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Sliding Mode Control for Four Wheels Electric Vehicle Drive

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Abstract

In this research a novel control schema of four wheels drive (4WD) propulsion system control is presented. The present paper introduces novel studies of sliding mode control applied on four independent wheels electric vehicle systems. The proposed propulsion system consists of four Induction Motors (IM) that ensure the driving of back and front driving wheels. This vehicle uses an electronic differential for speeds reference computations of four wheels. The electronic differential system ensures the robust control of the vehicle behaviour on the road; it also allows controlling, independently, every driving wheel to turn at different speeds in any curve. The result obtained is satisfactory for our electric vehicle sliding mode control's simulated in Matlab Simulink environment. It shows the efficiency of the proposed control comparing with classical PI controller with no overshoot. The rising time is perfected with good disturbances rejections.

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Keywords: 4WD; electric vehicle; induction motor; PI controller; sliding mode control.

1. Introduction

Electric vehicles (EVs) are developing fast during this decade due to drastic issues on the protection of environment and the shortage of energy sources. While commercial hybrid cars have been rapidly exposed on the market, fuel-cell-powered vehicles are also announced to appear in 5–10 years. Researches on the power propulsion system of EVs have drawn significant attention in the automobile industry and among academics. EVs can be classified into various categories according to their configurations, functions or power sources. Pure EVs do not use petroleum, while hybrid cars take advantages of energy management between gas and electricity [1, 3]. Indirectly

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driven EVs are powered by electric motors through transmission and differential gears, while directly driven vehicles are propelled by in-wheel or, simply, wheel motors [2, 6]. The basic vehicle configuration of this research has four directly driven wheel motors installed and operated inside the driving wheels on a pure EV [3, 8, 9]. These wheel motors can be controlled independently and have so quick and accurate response to the command that the vehicle chassis control or motion control becomes more stable and robust, compared to indirectly driven EVs [5, 6]. Like most research on the torque distribution control of wheel motor, wheel motors [3] proposed a dynamic optimal tactile force distribution control for an EV driven by four wheel motors, thereby improving vehicle handling and stability [5]. The researchers assumed that wheel motors were all identical with the same torque constant; neglecting motor dynamics the output torque was simply proportional to the input current with a prescribed torque constant. In this paper, a sliding mode decoupling controller for electric vehicle control is proposed. The reminder of this paper is organized as follows: Section 2 reviews the description of the principle components of Electric traction chain. Section 3 shows the indirect field-oriented control (IFOC) of induction motor. Section 4 shows the development of sliding mode controllers design for Electric vehicle. Section 5 gives some simulation results carried on Matlab Simulink software. Finally, the conclusion is drawn in Section 6.

Nomenclature

SMC	Sliding Mode Control
IFOC	Indirect Field Oriented Control
EVs	Electric vehicles.
PWM	Pulse Modulation Width
IM	Induction Motor

2. Electric traction system modelling and description

Fig.1 presents the general schema of four wheels electric vehicle using induction motor for motion (IM) supplied by voltage inverter [3, 5, 6, 9, 10].

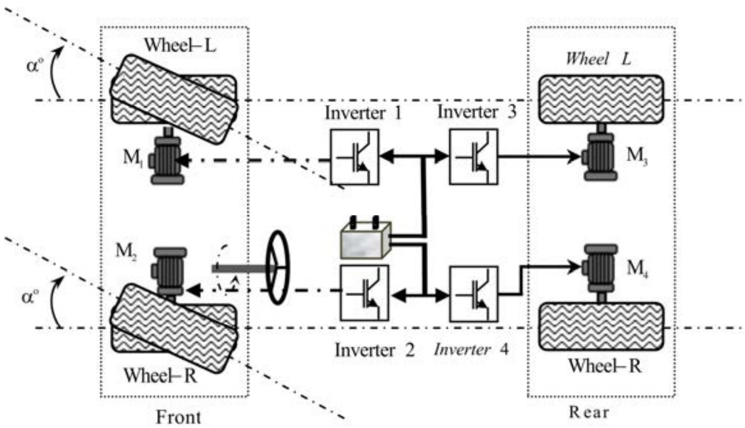

Fig.1. Electrical Propulsion system of four wheels electric vehicle chain.

The battery used in this paper is Lithium-Ion battery accumulator, a simplified version of the complex battery model reported in [11]. In this electric traction system, we use Pulse Modulation Width (PWM) techniques to obtain three balanced alternating current phases with variable frequency from the current battery:

$$\begin{bmatrix} v_{an} \\ v_{bn} \\ v_{cn} \end{bmatrix} = \frac{U_{dc}}{2} \begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix} \begin{bmatrix} S_a \\ S_b \\ S_c \end{bmatrix} \quad (1)$$