Torque Vectoring with a feedback and feed forward controller - applied to a through the road hybrid electric vehicle

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Abstract

This paper concentrates on the torque commands for electric propulsion motors in a through the road hybrid electric vehicle. By using a linear quadratic gaussian controller, a flat feed forward controller and a linear desired value generator the lateral vehicle dynamics are influenced. Understeering, oversteering, agility and cornering speed can be optimized by proper controller design. A 14 degree of freedom vehicle model with a Dugoff tire model is used to simulate the vehicle behaviour. The simulation results show improved vehicle dynamics and increased handling for the driver compared to an equal distributed torque command.

1. Introduction

Today more and more vehicles are produced as hybrid electric vehicles (HEV). On possible solution to implement an electric drivetrain into a internal combustion engine (ICE) based vehicle is the so called Through the Road (TtR) hybrid electric vehicle. In a TtR-HEV [1] the existing drive line will not be changed. Only the axle with no drive will be equipped with the electric components. These components include an electric energy storage - mostly a lithium-ion battery - and an electric machine controlled by an inverter.

For the electric drive there exist two design possibilities. In the first case there is one electric motor which is controlled by one inverter and mounted somewhere in the chassis. This system applies the motor torque to a final drive which routes the torque to the wheels. For the second design two electric motors with two inverters are necessary. These motors can be located in the chassis or inside the driving wheels as hub motors.

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With two motors the size of the machines can be smaller and a final drive is not needed. With two independent motors it is possible to apply positive and negative torque individually to each wheel. This means that it is possible to accelerate and brake the wheels independently. The torque generation of electric machines is very quick and accurate for accelerating and braking the driving wheels [2]. With the possibility of controlling the wheels individually the question arises: How to distribute the torque between the two motors? To answer this question a torque vectoring controller is developed.

In this paper a control strategy for torque vectoring will be presented and simulated for a through the road hybrid electric vehicle. The control structure and design of the sub-controllers will be shown in section 2. In section 3 the controllers will be simulated with a 14 degree of freedom vehicle model. Conclusions are given in section 4.

2. Torque Vectoring

The basic idea of torque vectoring is that given requests from the driver (steering angle, brake and acceleration pedal signals) will be processed and distributed as torque commands to the wheels of the vehicle. With