ELG4157: Case Study (Midterm 1: 10 marks)

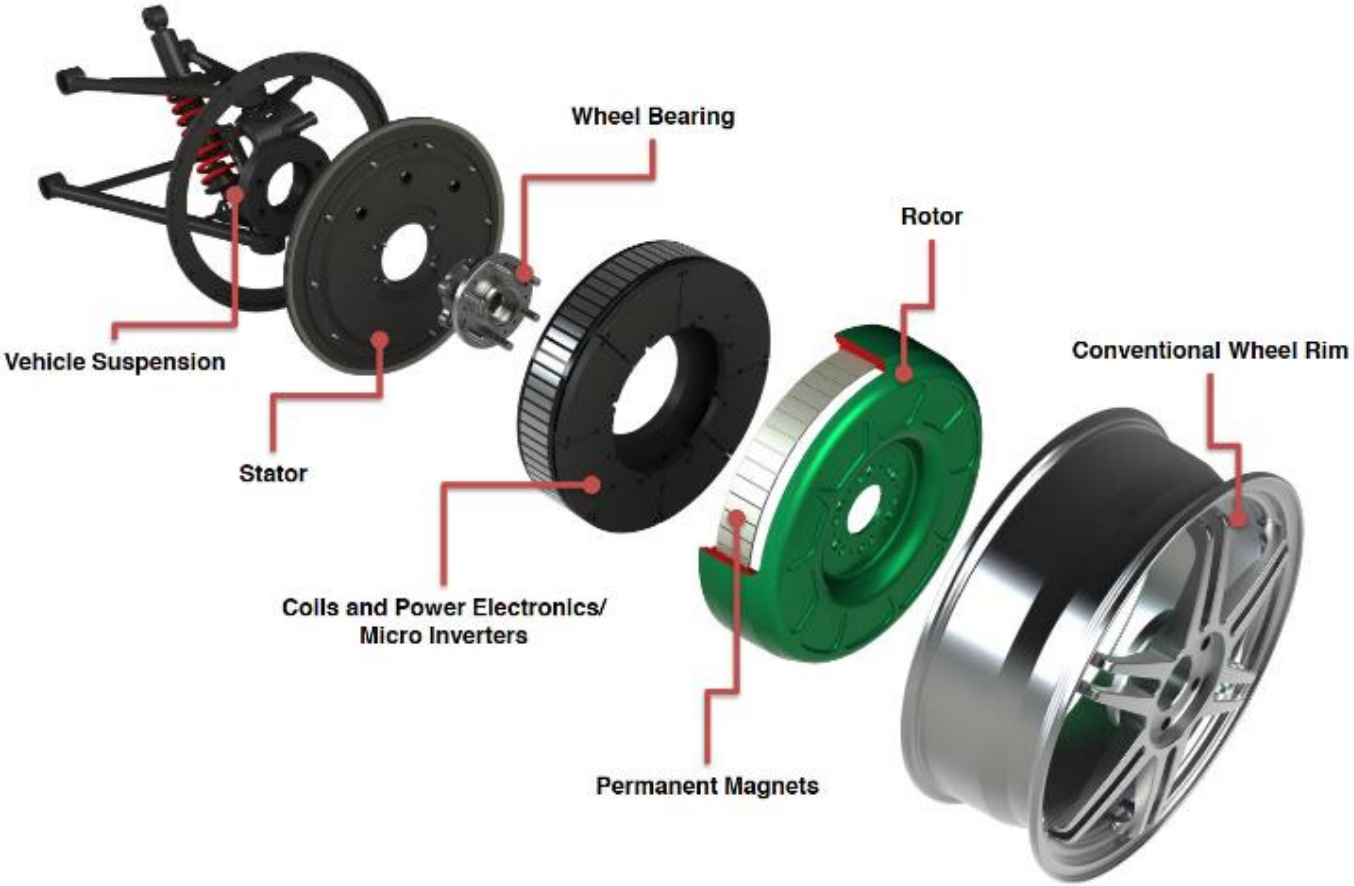
Group of Two Students Only

Analysis of In-Wheel Motor System

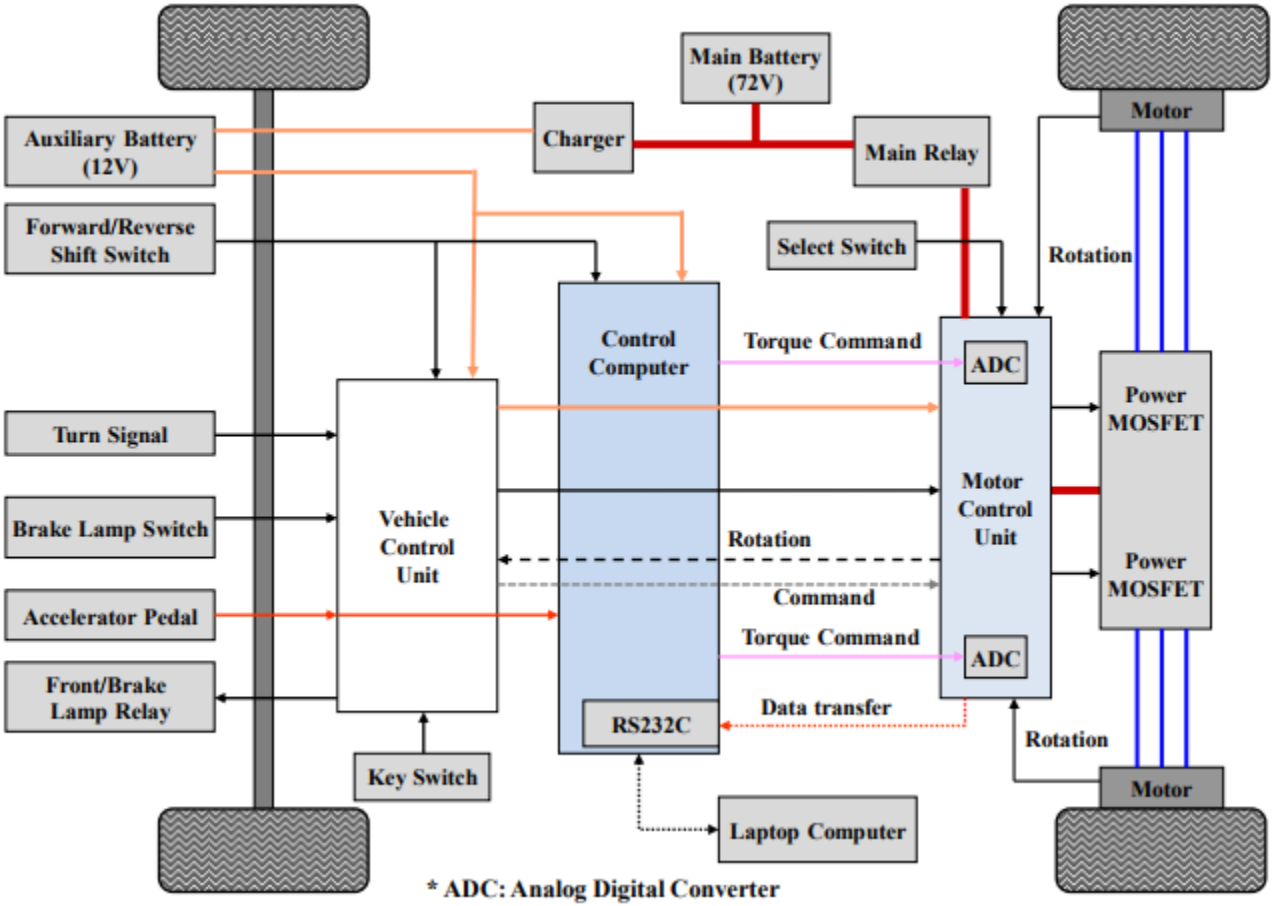
This case will be conducted to analyze (model and simulate) a powertrain to propel a typical passenger vehicle in an urban driving environment.

The “in-wheel motor system” acts as a powertrain that consists of electric motor, power electronics and electric energy storage system (battery, super capacitors) and many other electrical loads.

In-Wheel Motor System



Components of an Electric Vehicle



Why Modeling and Simulation?

- While designing a system, it is required to:
  - Size components
  - Find the best energy control strategy, and
  - Minimize the vehicle energy consumption.
- This can be achieved through modeling and simulation since prototyping and testing are expensive and complex operations.
- Developing a simulation model with a good level of accuracy for all the different components based on different physical domains (electric, mechanical, thermal, power electronic, electrochemical and control) is a **challenge**.
- This challenge will be carried out during the semester.

Task 1: Battery Management System

- Vehicle battery being the limiting factor in the range of the HEV vehicle, the energy usage of the battery requires optimization to ensure lowest energy dissipation, therefore gaining the most mileage out of the vehicle. **For this task:**
  - Predict the mathematical model of a battery system in terms of state variables. The state space model is able to mimic the complex dynamic behavior of a battery system.
  - Adopt a dynamical RC lithium-ion battery model and take into consideration major factors of battery aging.
  - Find values of **A**, **B**, **C**, and **D**.
  - Estimate state of charge (SoC) of the battery system.
  - Simulate a battery/supercapacitor management system using Matlab/Simulink.

Task 2: DC to DC Converters

- Modeling and simulating DC to DC converters using the modelling equations is necessary to design of power electronic converter circuit with the use of closed loop scheme.
- **For this Task:**
  - Model a DC to DC converter using proper technique.
  - Simulate the above DC to DC convert.

Task 3: Motor Modeling and Design

- The most adopted motor in automation these days is the permanent synchronous magnets motor (PMSM). You may adopt another suitable DC motor.
- **For this Task:**
  - Model the motor using proper technique.
  - Simulate the motor using Matlab/Simulink.

Reflection

- This task addresses control and technology strategies to achieve a novel design of integrated in-wheel motor system by building a high performance motor and developing algorithms for a robust power management, torque vectoring, and traction control.
- All the components required for drive including the electric motor, power electronics, controller, braking and cooling systems are installed in an integrated wheel hub drive.
- This highly-integrated system will provide considerable advantages in terms of manoeuvrability, driving dynamics, and safety.

Submission

- Conduct literature review about in-wheel motor system.
- Design a robust in-wheel motor system taking into consideration one or more of the following issues: power management, torque vectoring, and traction control.
- Simulate your design using MATLAB/SIMULINK or any other tool.
- Reflect your work by writing a 5-page research paper (IEEE Format).
- Rely on research papers related to one or more of the following key topics
  - In-wheel motor systems
  - Torque vectoring
  - Traction control
  - Power management

Research Paper

- This is an open-ended task with an objective to master technical communication and research methodology.
- The content of the task is flexible, however, it depends largely on the nature of the work you conducted in the lab in regard to optimizing components of the in-wheel motor drive.
- Follow the IEEE format to develop a 5-page research paper about one or more of the concepts of the topic.
- In the introduction section of the paper, you should survey and cite at least five research papers as your literature review.
- In the following sections, summarize your work, approach, analysis, and findings in terms of discussion, equations, figures, etc.
- The paper should start with an abstract and ends with conclusion of your investigation. These two parts are usually similar and should be written with care.
- References should be organized properly.