EV Design

Course Learning Objectives	• Work with HEV and EV technology and related components. Design, simulate and build prototype of EVs and subsystems. • Design, construct and assemble traction motor transmission system and cooling system. • Integrate the wiring of low-voltage EV components and test them for vehicle-level integration.
Course Outcomes	• Build and test the powertrain system of an EV • Selection of transmission system as per application • Implement the wiring of battery pack & battery management system • Perform experiments with the thermal management system of a battery pack

Course Duration: 45 Hours

UNIT I HEV powertrain Architecture

Problems with current transportation - Impact of air pollution - Current solutions - Hybrid electric vehicles and its subsystems - Concept of Hybrid electric drivetrain - Hybrid electric vehicle architecture, Series hybrid powertrain, Parallel hybrid powertrain, Power-split hybrid powertrain

UNIT II EV powertrain Architecture

Electrification advantages - EV components - Types of EV- Overall block diagram - Electric variant & new mechanical platform - Few examples of EV and their performance - Forces on the vehicle- Transmission system - Drive cycles- Power & Energy calculations- Powertrain & drivetrain - Charging infrastructure

Traction Motors- Working principle- Torque speed characteristics- Types of motors- Traction inverter basics,Power semiconductor devices, Single speed and multi speed transmission system - Efficiency maps for different gear ratios

UNIT IV Battery system for EV

Types of battery for transportation application - Lead acid - Nickel metal hydride - Lithium-ion cells and chemistries - choice of series and parallel number of cells - construction of the battery pack - Battery Management System- BMS topologies- Protection functions - Battery charging

UNIT V Thermal management system for EV

Overview of EV thermal management system - Cooling techniques for power converters - Heating and cooling requirements of battery pack - Cooling methods and comparison

Test Projects:

Use Cases:

INDUSTRY USE CASES:

1. Carry out electrical wiring of EV components - power and energy estimation based on vehicle specifications and performance requirements - 2-Wheeler - Calculation - Modeling - Matching simulation results with a prototype vehicle

Task 1: Determine the system specifications from the project definition

Task 2: Estimate the power rating of motor & energy requirements of battery pack

Task 3:Develop the Simulink model of vehicle & get the energy consumption in kWh/km for a selected driving cycle

Task 4: Procure the required components and assemble them. Test the EV on road with the selected driving cycle and find the actual energy consumption

Task 5: Compare the simulation and real world data Carry out electrical wiring of EV components - power and energy estimation based on vehicle specifications and performance requirements -

3 Wheeler - Calculation - Modeling - Matching simulation results with commercially available vehicle

Task 1: Determine the system specifications from the project definition

Task 2: Estimate the power rating of motor & energy requirements of battery pack

Task 3:Develop the Simulink model of vehicle & get the energy consumption in kWh/km for a selected driving cycle

Task 4: Procure the required components and assemble them. Test the EV on road with the selected driving cycle and find the actual energy consumption

Task 5: Compare the simulation and real-world data

2. Carry out electrical wiring of EV components - power and energy estimation based on vehicle specifications and performance requirements - 4 Wheeler - Calculation - Modeling - Matching simulation results with commercially available vehicle

Task 1: Determine the system specifications from the project definition

Task 2: Estimate the power rating of motor & energy requirements of battery pack

Task 3:Develop the Simulink model of vehicle & get the energy consumption in kWh/km for a selected driving cycle

Task 4: Procure the required components and assemble them. Test the EV on road with the selected driving cycle and find the actual energy consumption

Task 5: Compare the simulation and real world data

3. Carry out electrical wiring of EV components - power and energy estimation based on vehicle specifications and performance requirements - Electric Bus - Calculation - Modeling - Matching simulation results with commercially available vehicle

Task 1: Determine the system specifications from the project definition

Task 2: Estimate the power rating of motor & energy requirements of battery pack

Task 3:Develop the Simulink model of vehicle & get the energy consumption in kWh/km for a selected driving cycle

Task 4: Procure the required components and assemble them. Test the EV on road with the selected driving cycle and find the actual energy consumption

Task 5: Compare the simulation and real world data

4. Measure the overall efficiency of EV - Deriving the technical specifications for the Motor: speed, torque and power, Choose the suitable transmission system from different gearbox ratios - 2 Wheeler

Task 1: Determine the system parameters and specifications required regarding the project definition.

Task 2: Calculation of Vehicle characteristics (speed, torque and power) and propose the suitable type of transmission system and applicable gearbox ratio. Estimation of overall efficiency of the EV with the proposed transmission type.

Task 3: Developing the Simulation model of the EV with specified motor rating and including the proposed Transmission type and gearbox ratio for selected drive cycle.

Task 4: Procure necessary components proposed under the study and assemble them. Test the Vehicle on Road using the drive cycle selected for Simulation and obtain real time overall Efficiency of the model.

Task 5: Compare the Simulated data with the Real time data obtained for validation.

5. Measure the overall efficiency of EV - Deriving the technical specifications for the Motor: speed, torque and power, Choose the suitable transmission system from different gearbox ratios - 3 Wheeler

Task 1: Determine the system parameters and specifications required regarding the project definition.

Task 2: Calculation of Vehicle characteristics (speed, torque and power) and propose the suitable type of transmission system and applicable gearbox ratio. Estimation of overall efficiency of the EV with the proposed transmission type.

Task 3: Developing the Simulation model of the EV with specified motor rating and including the proposed Transmission type and gearbox ratio for selected drive cycle.

Task 4: Procure necessary components proposed under the study and assemble them. Test the Vehicle on Road using the drive cycle selected for Simulation and obtain real time overall Efficiency of the model.

Task 5: Compare the Simulated data with the Real time data obtained for validation.

6. Measure the overall efficiency of EV - Deriving the technical specifications for the Motor: speed, torque and power, Choose the suitable transmission system from different gearbox ratios - 4 Wheeler

Task 1: Determine the system parameters and specifications required regarding the project definition.

Task 2: Calculation of Vehicle characteristics (speed, torque and power) and propose the suitable type of transmission system and applicable gearbox ratio. Estimation of overall efficiency of the EV with the proposed transmission type.

Task 3: Developing the Simulation model of the EV with specified motor rating and including the proposed Transmission type and gearbox ratio for selected drive cycle.

Task 4: Procure necessary components proposed under the study and assemble them. Test the Vehicle on Road using the drive cycle selected for Simulation and obtain real time overall Efficiency of the model.

Task 5: Compare the Simulated data with the Real time data obtained for validation.

7. Measure the overall efficiency of EV - Deriving the technical specifications for the Motor: speed, torque and power, Choose the suitable transmission system from different gearbox ratios - Electric Bus

Task 1: Determine the system parameters and specifications required regarding the project definition.

Task 2: Calculation of Vehicle characteristics (speed, torque and power) and propose the suitable type of transmission system and applicable gearbox ratio. Estimation of overall efficiency of the EV with the proposed transmission type.

Task 3: Developing the Simulation model of the EV with specified motor rating and including the proposed Transmission type and gearbox ratio for selected drive cycle.

Task 4: Procure necessary components proposed under the study and assemble them. Test the Vehicle on Road using the drive cycle selected for Simulation and obtain real time overall Efficiency of the model.

Task 5: Compare the Simulated data with the Real time data obtained for validation.

8. Fabricate the mechanical fixture for the in-wheel hub motor - CAD model development - Analyze the unsprung mass and vibrations the motor has to withstand with Simulation

Task 1: Determine the specifications and dimensional requirement for the hub motor under the intended use.

Task 2: Development of the mechanical fixture using CAD tool with respect to the Hub motor selected and estimate the overall mass of the Motor with fixture setup.

Task 3: Development of simulation model to analyze the magnitude of vibrations to be handled by the in-wheel hub motor arrangement. Perform simulation of the model to check the durability of the fixture design.

Task 4: Develop a prototype of fixture as designed, assemble the required components to develop an EV and perform a road test.

Task 5: Compare the simulation results with the real time model results.

9. Develop the mechanical transmission system for 2 Wheeler with inner rotor motor - Fabrication of motor to wheel system -Verify the input and output speed and torque

Task 1: Determine the output performance characteristics of the suggested motor.

Task 2: Suggest an efficient transmission system capable of delivering the estimated power to the wheels.

Task 3: Develop a simulation model of the Powertrain system to obtain the speed torque output data with respect to a selected drive cycle.

Task 4: Procure necessary components and assemble the same to develop a real time powertrain system with the specifications regarding the project definition and log the real time speed torque data.

Task 5: Compare the Simulated and Real time model data.

10. Constructing a 7S5P battery pack with the cells - Electrical connections - Mechanical housing

Task 1: Learn the cell manufacturer's datasheet and understand the cell characteristics.

Task 2: Procure 35 cells and connect the cells in series and parallel to make the battery pack in 7S5P

configuration. Connect the 7S5P configuration to BMS as per guidelines.

Task 3: Determine the dimensions of the Battery pack assembled and develop CAD model as per the dimensions with proper tolerance. Tolerance to be considered for the bus bar, connectors, BMS system etc.Suggest a better material for the mechanical housing.

Task 4: Develop a real time Mechanical housing and test with a 7S5P real time battery pack with BMS.

11. Develop the mechanical transmission system for 3 Wheeler with inner rotor motor - Fabrication of motor to wheel system - Verify the input and output speed and torque

Task 1: Determine the output performance characteristics of the suggested motor.

Task 2: Suggest an efficient transmission system capable of delivering the estimated power to the wheels.

Task 3: Develop a simulation model of the Powertrain system to obtain the speed torque output data with respect to a selected drive cycle.

Task 4: Procure necessary components and assemble the same to develop a real time powertrain system with the specifications regarding the project definition and log the real time speed torque data.

Task 5: Compare the Simulated and Real time model data.

12. Develop the mechanical transmission system for 4 Wheeler with inner rotor motor - Fabrication of motor to wheel system - Verify the input and output speed and torque

Task 1: Determine the output performance characteristics of the suggested motor.

Task 2: Suggest an efficient transmission system capable of delivering the estimated power to the wheels.

Task 3: Develop a simulation model of the Powertrain system to obtain the speed torque output data with respect to a selected drive cycle.

Task 4: Procure necessary components and assemble the same to develop a real time powertrain system with the specifications regarding the project definition and log the real time speed torque data.

Task 5: Compare the Simulated and Real time model data.

13. Testing 7S5P battery pack for communications - Voltage/Current/Temperature monitoring

Task 1: Learn the cell manufacturer’s datasheet and understand the charge and discharge curves

Task 2: Procure 35 cells of NMC chemistry and connect the cells in series and parallel to make the battery pack

Task 3:Connect the BMS as per the guidelines

Task 4: Connect the BMS with external data logger or host microcontroller

Task 5: Get the data set of voltage, current and temperature

14. Measure the temperature rise of the battery pack with cooling system and without cooling system - Comparing the results with simulation

Task 1: Selection of an appropriate Battery pack configuration with and without a cooling system and

collecting necessary specifications to develop a simulation model.

Task 2: Development of Simulation models of a battery pack with and without a cooling system.

Task 3: Performing simulation and obtaining the temperature rise data of both the battery models.

Task 4: Compare the performance results of Battery packs with and without the cooling system and comment on the effects of including a cooling system with a battery pack.

Task 5: Procure necessary components , assemble them to obtain separate battery pack models ,one with and other without a cooling system and perform charge and discharge cycles and log the data.

Task 6: Compare the simulation results with the real time model results for validation.

15. Test the transmission system efficiency - mechanical transmission system for 2 Wheeler with inner rotor motor - Efficiency comparison of two gearbox with different gear ratio

Task 1: Select the suitable motor and transmission system as per the project definition.

Task 2: Develop a simulation model based on the selected powertrain component and simulate the same with multiple gear ratios. Estimate the efficiency values of the transmission system for the multiple gear ratios.

Task 3: Procure necessary components and assemble the same to develop a real time powertrain system with 2 different gearboxes similar to the simulation model and log the real time data. Estimate the transmission system efficiency for the selected gear box.

Task 4: Compare the Simulated results and real time model results, Validate the results.

16. Test the transmission system efficiency - mechanical transmission system for 3 Wheeler with inner rotor motor - Efficiency comparison of two gearbox with different gear ratio

Task 1: Select the suitable motor and transmission system as per the project definition.

Task 2: Develop a simulation model based on the selected powertrain component and simulate the same with multiple gear ratios. Estimate the efficiency values of the transmission system for the multiple gear ratios.

Task 3: Procure necessary components and assemble the same to develop a real time powertrain system with 2 different gearboxes similar to the simulation model and log the real time data. Estimate the transmission system efficiency for the selected gear box.

Task 4: Compare the Simulated results and real time model results, Validate the results.

17. Test the transmission system efficiency - mechanical transmission system for 4 Wheeler with inner rotor motor - Efficiency comparison of two gearbox with different gear ratio

Task 1: Select the suitable motor and transmission system as per the project definition.

Task 2: Develop a simulation model based on the selected powertrain component and simulate the same with multiple gear ratios. Estimate the efficiency values of the transmission system for the multiple gear ratios.

Task 3: Procure necessary components and assemble the same to develop a real time powertrain system with 2 different gearboxes similar to the simulation model and log the real time data. Estimate the transmission system efficiency for the selected gear box.

Task 4: Compare the Simulated results and real time model results, Validate the result

18. Vehicle integration testing - Battery pack + BMS + Motor controller + Motor - No load losses - Bench testing with various brake loads - Peak efficiency estimation - Comparison with simulated results

Task 1: Select the suitable motor and motor controller for the project and develop the simulink model

Task 2: Connect the battery pack along with the BMS to motor controller

Task 3: Run the motor on no load by applying the throttle. Measure the efficiency of motor + motor controller + transmission system

Task 4: Vary the load condition and establish the peak efficiency condition

Task 5: Compare the actual results with simulated and find the reasons for difference

19. On-road testing of prototype vehicle from fully charged to discharged battery condition - real-world drive cycle data logging - True range - Comparison with simulated results

Task 1: Select the suitable EV components for the project and develop the simulink model

Task 2: Connect the battery pack along with the BMS to motor controller

Task 3: Run the motor on no load by applying the throttle

Task 4: Connect the motor with transmission system and wheels

Task 5: Run the vehicle for a fully charged battery to fully discharged battery level and compare the range with simulated results

Student Assessment Plan:

Each of the above-mentioned test projects will be divided into tasks by the training partner for each specific institution. Such tasks will be jointly evaluated by the faculty and the training partner and the following weightage is to be followed.

- 70% weightage to the external practical assessment.
- 30% weightage to the internal assessment.

Final Test Project/External Assessment Plan:

The Final Test Project will be chosen from the list given above, jointly by the college faculty and the Training Partner. The Final Test Project will be assessed on the following tasks, for 70%

Details	**Marks**
Task: 1	20
Task: 2	20
Task: 3	20
Task: 4	20
Task: 5	20

Employment Potential:

This course shall enable mechanical, automobile and allied domain Engineers to get employment in sectors like Automobile, Manufacturing, Assembly and etc.