Roll No												

PRESIDENCY UNIVERSITY
BENGALURU

Department of Research & Development

Mid - Term Examinations - August 2024

Odd Semester: Ph.D. Course Work
Course Code: EEE811
Course Name: EV Battery Charging Technology
Department: SoE/EEE

Date: 12/08/2024
Time: 9:30am – 11:00am
Max Marks: 50
Weightage: 25%

Instructions:

(i) Read the all questions carefully and answer accordingly.
(ii) Do not write any matter on the question paper other than roll number.

PART A (THOUGHT PROVOKING)

Answer all the Questions. Each question carries 5 marks. (4Qx 5M= 20M)

1. Draw and Explain Basic charging Block Diagram of Charger.
(CO:1 Comprehension)

2. Explain the fundamental differences between AC and DC charging in electric vehicles. Discuss how the power conversion process occurs in each case and the implications for charging infrastructure.
(CO:1 Comprehension)

3. What is DAB Topology? Discuss its Real-Life Applications. (CO:2 BL:1Compreshision)

4. What is the principle of operation of a Dual Active Bridge (DAB) converter?
(CO:2 BL:1Comprehension)

PART B (PROBLEM SOLVING)

Answer all the Questions. Each question carries 10 marks. (3Qx 10M= 30M)

5. Consider an EV with a 85 kWh battery that has been used for 5 years, resulting in a 10% capacity degradation. The vehicle is being charged using a Level 2 charger that supplies 11 kW of power. Due to aging, the battery's internal resistance has increased, leading to a reduced charging efficiency of 80%. The battery is currently at 15% SoC, and you aim to charge it to 100%.
a) Calculate the degraded battery capacity.

b) Determine the actual energy that must be drawn from the grid to charge the battery from 15% to 100% SoC.
c) Estimate the total charging time, considering the efficiency loss.

(CO:1 BL:Application)

6. Consider an EV with a 90 kWh battery capable of accepting a maximum charging power of 150 kW. The charging rate, however, is not constant. The charging profile is as follows:
   - From 10% to 50% SoC, the charger provides the maximum 150 kW.
   - From 50% to 80% SoC, the charging power decreases linearly to 60 kW.
   - Beyond 80% SoC, the power decreases further to 30 kW and remains constant until 90% SoC.

   The battery temperature starts at 30°C and increases by 1°C for every 10 minutes of charging. When the battery temperature reaches 50°C, the charging power must be reduced by 10% to prevent overheating. The ambient temperature is constant at 25°C.

   a) Develop a piecewise function to model the charging power as a function of SoC and time.
   b) Calculate the total energy required to charge the battery from 10% to 90% SoC.
   c) Determine the total charging time considering the thermal constraints. Integrate the charging power function over time to obtain the total charging duration.
   d) Discuss how thermal management strategies impact the overall charging time and battery lifespan.

   (CO:1 BL:3 Application)

7. A 400W LLC resonant converter operates with an input voltage Vin of 400V and an output voltage Vout of 24V. The switching frequency fs is 100kHz, and the resonant tank consists of the following parameters:
   Resonant inductor Lr: 100µH, Resonant capacitor Cr: 20nF, Magnetizing inductance Lm: 400µH

   a) Calculate the resonant frequency f0 of the LLC converter.
   b) Determine the characteristic impedance Zr of the resonant tank.
   c) Find the quality factor Q of the resonant circuit.
   d) Calculate the maximum gain of the converter.

   (CO:2 BL:3 Application)