

Birla Institute of Technology & Science, Pilani
Work Integrated Learning Programmes Division
First Semester 2022-2023

Comprehensive examination
(EC-3 Regular)

Course No. : AE ZG518 / AEL ZG518
Course Title : Electric & Hybrid vehicles
Nature of Exam : Open Book
Weightage : 40% (As per Course Handout)
Duration : 2 Hours
Date of Exam : 26/11/2022

No. of Pages	=
No. of Questions	=

Note to Students:

1. Please follow all the *Instructions to Candidates* given on the cover page of the answer book.
2. All parts of a question should be answered consecutively. Each answer should start from a fresh page.
3. Assumptions made if any, should be stated clearly at the beginning of your answer.

Please Note:

Q.1. A fuel cell electric hybrid vehicle has the following parameters.

Parameters	Value	Unit
Vehicle glider mass, m	592	kg
Gravity, g	9.81	m/s ²
Rolling resistance coefficient, f_r	0.009	—
Transmission efficiency, η_t	0.92	—
Air density, ρ_a	1.2	kg/m ³
Aerodynamic drag coefficient, C_d	0.335	—
Frontal area, A_f	2.0	m ²
Wheel radius	0.282	m
Average electrical accessory load	700	W
Vehicle cargo mass	136	kg
Electric motor mass	91	kg
Fuel cell system mass	223	kg

- a. Determine the base power provided by the fuel cell system if the cruise speed is 60km/hr. Make suitable assumptions for transmission and motor efficiency
- b. If the vehicle has to accelerate to 60km/hr in 40s, determine the total electric power required by the vehicle
- c. It is proposed to have either a battery or ultracapacitor for this hybrid system. Design these sources to provide the dynamic power. Determine the battery module and capacitor bank module's specifications (no. of cells) Compare and write your conclusions. The specifications for the battery and ultracapacitor are given below.

Manufacturer	A123-Systems
Type	pouch
Model	26Ah
Source	[7]
Length [m]	0
Diameter [m]	0
Height [m]	0.227
Width [m]	0.16
Thickness [m]	0.00725
Mass [kg]	0.496
Capacity [Ah]	19.5
Voltage [V]	3.3
C-rate (cont.)	1
C-rate (peak)	10

Cell Capacitance (F)	Weight Per cell (kg)	ESR (mΩ)	Specific Energy (Wh/kg)	Specific Power (W/kg)	Cell Voltage (V)	Time Constant ($\tau=RC$)
2700	0.52	0.6	2.49	8929	2.5	1.6

Make suitable assumptions for the efficiencies and write any other assumptions made.

[15 Marks]

- Q.2. Design a suitable bidirectional DC-DC converter for 10kW system with an output current of 75A and 80A during braking with a current and voltage ripple of 10% and 8% respectively. Assume switch loss is 2V. Make suitable assumptions.

[8 Marks]

Q.3. The specifications of the 2004 Toyota Prius with NiMH battery is given below

- 168 cells (28 modules)
- 201.6V nominal voltage
- 6.5Ah nominal capacity
- 28hp (21 kW) output power
- 1300 W/kg specific power
- 46 Wh/kg specific energy.

- What is the energy rating of the battery module?
- If the battery can be discharged at 60A upto 30% determine the time of use if initial SOC =100%.
- If the battery is charged from 20% to 75%, determine the time for charging
- If the battery is modelled as R_{int} model, Calculate the efficiencies for a charge at current of 60A with $R_{int} = 0.04\Omega$ and discharge at current of 40A with $R_{int} = 0.15\Omega$. Calculate the drops across the R_{int} .

[10 Marks]

- Q.4. Compare different types of battery charging methods

[7 Marks]
