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Solar Bicycle using Direct Current Motor: A Realistic Prototype

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Abstract — As we all know the fuel prices especially the petrol is rising steadily day by day. Again the pollution due to vehicles in metro cities & urban areas is increasing continuously. To overcome these problems, an effort is being made to search some other alternative sources of energy for the vehicles. Again, it is also not affordable to purchase vehicles (mopeds, scooters or motorcycles) for all the class of society. Keeping this in mind, a search for some way to cater these economically poor people as well as to provide a solution for the environmental pollution was in progress. The solar assisted bicycle developed is driven by DC motor fitted in front or rear axle housing & operated by solar energy. The solar panels mounted on the carriage will charge the battery & which in turn drive the hub motor. When the bicycle is idle, the solar panel will charge the battery. This arrangement will replace the petrol engine, the gear box & the fuel tank in case of a two wheeler or a chain sprocket, chain & gear shifting arrangement of conventionalbicycle being used by most common man.As a part of dissertation work, the solar assisted bicycle is fitted with a dc hub motor on front axle of a bicycle with power rating of 250W and with a travelling speed of around 25-30 kmph. It is provided with a pair of lead acid batteries of 35 Ah each, a photovoltaic solar panel with capacity of 20 watt, a voltage regulator of 24v 10Amp, accelerator and motor controller of 24v 25Amp. There is also a provision for charging of the battery with 220-240V, AC wall outlet supply, in case of poor solar supply due to cloudy weather.

Keywords - Solar Assisted Bicycle (SAB), Hub Motor, Solar Panel, Motor Controller, Voltage Regulator.

I. Introduction

The solor assisted bicycle consist of following components (fig.1) – hub motor, solar panel, voltage regulator, lead acid battery, motor controller, accelerator, bicycle.

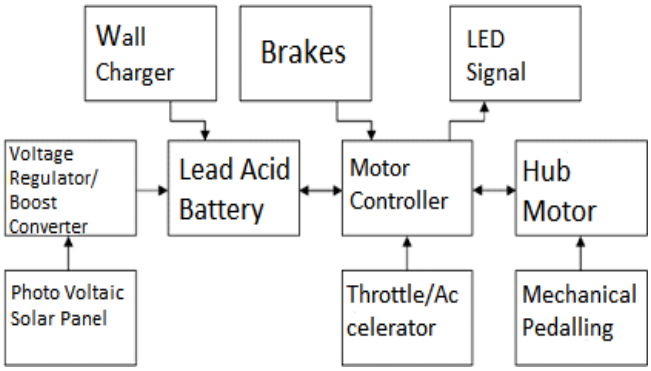

Fig 1-Block diagram of solar assisted bicycle

A. Hub Motor

The hub motor is a conventional Dc motor. The rotor (Fig.2) is outside the stator with the permanent magnets mounted on inside. The stator (Fig.3) is mounted and fixed onto the axle and the hub will be made to rotate by alternating currents supplied through batteries. Hub motor generates high torque at low speed, which is highly efficient and which doesn't need sprockets, brackets and drive chains. This means they are very reliable and have a long life. The main characteristic of Brushless DC Machines is that they may be controlled to give wide constant power speed ranges.[10][11][12]

Fig 2: Hub Motor Rotor

Fig 3:Hub Motor stator

Table 1: Specifications of Hub Motor

Type of Motor	Hub motor
Design of Motor	BLDC (Brushless DC)
Power Rating	250W
Torque	12 N-m
Speed (rpm)	300
Rated Voltage (V)	24
Efficiency (%)	≥80
Noise(dB)	<65
Weight(kg)	4

B Solar cells/Panels

As the title suggests the bicycle is operated by solar energy. The lead acid battery is charged with solar energy with the help of a solar cell. Solar cells convert the energy of sunlight directly into electricity through the use of the photovoltaic effect. The photovoltaic effect involves the creation of a voltage into an electro- magnetic radiation.

The photoelectric and photovoltaic effects are related to sunlight, but are different in that electrons are ejected from a material's surface upon exposure to radiation of sufficient energy in photoelectric, and generated electrons are transferred to different bands of valence to conduction within the material, resulting in the build- up of voltage between two electrodes in photovoltaic.

Solar cells are electrically connected and fabricated as a module with a sheet of glass on top to allow light to pass and protect the semiconductor from the weather. To obtain a desired peak DC voltage we will add solar cells in series, and to obtain a desired peak current, the solar cells are put in parallel position (Fig.4).

Fig 4: Solar panel

Table 2: Specifications of solar cell

Maximum Power (Watt)	20
Charging Current (Amp)	2
Open Circuit Voltage (V)	21.6
Max Power Voltage (V)	17
Short Circuit Current	1.316
Power Measured at Standard Test Condition	1000W per m2 at 25^0C
Lifespan	25 years

C Voltage Regulator

It is essential to regulate the voltage output from the solar panel before it is supplied to the battery. A voltage regulator is a power converter with an output DC voltage greater than the input DC voltage. This is used to regulate an input voltage to a higher regulated voltage.

The output of the solar panel is not always be stable due to fluctuations in intensity of sunlight, angular changes with respect to the direction of sunlight, as well as other environmental factors. This is the voltage regulator/Boost Converter comes into SAB. The output of the solar panel is the input of the boost converter, which then outputs into the battery for charging. Because the output of the solar panel willbe varying constantly,weneedavoltage regulator/boost converter that will take an input from a wide range of voltages and output a specific, constant voltage value.

A voltage regulator/boost converter is a power converter that will take in a DC voltage and output a higher value DC voltage. Our voltage regulator/boost converter requires output of the solar panel, which can range from 0V to 27.2V, and output for charging of the battery.We were initially attracted to the SPV Instruments (Fig.5, Fig.6) Module because it has the characteristics of taking in an input range of 9.6V to 13.2V and outputting 24V at a maximum of 2-3 amps .This SPV has an area of 2.5 square inches so it is also small in size, which makes it very feasible to be placed anywhere on the bicycle. We go thought the battery voltage & we need to supply 24V in order to charge it. [6]

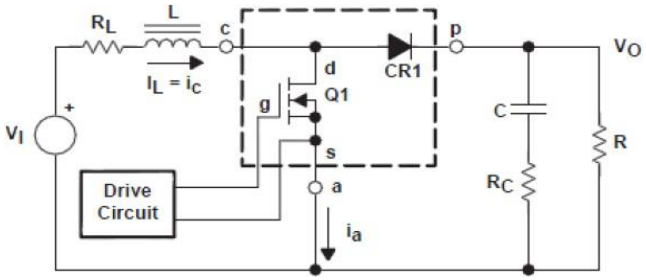

Fig 5: Circuit Diagram Of Voltage Regulator

Fig 6: Voltage regulator/Boost converter

Table 3: Specification Of Solar Charger

Output Voltage	24 V
Open Circuit Voltage	26.8 V
Amp- Hour Rating	10 A

D Lead Acid Battery

Lead acid batteries (Fig.7) are one of the most popular types of battery in electronics. Although slightly lower in energy density than lithium metal, lead acid is safe, provided certain precautions are met when charging and discharging. This have a many advantages over other conventional types of batteries, the lead acid battery is the optimum choice for a solar assisted bicycle.

Current supplied from battery indicates the flow of energy from the battery and is measured in amperes (or Amps) (Fig.10). The higher the current flow faster the battery will discharge. A battery is rated in ampere-hours (abbreviated Ah) and this is called the battery capacity. (Fig.9)

This project revolves around supplying and utilizing energy within a high voltage battery (Fig.8). It demands for a battery with longer running hours, light weight with respect to its high output voltage and higher energy density. Among all the existing rechargeable battery systems, the lead acid cell technology is the most efficient and practical choice for the desired application. The battery chosen for this project was a high capacity lead acid battery pack designed specifically for vehicles. Plastic casingis provided to house the internal components of the battery. [1] [3]

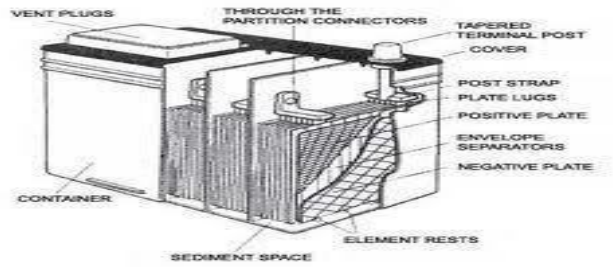

Fig 7: Parts of Lead Acid Battery Cell

Fig 8: Lead Acid Battery

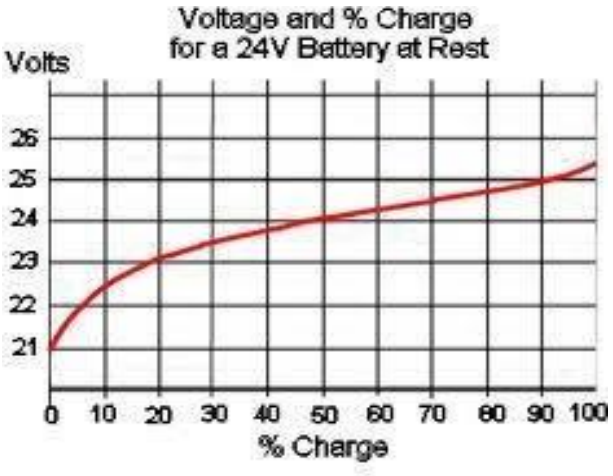

Fig 9: Voltage and % of Charge of Lead acid battery

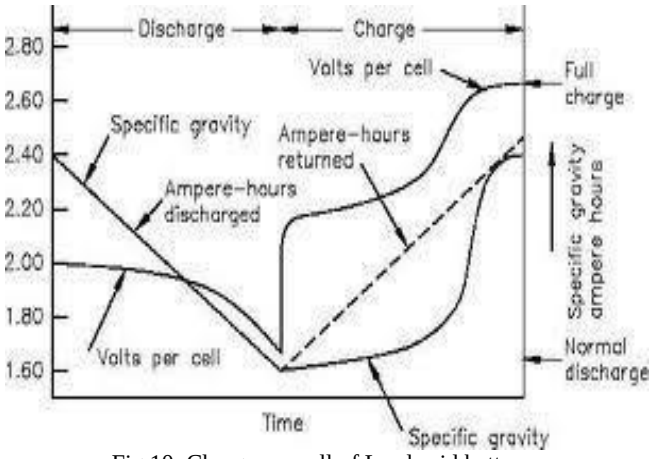

Fig 10: Charge per cell of Lead acid battery

Table 4: Specifications of Lead Acid Battery

Type of Battery	Sealed Lead Acid
Size (l× w × h)	210×140×356 mm.
Number of Batteries	TwoBatteries connected in series
Voltage	12 V
Amp-Hour Rating	35 Ah
Charge Termination	Whenbattery charge reaches 25.8 V
Standby Battery Voltage	25.4 V
Open Circuit Voltage (Volts)	2.87 V
Charging Time	8-9 hours
Weight	8 Kg
Safety	Good
Cycle Life (n0. Of cycles)	400
Operating Temperature ^{0}C	-10 to 60

E Motor Controller

The motor controller (Fig.12) is an important component of the system. It is essential to control the amount of power supplied and to drive the BLDC hub motor. The controller converts the DC voltage from battery to an alternating voltage with variable amplitude and frequency that drive the hub motor at different speeds(Fig.11). It basically consists of MOSFET transistors and small microprocessor that vary from detecting any malfunctions with the motor hall sensors, the throttle, to protect functions against excessive current and under-voltage, which are ideal for protecting the system. [5]

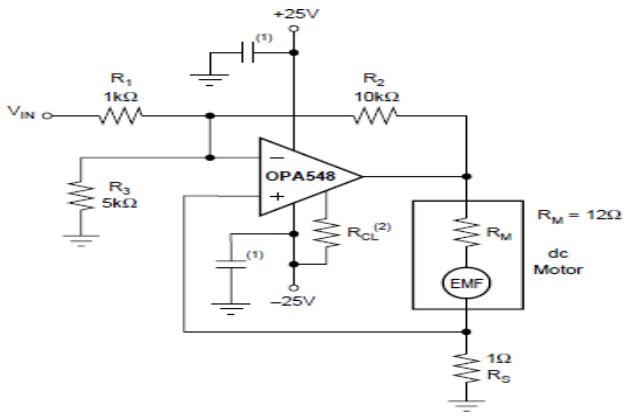

Fig 11: Circuit Diagram of Motor Controller

Fig 12: Hub Motor Controller

Table 5: Specifications of Motor Controller

System Voltage (V)	24
Max. Load Output Current	25
End Of Charge Voltage (V)	27.4
Boost Charge Voltage(V)	28.8
Ambient Temperature (^{0}C)	0-50
Weight(gm.)	180
Dimensions(l×w×h)(mm)	130×88×39

F Accelerator/Throttle

The maximum speed of a bicycle is 30 kmph. It is required to vary the speed depending upon the road conditions & traffic. Therefore an accelerator or a throttle (Fig.13) is necessary.

Throttle allows us to drive the motor from zero speed to full speed. The throttle is fitted on right side of the handle bar and is connected to controller. The throttle converts DC voltage from battery to an alternating voltage with variable amplitude and frequency that drives the hub motor at different speeds. It consists of MOSFET transistors and a small microprocessor.

This throttle is technically referred to as a Hall Effect type. The throttle has three wires contains a black, red, and green. The supply voltage is via red and black wires and is usually around 4 volts. Green wire voltage increases as the throttle is turned.

G Solar Bicycle

" The solar assisted bicycle (Fig.14) is driven by DC motor fitted in front axle housing & operated by solar energy. The solar panel mounted on the carriage is charge the battery & which in turn drive the hub motor. When the bicycle is idle during the day, the solar panel will charge the battery. The system will make bicycle operate more efficiently.

The basic configuration of an solar bicycle drive consists of a controller that controls the power flow from the battery to the electric motor. This power flow acts in parallel with the power delivered by the rider via the pedal of the bike. The rider of an solar bicycle can choose to rely on the motor completely, pedal and use the motor at the same time or pedal only (use as a conventional bicycle).

This arrangement replaces the petrol engines, the gear box and the fuel tankin case of a two wheeler or chain sprockets, chains & gear shifting arrangement of a conventional bicycle being used by most common man.

Solar power bicycle is a modified version of a regular bicycle but is driven by solar energy. Some of the components used to create it are mentioned in the block diagram in Figure. 2. The hub motor is a DC motor used to rotate by AC current which is provided from the battery, it provides high torque at a low speed which is very efficient. While the solar panels are, as mentioned before, converting solar energy to electrical energy which is used to charge the lead acid battery. Solar cells in this project design are positioned in parallel, to obtain the desired peak voltage.

A voltage regulator is used to regulate the voltage output from the solar panels before it supplies the battery. It does so by having an output DC voltage larger than the input, which allows the input voltage to be regulated to a higher voltage. Due to the intensity and strength of the sunlight as well as the position of the panels in order to maintain a specific constant voltage value as we will not be constantly obtaining a regular output from the solar panels.

The focus in this article is to create a solar powered bicycle that can be recreated inexpensively, to be able to convert electric bicycles to solar-powered electrical bicycles. They include the calculations needed in order to select the correct DC motor and the maximum power that will be obtained. Solar energy is obtained from the solar panels and is stored in the battery. The electrical energy which is stored inside the battery is used in the DC motor to allow rotation to occur in the bicycle wheel, as shown in the block diagram in Figure.

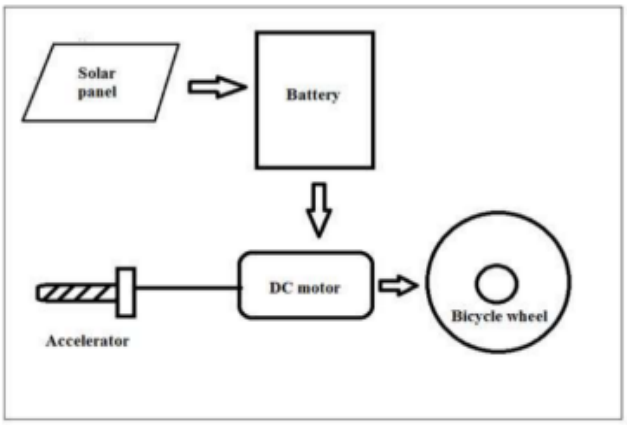

Figure Block diagram of the system

Table 6: Specifications of Accelerator/Throttle

Supply Voltage (V)	24
Return Voltage (V)	4
Max. load output current (A)	25
Handle Bar Diameter(mm)	22
Three wires red, green, black	May differ from works. Fits for 24v supply

Fig 13: Throttle/Accelerator

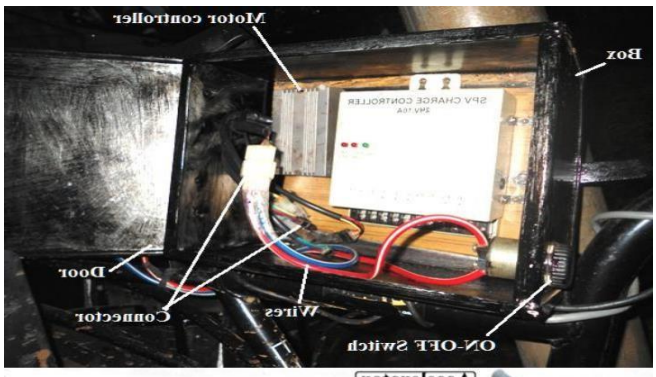

Fig 14: Solar Bicycle

Conclusion

Solar assisted bicycle is modification of existing bicycle and driven by solar energy. It is suitable for both city and country roads, that are made of cement, asphalt, or mud. This bicycle is cheaper, simpler in construction & can be widely used for short distance travelling especially by school children, college students, office goers, villagers, postmen etc. It is very much suitable for young, aged, handicap people and caters the need of economically poor class of society. It can be operated throughout the year free of cost. The most important feature of this bicycle is that it does not consume valuable fossil fuels thereby saving crores of foreign currencies. It is ecofriendly & pollution free, as it does not have any emissions. Moreover it is noiseless and can be recharged with the AC adapter in case of emergency and cloudy weather. The operating cost per kilometer is minimal, around Rs.0.70/km. It can be driven by manual pedalling in case of any problem with the solar system. It has fewer components, can be easily mounted or dismounted, thus needsless maintenance.

REFERENCES

[1] T. Markel, K. Bennion and W. Kramer, National Renewable Energy Laboratory & J. Bryan and J. Giedd Xcel Energy "Field Testing Plug-in Hybrid Electric Vehicles with Charge Control Technology in the Xcel Energy Territory" Journal of International Conference on Renewable Energies and Power Quality (ICREPQ'11) Las Palmas de Gran Canaria (Spain),13th to 15th April, 2011.

[2] The Pandit G. Patil, Energy Systems Division, Argonne National Laboratory "Advanced Battery Technology for Electric Two-Wheelers" Journal of Energy Systems Division, Argonne National Laboratory June 2009.

[3] Jean-Marc Timmermans1, JulienMatheys, Philippe Lataire, Joeri Van Mierlo, Jan Cappelle2 "A Comparative Study of 12 Electrically Assisted Bicycles" World Electric Vehicle Journal Vol. 3 - ISSN 2032-6653 - © 2009 AVERE.

[4] Ahmad A. Pesaran and Tony Markel, Harshad S. Tataria, David Howell "Battery Requirements for Plug-In Hybrid Electric Vehicles – Analysis and Rationale" Conference Paper of National Renewable Energy Laboratory, USA NREL/CP-540-42240 July 2009.

[5] Tony Markel, Michael Kuss, and Paul Denholm "Communication and Control of Electric Drive Vehicles Supporting Renewables" Conference Paper of Center for Transportation Technologiesand Systems National Renewable Energy Laboratory, NREL/CP-540-46224 August 2009.

[6] T. Markel, K. Bennion and W. Kramer, National Renewable Energy Laboratory & J. Bryan and J. Giedd Xcel Energy "Field Testing Plug-in Hybrid Electric Vehicles with Charge Control Technology in the Xcel Energy Territory." Technical Report of National Renewable Energy Laboratory, NREL/TP-550-46345, August 2009.

[7] C. E. (Sandy) Thomas" Fuel Cell and Battery Electric Vehicles Compared" Journal ofH2Gen Innovations, Inc., Alexandria, Virginia, 22304, USA.

[8] Todd Litman, "Efficient V ehicles Versus Efficient Transportation "comparing transportation energy conservation strategies. Journal paper of Victoria Transport Policy Institute 26 August 2009.

[9] An MIT Energy Initiative Symposium, "Electrification of the Transportation System". Journal paper of An MIT Energy Initiative

