

THE HONG KONG POLYTECHNIC UNIVERSITY
DEPARTMENT OF ELECTRICAL ENGINEERING

Subject Code : EE512/EE512A
Subject Title : Electric Vehicles
Session : Semester 1, 2018/19 **Venue** : SPH
Date : 18 December 2018 **Time** : 19:00 – 22:00
Time Allowed : 3 Hours **Subject Examiner(s)** : NC Cheung

This question paper has a total of 4 pages (attachments included).

Instructions to Candidates: This paper has 6 questions
Attempt any 5 questions
All questions carry equal marks

Physical Constants: Nil

Other Attachments: Nil

Available from Invigilator: Nil

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

Question 1

- (a) Draw a typical torque-speed requirement graph (in dots) of an electric vehicle, when it is driving under highway condition. Support your answer by highlighting and explaining the parts of the graph that show the highway driving features. (7 marks)
- (b) Draw a typical torque-speed requirement graph (in dots) of an electric vehicle, when it is driving through a hilly terrain (i.e. with lots of uphill and downhill). Support your answer by highlighting and explaining the parts of the graph that show the hilly terrain. (7 marks)
- (c) In your opinion, which of the following type of transport is most difficult to electrify:
- A motorcycle
 - A 4-seater passenger car
 - A container truck

For each of the above case, give your opinion, and explain why. (6 marks)

Question 2

- (a) Fig. Q2 shows the simplified configuration of a fuel cell (FC) electric vehicle (EV). Two types of power sources are fed to the power converter (P), which then drives the electric motor.
- Explain why FC EV needs a battery (B) as the secondary power source. (3 marks)
 - Explain why a reformer (R) is needed in a FC EV. (3 marks)

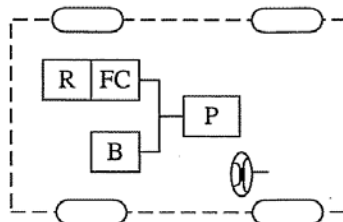


Fig. Q2

- (b) Draw the cross sectional diagrams of an inner-rotor in-wheel drive and outer-rotor in-wheel drive and. Compare the advantages and disadvantages between the two configurations. (6 marks)
- (c) Compare the force speed characteristics of a 5-gear ICE vehicle with a fixed-gear electric vehicle. Explain why EV has a much superior acceleration performance. (8 marks)

Question 3

- (a) What are the 4 key goals in the power flow control of a hybrid electric vehicle? (4 marks)
- (b) Fig. Q3 shows the control block diagram of a series hybrid. Explain what happens to the internal power flow under the following conditions: (8 marks)
- Start-up/normal driving/acceleration
 - Light load
 - Deceleration/braking
 - Battery charging

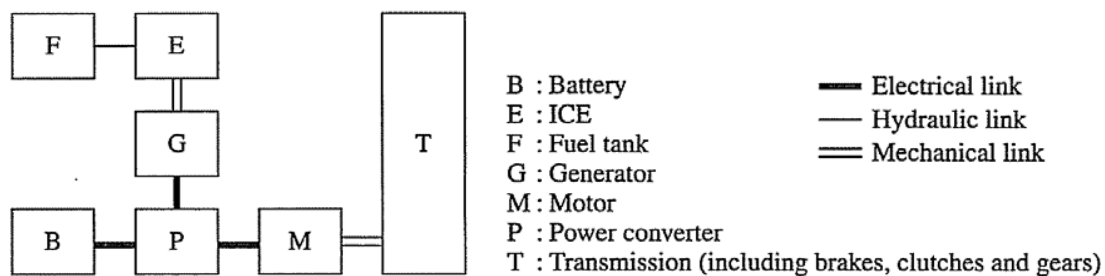


Fig. Q3

- (c) The series hybrid, as mentioned in (b), will be modified to become a plug-in series hybrid. Redesign your power flow, and only use the ICE power backup when absolute necessary
- What additional functional block needs to be added to the control? (2 marks)
 - Describe what happens to the power flow when the car is (i) accelerating/normal driving; (ii) decelerating; (iii) plug-in charging; and (iv) range extended driving (6 marks)

Question 4

- (a) Electric vehicle can use a single motor or dual motors, as its left and right wheel drive. Compare the advantages and disadvantages between these 2 configurations. (6 marks)
- (b) In an electric vehicle, induction motor could be operated as constant torque mode, constant power mode, and high speed mode. By referring to the electrical and mechanical characteristics of an induction motor, explain how these 3 modes can be realized. (9 marks)
- (c) Draw the block diagram of VVVF control of induction motor, and briefly explain its operation. (5 marks)

Question 5

- (a) For each type of power source listed below, give 1 key advantage and 1 key disadvantage of using this power source energy storage in electric vehicle:
- (i) Fuel Cell
 - (ii) Metal Air Battery
 - (iii) Lithium-ion Battery
 - (iv) Lead Acid Battery
 - (v) Super Capacitor
- (10 marks)
- (b) Give 5 main tasks of a Battery Management System (BMS). (5 marks)
- (c) What are the main technical challenges for implementing inductive charging in EV? (5 marks)

Question 6

- (a) Draw the configuration of a regenerative hydraulic braking system of an electric vehicle, and explain its operation. Explain why, only a portion of the energy could be collected from regenerative braking for modern electric vehicle. (10 marks)
- (b) What are the non-technical challenges for implementing battery swapping for private electric vehicles? (5 marks)
- (c) In your opinion, what are the 5 main reasons for electric vehicles to replace ICE vehicles in the next 20 years? (5 marks)

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