MJRET
Open Access
Multidisciplinary Journal of Research in Engineering and Technology
Journal homepage: www.mjret.in
ISSN:2348-6953

An Improved & Efficient Electric Bicycle system with the Power of Real-time Information Sharing

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Abstract

This paper presents the development of anassociate degree'Electric Bicycle System' with an innovative approach. The aim of this paper is to show that the normal bi-cycle can be upgraded to electric one by some means– that including the development of a regenerative braking system and innovative BLDC motor control – but also uses real-time sensing and the powers of crowd sourcing to improve the cycling experience; get more people riding bikes; and to aid in the design and development of cities. Electric bikes have simultaneously gained popularity in many regions of the world and some have suggested that it could provide an even higher level of service compared to existing systems. There are several challenges that are related electric bike design: electric-assisted range, recharging protocol, and bike and battery checkout procedures. This paper outlines system requirements to successfully develop and deploy an electric bike, focusing on system architecture, operational concepts, and battery management. Although there is little empirical evidence, electric bike could be feasible, depending on demand and battery management, and can potentially improve the utility of existing bike systems.

Keywords: *BLDC motor, controller, solar recharging, dynamo.*

M15-1-2-7-2014

1. INTRODUCTION

The idea of a motorized bicycle isn't a recent conception and has been around for over a century. Until 1895, the electrical bicycle created its place in history. That year, OgdenBolten was granted U.S. Patent 552,271 for a powered bicycle with a six-pole brush-and-commutator DC hub motor mounted within the rear wheel. The bike itself had no gears and therefore the motor may draw up to 100A with a 10V battery. Since then, the conception of the electrical bike became possible and sensible. Because the years progress, additional and additional electrical bikes were made with varied driving mechanisms.

The electrical bicycle offers a cleaner various to travel short-to-moderate distances instead of driving a patrol/diesel-powered automotive. The value of crude has multiplied consider over the past few years and it looks to be no turning back. The electrical bicycle could be a project which will promote each cleaner technology also as a lesser dependence on oil. it' ll run on clean power with the flexibility to recharge the battery three separate ways: through the 120V AC wall supply, by generating power through the pedals of the bicycle,dynamo and by solar-cell generative power. Fashionable electrical bicycles integrate many inventionsfrom technology and style, significantly within the past year.

2. DESIGN REQUIREMENTS

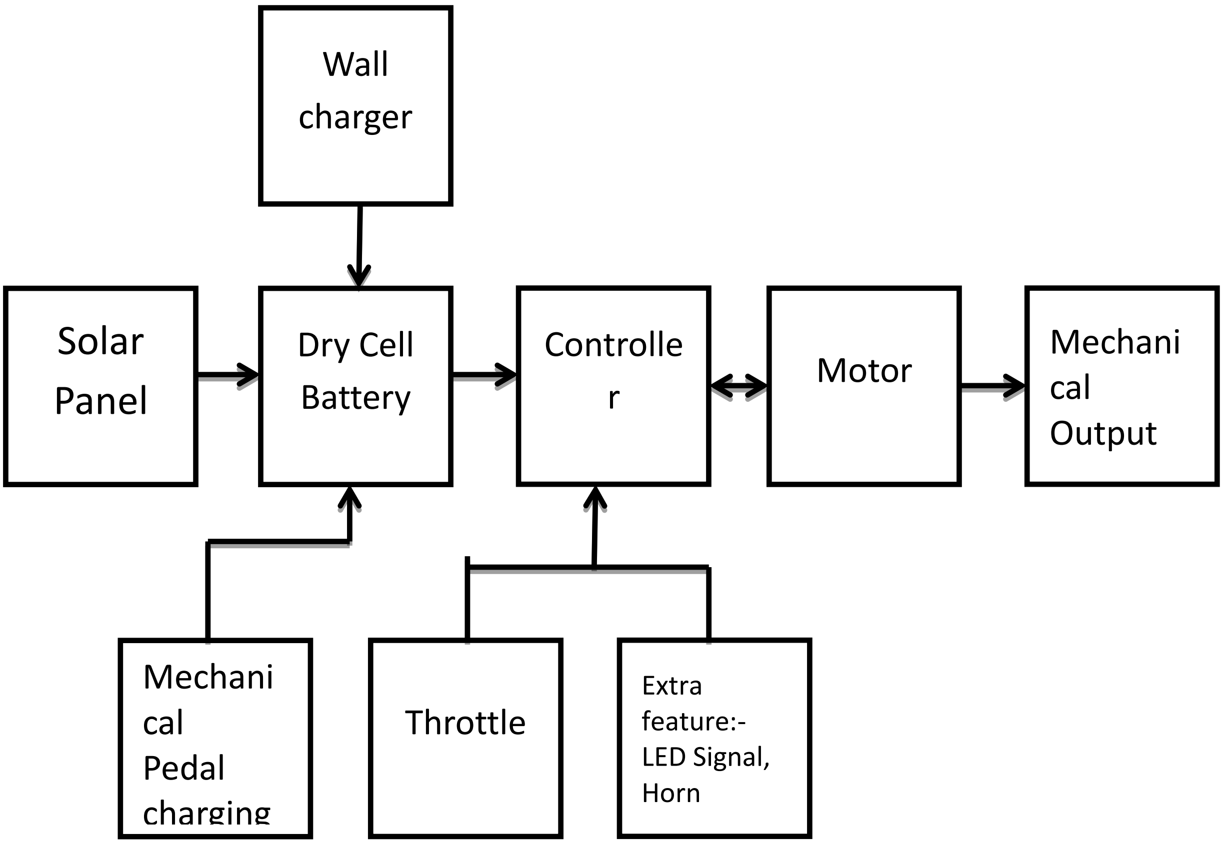

Fig1. System Block Diagram for Entire Project

There are many different components shown in a block diagram. The main components are brushless DC motor, motor controller, photo-voltaic, dry cell battery and solar panel. Also throttle and extra features such as horn, speedometer, and LED signal etc are shown in this diagram. The power source for this system is given by dry cell battery. The output of dry cell battery is 48V. There are multiple forms of charging source is used such as AC voltage through an outlet, solar energy and mechanical pedal charging system. The source of battery charging is photovoltaic solar panel and it is light weight. The solar panel output is 12V and 20 watt. Once a voltage and current is generated through the solar panel and it give to battery source. Also we use mechanical pedal charging system, so dynamo is use for this charging system.

A dynamo is an electrical generator that produces direct current with the use of a pedal. This dry cell battery block connected with a controller block. So this controller block control the all function of the system. The controller is to regulate the amount of applied power on brushless DC motor. Also there are many functions for this controller that over current protection, under voltage protection and also throttle are use to control the speed of a brushless dc motor. These functions are beneficial to the system and also provide a solution to any troubleshooting and damages that may occur.

3. BLDC MOTOR

Brushless DC (BLDC) motors are synchronous motors consisting of armature windings on the stator permanent and magnets on the rotor. The stator of a BLDC motor consists of stacked steel laminations with windings placed in the slots and these stator winding can be arranged in two patterns i.e. a star pattern or delta pattern. The major difference between the two patterns is that the star pattern gives high torque at low RPM and the delta pattern gives low torque at low RPM. There are many advantages of BLDC motor such as better speed versus torque characteristics, high dynamic response, high efficiency, long operating life, noiseless operation, higher speed ranges.

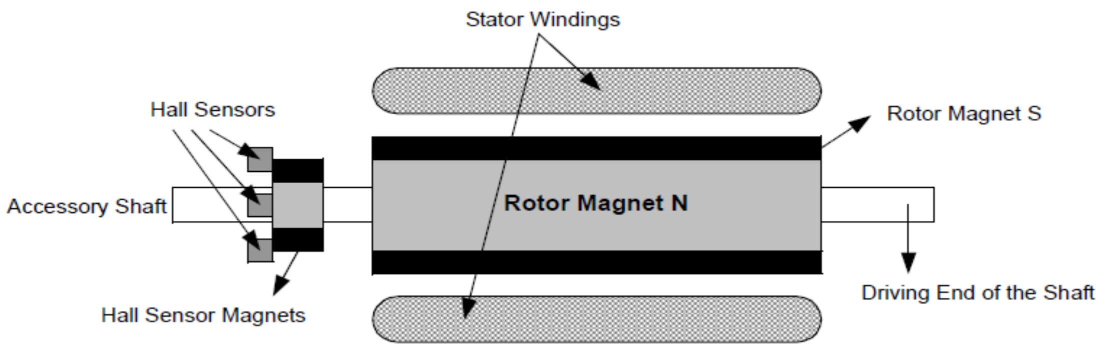

Fig2. BLDC Motor transverse section

In this Fig.2 shows transverse section of a BLDC motor. The rotor has alternate N and S permanent magnet s. The Hall sensors are embedded into the stationary part of the motor. Here hall sensors are connected with hall sensor magnet to detect the position of rotor. In BLDC motors the phase windings are distributed in trapezoidal fashion in order to generate the trapezoidal waveform. The commutation technique generally used is trapezoidal commutation where only two phases will be conducting at any given point of time.

Typically BLDC motors have three phase windings that are wound in star or delta fashion and need a three phase inverter bridge for the electronic commutation. The brushless motors are generally controlled using a three phase power semiconductor bridge. The motor requires a rotor position sensor for starting and for providing proper commutation sequence to turn on the power devices in the inverter bridge.

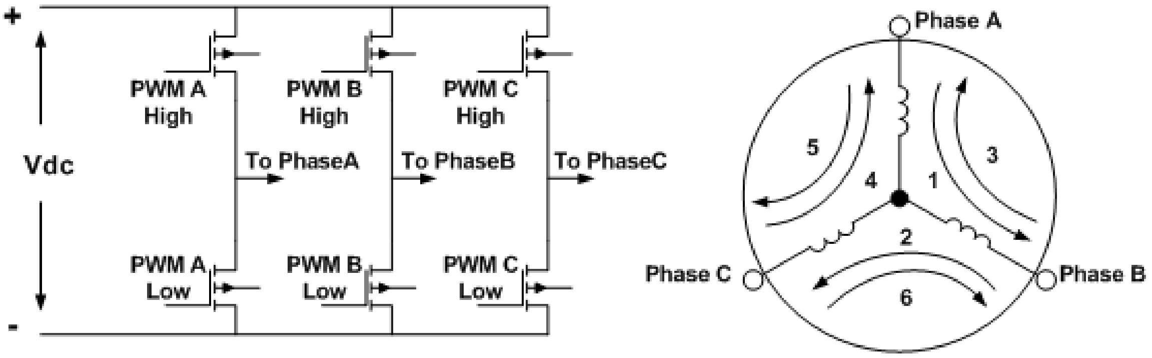

Fig3. Commutation Logic with Hall Sensor Inputs

In Fig.3, the three phase BLDC motor is operated in a two phase on fashion that means two phases that produce the highest torque are energized and the third phase is non-energized. Which two phases are energized depend on the rotor position. The cross section of a three phase star connected motor along with its phase energizing sequence. Each interval start with the rotor and stator field lines 120^o apart. There are six outputs which is control by six MOSFET. These MOSFET control the direction of the current through the coil. There are two MOSFET connected to each phase. One is positive and another is negative current are flowing through it. In commutation sequence has one of the winding energized to positive power (current enter into the winding), the second winding is negative (current exits in the winding) and the third winding is in a non-energized condition.

The BLDC commutation is sense the rotor position, then energize the phases that will produce the most amount of torque. The rotor travels 60 electrical degrees per commutation step. The appropriate stator current path is activated when the rotor is 120 degrees from alignment with the corresponding stator magnetic field.

Switching interval	Seq. number	Pos. sensors			Phase Current		
		H1	H2	H3	A	B	C
0° – 60°	0	1	0	0	+	-	off
60° – 120°	1	1	1	0	+	off	-
120° – 180°	2	0	1	0	off	+	-
180° – 240°	3	0	1	1	-	+	off
240° – 300°	4	0	0	1	-	off	+
300° – 360°	5	1	0	1	off	-	+

Fig4. Switching sequence of BLDC Motor

In additional there are 3 Hall Effect sensors which detect the position of the wheel by sensing a magnet as it passes by the sensor. There are three Hall Effect sensor which detect the position of the alternating magnets. Hall Effect sensors are polar so they switch ‘on’ when a south pole of a magnet is overhead. Each Hall Effect sensor detect when the south pole of a magnet is overhead, sending a signal to one of the three sense input of the controller.

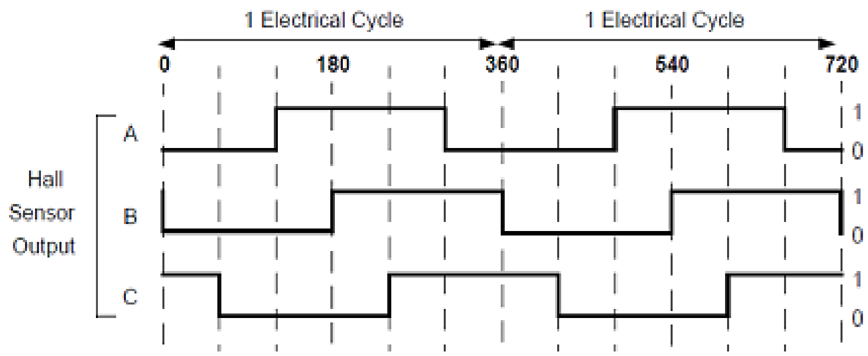

Fig5. Hall sensor signal

As in Fig.5 shows that the hall sensor output. Every 60^0 of rotation one of the hall sensor change the state and it takes six step to complete a one electrical revolution. Every 60^0 rotation the phase current switching should change. If the number of electrical revolution is to be repeated then it contain the mechanical revolution, which is determined the rotor pole pair. If number of pole pair increases then more electrical revolution is occur and hall sensor change will be faster and commutation change will also faster.

4. PIC CONTROLLER

Here we use PIC16F72 controller to control the electric bicycle system. In this electric bicycle system some components are installed such as brushless dc motor, PIC controller, battery and dynamo, so here required to controller for controlling the different component of electric bicycle system. There are different functions of this controller such as under voltage protection, over current protection, control power supply, also to drive and control the Brushless dc motor. There are different signal were transmitted to pin of PIC controller to drive and control brushless dc motor, such as current detection signal, motor speed control signal, capacity detection system.

In this PIC16F72 controller has 28 pins, 22 I/O pins that are user configurable on a pin-to-pin basis. There are 35 number of instruction in this PIC controller. The operating frequency is 20 MHz Also in this controller there are three I/O port are use such as PORTA, PORTB and PORTC and three Timers are use Timer0, Timer1 and Timer2. In this pin diagram RA1, RA4 and RA5 pin there are transmitted speed control, helping signal, current detection signal. The current detection signal use here because, if any heavy current situation electric bicycle is running at heavy load the current is increasing in motor. Then it will be damages winding of motor and component of motor. Here required current detection signal for controlling the current. Also there are under voltage protection is required because of avoid the low voltage supply, which is affect on electric bicycle running normally, then controller should be provide capacity checking. The voltage consists with resistance then it transmitted to PIC controller. If voltage supply signal transmitted to PIC controller then checking supply voltage.

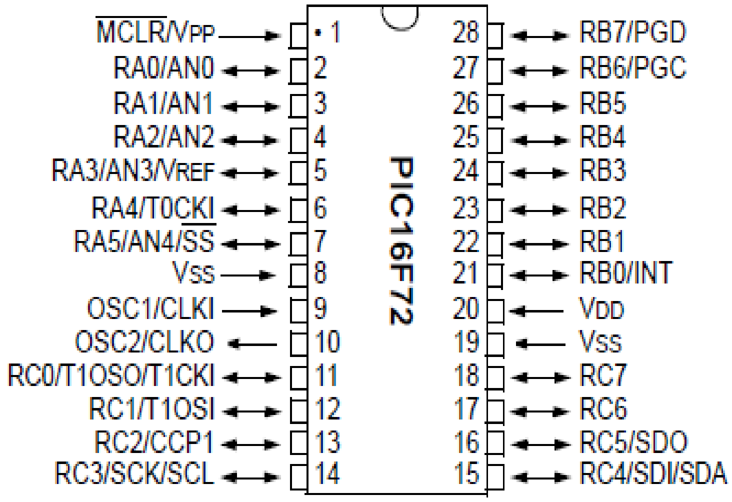

Fig6. Pin diagram of PIC16F72 Controller

The pins RB2 to RB7 are use for signal for driving motor. Here RB2, RB3 and RB4 are connecting with higher level signal of Phase A, B and C. And RB4, RB5, RB7 are also connecting with lower level signal of Phase A, B and C. The A/D is allowed a conversion of analog input signal to 8-bit digital number. Here pins AR0-AR4 support for analog to digital conversion. If signal transmitted to pins of PIC controller then after analog to digital conversion the brushless dc motor driven through this signal.

5. DYNAMO

In electric bicycle system we use a dynamo for generation the electric power. A dynamo is electrical generator they produce power with use of a commutator. Here in electric bicycle dynamo is placed on front wheel of the bicycle and dynamo commutator is connected with front wheel of bicycle. If bicycle is running, at this condition by help of wheel the commutator is rotating and it generates the power. In dynamo use a rotating coil of wire and magnetic, so it converts mechanical rotation into an electric current through Faradays law of induction. A dynamo is simple generator that used to convert mechanical motion into electrical motion with the help of magnet. It consist of powerful magnet and pole on which coil has been rotate about. The rotating coil cuts the line of magnetic force, there by inducing current to pass through the wire. The mechanical energy produced by the rotation is thus converted into electrical current in the coil.

6. SOLAR PANEL

Here we also use solar panel for generating power. In this bicycle we are using 20W solar panel and it is connected to 12V battery, so which help for charging the battery. They charging the battery are through the use of a solar panel. The solar panel convert energy of sunlight directly into electricity through utilization of photovoltaic effect. The solar panel are electrically connected as module with sheet of glass on top to allowed light pass and it protected the semiconductor from weather. This solar panel is connected in series in module and creating an additional voltage.

In solar panel photons in sunlight hit on solar panel and it absorbed by silicon material. If sunlight absorbed by silicon then electron excited, if electron is excited they dissipate the energy and it travel through cell until it reaches an electron. These electrons are only allowed to move in single direction, then solar cell convert solar energy into direct current electricity.

7. COMPARISON

Sr. No.	Manufacture/ Brand	Model	Advertised Range	Power control	Battery Type	Motor or drivetrain
1	**Eco-Brand Exim** (China)	Multiple Models Samurai model cited at right	Not available	Pedelec or optional throttle	3*12 volt 8Ah sealed Lead acid, with NiMH or Li-Ion optional	250W
2	**EcoBike** (USA)	Vatavio Elegance Adventure	29-56 Km	Traditional PAS Throttle only	36V, 8A Li-MnO	290W-360W (700W peak) Hub Motor
3	**Belize Bicycle** (Canada)	E-RIDER MTB	Over 30 Km	Manual + pedelec	36V, 8A NiMH	350W Hub Motor
4	**Bike Tec** (Switzerland)	Flyer T8 Premium	36 Km	Manual	Li-Ion	Panasonic Drive 8-speed hub gear
5	**PROJECT**	-	60 Km	Manual + pedelec	Dry Cell 48V 33Ah	750W BLDC Hub Motor

9. CONCLUSION

The issues associated with electric bicycles may be addressed by custom-designed drives that are most efficient over a given operating cycle. The results of the studies listed here can serve as a platform to improve electric bicycle performance, if new drive systems are designed around key parameters that will result in improvement of the system performance. Furthermore, they can be used for comparison of existing drives in a systematically, comprehensive, and technical way. Also we take PIC16F72 controller and this controller has function of over-current protection, under-voltage protection, helping and so on. Experiment turned out controller has better dynamic characteristics and run steadily.

ACKNOWLEDGMENT

It gives us immense pleasure to compete Project on **"**An improved & efficient electric bicycle system with the power of real-time information sharing**."** We are profoundly grateful to our guide Prof. JAYASHREE DEKA for her expert and continuous encouragement with timely guidance, with interest and curiosity in work for the completion of this project report.

We also extend my sincere thanks to Principal Dr. Sanjeev Wagh and Prof. Mrs. N. M. Lokhande (HOD Electrical Engineering Department) for providing all facilities for this

Project. Finally we would like to thank all staff members of Electrical Department and those who have helped us in preparing this Project report directly or indirectly.

Immense thanks to all our friends for giving us the timely support and cooperation with no time constraints. And last but not the least we are grateful thankful to all non-teaching staff members of the department of K.J. College of Engineering Management and Research, Pune, who have knowingly or unknowingly helped in completing this Project report.

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