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MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

VII SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, NOVEMBER-DECEMBER 2023

INTRODUCTION TO ELECTRIC VEHICLES [ELE4084]

Time: 3 Hours **Date: 09 DECEMBER 2023** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. Discuss the need for electric vehicle penetration & its adoption, challenges, and possible solutions with regard to the Indian Scenario. **04**

1B. Derive the mathematical equation to determine the road-load power by considering different forces acting on the vehicle. **03**

1C. The Tesla Model S is traveling down a −8° slope at 120 km/h. The mass of the vehicle is 2155 kg and vehicle parameters are A=177.2 N; B= 1.445 $\mathrm{N/ms^{-1}}$; C=0.35 $^{N}/_{m^2s^{-2}}$ respectively. Assuming calm conditions, how much regenerative power is available to brake the vehicle while maintaining a constant speed? **03**

2A. Explain the different power flow control modes of a typical parallel hybrid system with the help of block diagrams. **03**

2B. Illustrate the layout of an electric vehicle using a schematic diagram and describe its main components. **03**

2C. The Nissan Leaf electric vehicle has a battery energy of 90 kWh. The vehicle parameters are A=133.3 N, B=0.7094 N/ms^{-1}, C=0.491 N/$(ms^{-1})^2$ respectively. Furthermore, the efficiency of the power train from the battery to the transmission is 85%.

i. Estimate the range of the above electric vehicle at 120 km/h.

ii. Determine the reduction in range for the above BEV if the vehicle has a continuous heating, ventilation, and air conditioning (HVAC) load of 6 kW. **04**

3A. Determine the beginning-of-life kilowatt-hour storage required in a BEV battery pack based on the following requirements: 6 years of operation, an average of 55 km of driving per day S_{day} over the 365 days of the year, daily charging, and an average battery output energy per kilometer $E_{km}=180\,\mathrm{Wh/km}$. Assume battery pack cycle lifetime index L = 3 and number of **04**

charge\discharge cycles for 100% depth of discharge $N_{100\%}=1000$. Assume two parallel battery strings with 96 Li-ion cells per string, with a total number of cells $N_{cell}=192$, and a nominal voltage of 3.75 V per cell. Assume that the capacity of the battery pack will reduces to 80% at the end of life.

i. Determine the ampere-hours per cell.

ii. What are the vehicle ranges at beginning of life (BOL) and end of life (EOL)?

3B. Explain the basic principle of supercapacitor-based energy storage system in hybrid electric vehicles. **03**

3C. Explain the working principle of a fuel cell with its dynamic characteristics. **03**

4A. A fully loaded fuel cell-based tractor has the following parameters: mass m = 36,280 kg, drag coefficient $C_D = 0.7$, vehicle cross-section $A=10m^2$, and coefficient of rolling resistance $C_R=0.008$. The nominal efficiency of the powertrain and transmission $\eta_{pt}=85\%$, and the auxiliary load is 2 kW. Let the density of air $\rho_{air}=1.2kg/m^3$. The overall mass of the fuel cell system (including the fuel cell, balance of plant, storage tanks, and mechanical bracketing) is 400 kg plus 80 kg per 5 kg of stored hydrogen.

i. Determine the Miles per gallon equivalent (mpge), and the overall mass of the fuel cell system if the vehicle is to travel at a constant speed of 64 km/h for two work shifts of 8 h total, or 512 km. The fuel cell plant efficiency is 50% for this operating condition.

ii. Determine the mass of the battery which would be required if the specific energy is 0.15 kWh/kg. **04**

4B. Describe the characteristics of a PMSM motor and explain the control technique employed to regulate the speed of PMSM. **03**

4C. With the help of a neat diagram explain the four-quadrant chopper-based speed control of DC motors. **03**

5A. Discuss the various methods used for charging batteries, providing a comprehensive comparison between each method. **03**

5B. Explain the role of the power electronic converter employed in battery electric vehicles to capture the energy generated during regenerative braking of the vehicle with a neat circuit diagram. **04**

5C. Discuss the implementation issues of energy management strategies for an HEV. **03**