DEPARTMENT OF ELECTRICAL ENGINEERING
DELHI TECHNOLOGICAL UNIVERSITY
GOVERNMENT OF NCT OF DELHI
SHAHBAD DAULATPUR, BAWANA ROAD, DELHI-110042

Chargers and Charging Infrastructure (EV355)

ASSIGNMENT NO 3

Last Date of Submission: November 16, 2024

Course Outcomes (CO's): Students will be able to

CO1	understand the different types of Electric Vehicles (EVs) such as Battery EVs, Hybrid EVs, Fuelled EVs, Solar-Powered EVs and associated technologies.
CO2	gain a detailed understanding of various energy storage systems and also able to evaluate key parameters such as battery sizing, charging/discharging cycles, and energy storage modelling for different types of EVs.
CO3	to analyse and design EV charging infrastructure, including the differences between slow and fast chargers, the necessary design ratings for chargers, and the standards used.
CO4	design and analyse the basic requirements of a charging system, the selection of appropriate power components (e.g., Boost PFC, Boost inductor sizing), and loss calculation in chargers.
CO5	select and specify the appropriate AC (Type-1, Type-2, Type-3) and DC chargers based on type of vehicle, battery pack, and infrastructure availability.

Q1. Model the battery using a simple equivalent circuit model (Thevenin equivalent).

Given:

Open-circuit voltage of the battery (V_{oc}) = 12 V
Internal resistance (R_{int}) = 0.2 Ω
Load resistance (R_{load}) = 10 Ω
Current drawn from the battery (I) = 1 A

Find:

The terminal voltage of the battery under load.
The power delivered to the load.

Q2. A BEV has the following requirements: eight years of operation at an average of 24,000 km per year, averaged out over 365 days per year. Assume an average battery output of 204 Wh/km and a rated cell voltage of 3.6 V, a capacity of 3.4 Ah, and a lifetime index of L = 1.

i) Determine the beginning of life kWh storage.
ii) How many cells do you need and what is the beginning of life range?
iii) What is the beginning of life (BOL) storage and how many cells are required for a larger pack in order to increase the beginning of life (BOL) range to 425 km?
iv) How many parallel strings are required if the pack has 96 cells in series?
v) What is the battery pack mass, assuming a battery with a pack density of 150 Wh/kg?
vi) If the peak power is 325 kW, what is the power to energy (P/E) ratio of the battery for the larger pack?

Q3. A NiMH HEV battery pack is sized based on the following requirements: 10,000 cycles of 60 Wh per year for ten years, a 6.5 Ah cell with a rated voltage of 1.2 V and an life index of L = 1.5.

i) What is the beginning of life (BOL) battery pack energy storage?
ii) What is the total number of cells required?
iii) What is the pack voltage if the cells are all in series?
iv) If the peak power is 30 kW, what is the power to energy (P/E) ratio of the battery?

Q4. A hybrid electric vehicle uses a 30 kW bidirectional converter to generate a 650 V dc link voltage from the 288 V NiMH battery. The bidirectional converter has an inductance of 245 μH and switches at 10 kHz. The vehicle is operating in generating mode, and the bidirectional converter is required to act as a buck at full power.

i) Calculate the rms currents in the low-voltage capacitor and in the inductor.
ii) Calculate the maximum, minimum, rms, and average currents in the IGBT and diode.
iii) Calculate the rms current in the high-voltage capacitor.
iv) Determine the low-voltage and high-voltage capacitor values if the peak-to-peak voltage ripple is 0.5%.
Ignore component losses.

Q5. In a conventional PFC boost converter operating in CCM, consider all components to be ideal. Let Vin be 85‑265 V, Vo = 400 V (regulated), Po = 1650 W, and fs = 70 kHz. Calculate Lmin, low-frequency and high-frequency ripple current in the output capacitors, and the capacitance value if the desired low-frequency voltage ripple at the output is assumed to be 10% of nominal output voltage.

Q6. Calculate the amount of energy that the UC releases when it is discharged from 125 to 100 V.

Q7. When the ultra-capacitor (UC) is discharging at 100 A in constant current discharge mode, how long does it take to discharge the UC from 125 to 45 V?

Q8. Calculate the discharge current if the UC voltage is reducing from 125 to 75 V in 300 s.