Design of Multi Way Charging Hover Board

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Abstract— The main aim of this paper is to develop a hover board, which can be charged through battery as well as solar panels. It is a two way charging hover board. This kind of vehicle is interesting since it contains a lot of technology considered as a solution for future needs of the world relevant to an environment friendly and energy efficient transportation industry. The hover board consists of a metal frame on which the hardware is assembled in such a way that it works on the principle of balancing robot. The user have to stand on the segway and by applying the pressure, the infrared signals gets blocked by the pedal sensor and then the signal is given to the mother board to control the speed. The natural movements of the rider (lean forwards or backwards in combination) should be the rider input required to ride the vehicle (self-balancing personal transporter) consisting of two motorized wheels connected to a pair of articulated pads on which the rider places their feet and applies pressure for the movement of vehicle. The rider has to control the speed by leaning forward or backward and for turns by twisting the pads. The solar panels are connected to voltage booster circuit so as to charge the battery naturally and minimizing the use of fuel for short distance travelling.

Keywords— hover board, solar panel, motherboard, battery, voltage booster circuit.

I. INTRODUCTION

In the recent years, there is a growing interest in the research and education implementation of miniature robots, hover boards are also the application of self balancing robots. The use of fossil fuel even for short distance travelling has been resulting in more pollution and lacking use of renewable resources. Industries which are spread over large areas, prohibits the use of vehicles, to avoid the risk of contamination due to emissions. There are many other ways of transportation to avoid excess use of fossil fuels. To make the transportation and travelling pollution free and easier, research on eco-friendly transportation has been increased. The use of solar panels in the paper makes the charging of the hover board more efficient during day time, as it is continuously charges the battery even when it is working condition. For short distance travelling or commuting, to save time and fuel there have been many advancements is the vehicles used. From walking to cycle to electrical vehicles mostly used in industries, the demands are increasing every day. So two way charging makes the use of the electrical vehicle easy to use and it even reduces time to charge is low battery.

II. MODEL OF THE SYSTEM

The battery can be charged in two ways, the focus is on the hover board battery to charge it through solar panels. The battery is 36 volts DC and the normal charging time with the charger is 2 to 3 hours[1][2]. So to avoid plug charging, solar panels are installed for continuous charging for both when in use or not in use. Solar panel requires space to install, which the issue is faced due to less space in the hover board[3][4]. So, two solar panels of 6 volts each are connected in series to increase the voltage and for fast charging of the battery. As the 36 volts battery require at least 24 volts charging input to charge in hours, the output of the solar panel is connected to the voltage booster to increase the rate of charging of the battery[4][5][6].

Block diagram of the vehicle:
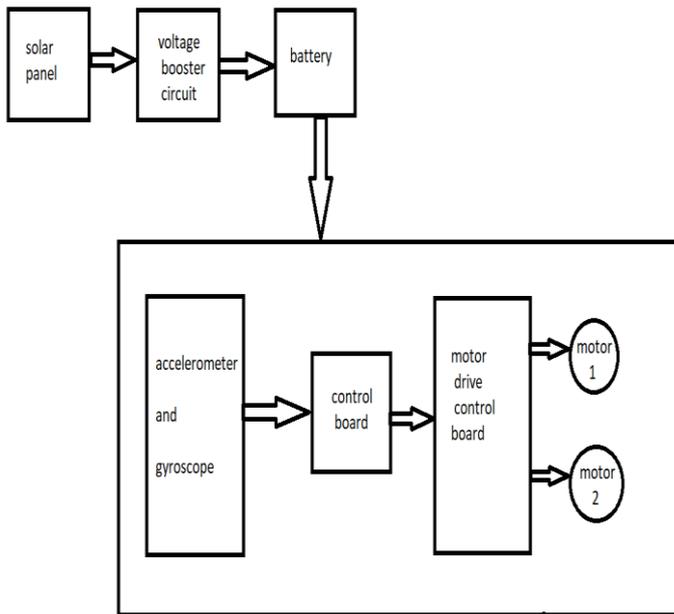
Fig. 1 Electronic flow chart

The functioning of the hover board is controlled by the control board and sensors. When the power button is switched ON, there is power supply given to the boards, sensors and the hub motor[2][3][6]. The two control boards are connected to each other to control the functioning of the two motors. When a rider stands on the foot pressure pads of the hover board, the pressure switches placed below the foot pads blocks the infrared signal produced by the infrared (IR) sensor[7][9]. The IR sensor detects the obstacle and sends signal to the master control board and the slave control board[8][9]. These control boards further which is connected to accelerometer, gyroscope and magnetometer sensors, gives signal to function it. These three sensors are known as 9-axis sensors as all three have 3-axis each. As long as the rider stands still, the tilt sensor does not detect any leaning and the hover board remains still. When the sensor senses the tilt by the rider, the speed sensor calculates the speed by which the hover board is moving in revolutions-per-minute (RPM) and the data is send to the gyroscope and other sensors[9][10]. The output of the gyroscope sensor is then given to the control section of the board. The purpose of the control system is to keep the system within a specified range of the working element. Motor driver will calibrate the values of the gyroscope and accelerometer sensors[6][8]. Then the driver looks for the balanced position of the model. . Motor controllers control the motors rate of turn and its rate of turn by varying the output voltage signal. The controller provides the facility for a pulse width modulation (PWM) signal output for varying the motor speed [2][4].

III. **DESIGN OF SYSTEM**

The design of the system includes all the hardware components, its assembling and powering the vehicle through solar panels. The components of the vehicle and its weight are taken into consideration for the arrangement of the solar panels. The maximum speed limit of the kind of vehicle used is 10 km/hour. So, weight analysis is required for selection of motor and other components. Additionally the weight of solar panel is also added to the vehicle with the driver's weight.

Components specification:

a. **Metal frame**

Frame is generic and made to fit multitude of different boards. The frame fits scooter with wheel sizes ranging from 6.5 inches to 10 inches. The wheel size used is 6.5 inches. The weight of the frame is approximately 2.26 kg. On the top of the frame there are two spaces (left and right), to place the components and the central pivot is provided with holes for the wires.

b. **Solar panel**

It is made of specialized semiconductor diode that converts visible light into DC current. Some of the PV modules also convert infrared and ultraviolet rays into electrical energy. The PV cell rating used in this paper is 6V-3W, where maximum power is 3 Watts, rated voltage is 6 Volts, and rated current is 0.353 Amps, open circuit voltage is 10 volts; short circuit current is 0.395 amps, maximum system voltage is 1000 volts. The size of the solar panel (Figure.2)is 180*180*17MM,

Fig. 2 Solar panel

c. Control board

There are two control boards used which consists the motherboard part as well as different sensors like gyroscopic board, infrared sensor, accelerometer and motor-driver set. The two control boards are known as master board and slave board. Both the boards have same functioning and master board has some extra connection pins. Figure 3 and Figure 4 respective figures of Master control board and Slave control board.

Fig. 3 Master control board

Fig.4 Slave control board

Motor drive control board
The motor drive control board is used to control the direction of the motor either forward or backwards or combination of the motors for rotation. Because motors are compatible with PWM control, speed and directional control, it is enabled by giving pulse to the MOSFETs to drive them. The MOSFETs acts as switches just think of them as simple on/off switches. In the new 2-chip design, 2 pieces of STM32F103C8T6 from ST are used to control the Brushless DC (BLDC) electric motors to receive and handle signal of gyroscope on both wheels. Thus the two wheels can operate independently, but

the communication interface between 2 chips connects the BLDC motors in order to make the wheels rotate coordinately. The Motor drive control board can see in below Figure 5.
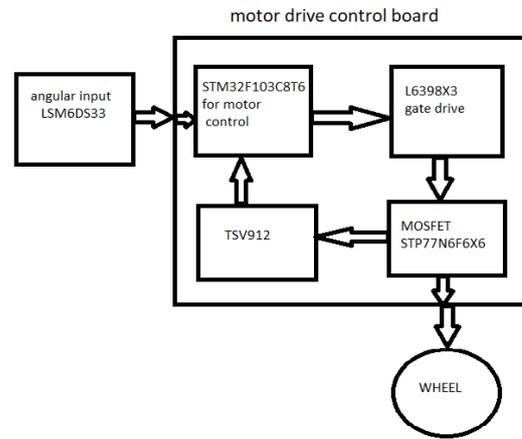
Fig. 5 Motor drive control board

Gyroscope: As gyroscope measures both linear and angular velocity and tilt of an object, the gyroscopes are overtakes the function of accelerometer too. Accelerometer measures the acceleration directional movement of an object. These sensors are usually packed with different integrated chips which helps makes gyroscopes available for multiple axes system. It is measured in degrees per second as it measures angular velocity, which is the change in the rotational angle of the object per unit time.

d. Infrared sensor
Infrared sensor is a component which detects the characteristics of its surrounding, either by emitting or detecting infrared radiation. There are two types of infrared (IR) sensor they are passive infrared sensor and active infrared sensor. The IR sensor used in the paper is active infrared sensor (Figure 6). It detects obstacles. An active IR sensor has emitter and receiver. Emitter emits beam of light towards the receiver. The receiver receives the signal if there is nothing in the way. Emitter and receiver are set in such a way that they are kept very close and facing each other. The arrangement is made so that receiver can easily detect the signal but if the receiver fails to receive the signal (IR beam),

the receiver detects an object's reflection when it is in that area.

Fig. 6 Infrared sensor

e. Pressure switch

Pressure switches acts as pedal sensor (Figure 7). It is made of rubber. It is designed in a plunger like structure. Each foot pad as combination of two pressure switches arranged in such a way that when pressure is applied, these switches block the infrared radiation between the emitter and receiver of infrared sensor.

Fig. 7 Pressure switch

f. BLDC hub motor

Hub motor is an electrical motor which is coupled to the wheels, making it useful for the electrical vehicle. The most suitable is brushless DC (BLDC) motor comes with hub motor (Figure 8). The motor comes in a wheel like package. The characteristics of the BLDC motor like high torque and light weight makes it suitable for smooth running performance. It is permanent magnet hub synthesized. Other motors provide vibration which affects the stability of the hover board. A normal electric motor uses commutator and two carbon brushes to reverse the electric current periodically to ensure the movement of the axle in same direction.

Fig. 8 BLDC hub motor

g. Voltage booster circuit

The voltage booster circuit (Figure 9) is used to increase the voltage coming from the solar panel. This circuit is designed so as to boost the output of the solar panels to charge the battery fast. The basic function of the voltage booster circuit is to step up the incoming voltage by using power module circuit and other components in order to connect it to the circuit. The input to the boost converter is DC and output is also DC.
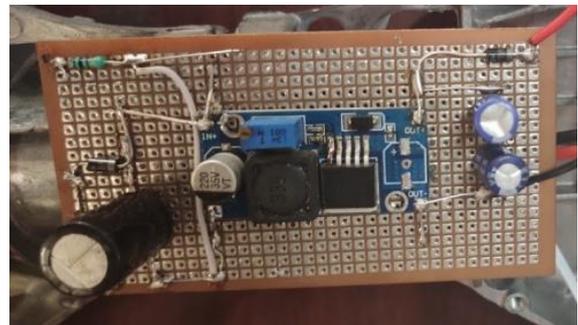
Fig. 9 Voltage booster circuit

h. Battery pack

Several batteries are connected in series to develop a 36 volts lithium ion battery which has a battery management system (BMS) unit (Figure 10). The pack is designed in such a way that each battery is connected to the BMS, then it has red (positive) and black (negative) wires that leads into a yellow orange clip known as XT60 connector plug.

Fig. 10 Battery pack

i. Charging port and power switch

It is the port which is provided towards outside of the hover board to connect the charger cable. It is a 3 pin- 2 wire charger ports (Figure 11). which is universal at the connecting point, characterized by 3 prong metal connector. It is the switch to power on the hover board that has two wire connections going into the control board. It comes with wires and clamp to connect to the motherboard.

Fig. 11 Charging port and Pressure switch

IV. DESIGN CLCULATIONS

To calculate force:
Gross weight: 120 kg
Maximum speed: 10km/hr = 2.8 m/s
Friction between tyres and road: 0.1
Let the acceleration time be 0.2 seconds
Diameter of the wheel: 16.51 cm
Radius of the wheel: 8.225 cm
Step 1:Rolling resistance = friction coefficient*normal force

=friction coefficient*mass*gravitational force
= 0.1*120*9.8 =118N

Step 2:Force due to acceleration = mass*maximum speed/ acceleration time
= 120*10*5/(18*2) = 168N

Step 3:Total tractive effect = step 1+ step 2
= 118 + 168 = 286 N

Hover board has 2 tyres. So, Force produced at each tyre = 286/2 = 143N

Torque calculation: Torque = force* radius of wheel* sin90
= 143*0.08225*1 = 11N-m

Calculation of RPM: Speed = 2*pi*radius*RPM/60
RPM = 60*maximum speed/ (2*pi*radius)
= 60*2.8 / (2*3.14*0.08225)= 325.24 RPM

Power rating of motor: P = 2*pi*RPM*Torque/60

=2*3.14*325.24*11/60=374.45 watts

So, the nearest power rating of BLDC hub motor used is 350 watts, and the weight of the rider is limited to 90-100 kg.

V. RESULTS

The two way charging hover board was successfully developed by reducing the cost of the vehicle which was also a challenge (Figure 12). To occupy less space, two solar panels of less rating are connected in parallel for effective use. The efficiency of the vehicle is increased by continuous usage and avoiding the charging of the vehicle through charging board and utilizing eco-friendly charging during day time.

Fig. 12 final shape of the multi way charging hover board

VI. CONCLUSION

The main aim of the solar charging hover board was to make this paper in low cost and effectively charge the vehicle using solar energy. By reusing the spare components electronic components like control boards and sensors, and due to addition of other few components cost of vehicle is drastically reduced. By using the spare parts, and latest control boards, which are space efficient due to combined sensors and motherboard the space to manage the other components were managed. In this research, the development of vehicle was done. The attempt to change the existing design of self balancing hover board was successfully completed. This paper was implemented with an idea to find an effective solution for short distance transportation problem and effective charging of the vehicle. The objective of the paper is to achieve space utilization and minimize the fuel consumption especially for commuting over shortest distance by using solar charging method.

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