Design and Development of Self Balancing Transport e-Vehicle

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ABSTRACT

The Segway Personal Transporter is a frugal solution to electrical vehicle, replacing the car as a more towards environmentally friendly transportation method in metropolitan areas. The dynamics of the vehicle can be resembled to the classical control problem of an inverted pendulum, which means that it is unstable and prone to tip over. This is prevented by electronic sensing and calibrating the values of accelerometer, the pitch angle and its time derivative, controlling the motors to keep the vehicle balancing. The rider controls are supposed to be natural movements; leaning forwards or backwards in combination with tilting the handlebar sideways should be the only rider input required to ride the vehicle. The handlebar is attached to the chassis and serves as support for the rider and placeholder for the HMI (Human Machine Interface). To build segway with self balancing with relatively low cost and eco-friendly. Detachable carrier which can be used to move objects from one place to another in the industry.

Keywords*: Personal transporter, self balancing, tilting motion, detachable carrier ,eco friendly etc.*

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1. Introduction

Companies working in the field of transportation are required to put more work into building environmentally friendly vehicles than ever. Air pollution, global warming and the need for sustainable energy pushes the demands for efficient, green energy powered vehicles. The manufacturers have a great need for competence in the field of hybrid vehicle technology or even fully electrical vehicle technology as a step towards fulfilling these goals. These new vehicles are complex machines and require engineering competence in many fields; mechanics, vehicle dynamics, automatic control, power electronics, battery technology, software engineering, microcomputer programming, network and communication engineering to name a few[1]. This project aimed to be a feasibility study and preparation for building two wheeled balancing vehicles in one of these evening projects at Epsilon. The vehicle is similar to the Segway Personal Transporter. This kind of vehicle contains many of the technologies required to build a hybrid or electrical car, and is sufficiently small to be a good platform for experimentation and learning for engineers aiming to build more environmental friendly passenger cars.[6]

Another aim of the project was to implement a linear controller to make the vehicle balance and investigate if safe operation can be achieved without adapting the controller for riders of different weight and height.

Fig. 1. Mechanical Model

The project is aimed at making a two wheeled self balancing electric vehicle.[7] A processor and electric motors in the base of the device keep the vehicle upright when powered on with balancing enabled . Users lean forward to go forward, lean back to go backward. Motors driving the wheels are commanded as needed to bring the vehicle back into balance. The dynamics of the vehicle are identical to a classic control problem, the inverted pendulum. The vehicle has electric motors powered by 24V battery. It balances with the help of a microcontroller , one tilt sensors, and one accelerometer[3]. The rider accelerates or decelerates by leaning forward or backwards in the direction he or she wishes to travel. Steering can be controlled by simply varying the speeds between the two motors, rotating the vehicle (a decrease in the speed of the left wheel would turn the vehicle to the left)[4].

2. Literature Review

The two wheel balancing robot is a very popular project in the fields of robotics and control engineering. Therefore is a lot of work that has been done and more work is still been done on balancing a two wheeled robot. The following section is a literature review on this particular topic.[4] A literature review is part of a research project where a researcher researches on similar work to his or hers. This very important part of the research helps the researcher to find out how other researchers have tackled the problem he/she is attempting to solve. It gives insight on how to go about solving the problem at hand and provides information on available technologies and tools for solving the problem. The Segway Personal Transporter is a small footprint electrical vehicle designed by Dean Kamen to replace the car as a more environmentally friendly transportation method in metropolitan areas[6]. The dynamics of the vehicle is similar to the classical control problem of an inverted pendulum, which means that it is unstable and prone to tip over. This is prevented by electronics sensing the pitch angle and its time derivative, controlling the motors to keep the vehicle balancing. This kind of vehicle is interesting since it contains a lot of technology relevant to an environmentally friendly and energy efficient transportation industry. This thesis describes the development of a similar vehicle from scratch, incorporating every phase from literature study to planning,

ISSN: 2321-8169
1091 – 1097

design, vehicle construction and verification[7]. The main objective was to build a vehicle capable of transporting a person weighing up to 100 kg for 30 minutes or a distance of 10 km, whichever comes first. The rider controls are supposed to be natural movements; leaning forwards or backwards in combination with tilting the handlebar sideways should be the only rider input required to ride the vehicle[3]. The vehicle was built using a model-based control design and a top-down construction approach. The controller is a linear quadratic controller implemented in a 100 Hz control loop, designed to provide as fast response to disturbances as possible without saturating the control signal under normal operating conditions.

The need for adapting the control law to rider weight and height was investigated with a controller designed for a person 1,8 m tall weighing 80 kg. Simulations of persons having weights between 60-100 kg and heights between 1,6-1,9 m were performed, showing no need to adapt the controller. The controller could safely return the vehicle to upright positions even after angle disturbances of ±6 degrees, the highest angle deviation considered to occur during operation[1].

3. Overview of Vehicle

This gives an overview of the final vehicle, which describes the design and implementation of the control system. The aim of this overview is to provide the better understand the vehicle before going into the details of the subsystems.[3]

3.1 Mechanical Overview

The mechanical system is mainly composed of custom made aluminium parts that have been processed in the workshop. The wheels are attached to the motor gearbox with a steel hub, and the motor is bolted to the chassis. The chassis itself consists of bent aluminium sheet metal formed into a box which protects the vital components while serving as a standing platform for the rider and mounting place for the handlebar.[5] To reduce the risk of slipping, the platform has been covered with grip tape.[4]

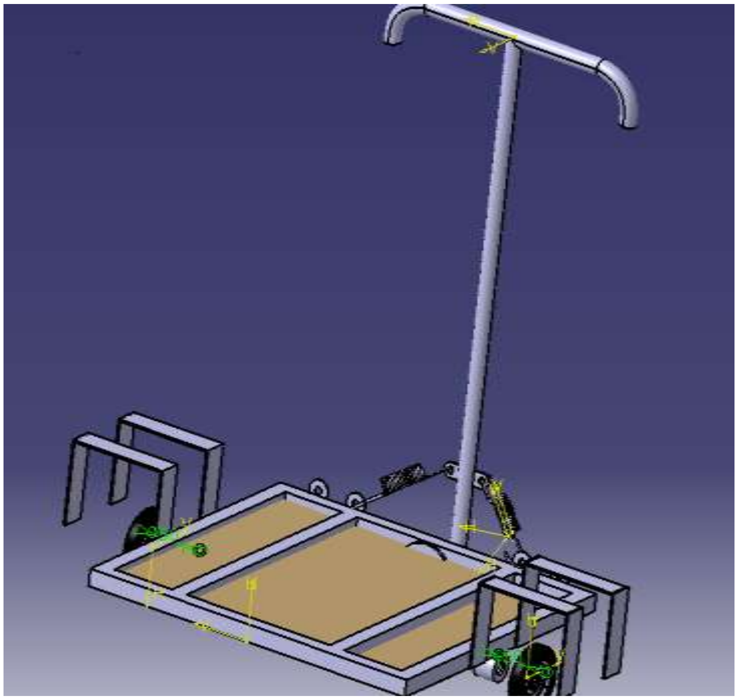

Fig .2. Model of e-vehicle

ISSN: 2321-8169
1091 – 1097

3.2 Electrical Overview

The electrical system is cantered on the battery and the distribution of the battery voltage and current to the other subsystems. Since the battery for this kind of vehicle contains a lot of energy it is necessary to monitor the operational status of the main electrical system and have safety features to turn it off in case of an emergency or malfunction.[7] The safety measures in this system consist of fuses, a dead man's switch and a power management system.

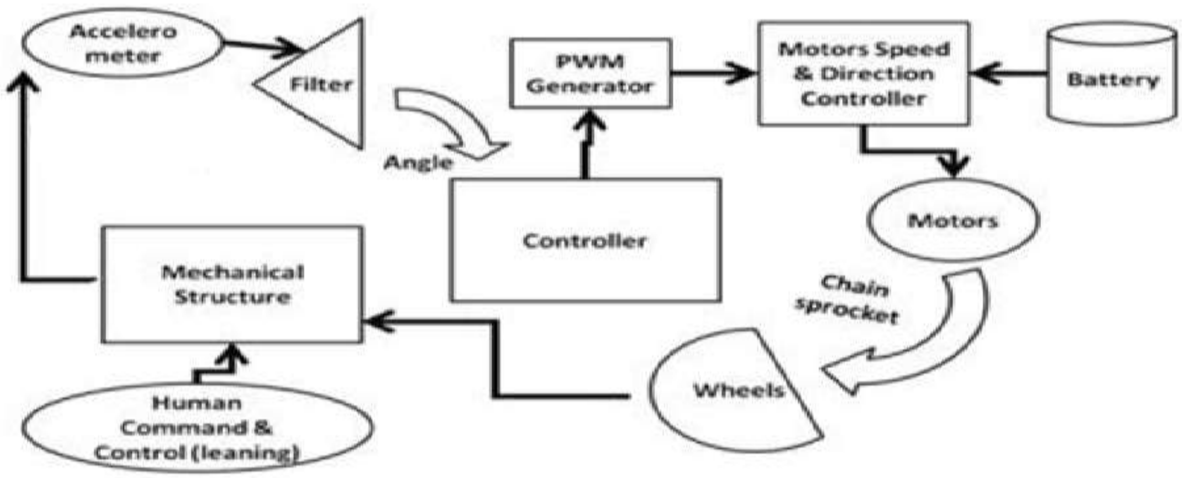

Fig.3. Block Diagram of Electrical System

Power source, 24volt lead acid battery. The battery was selected to fulfil the goal of 10 kilometres range on one charge, as well as provide sufficient current for the torque needed to drive the vehicle. This battery also came with an internal battery management system, which monitors and balances each cell of the battery during charging. This made the integration of the battery into the electrical system easier and less time consuming. This battery requires less maintenance[2].

4. Basic Components

1.Motors

Model: MY1016Z2
Voltage: 24 Volt DC
Output: 250 Watt
RPM (after Reduction) – 324
Full load current – 19.2A

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1091 – 1097

Fig.4. Motor

2. Wheels

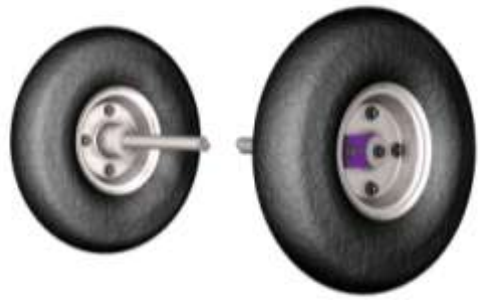

Fig.5. Wheel

3.Power Source

Model No.-EXCL65L

Voltage-24V,65Amphr

Fig.6. Battery

4.Accelerometer

Fig.7. Accelerometer

5.Chassis

Fig.8. Square Pipe

6.Handlebar

Fig.9. Handle Bar

5. Working principle of e-Vehicle

To move forward or backward on the Segway, the rider just leans slightly forward or backward. To turn left or right, the rider turns the right handlebar forward or backward.

This balancing act is the most amazing thing about the Segway, and it is the key to its operation. To understand how this system works, it helps to consider Kamen's model for the device -- the human body.[7]

If you stand up and lean forward, so that you are out of balance, you probably won't fall on your face. Your brain knows you are out of balance, because fluid in your inner ear shifts, so it triggers you to put your leg forward and stop the fall. If you keep leaning forward, your brain will keep putting your legs forward to keep you upright. Instead of falling, you walk forward, one step at a time.[4]

The Segway does pretty much the same thing, except it has wheels instead of legs, a motor instead of muscles, and set of sophisticated tilt sensors instead of an inner-ear balancing system. Like your brain, the Segway knows when you are leaning forward. To maintain balance, it turns the wheels at just the right speed, so you move forward.[1]

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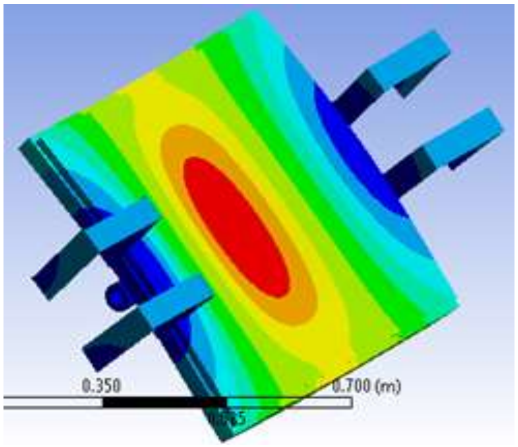
5.1 Analysis Of Frame



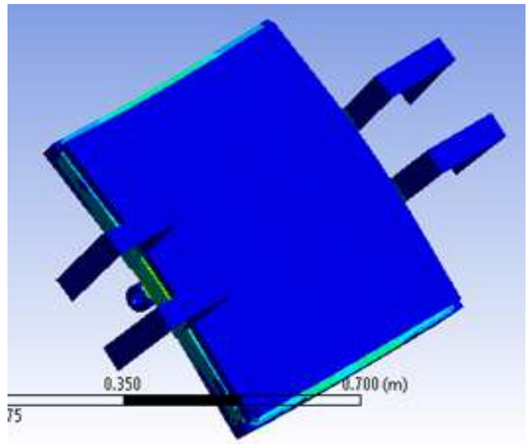


Fig.10. Deformation.

Fig.11. von Misses Stresses

6. Conclusion

The main goal of this project was to build a functional two wheeled transporter and this goal has been fulfilled. The overall functionality and performance of the vehicle has been evaluated thoroughly by a number of test drives. The vehicle has been tested by a number of different people, with and without previous experience of riding this kind of vehicle. All were able to ride the vehicle.

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