Charge (SoC) and State of Health (SoH) of a vehicle battery set accurately, some calibration is needed regularly. Discuss the difficulty, if any, in such process for the two types of vehicles. (4 marks)

(b) A battery bank used for an electric vehicle has the following specification:

a. Battery cell Voltage =3.65V
b. Energy content = 22kWh
c. Standard charging current = 2C
d. Maximum voltage for each cell = 4.3V
e. Minimum cell voltage for discharge = 2.5V
f. Number of battery cells =120

Sketch a charging profile of the battery including both constant current and constant voltage modes when the battery starts from minimum voltage. You should label all the values in your profile for the battery voltage, current, SoC and power. You may assume the end of constant voltage mode is 2% of the rated charging current. (4 marks)

(c) Battery swapping has been suggested to reduce the battery charging time for electric vehicles. State 3 considerations for the design of such system. (4 marks)

(d) Draw a sketch of a battery management system (BMS) for electric vehicles. Discuss its functionality and explain why the BMS is important for a battery system. (4 marks)

(e) State 4 different types of Li- batteries. Compare their performance and their safety. (4 marks)

Question 6

(a) Discuss the brushed DC motor and brushless DC motor used in electric vehicles. Your discussion should include equivalent motor circuit, driver circuit, advantage(s) and disadvantage(s). (4 marks)

(b) Fig Q6 shows an in-wheel motor. Discuss the motor type, principle of operation and the inductance characteristics of the motor. (4 marks)

(c) State 4 advantages of the motor in (b) for EV application. (4 marks)

(d) Sketch the per-phase circuit of the motor in (b) when
(i) all the phase transistors are on,
(ii) only one phase transistor is on, and
(iii) all phase transistors are off. (4 marks)

(e) For the motor in (b), write down the torque equation. If the maximum inductance slope is 3mH/deg, calculate the maximum torque at 10A phase current. (4 marks)

Fig Q6.

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