IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331,
PP 100-104
www.iosrjournals.org

Hybrid Bicycle

Basil P Elias[1], Dino Devassykutty[2], John George[3], Akhila K[4]
[1,2,3](Student scholar, Department of Electrical & Electronics Engineering, ASIET, Kerala)
[4](Assistant Professor, Department of Electrical & Electronics Engineering, ASIET, Kerala)

Abstract: *The project on Hybrid Bicycle mainly focusses on energy conservation. The Hybrid Bicycle system consists of a light weight and compact hub motor in the front wheel which is powered from a lithium-ion battery. Three different ways of charging the battery are incorporated: the 220V AC wall outlet, energy from pedaling, and solar power. The Hybrid Bicycle enables substantially longer distance power assisted cycling by regenerating power from pedaling energy (human energy) and solar energy and charging it in the battery.*
Keywords: *Hub motor, solar power, regenerative charging, wall charging, dc-dc boost converter*

I. Introduction

In present scenario, owing to the increasing number of automobiles the need for petroleum products is reaching its peak point. Petroleum products are non-renewable and may possibly get exhausted in future, so it is better to move to alternate energy sources. Crude oil prices have increased significantly over the past few years and there seems to be no turning back. Currently, there has also been a focus on the environment and it seems that the demand for cleaner alternatives for fuel has become critical. The increasing demand for pollution-free transportation has boosted the use of electric power for transportation thereby reducing the reliance on automobiles. An Electric Bicycle is a low cost alternative to an automobile. Although the concept of electric bicycle is not new [1,2], it has not been completely explored. This project focusses on the design and testing of a hybrid electric bicycle. The project is challenging with respect to the conversion of the existing mechanical system to the one that incorporates both human pedaling and utilization of solar energy.

"Hybrid" usually indicates the use of multiple energy sources to provide power to a vehicle. Energy from ac wall outlet, solar power as well as from human pedaling is utilized in this project to charge a battery. Solar power is not only used to charge the battery, but may also be used for powering communications, controls and other auxiliary functions. The hub motor attached to the front wheel of the bicycle is charged from the battery. The project on hybrid bicycle promotes cleaner technology as well as a lesser reliance on petroleum product [3].

II. Methodology

The methodology used in constructing the Hybrid Bicycle has been illustrated as a block diagram in figure 1. The main aim of the project was to ensure efficient operation of the Hybrid Bicycle by meeting the drive requirements. Considering legal limits on the speed of electric bicycles, the maximum speed of the Hybrid Bicycle was considered to be 28kmph. Since regeneration is involved, determining the type of components to be used, given the constraints of weight and size became more crucial. The main components required for this project are listed below.

- Motor
- Battery
- Solar Cell
- Throttle
- Frame
- DC-DC Boost Convertor

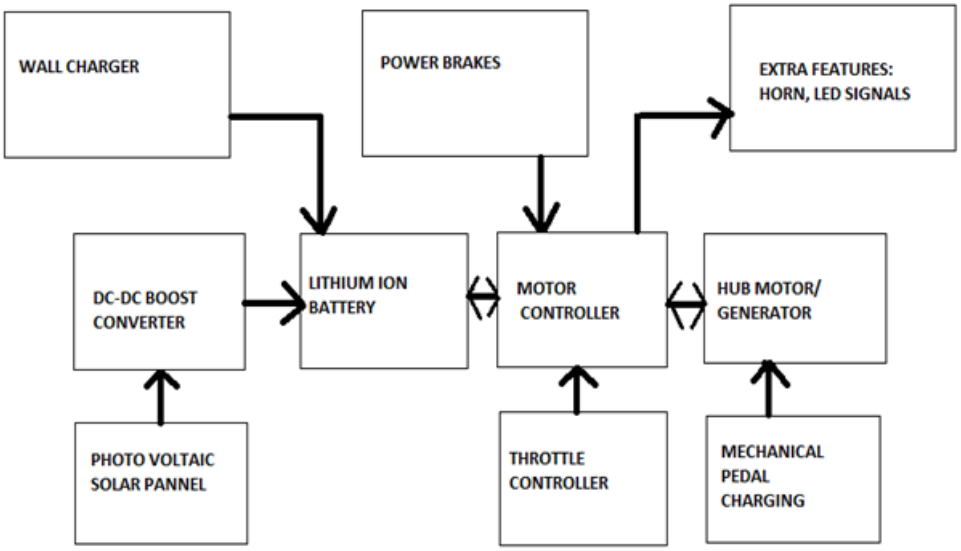

Figure 1: Block Diagram

The battery and motor required for Hybrid Bicycle has been chosen assuming that the external forces such as wind drag, rolling resistance of tyres, etc. has been neglected. The focus is more on energy conversion between kinetic/potential and electrical energy. To accelerate the Hybrid Bicycle from cold start, sufficient torque needs to be provided and hence a sufficient amount of current needs to be drawn by the motor. If the terrain is flat, there is no potential energy which would have caused the motor to deliver a counter torque to oppose the force of gravity. We therefore look at only the kinetic energy required for acceleration. The energy relationships have been provided by equations (1) to (3).

$$Kinetic\ Energy = \tfrac{1}{2}\, m\Delta V2 \quad (1)$$

$$Electrical\ Energy = V \times I \times T \quad (2)$$

$$K.E. = voltage\ rating\ motor \times current\ required \times time\ to\ accelerate \quad (3)$$

2.1. MOTOR SELECTION

A Permanent magnet DC Hub motor of 250 watts was selected for the following reasons:

- Easiness of control
- Ability to function as a generator and regenerate power
- Good torque-speed relationships
- High power – weight ratio

Given the time constraints and the challenges in design, a permanent magnet DC Hub motor was considered as ideal for our Hybrid Bicycle. This motor is capable of delivering adequate torque required for the system. Furthermore, compared to brushless motors, permanent magnet motors are lower in cost and can be easily integrated into the existing bicycle system. Since the speed of the motor is dependent on voltage, the voltage rating of the motor was also crucial. If the voltage rating is high, the motor will produce more power. The appropriate choice of voltage also helps to limit the current drawn by the motor which can limit the heating effects. There is a trade-off between speed and torque given by equation (4).

$$P = T \times RPM \quad (4)$$

Considering all the above mentioned aspects, a 36 V motor was chosen. It was chosen because it was the most common selection for electric bikes, and was compatible with our goals for the system. The motor specifications are given below.

- 250 Watt hub motor
- 2100 RPM
- 4.5 in x 5.5 in
- 36 V x 7 Amp continuous rating
- Peak ratings (intermittent duty)

2.2. BATTERY SELECTION

The primary concern while selecting batteries were cost, durability, energy density, and the number of recharge cycles. Commonly used batteries are sealed lead acid batteries due to their low costs, and reasonably good energy density. After investigating various electric bike designs, we observed that most of them used three 12V batteries with Amp-hr capacities varying between 7 and 20 Amp-hrs. This project on Hybrid Bicycle also proposes to use three 12V, 7-Amp-hr Sealed Maintenance Free Batteries (SMFB) which are rechargeable lead acid batteries. Plastic casing is provided to house the internal components of the battery.

2.3. SOLAR PANELS

Solar cells convert the energy of sunlight directly into electricity through the use of the photovoltaic effect. The specifications of the solar panel that is proposed to be used in this project are listed below.

- Maximum Power 20 W
- Voltage at max Power 17 V
- O.C Voltage 12 V
- S.C Voltage 1.2 A

2.4. THROTTLE

The speed of the motor will have to be varied depending on the road conditions and traffic. Therefore an accelerator or a throttle is necessary which facilitates the motor to run 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.

III. Simulations

A simulation model using Matlab was constructed in order to study the effectiveness of charging the battery through solar panel and pedaling. This is illustrated in figure 2. Since the intensity of sunlight varies depending on the time of the day, a buck-boost converter (converter 1) is used to boost the voltage from the solar panel to a steady value of 12 V. The voltage obtained through regeneration from pedaling is reduced to 12 V using another buck-boost converter (converter 2). The output voltage obtained from both converters is fed through a controller to charge the batteries. The results from the simulation are discussed below.

Table 1and Table 2 lists the input and output voltages from both the converters and figures 3 and 4 illustrates the corresponding graphs. Table 1 show that even when the output voltage from the solar panel (i.e. the input to the converter) is very low as in the case of morning, the output from the converter will be approximately 13 V. The regenerative voltage from pedaling also varies depending on the riding speed. Table 2 shows that for different regenerative voltage, the converter gives a steady voltage of approximately 13 V. The regulated voltages from both the converters is used to charge three 12 V batteries simultaneously which is used to run the motor.

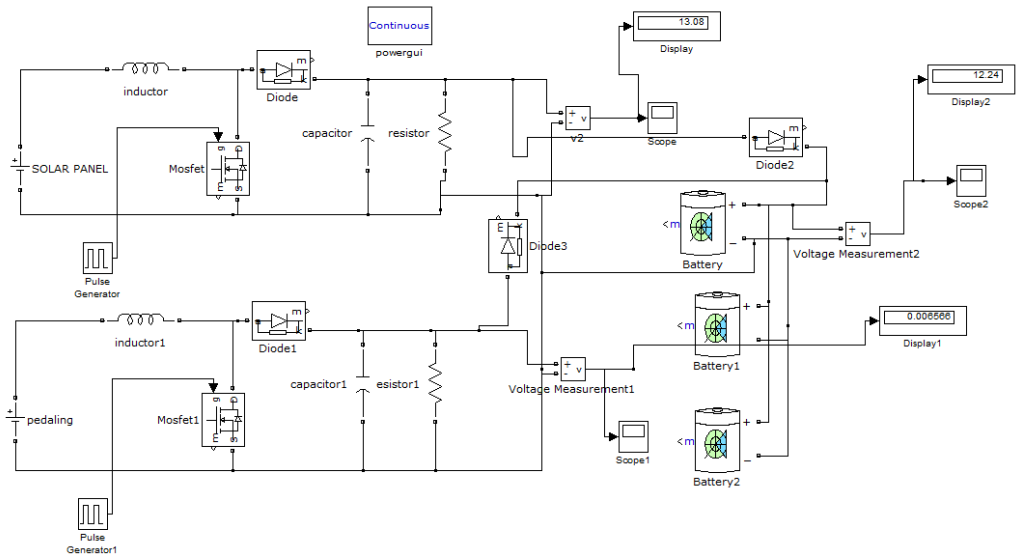

Figure 2: The simulation model

Table 1: Input versus Output from converter 1

INPUT (V)	OUTPUT (V)
0.1	0.03702
0.5	1.299
1	3.827
2	8.858
3	11.23
4	13.11
6	13.12
8	13.14
10	13.16
12	13.17
13	13.18

Table 2: Input versus Output from converter 2

INPUT(V)	OUTPUT (V)
0.1	0.0065
6	13.06
12	13.1
14	13.12
20	13.6
24	13.2
30	13.24
36	13.29

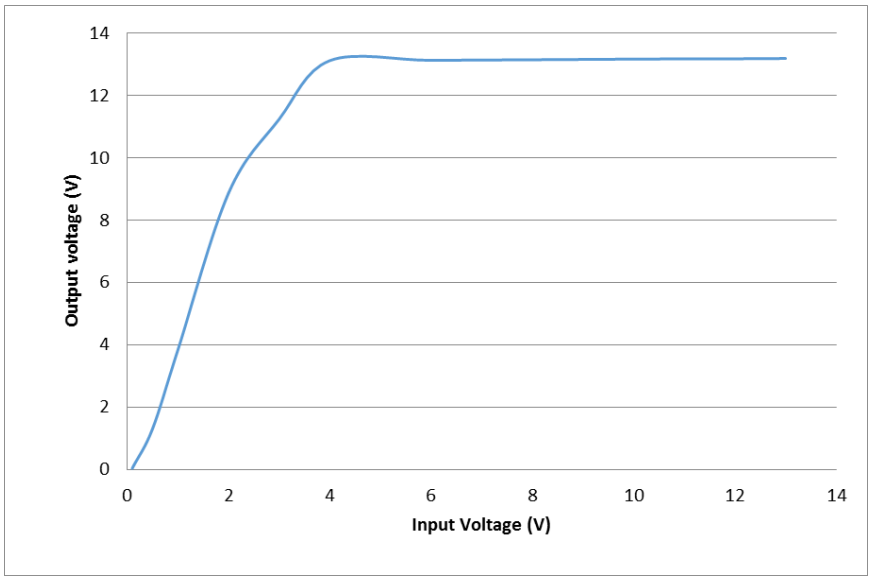

Figure 3: The output voltage from converter 1 as a function of input

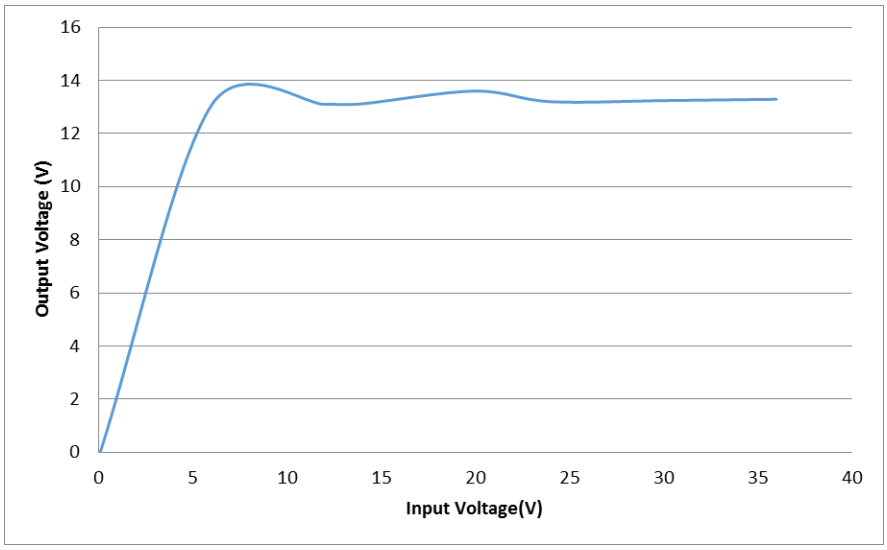

Figure 4: The output voltage from converter 2 as a function of input

IV. Conclusion

This project on Hybrid Bicycle is an alternative to automobiles for medium distance travel and focuses on energy conservation. When the Hybrid electric bicycle is kept under sunlight the battery gets charged which powers an electric motor in the front wheel. The use of motor aids the resistance in pedaling while going up hills. When there is no sunlight, the bicycle can be charged by ac mains. The project focuses on constructing a hybrid bicycle with a minimal additional weight that is capable of greater efficiency through its use of regenerative motor and various other mechanisms. The implementation of the proposed system is on its way and is yet to be completed. In future we also need to look more into the different mechanisms for decision making and control.

Acknowledgment

We would like to express our gratitude towards our guide and mentor Mrs. Akhila K (Asst Professor, Dept of EEE, ASIET) for her valuable advice, positive criticism, and consistent encouragement. I would also like to thank our all faculties for their blessings, moral and emotional support and valuable feedback, without which this work would not have been completed.

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