Electronic Diffrential System for Light Electric Vehicle with Two in Wheel Motor

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Abstract

This paper introduces the modeling and simulation of the Electronic Differential System (EDS) of the two-wheeled self-propelled electric vehicle (EV). The electronic variant is used in EVs due to certain constraints of traditional machine variations such as being heavy and large systems suitable for EV, and equipment losses caused by powertrain. In this study, EDS for front-wheel drive EV with in-wheel motor model replaces the rare wheels that are commonly read in the literature. The general rule of the proposed gadget is that it is not something directional sensor to test steering position and speed of steering wheels. Each important volume is miles used improperly by remote control of electric bicycle controls and the description of driving the Arduino system. These extra items are smart and can be found almost anywhere in the world.

1.INTRODUCTION

Light motor vehicles (LEVs) are currently one of the most important means of achieving the goal of sustainable urban mobility. Although the concept of LEV is not well defined, we can assume that it can be used in those vehicles whose weight is equal to the total weight of the passengers for which they are designed. Therefore, its main feature is the low weight, which leads to much lower power consumption and, therefore, higher efficiency than those of conventional electric vehicles. LEVs are widely used today with two-wheeled models: electric bicycles, mopeds and motorcycles. In addition to their reduced weight, another advantage of LEVs is that they have a single steering wheel. Therefore, the control system and the motor (usually the hub motor) have low weight and cost.

The use of an ED also allows improving the stability of tricycles with two drive wheels. There are different ways to implement an ED. Some are complex, such as the "side slip control", which lies in the torque in each motor is regulated to improve the yaw rate of the vehicle. However, the simplest way to implement an ED is to apply the same torque to each of the driving wheels. Even in this simplest form of implementation, a controller of these characteristics presents a level of complexity quite superior to the standard controllers of electric bicycles, which are designed to regulate the power of a single motor. Therefore, the use of this type of low cost and widespread controllers should be discarded, with the consequent increase in the overall cost of the system. Most of ED controllers require at least sensors to measure the speed of the driving wheels, the current of each motor and the steering angle. However, some controller designs eliminate some of these sensors to gain simplicity at the expense of reducing some of their features. In this line, a controller without wheel speed sensors is proposed in and another controller without steering angle sensor or speed sensors is proposed in paper. Both designs are applied to EVs driven with induction motors. In standard industrial frequency converters are used instead of the design of a new type of controller. This allows obtaining the advantages of higher reliability, low price and broad range of products and suppliers. In this paper a design similar to the previous one is proposed, but applied to a LEV equipped with BLDC motors and standard electric bicycle controllers. The control system has been completed with the well-known Arduino platform, which allows the addition of special functions such as traction control and anti-lock wheel system.

1.1 OBJECTIVE

To find the optimal component sizing for a given requirement set and to investigate the trade-offs between the energy consumption, the powertrain cost and the acceleration performance. The project concludes with a discussion of the relative merits of the different topologies and their applicability to real-world passenger cars. The modeling and real time simulation of an electronic differential has been the first objective of this project. The next objectives have been to fabricate the inverter and driver circuit followed by hardware in loop testing of the brushless DC motor with Opal RT.

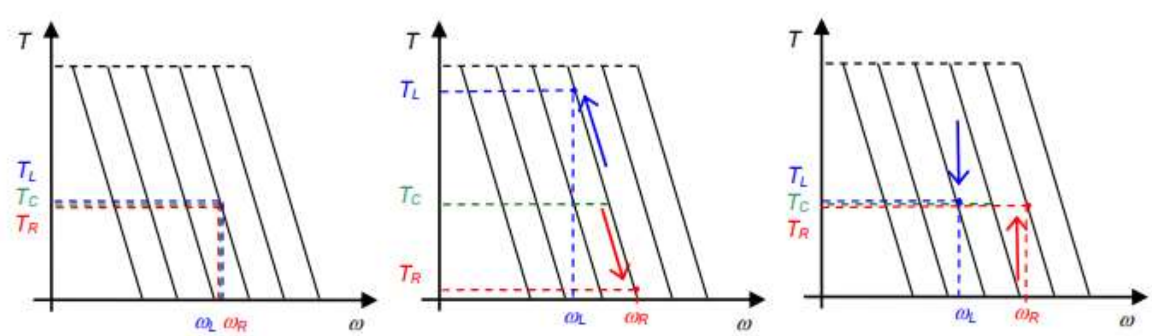
RESEARCH METHODOLOGY

The suggested ED's principle of operation is to ensure that the power train's two motors generate the same torque while rotating at different speeds. For various quantities of the applied voltage (corresponding to the duty cycle of the control signal), the torque-speed curves of a BLDC motor are displayed. When the vehicle is travelling in a straight line at a medium speed, the operating point of the two motors is also shown (we assume that the two engines have identical characteristics and the torque set point TC is set by the accelerator). When the vehicle is forced to trace a curve by the steering system, the torque of each motor (TL and TR) is adjusted to allow each wheel to turn at a different rate. When the vehicle is forced to trace a curve by the steering system, the torque of each motor (TL and TR) is changed to allow each wheel to turn at a different speed (before the response of the control system occurs). Given the variation in torque delivered to each wheel, the control system reduces the duty cycle of the inner wheel motor's control signal (left) while increasing the duty cycle of the outer wheel motor's control signal until the torque delivered by both motors is equal to the set point set by the accelerator. The motors' speed is now sufficient to draw the curve appropriately in this new state.

To implement the ED presented in this paper, two hardware variants have been built. Only two sensors were utilised in the initial iteration to detect the current applied to each motor. A BLDC motor's torque is proportional to its current, so it can be calculated by measuring the current. There is no speed sensor available in this version to measure the speed of the driven wheels. This has the disadvantage of not being able to detect aberrant situations such as wheel blockage or slippage. A second hardware version has been created to address this issue. The signals from the BLDC motors' Hall effect sensors were used to estimate the wheels' rotation speed in this version. There was no need to add a new speed sensor to the system as a result of this.

HARDWARE REQUIRMENT

To implement the ED presented in this paper, two hardware variants have been built. Only two sensors were utilised in the initial iteration to detect the current applied to each motor. A BLDC motor's torque is proportional to its current, therefore it may be calculated by measuring the current. There is no speed sensor available in this version to measure the speed of the driven wheels. This has the disadvantage of not being able to detect aberrant situations such as wheel blockage or slippage. A second hardware version has been created to address this issue. The signals from the Hall effect sensors on the BLDC motors were used to estimate the rotation speed of the wheels in this version. It was not essential to add a new speed sensor to the system in this way.



(a) (b) (c)

Figure 3.1. Example of operation of an ED with torque equalization in brushless DC motors (T_C: Torque setpoint; T_L,ω_L: Torque and speed of left motor; T_R,ω_R: Torque and speed of right motor)

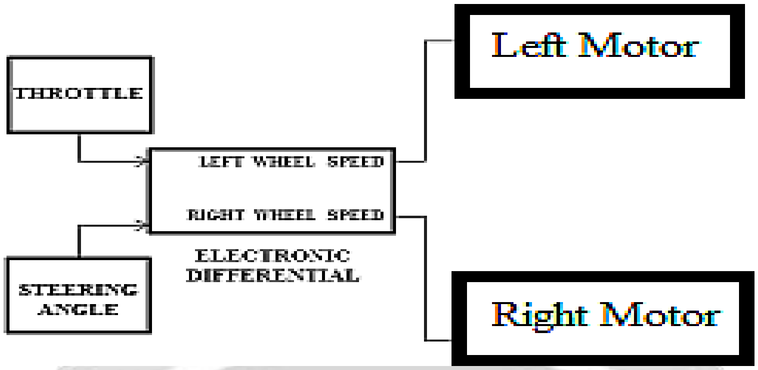


Figure 3.2: Electronic Differential and Hardware in Loop diagram

The equations for the differential are as follows:

$$v_L = \omega_v\left(R + \frac{d_w}{2}\right) \quad (1)$$

$$v_R = \omega_v\left(R - \frac{d_w}{2}\right) \quad (2)$$

The relation between the radius of the turn and steering angle and wheel base is:

$$R = \frac{L_w}{\tan\delta} \quad (3)$$

Substituting (3) in equations (1) and (2), we get angular speed of each wheel

$$\omega_{rL} = \frac{L_w + \frac{1}{2}d_w \tan\delta}{L_w}\omega_v \quad (4)$$

$$\omega_{rR} = \frac{L_w - \frac{1}{2}d_w \tan\delta}{L_w}\omega_v \quad (5)$$

When the steering input is given by the driver, the electronic differential immediately acts by reducing the speed of the inner wheel and increasing the speed of the outer wheel. The driving speeds of the wheels are:

$$\omega_{rL}^{*} = \omega_v + \frac{\Delta\omega}{2} \quad (7)$$

$$\omega^*_{r\,R} = \omega_v - \frac{\Delta\omega}{2} \qquad (8)$$

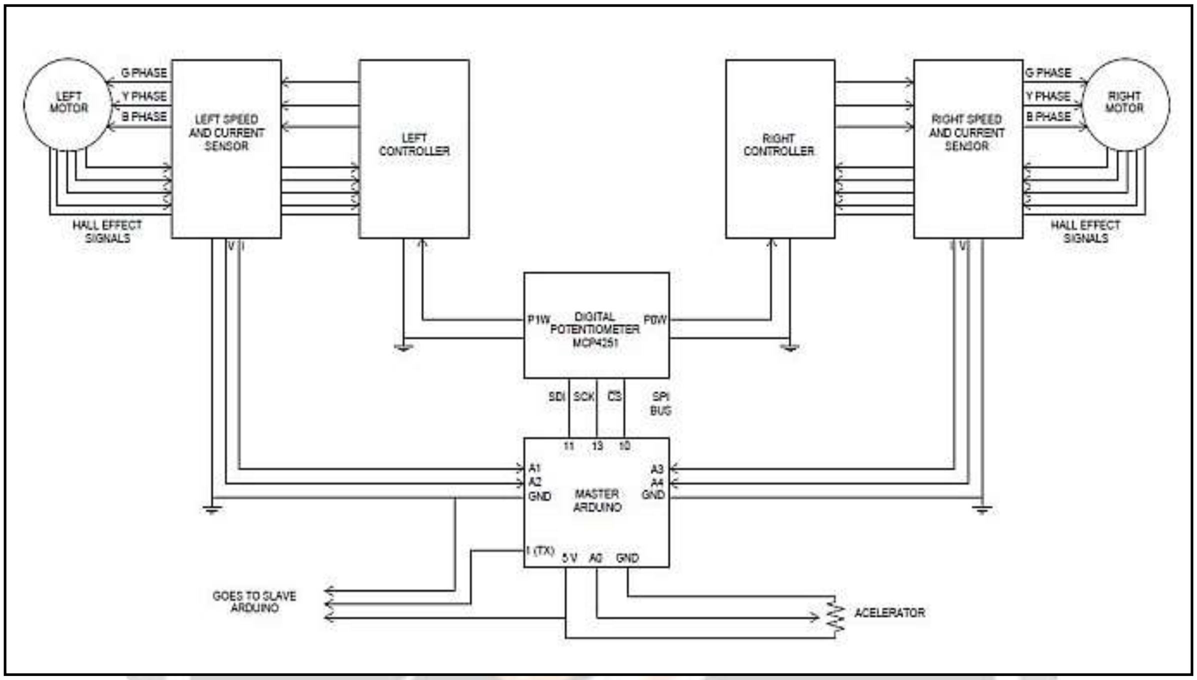


Figure 3.3. Hardware General block diagram

Figure 2 shows the block diagram of the second version of the hardware. The main components of the hardware are the following:

1) Brushless DC motors

The ED was implemented with the help of two BLDC motors. The motor in question was a Nine Continent RH205B.

2) BLDC (battery-less direct current) controllers

Two normal Infineon 30A bicycle controllers were utilised.

3) Current and speed sensors

For each wheel, speed and current sensors have been combined in a single unit. To measure current, we employed unidirectional "shunt" sensors, while speed sensors used Hall effect sensors that are already built into BLDC motors.

4) Platform Arduino

The Arduino UNO platform is the microcontroller that was utilised to implement the control algorithm.

5) Potentiometer (digital)

A potentiometer is used in electric bicycle standard controllers to set the duty cycle of the output transistors control signal. This regulates the amount of power given to the motor. This potentiometer establishes a voltage at the controller's input that ranges from 1 to 4 volts. The potentiometer can be omitted by connecting the output of a digital to analogue converter straight to the controller's input (DAC). This type of output is available on the Arduino Zero and Arduino DUE platforms, and it can be used by connecting it directly to the controller input. This allows the voltage at the controller's input to be automatically regulated at a level determined by the Arduino platform's control algorithm. However, we used an Arduino UNO platform in our Hardware version, which does not have DAC outputs. As a result, the solution employed was to replace the controller's potentiometers with digital potentiometers controlled by Arduino. A chip called MCP4251 was utilised, which has two digital potentiometers, one for each motor.

RESULTS & DISCUSSION

SYSTEM TESTING AND RESULTS

The system was put on a prototype and then tested to ensure that it worked properly. The prototype is a three-wheeled vehicle based on a bicycle with two rear wheels held in place by a bar support. These wheels are directly linked to BLDC motors. To test the ED's performance, the vehicle was put through the worst-case scenario: a circular path with the smallest radius. The car was driven around a circle with a radius of 4 metres, collecting and analysing current and speed data from the motors.

7.2 DISCUSSION

The first and final straight trajectories correspond to the first and last straight stretches, in which both wheels travel at the same speed. When the trajectory curves, the inner wheel speed (in this case, the left wheel) is lower than the outer wheel speed (right one). The current signal, on the other hand, is nearly similar for both motors, implying that the torque is the same. The theoretical speed ratio between both wheels was also compared to the experimental measurement, yielding a 2,03 percent inaccuracy. Due to the difficulties of maintaining an accurate radius of 4 metres during the entire trip, this mistake is within the expected range. Based on the study of these data, we can conclude that the ED operates correctly at moderate speeds in severe curves when none of the wheels are slipping.

OUTPUT

It is evident that as the direction bends, the inside wheel pace (in this case, the left wheel) is slower than the external wheel pace (right wheel).

However, the current sign flow remains virtually indistinguishable between the two engines, implying that the force is similar.

We can reduce the force of an engine whose pivot is delayed as compared to other Handed for greater vehicle security while turning or at street bends. The yield diagram is shown below.

7.3 OUTPUT

It is noticeable that when the direction becomes bend, the inward wheel pace (the left wheel for particular situation) is lower than the external wheel (right wheel).

Then again, the flow of current sign remaining parts for all intents and purposes indistinguishable for the two engines, which implies that the force is something similar.

We can lessen the force of engine whose pivot is delayed when contrasted with other Handed for better security of the vehicle while turning or at the bends of the street. The yield diagram is displayed beneath.

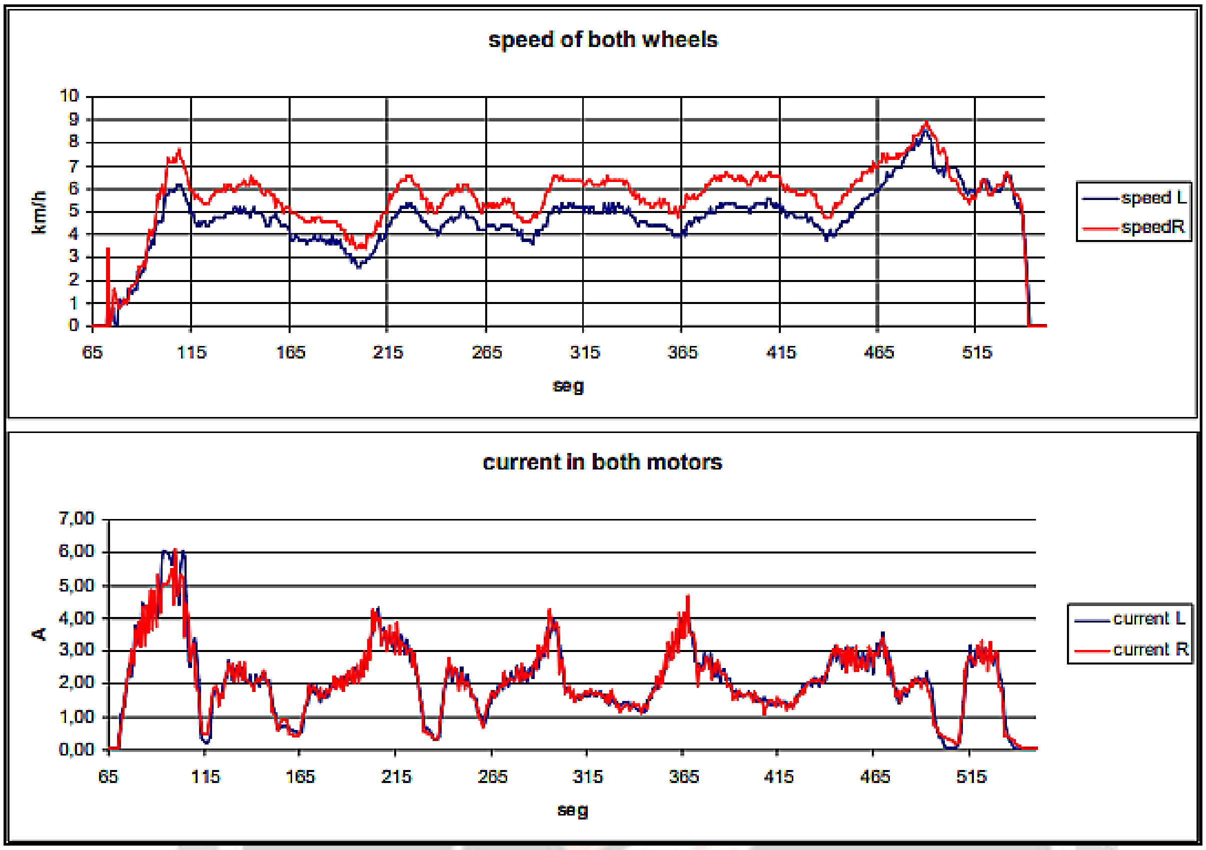


Figure 7.2: Output graph

CONCLUSION

It has been demonstrated that an electronic differential system may be implemented without the use of steering angle sensors or specific speed sensors. The system's hardware is based on conventional BLDC technology. motors and controllers, as well as general use Arduino platform. Its primary characteristics are its light weight and low cost. This makes it ideal for usage in light electric vehicles. vehicles with several driving wheels In order to conduct a more thorough assessment of the situation, new tests should be conducted out at a proposed system, new tests should be carried out at a proposed system, new tests should be carried out at greater speeds and when the drive train is slipping wheels. Our goal is to run these tests on a fresh set of data. A four-wheeled vehicle that is currently under construction development.

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