Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent unit of MAHE, Manipal)

II SEMESTER M.TECH (ELECTRIC VEHICLE TECHNOLOGY)

END SEMESTER EXAMINATIONS, APRIL- MAY 2024

SUBJECT: ENERGY STORAGE SYSTEMS FOR ELECTRIC VEHICLE [ELE 5214]

Time: 3 Hours **Date: 30 APRIL 2024** **Max. Marks: 50**

Instructions to Candidates:

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

1 A. Distinguish the various advantages and disadvantages of Li-ion cells over most other secondary cells **4**

1 B. Explain the importance of energy storage devices and notify the criteria for choosing a particular energy storage device. **2**

1 C. Elucidate various methods to estimate the SOC of a battery and explain any two methods. Also, mention the limitations of those methods. **4**

2 A. A battery has 96 cells in series per string with two parallel strings. Each cell has a no-load voltage of 4.18 V and an internal resistance of 2.8 mΩ.

i) Determine the pack current and voltage under an 80 kW discharge if the battery is fully charged.

ii) Determine the discharge efficiency of the battery. **3**

2 B. Illuminate the significance of battery thermal management systems and their classifications in detail. **4**

2 C. Illustrate the different modes of operation in the charge controller and explain each using its characteristics. **3**

3 A. With the help of a neat diagram explain different control techniques associated with the fuel cell to regulate the output power. **3**

3 B. Explain the dynamics of the fuel cell system with V-J (mA/cm^2) Characteristics. **2**

3 C. A fully loaded bus has the following parameters: mass m = 20,000 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 **5**

(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 hydrogen mass and the fuel cell system's overall mass if the vehicle travels at a constant speed of 64 km/h for two work shifts of 16 hours total, or 1024 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.

iii. Evaluate the range of the vehicle without passengers if the weight drops by 1/3? The fuel cell plant efficiency is 53% for this operating condition.

4 A. Explain various methods of hydrogen production with a neat block diagram. **4**

4 B. Explain the battery and ultracapacitor as energy source elements in an electric vehicle. **3**

4 C. The 2015 Nissan Leaf is traveling down a −8° slope at 120 km/h. The vehicle parameters of the Nissan Leaf 2015 model are A=133.3 N, B=0.7094 $\mathrm{N/ms^{-1}}$, C=0.491 $\mathrm{N/(ms)^{-2}}$. Assuming calm conditions, estimate regenerative power is available to brake the vehicle while maintaining a constant speed? **3**

5 A. With appropriate justification, explain how modern predictive control (MPC) can tackle the problem of dynamic programming algorithm (DP) **2**

5 B. An electric vehicle has the following attributes: drag coefficient $C_D = 0.25$,vehicle cross-section $\mathrm{A=2.5m^2}$, and available propulsion energy of $\mathrm{E_b=20kWh}$. Let the density of air $\rho_{\mathrm{air}}=1.2\mathrm{kg/m^3}$. Instantaneously at a vehicle speed of 120 km/h, estimate the aerodynamic drag force, power, and range, while driving in

i. Calm conditions with no wind and

ii. Windy conditions with a 12 km/h tailwind. **3**

5 C. Categorize the offline optimization-based energy management systems with respect to operating principles, advantages, and disadvantages. **5**