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Design and Implementation of Solar Powered Tricycle for Physically Challenged Person

[1]P.Karthikeyan, [2]C.Bala Subramanian, [3]V.Arunprasad, [4]M.Karthik

[1]*Assistant Professor, Department of Electrical & Electronics Engineering, Kongu Engineering College, Tamilnadu, India. E-mail: pmanjukarthick@gmail.com*
[2]*Assistant Professor, Department of Computer Science and Engineering, Kalasalingam Academy of Research and Education, Anand Nagar, Krishnankoil, Tamilnadu, India. E-mail: baluece@gmail.com*
[3]*Associate Professor, Department of Mechanical Engineering, TheniKammavarSangam College of Technology, Theni, Tamilnadu,India. E-mail: arunprasad2978@gmail.com*
[4]*Associate Professor, Department of Electrical & Electronics Engineering, Kongu Engineering College, Tamilnadu, India. E-mail: karthik.prm@gmail.com*

Abstract

In this paper, solar powered electric tricycle is designed for physically challenged people. According to the Indian Council of Medical Research (ICMR) survey, in India there are nearly 2.72Cr people are physically challenged. Majority of this physically challenged people are living in rural areas (1.85 Cr) and remaining in urban. The increasing population of physically challenged people is a great concern of the society. It is truly hard to understand the problems of a physically challenged people. The mobility among these people is getting reduced due to the increasing cost of the vehicle which they are using for transportation.The main aim of Solar Operated Tricycle (SOT) is increase mobility among the physically disable person. In this proposed method tricycle is operated by two ways,

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one is manually with minimum effort and another one is electrically. The solar powered tricycle is mainly used in a place where there is no electricity. After analyzing the problems spaced by the disabled persons, the design specifications of the tricycle were carried out. The SOT provides more safety and comfort to the physically challenged person.

Keywords: Solar tricycles, Photovoltaic cells, battery chargers, microcontrollers, Electric vehicles

1 Introduction

India is one of the developing countries in this word. As on date the no of population in our country is 121 Cr. In this, more than 60% populations are youngster. India exports various cultivation products, manufacturing product, medical equipment, electrical and electronics product to various counties. As per ICMR survey about health condition in Indian people, around 2.21% of Indian people are physically challenged persons, they are suffered from various physical illness. One of the physical illnesses is unable to walk. This make their self-confidence level is getting reduce day by day. They depends others to move one place to other place in order to fulfill their task. Some time it makes them felt uncomfortable and also felt very sorry for themselves. There are few devices available for them to overcome their struggle such as walking assistance device, tricycle etc., but the problems in the available devices are not suitable for long distance travel, give physical pain to them after using the devices, speedup pedaling is required in some places and device depends on fuel/electrical energy. Presently physically challenged persons are unable to overcome these problems. So they need mechanism (device or equipment or vehicle) to overcome all the existing problems. One of such a mechanism is solar powered tricycle with primary safety equipment. In this proposed method we have designed such a vehicle which overcomes all the problems faced by the physically challenged person in particularly the person unable to wall themselves.

In general, all electric vehicles use either 100% of energy from electric power or 50% from electric power and remaining 50% from fossil fuel. By using mechanical device such as motor, the electric vehicle is operated instead of an internal combustion engine. During day time only photovoltaic cells generate electric energy which is directly connected to motor through batteries. Only the battery energy is supplied to vehicle during the absence of energy from PV cells. The solar powered vehicles, boats, bicycles and airplanes have been developing for the past five decays. Paddle tricycle, motorized tricycle and electric tricycle are being used by physically challenged people. But there are certain drawbacks in these vehicles such as

pedal tricycle required lots of human energy to pedal and also fuel tricycle is not eco friendly.

2 Related works

FahimBhuiyan et al. [1] designed the basic arrangement of solar powered electric tricycle. In their work 50% of energy was supplied by solar PV and remaining energy by electric supply. To validate their work, efficiency and rated solar power was observed and calculated.

Anon Namin et al. [2] reported on research into the lateral misalignment maximum power point tracking (MPPT) wireless power transfer (WPT) in recharging the vehicle's battery.

Mohamed Dahbi et al. [3] observed that the study on performances of an electric tricycle with solar panels. The simulations of different topologies were presented along with calculation of solar panels power losses and batteries autonomy. A solution for increasing batteries autonomy was also discussed.

T. Faraz et al. [4] found that the torque sensor based hybrid rickshaws have a longer battery life that requires infrequent charging, were faster than conventional rickshaws and need less human effort.

A. R. M. Siddique et al. [5] experimentally summarized that the financial feasibility analysis of a micro controller based solar powered tricycle for Bangladesh was financially feasible and Life cycle unit cost of the system was lowest compared to grid powered battery driven tricycle.

D. Thiruvonasundari and K. Deepa [6] reported a brief review about the Electric Vehicle Battery modelling methods based on state of charge in which five important lithium-ion battery models were (Empirical, Equivalent circuit, Electro chemical, Reduced-order and Data driven models) discussed based on the state of charge estimation and compared along with their advantages and disadvantages.

P.K.Devan et al. [7] designed an eco-friendly motorized tricycle for physically challenged person. In their work vehicle was not tested in all environment condition. The converter used in their work was conventional one and not performed regenerative braking operation. Without much physical effort this vehicle was operated.

K. SankaradityaVikas et al. [8] experimentally summarized the charge Controller for Electric Vehicles at Workplaces using Solar Energy. The performance of the system was demonstrated with MATLAB/Simulink and a section of the system was tested by using dSPACE control desk.

MohamadAzlanHussin et al. [9] proposed a drive range improvement system for electric vehicle powered by solar energy. In this work, power consumption modeling, calculation, analysis and various tests were performed based on Savvy technical specifications.

T. Harakawa and T. Tujimoto [10] proposed the most feasible solar power generation system mounted on the electrical vehicles to charge smart battery during running. In their work two kinds of efficiency tracking system for electrical vehicles were used, one was the feed forward type and other was the robust efficiency tracking climbing method (QF2 method). Experimental results were shown the effectiveness of proposed method.

ChaitanyaKanumilli et al. [11] concluded the application of solar energy to increase the range of plug-in electric vehicles and the design considerations related to the plug-in electric solar vehicle.

B. Revathi et al. [12] designed a MOSFET based DC to DC converter to increase the voltage from the solar panel. In order to get high value of output, the Maximum Power Point Tracking (MPPT) was used. There was one more DC to DC converter was used in between the battery and electric vehicle for supplying the required voltage. This work was carried out in the MATLAB SIMULINK environment.

Deepesh S Kanchan and NiranjanHadagali [13] reported that the discharge of energy during acceleration of vehicle was recharged by braking. Propulsion machine and bidirectional converter were used to recharge the battery.

B.R. Borchers and J.A. Locker [14] reported the procedure of various electric system designs for electric vehicle. These procedure including selection of solar panel, brushless DC motor, inverter fed electric drive and optimal battery storage.

3 Block Diagram of the Proposed System

The solar powered tricycle [15] for physically challenged persons is a tricycle in which the conventional fuel is used to run the tricycle. Here the conventional energy source is solar energy. Solar energy is the mother of all the energy sources. This solar energy from the sun is converted into electrical energy by using solar panel. The block diagram of the proposed method is shown in figure 1. In this method one or two solar panel are used. The energy from the solar panel is connected to motor through charge controller, battery and power controller. The solar energy available only day times, during this time only solar energy is converted into required energy to drive vehicle. The battery present in the proposed method is lead acid battery [16] which store electrical energy from the solar panel and supply energy to the motor via power controller. During day time solar energy is stored in a battery and the

energy in the battery is utilized by the motor during night time or a period in which solar panel unable to generate energy. It is important to maintain the maximum charging capacity of battery [17]. The life time of battery is getting reduced if it is overcharge over a long time period. In order to avoid such a condition, the charging level of the battery is continuously monitored by battery state measurement unit. The Battery State Measurement [18] unit consists of battery state sensor, micro controller and display unit. The battery state sensor continuously measures the level of charge present in the battery and the output of sensor is connected to microcontroller. The micro controller generate required command signal to charge controller in order to maintain the battery voltage at required value. Battery voltage level is displayed in the display unit.

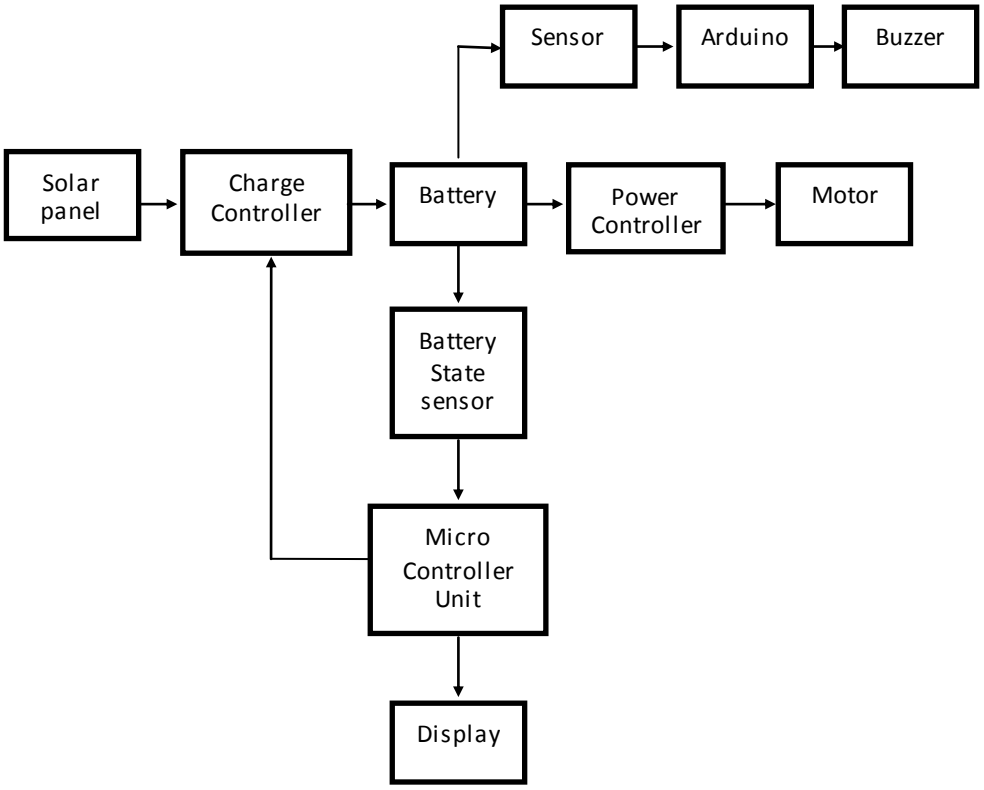

Figure 1 Block diagram of proposed system

The speed of the tricycle is controlled by power controller, which is connected in between battery and motor. To avoid accident and damage

caused by other vehicle, ultrasonic sensor is used. This sensor is activating arduio and buzzer when it is subjected to any disturbance.

3.1 Charge Controller

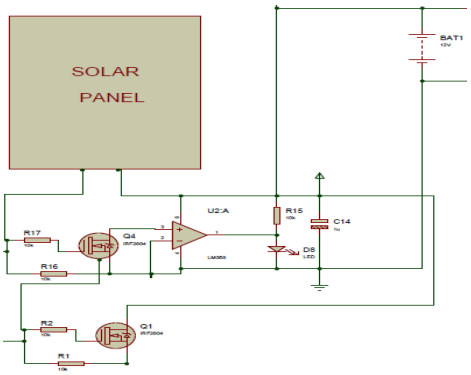

Figure 2 Circuit diagram of charge controller

The solar charge controller [19] is an essential part of this proposed method. The basic functions of a charge controller are blocking reverse current and prevent battery overcharge which may reduce battery performance or lifespan. A solar charging system is imperfect without charge controller. The charge controller limits the rate at which electric current is supplied or drawn from electric batteries. The controller operation is controlled by microcontroller whose operation is based upon the voltage level of battery. In this proposed method, MOSFET based charge controller is used. It is the most widely used types of insulated gate FETs (Field Effect Transistor). These are used in various applications due to its simple working phenomena and advantages over other FETs. Zener diodes will cut off the supply when the solar voltage exceeds 22V or reduced below 11V. So, the reversal of voltage from the battery to solar panel can be prevented.Figure 2 gives circuit diagram of charge controller.

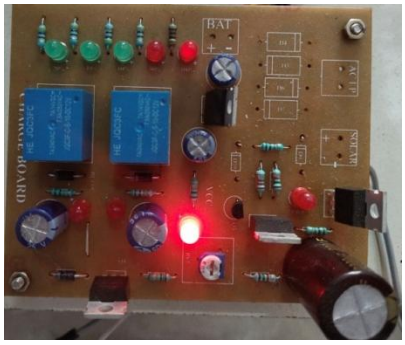

Figure 3 Hardware design of the charge controller

3.2 Motor

A 24V, 250W DC gear motor is used in this proposed method. To obtain high torque, gear motor is preferred and its mechanical output is drive tricycle with required speed. The motor is driven by 24 volt battery. Thus, it drives the electric tricycle efficiently. The tricycle can run at the maximum speed of about 20-35 kmph. The motor drives effectively until the charge in the battery gets emptied. Even though the battery gets discharged completely, the tricycle can be driven by pedaling. The motor specification of the motor is shown in table no 1. Figure 4 gives hardware setup of DC motor

Table 1 Specification of DC gear motor

S.NO	Specification	Ratings
1.	Torque Stall	40 Nm (400 kg-cm)
2.	Torque Constant	8 Nm (80 kg-cm)
3.	No load speed	400rpm / 30Kmph
4.	Maximum load	150kg
5.	Horsepower	0.33

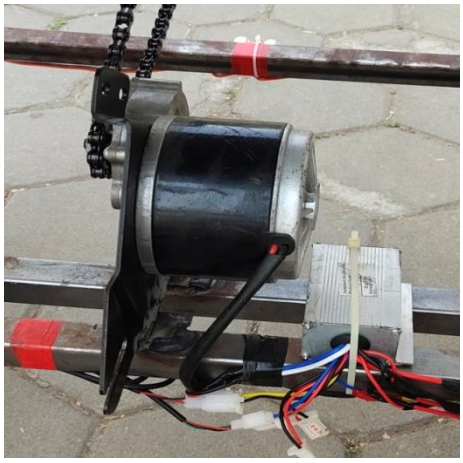

Figure 4 Hardware setup of DC motor

3.3 Battery State Measurement

The Battery State Measurement (BSM) unit continuously measures the voltage value of battery by using battery state sensor. This sensor sense the voltage value of the battery and its output is connected to micro controller. The maximum battery charging limit and minimum discharging limit is controlled by BSM unit and charge controller. The circuit and hardware design diagram of the BSM is shown in Figure 5 and Figure 6.

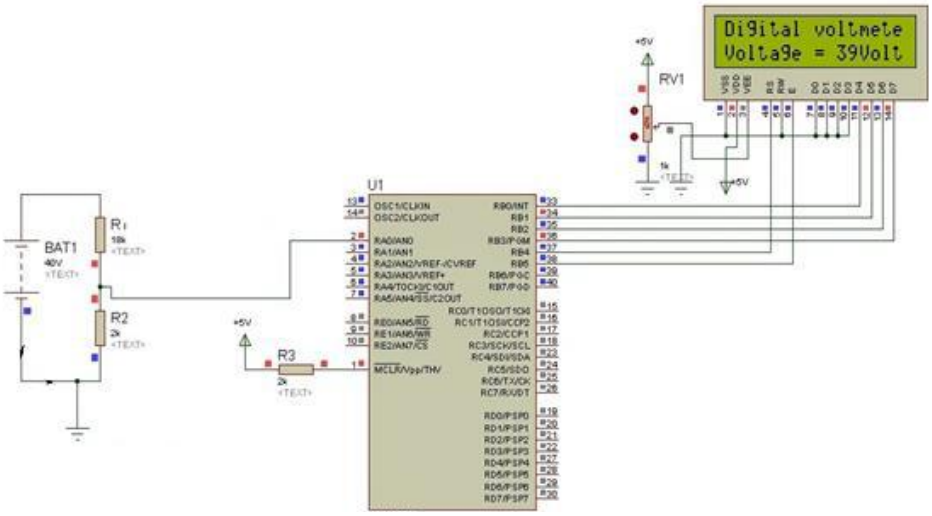

Figure 5 Circuit diagram of battery state measurement

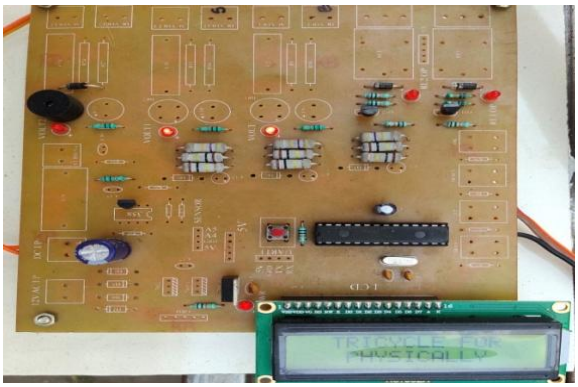

Figure 6 Hardware design of the battery state and solar charge measurement

3.4 Power Controller

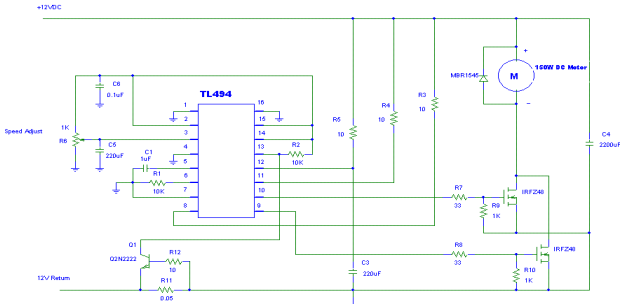

Figure 7 Circuit diagram of 24V PWM Motor controller circuit

The circuit diagram of the power controller is given in figure 7. It is a device that serves to govern the performance of an electric motor in a predetermined manner. A motor controller can be operated in manual or automatic mode for starting, stopping the vehicle, selecting forward or reverse rotation, regulating the speed, limiting the torque, protecting the motor against overloads and faults. In this proposed work PWM based motor control unit is designed.

3.5 Motor Transmission

The speed of the motor is controlled by using power controller. The shaft of the motor is connected with chain sprocket which acted as motor transmission for tricycle. This motor transmission provides required torque to tricycle. In this proposed vehicle, three chain sprockets is used, one is

supplying mechanical energy to shaft of back wheels and other two drives vehicle. The hardware setup of motor transmission is given in figure 8.

Figure 8 Hardware design of motor transmission

3.6 Manual Transmission

The hardware setup of manual transmission is given in figure 9. The transmission can be provided manually whenever the motor transmission system get failed to supply mechanical energy. During the rainy season, cloudy condition and over utilization of battery energy, the mechanical transmission system failed to supply its power to vehicle. This condition is managed by manual transmission in which a person in the vehicle provide sufficient driving force.

Figure 9 Hardware design of manual transmission

3.7 Ultrasonic Sensor

Ultrasonic sensor is placed at the back side of the tricycle. It continuously measures the distance between the tricycle and a object behind the tricycle and its distance is displayed in the LCD. When the tricycle move closer to any object whose distance is less than 50cm causes the buzzers turns on and continues until the object clears the way or the tricycle moved away. This system provides additional safety to the person and the vehicle. The hardware setup of ultrasonic sensor is given in figure 10.

Figure 10 Hardware design of ultrasonic sensor

3.8 Solar Panel

Solar panel of about 75W is used to charge the lead acid battery. The hardware setup of solar panel is shown in figure 11. The panel is placed on the roof of the tricycle. It is connected to the battery via charge controller. It supplies enough voltage to charge two 12V batteries.

Figure 11 Hardware setup of solar panel

Figure 12 Left and right side view of hardware setup

Figure 13 Front and Back view of hardware setup

Figure 14.2 Output of ultrasonic sensor (>50cm)

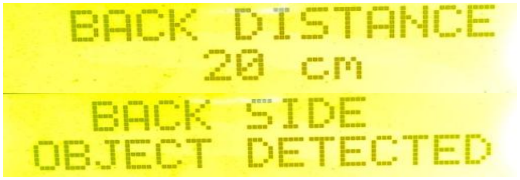

Figure 14.3 Output of ultrasonic sensor (<50cm)

The left side, right side, front and back view of hardware stepup is shown in figure 12 and figure 13. The voltage level of battery is shown in figure 14.1. The BSM unit is continuously measure the voltage value and it is displayed in LCD. In this tricycle, the ultrasonic sensor is placed at the backside of vehicle and used to sense an object. The LCD is used to display no object is detected information when the distance between the tricycle and an object is greater than 20cm which is shown in figure 14.2. The same LCD also used to display object is detected information when the distance is greater less than 20cm which is shown in figure 14.2.

4 Conclusion

To achieve anything in this word, the physical challenges are not an issue. As per the Indian government survey, there are quite numbers of physically challenged persons have been participated in various activities and mark their achievement. To encourage their activities and make their mobility from one place to other place, this proposed method is implemented. In this proposed work, the tricycle is powered by renewable energy source such as solar. It is pollution free energy source and requires less maintenance. The energy generated by the solar panel is stored in the battery which drives the vehicle through power controller. The average and maximum speed has obtained as 10 kmph and 20 kmph respectively. In this tricycle we were used medium size solar panel, battery and motor. Hence speed of the tricycle is medium range. This may increased by increasing size and rating of the devices. Due to limited solar energy availability during cloudy and rainy days, the tricycle has provision to charge it from external electric power source. In future hybrid tricycle can be developed in which the battery is powered by solar and also mechanical energy from wheels. In addition, tricycle location is monitored by placing navigation system and gear variation system can also be implemented in order to increase speed of the vehicle. Finally solar tricycle proved a complete blessing to the disable community compared to other vehicle.

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Biographies

P.Karthikeyan was born in India, Tamilnadu, in 1986. He received the degree in Electrical and Electronic Engineering, the ME degree in Power Electronics and Drives from the Anna university Chennai, Anna University Coimbatore, in 2008 and 2010. Since 2010, he has been with the department of Electrical and Electronic Engineering, Kongu Engineering College, where he is currently an Assistant Professor. He published 09 research articles in

national and international journals. His research interests include Electric vehicle, renewable energy, power electronics, power quality and digital control of power converters.

C Bala Subramanian received his Bachelor of Engineering in Electronics and Communication Engineering from Anna University, Chennai by 2006. He received his master of Engineering in Applied Electronics from Anna University, Chennai by 2008. He is pursuing Ph.D degree in Information Technology under, Kalasalingam University. He is working as an Assistant Professor in the Department of Computer Science and Engineering, Kalasalingam Academy of Research and Education. He has published more than 20 papers in reputed International Journals and Conferences. His areas of interest are Image and Signal Processing, Sensor Networks, Adhoc Networks.

V.Arunprasadworking as an Associate Professor in the Department of Mechanical Engineering at Theni, KammavarSangam College of Technology, Theni, Tamilnadu. He has seventeen years of teaching experience and one and half year of industry experience. He has fabricated solar equipment such as solar water heater. He published 5 research papers in national and international journals. He presented more number of papers in national and international conference. He is active researcher and filed 2 number of patents in IPR. His research area includes solar energy, heat transfer, and internal combustion engines.

Karthik M graduated in Electrical and Electronics Engineering from ManonmaniamSundaranar University, Tirunelveli, India and received the Master degree in Applied Electronics from Anna University, Chennai, India in 2004 and he was awarded PhD in Electrical Engineering in 2016 at Anna University, Chennai. He is currently with Kongu Engineering College affiliated with Anna University, Chennai. He has published and presented several papers in International journals and conferences respectively. He has also conducted several workshops and seminars in his research area. His research interest includes Fuel Cell Hybrid Electric Vehicles, Energy conversion/storage systems, Renewable Energy systems Modeling and Integration with Electric Grid.