Reg. No.									

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A constituent Institution of MAHE, Manipal)

II SEMESTER M.TECH (ESM / PED)

END SEMESTER EXAMINATIONS, APRIL 2018

SUBJECT: ENERGY STORAGE DEVICES [ELE 5237]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 25 April 2018** **Max. Marks: 50**

Instructions to Candidates:

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

1A. What is the importance of energy storage devices in power system or transportation system and classify the energy storage devices with some examples ***(04)***

1B. Define SOC (state of charge), DOD (depth of discharge), Specific charge, Energy density for a battery. ***(02)***

1C. What are the different methods to estimate SOC of a battery and explain any two methods? ***(04)***

2A. What is cell-imbalance and explain any two cell balancing methods for a given battery pack? ***(04)***

2B. A 24 kWh battery pack can be fast charged from 0% to 60% SOC in 30 min. Determine the approximate charge current and power in order to achieve this charge time. Assume that the battery pack voltage is 360V. ***(02)***

2C. A battery has 96 cells in series per string with two parallel strings and the internal resistance of each cell is 2.8 mΩ. Determine the pack current and voltage under a 50 kW charge if the battery is fully discharged. The cell voltage drops to 2.5 V when fully discharged. How efficient is the charging of the battery at this power level? ***(02)***

2D. The capacity(C) of the cell is approximately 33.3 Ah with a rated voltage of 3.75 V. Determine the maximum useful energy for a discharge rate of 3C. Assume R_b=5 mΩ ***(02)***

3A. Describe about the modeling of Fuel Cell, which predicts the electrical and thermal performance of the Fuel Cell. ***(03)***

3B. What are the applications of Fuel Cells? ***(02)***

3C Define specific power density of a fuel cell. ***(01)***

3D. A FC system is connected to the utility grid, where the FC units has to provide 576 kW of power. In this system, there is a boost converter connected to each FC unit with $V_{dc,output}$=480V and 0.4 duty cycle. Assume that voltage and current of FC stack are 24 V and 16.6 A and each FC unit can provide 48 kW of power. Determine

1) Number of FC units required

2) Number of FC stacks connected in series in each FC unit.

3) Total number of FC stacks to be used in each FC unit. ***(04)***

4A. Explain about super conducting magnetic energy storage and mention its merits and demerits? ***(03)***

4B. Explain about the working principle of Flywheel based energy storage technology through a block diagram and mention its applications in power system. ***(03)***

4C. Describe about the working principle of pumped hydro energy storage. ***(02)***

4D. What are the advantages and disadvantages with compressed air energy storage (CAES)? ***(02)***

5A. Determine the percentage increase in the required power and energy consumption when a driver who normally drives at 80 km/h increases the speed to 100 km/h. Consider drag force only. ***(02)***

5B. An electric vehicle has an available battery energy of 90 kWh. Let the efficiency of the powertrain from the battery to the transmission be 85%. The vehicle parameters of the Tesla Model S are A=177.2 N, B=1.445 $\mathrm{N/ms^{-1}}$, C=0.354 $\mathrm{N/(ms)^{-2}}$.

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

2) 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)***

5C. 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 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.

1) Determine the ampere-hours per cell.

2) What are the vehicle ranges at beginning of life (BOL) and end of life (EOL)? ***(04)***