

THE HONG KONG POLYTECHNIC UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

Subject Code : EE512
Subject Title : Electric Vehicles
Session : Semester 1, 2023/24 **Venue** : FSCH
Date : 9 December 2023 **Time** : 19:00 – 22:00
Time Allowed : 3 Hours **Subject Examiner(s)** : Dr N.C. Cheung
Dr W. Liu

This question paper has a total of 7 pages (attachments included).

Instructions to Candidates: Attempt ALL questions.
Put your **Part A** answers in the **Pink** answer book and **Part B** answers in
the **Blue** answer book.

Physical Constants: Nil

Other Attachments: Nil

Available from Invigilator: Nil

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

PART A (5 questions in total)

Question 1 (10 marks)

Fig. Q1 shows the torque-speed driving record of an electric vehicle.

- (i) By referring to specific parts of this graph, point out the different driving conditions of this electric vehicle. (3 marks)
- (ii) Give reasons to explain why this vehicle is driving on the highway. (2 marks)
- (iii) Sketch another torque speed graph, to show that the vehicle is driving in the urban area. Explain the reasons for the locations of the dots on your graph. (5 marks)

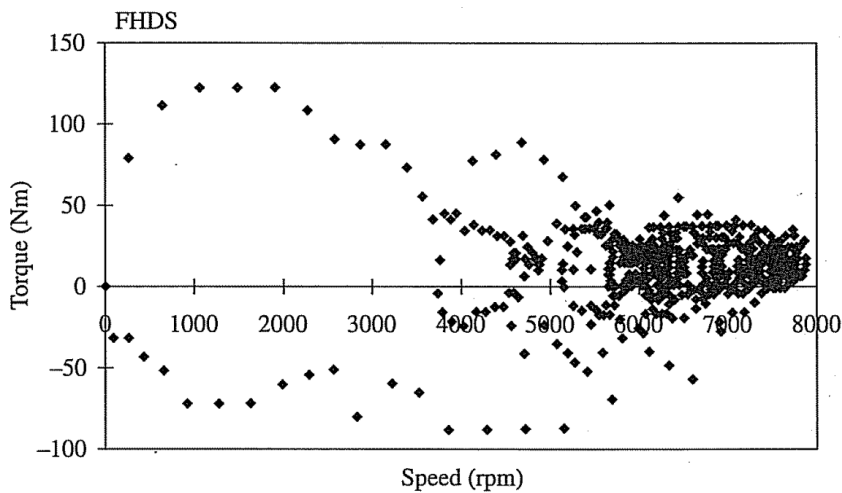


Fig. Q1

Question 2 (10 marks)

Fig. Q2 below shows two possible electric vehicle configurations, connected to more than one type of battery. Compare these two configurations, on the following issues:

- (i) Reasons for multi-battery system. (5 marks)
- (ii) Advantages and limitations. (5 marks)

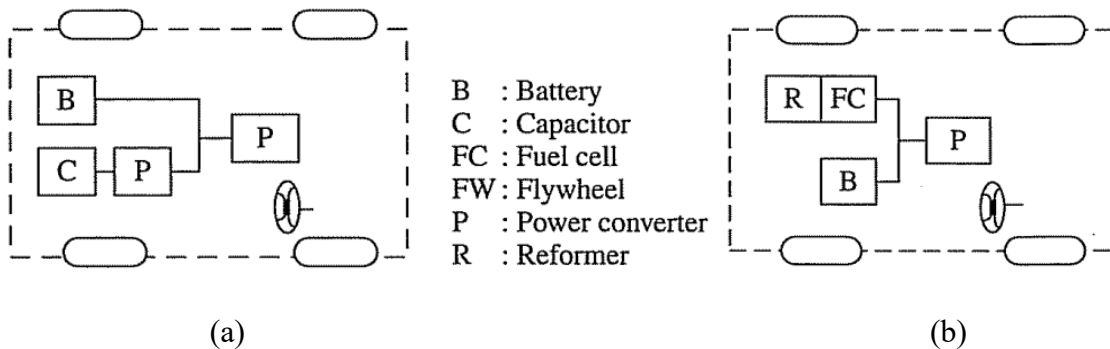


Fig. Q2

Question 3 (10 marks)

Draw the construction diagram of an Electric Heavy Parallel Series Hybrid Vehicle. Use diagrams to explain, what happens to the energy/fuel flow, when the vehicle is operating on the following modes:

- i. Startup/light load
- ii. Acceleration
- iii. Normal driving
- iv. Deceleration/braking
- v. Battery charging during driving
- vi. Battery charging during standstill

Question 4 (10 marks)

Draw the construction diagram of a switched reluctance motor for electric vehicles. Give two advantages and two disadvantages of using switched reluctance motors in electric vehicles.

Question 5 (10 marks)

With the help of suitable diagram(s), explain how pole-changing control is implemented in induction motor drives for electric vehicles.

- End of Part A -

PART B (5 questions in total)**Question 1 (10 Marks, 2 Marks each)**

1. What are the systematic differences among the (all) battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs)?
 - (i) Largest battery capacity in BEVs
 - (ii) Largest battery capacity in PHEVs
 - (iii) No battery in FCEVs
 - (iv) Has plug-in in FCEVs
 - (v) Driven by electric motor in BEVs and FCEVs
 - (vi) Driven by electric motor and internal combustion engine in HEVs
 - (a) All of the above
 - (b) (ii), (iv) & (v)
 - (c) (i), (iii) & (vi)
 - (d) (i), (v) & (vi)
 - (e) (ii), (iii) & (v)
 - (f) No suitable answer

2. Which of the followings are the functions of a battery management system for an electric vehicle?
 - (i) Estimation of battery's states (SoC, SoH, and SoT)
 - (ii) Avoidance of overcharge and over-discharge
 - (iii) Braking system
 - (iv) Motor drive control
 - (v) Onboard charger
 - (a) All of the above
 - (b) (i) & (ii)
 - (c) (i), (ii) & (iv)
 - (d) (i), (ii) & (iii)
 - (e) No suitable answer

3. What are the merits and demerits of electric vehicle infrastructure?
 - (i) Demerit: peak shaving
 - (ii) Merit: peak shaving
 - (iii) Demerit: harmonic contamination
 - (iv) Merit: vehicle-to-grid operation for frequency stabilization
 - (v) Demerit: current demand burden to power system
 - (vi) Merit: absorption of excessive generation from renewable energy
 - (a) All of the above
 - (b) All except for (i)
 - (c) All except for (ii)
 - (d) (i), (iii), (iv) & (v)
 - (e) (ii), (iii), (v), & (vi)
 - (f) No suitable answer

4. Manufacturers of electric vehicles recommend users to replace or service the battery when its state of health (SoH) drops to:
- (a) 10%
 - (b) 20%
 - (c) 40%
 - (d) 60%
 - (e) 80%
 - (f) No suitable answer
5. The voltage of the battery pack in recent electric vehicles can reach up to:
- (i) DC
 - (ii) AC
 - (iii) 800V
 - (iv) 300V
 - (v) 500V
- (a) (i) and (iii)
 - (b) (ii) and (iii)
 - (c) (i) and (iv)
 - (d) (ii) and (v)
 - (e) (i) and (v)
 - (f) No suitable answer

Question 2 (5 marks)

- a) Suggest 5 energy storage requirements in electric vehicles. (3 marks)
- b) Suggest 3 key performance indicators of high-power batteries for future electric vehicles. (2 marks)

Question 3 (10 marks)

- a) A battery pack has a coulometric capacity of 100 Ah, and is operating at a discharging rate of $C/2$. Calculate the discharging current. (2 marks)
- b) For a battery pack rated at 100 Ah, calculate the charging rate if it is charged at 150 A. (2 marks)
- c) 1) Explain why the battery manufacturers shall label the energy capacity or coulometric capacity associated with other necessary information, such as C -rate or temperature. (2 marks)
- 2) According to Fig. Q3c, the battery pack is discharged at a constant current of 20 A, and its voltage drops from the initial voltage of 500 V to the cut-off voltage of 350 V. Calculate the energy capacity of the battery in electric vehicles. (2 marks)

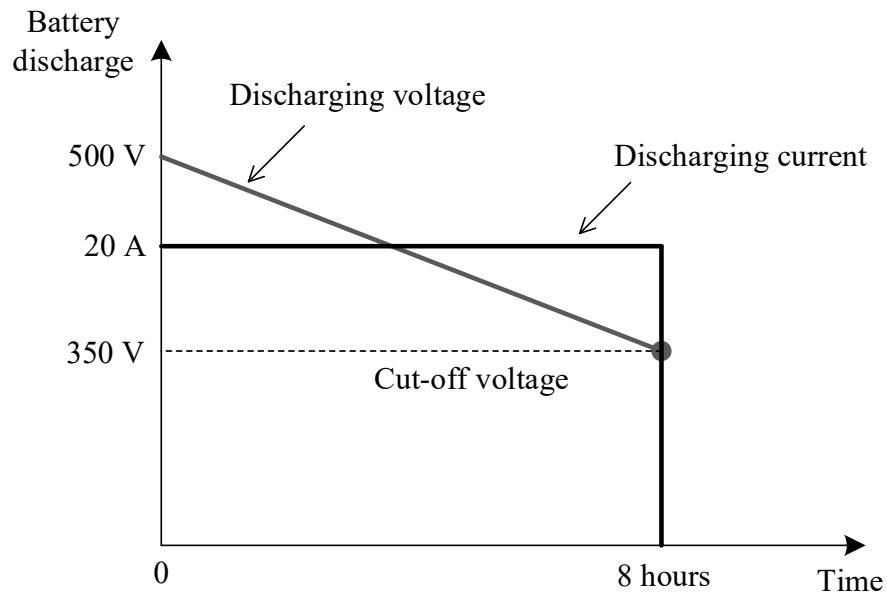


Fig. Q3c

- 3) Based on Fig. Q3d, calculate the coulometric capacity of the battery in electric vehicles, assuming that the battery voltage keeps constant at 450 V. (2 marks)

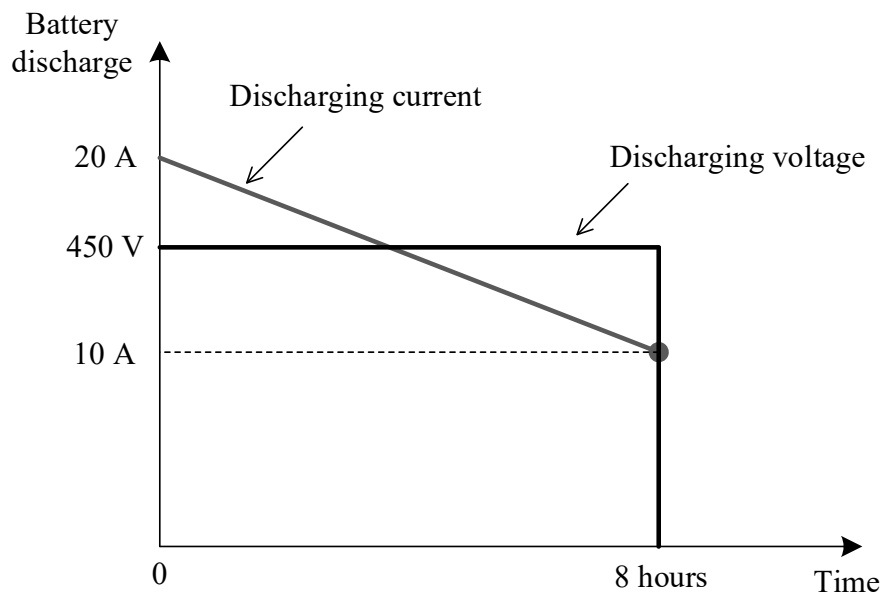


Fig. Q3d

Question 4 (10 marks)

- a) Discuss the features of onboard chargers and off-board chargers relating to electric vehicles. (2 marks)
- b) Discuss the difference between conductive (wired) chargers and inductive (wireless) chargers relating to electric vehicles. (2 marks)
- c) Sketch the system configuration of an inductive (wireless) charger. (3 marks)
- d) Explain the basic principle of the inductive (wireless) charger sketched in Question 4 c). (3 marks)

Question 5 (15 marks)

- a) Give 3 advantages of electric vehicles as compared with internal combustion engine vehicles in the aspects of energy and environment. (3 marks)
- b) Give 2 advantages of stator-permanent-magnet motors as compared with conventional rotor-permanent-magnet motors in electric vehicles. (2 marks)
- c) List 3 topologies of stator-permanent-magnet motor drives. (3 marks)
- d) Sketch the system configurations of motor drives and discuss their main differences in operating principles.
 - 1) Sketch the system configuration of singly-fed stator-permanent-magnet motor drives. (2.5 marks)
 - 2) Sketch the system configuration of doubly-fed stator-permanent-magnet motor drives. (2.5 marks)
 - 3) Discuss their main differences in operating principles. (2 marks)

- End of Part B -

- End of Paper -