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Question Paper Code : 50994

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2024.

Fifth/Sixth Semester

Electrical and Electronics Engineering

EE 3026 – DESIGN OF MOTOR AND POWER CONVERTERS FOR ELECTRIC VEHICLES

(Regulations 2021)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Compare tractive effort and traction

2. Determine the tractive forces and power needed for a vehicle with mass 1250 kg, which accelerates at speed of 96 kmph in 10 seconds.

3. State the advantages of switched reluctance motors and brushless DC motors over other types.

4. How speed control in AC motor is different from DC motors?

5. "Above the base speed, the motor torque drops hyperbolically with increasing speed" – Justify.

6. Write the need of state space modeling in control system.

7. One of the difficult challenges in planning an EV conversion is choosing the voltage and size of the battery pack you plan to use. Justify the statement

8. Compare buck and boost converter.

9. What are the parameters used to analyze the performance of a vehicle?

10. Define time ratio control in DC–DC converter.

PART B — (5 × 13 = 65 marks)

11. (a) Discuss the factors affecting motor efficiency in an EV and also explain about the dynamics of electric vehicles.

Or

(b) What is the role of energy management module? Describe energy management in electric vehicle.

12. (a) Describe the application of permanent magnet BLDC drives in HEVs/EVs. What type of control mechanism is employed in these motor drives? How is it advantageous over induction motor drive?

Or

(b) Discuss in detail about four quadrant operation of a DC motor with appropriate plots and tables.

13. (a) Analyze the stability of converter loop gain using polar plot and bode plot for the following cases

(i) Stable case (4)

(ii) Unstable case and (4)

(iii) Marginally stable case. (5)

Or

(b) Describe the state space modelling approach used in control systems and method of obtaining transfer function from state space model with suitable illustration.

14. (a) Develop a small signal model of Buck converter and explain its process.

Or

(b) Obtain the average model of Buck converter using state space averaging technique.

15. (a) Write the different configurations of complex hybrid vehicle. Consider a Buck type DC/DC converter with input inductor current and the output capacitor voltage as state variables. Design a variable structure control law for desired output voltage based on voltage mode control. Assume that the converter operates in continuous conduction mode.

Or

(b) Obtain the power stage transfer functions of buck-boost converter in CCM operation with necessary plots.

PART C — (1 × 15 = 15 marks)

16. (a) Describe the application of permanent magnet synchronous drives in HEVs/EVs with suitable illustration. What type of control mechanism is employed in these motors drives? How is it advantageous over induction motor drive?

Or

(b) What are the alternate sources of energy for hybrid electric vehicles? Explain and state their advantages over conventional electrical power sources. Obtain the input-to-output transfer function of the small – signal circuit model of buck converter and illustrate its relationship with time-domain circuit variables. Also consider a buck converter operating with $Vs = 16\,V$, $L = 40\,\mu F$, $RI = 0.1\ \Omega$, $C = 470\,\mu F$, $Rc = 0.05\ \Omega$, $R = 1\ \Omega$, $fs = 20\ kHz$, and $D = 0.25$. Determine the time domain parameters related to input-to-output transfer function of the converter.