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A modified integral sliding mode control to lateral stabilisation of 4-wheel independent drive electric vehicles

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This paper presents a novel sliding mode controller (SMC) and its application in the lateral stability control of a 4-wheel independent drive electric vehicle. The structure of the SMC is modified and online-tuned to ensure vehicle system stability, and to track the desired vehicle motion references when an in-wheel motor fault happens. The proposed controller is faster, more accurate, more robust, and with smaller chattering than common SMCs chatter. The effectiveness of the introduced approach is investigated through conducted simulations in the CARSIM and MATLAB software environments.

Keywords: electric vehicle; fault tolerant; in-wheel motor; sliding mode control; vehicle lateral stability control

1. Introduction

Rapid development of electric vehicle technology in recent years, and heavy investments of automotive companies in this area indicate the importance of these types of vehicles in the near future. Limitation of fossil resources and the environmental problems caused by fossil fuel combustion in vehicles are the main motives of this movement. Therefore, to solve these problems, electric and hybrid electric vehicles with a variety of structures have been utilised.[1] An interesting structure is the 4-Wheel Independent Drive (4WID) vehicles in which each wheel is driven by an electric motor. The electric motors usually known as in-wheel motors can be placed in the inner space of the wheels.[2] This power train system can be used for almost all types of electric vehicles, and series hybrid electric vehicles. Despite all the benefits of an electric vehicle with in-wheel motors, the main problem with these vehicles is the need for a coordinated motor control system for balancing the vehicle, especially in corners and fault conditions.[3–5]

For path tracking in the vehicles with no mechanical differential, several electric differentials have been proposed in [6–9]. In these electric differentials, an observer estimates the motor speed, and then speed references are generated to drive the motors. Although the performance of the proposed methods can be acceptable in normal driving conditions, vehicle stability is not guaranteed in critical conditions such as driving on slippery roads, severe steering angle changes, and in the case of an unskilled driver.

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