UNIVERSITY OF BIRMINGHAM

Hybrid Bus Powertrain Optimisation

Introduction

The aim of this project is to investigate the potential for optimisation in the efficient operation of the dual traction systems found within a hybrid-electric bus. The project initially involves the development of a hardware model of the power train based on a DC motor, dual power sources, and a microcontroller managed switching and control fabric. Testing will then be undertaken using the hardware model to identify the balance point between the two traction packages for varying operational conditions. A condition-driven control algorithm will then be developed based on the balance points identified during the testing phase.

Background

The depletion of oil resources is predicted to happen in a few decades. The development of energy-saving vehicles and the popularisation of public transport has become more and more important. A typical hybrid electric bus has a powertrain consisting of both a diesel engine and an electric motor to power the bus either independently or cooperatively. By switching between the two traction packages and recuperating the energy which is normally lost, the bus can be more fuel-efficient and the gas emission can be reduced.

There are two main types of hybrid buses under operation today. One of them is called the serial hybrid bus. The serial hybrid system has no mechanical link between the diesel engine and the axle and all the power to the axle comes from the electric motor. The motor is either driven by the electric power from the diesel engine coupled to a generator, or from the battery. In both architectures, the diesel engine is able to charge the battery when the power storage is becoming low. The battery can also recuperate the energy from the electric motor when the bus is braking. In my project, I am using a system structure which is similar to the serial hybrid system. Below is the block diagram of the serial hybrid system.

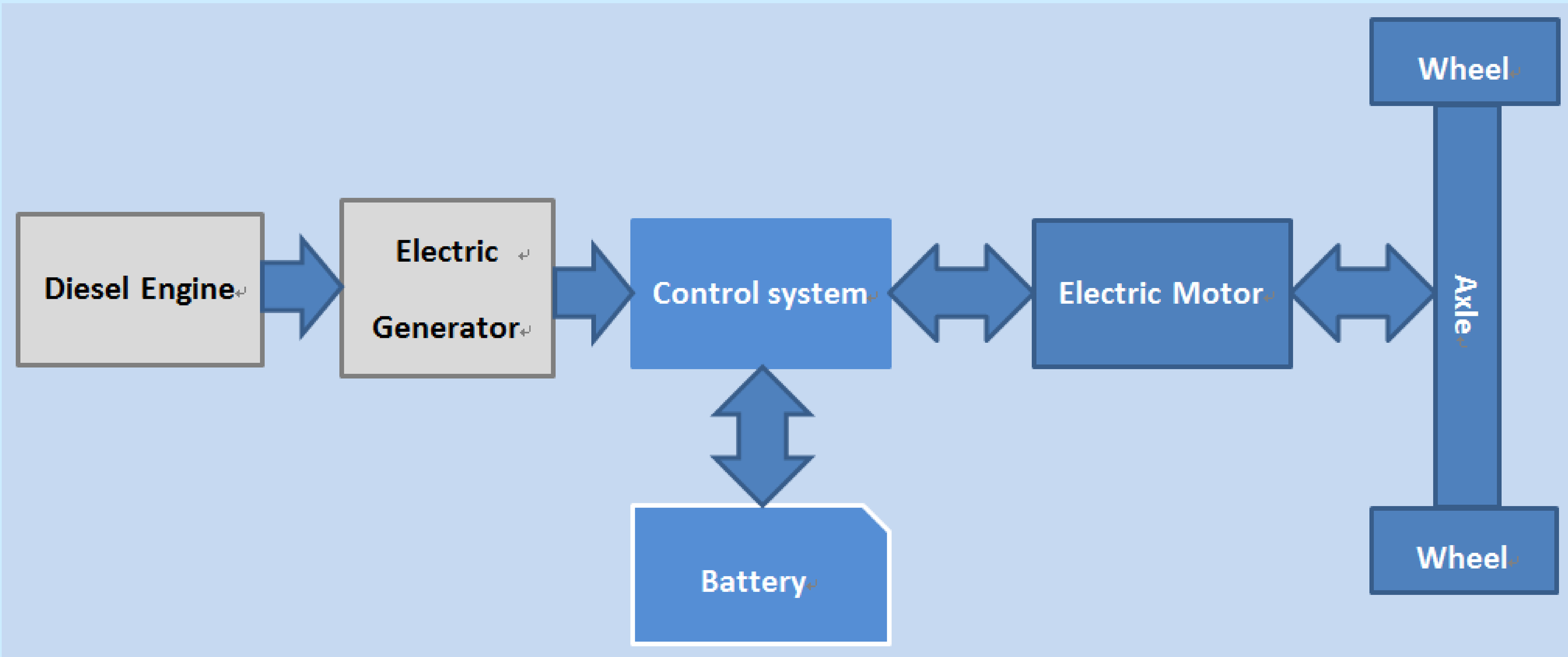

Figure1. Serial Hybrid System

Model design

To create a hardware model of the system for simulation, a 12V lead-acid rechargeable battery and the bench power supply (instead of the diesel engine and the electric generator) work as the two power sources. A PIC microcontroller is responsible for controlling the relays to switch between the two energy sources. Temperature sensor, voltage and current transducers are used to monitor the operational condition of the battery. Finally, a rotary encoder helps the PIC to calculate the motor speed, which is important for the decision-making of the powertrain operation. The hardware structure is illustrated in the block diagram below.

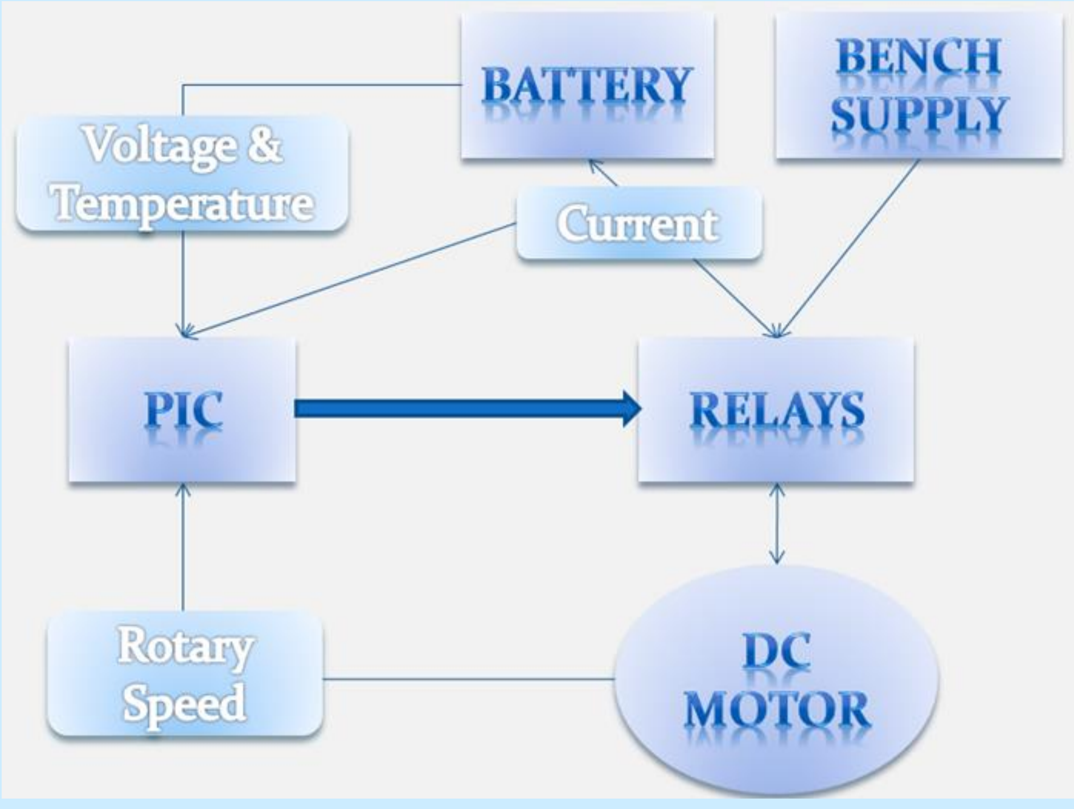

Figure2. Hardware structure

Expected Outcomes

Under successful implementation, the system should perform the following operations. 1. As soon as the bus is accelerated from stationary, both traction packages should be switched on in order to provide enough power to the electric motor. 2. Once a steady speed is reached, the "diesel engine and electric generator" alone will provide the motor with all the energy needed to drive the vehicle. 3. When the bus decelerates, the bench power supply is switched off and let the battery recycle the energy flowing back from the motor which now is working as a generator. 4. If abnormal operational status of the battery is detected by the microcontroller, the powertrain should stop working until danger is eliminated.

Further investigations on the powertrain model should be undertaken in a few ways. 1. The optimisation switching point could be found and demonstrated in computer software. 2. More complex sensors could be used to understand the characteristics of electric motor in real vehicle operation, and the microcontroller could implement more complicated switching decisions using detailed system status. 3. Real bus duty cycles could be recorded and input into the model for analysis. 4. The model could be adapted to railway vehicles using completely rigid performance and route simulations.

Shen Xiang (SXX138@bham.ac.uk)

Centre for Railway Research and Education

www.railway.bham.ac.uk