DESIGN AND IMPLEMENTATION OF SPEED CONTROL FOR AN ELECTRIC POWER ASSISTED BICYCLE

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Abstract: Smart transportation, an important dimension of smart cities, includes not only intelligent transportation solutions, but also "green" transportation solutions. Cycling, as one of the most sustainable form of transportation, occupies an important place in the context of smart cities. They have several advantages when compared to traditional bicycles, but also issues that relate to battery limited capacity and long periods of charging. Consequently energy-efficient solutions for electric bicycles are of very high research interest. This paper presents a modest method to design the speed control system of motor drive for an electric bicycle. By properly selecting the current controller time delay and speed controller time delay, frequency of PI controller can be found. Finally, a prototype of hub brushless dc motor has a specification of 250W, 60V. For the above specification a dc motor drive has been designed and mechanically implemented. The paper shows the feasibility and fidelity of the complete designed system.

***Keywords*- Electrical bicycle, Speed controller, Hub brushless dc motor, Smart transportation**

I. INTRODUCTION

Smart cities represent a hot research topic both for academia and industry. The main purpose of smart cities is to make use of city facilities (buildings, infrastructure, transportation, energy, etc.) in order to improve people's quality of life while creating a sustainable environment. In this context, smart transportation, as a fundamental dimension of smart cities, relates to both intelligent and "green" transportation solutions. Cycling is considered to be one of the most sustainable and green forms of transportation. Therefore, it is not surprisingly that cycling occupies an important place among smart transportation initiatives in particular and smart cities initiatives in general. For instance, promoting cycling is listed as main objective of initiative on smart cities.

In recent times, the permanent magnet synchronous motors have been increasingly employed to substitute brush DC motors as actuators for scooters. However ,the latter possess many merits, such as simple in motor structure and power converter, better control technology, having excellent torque generating capability etc.

Storing of energy is the key factor in EV or HEV model, so appropriate secondary batteries must be opted as they are the main source of energy for successful operation of EV's. These days, bi-directional converter used in electric vehicles offer energy storing in battery as well as charging feature. The non-isolated converters are classified into buck, boost and buck boost types, which are economical, compacted, without transformer and simple control mechanism since it has a common ground.

With proper selection of current controller time delay and the corner frequency of PI controller can be determined. For proper operation, the rotor frequency must be designed to be working in the specified range. By tuning controller parameters, the range of the operating speed can be appropriately implemented, not only speed up the design but also reduces the time in implementing speed controller.

II. OBJECTIVE

- The model is designed for the investigation of both the instantaneous and the overall performance of direct-drive brushless dc hub motor electric bicycle drive systems under different riding conditions. To this aim, it allows:
- Investigation of various instantaneous drive parameters, such as motor current, voltage, torque, remaining battery energy, and system efficiency.
- Overall performance evaluation of the drive over a given driving cycle, such as system efficiency and total power consumption.
- Investigation of the influence of controller, battery, and motor parameters on the different drive parameters. For example, battery internal resistance, motor inductance and resistance. Thereby, modifications to better meet the demands of custom-designed electric bicycles can be identified and verified.

Here, only direct-drive systems with brushed dc-motors of fully-powered electric bicycles are considered. However, the model can be extended at a later stage to include brushless dc motors and/or the additional control of the output power due to therequired human-to-motor power ratio of "pedelec"- type electric bicycles. With "pedelec"-type electric bicycles, only a certain pre-determined, speed-dependent fraction of the bicycle propulsion power is delivered by the drive.

III. EXISTING SYSTEM

- A bicycle, also called a cycle or bike, is a human-powered, pedal-driven, single-track vehicle, having two wheels attached to a frame, one behind the other.
- From the beginning and still today, bicycles have been and are employed for many uses. In a utilitarian way, bicycles are used for transportation, bicycle commuting, and utility cycling. It can be used as a 'work horse', used by mail carriers, paramedics, police, messengers, and general delivery services.
- Bicycles can be categorized in many different ways: by function, by number of riders, by general construction, by gearing or by means of propulsion.
- Since it is a complete human powered, consistency may not be same for longer period and long distance travelling may become burden to the rider.

3.1 PROPOSED SYSTEM

- The bicycle has undergone continual adaptation and improvement since its inception. These innovations have continued with the advent of modern materials and computer-aided design, allowing for a proliferation of specialized bicycle types, improved bicycle safety, and riding comfort.
- An electric bicycle, also known as an e-bike, power bike or booster bike, is a bicycle with an integrated electric motor which can be used for propulsion
- Proposed e-bikes uses rechargeable batteries and the lighter ones can travel up to 25 to 32 km/h (16 to 20 mph), depending on external factors, while the more high-powered varieties can often do in excess of 45 km/h (28 mph).
- The proposed e- bicycle uses a BLDC motor for electric power assistance with speed controlling units.
- e-bikes combine both pedal-assist sensors as well as a throttle, which helps rider to save his/her energy by using either of the options for bicycle propulsion.
- Proposed system is one of the economical way of controlling environmental pollution as well as a good solution for traffic issues.

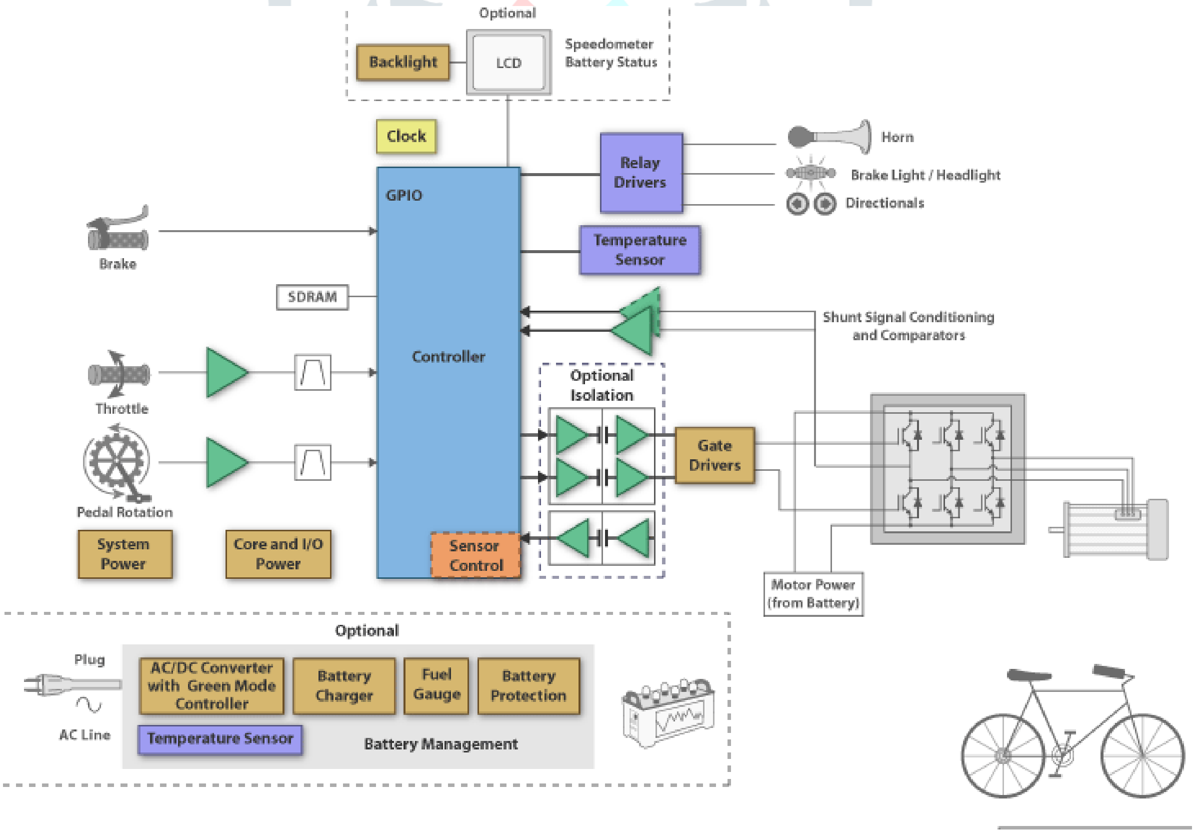

Fig 1: Block diagram of the proposed machine

Circuit Diagram

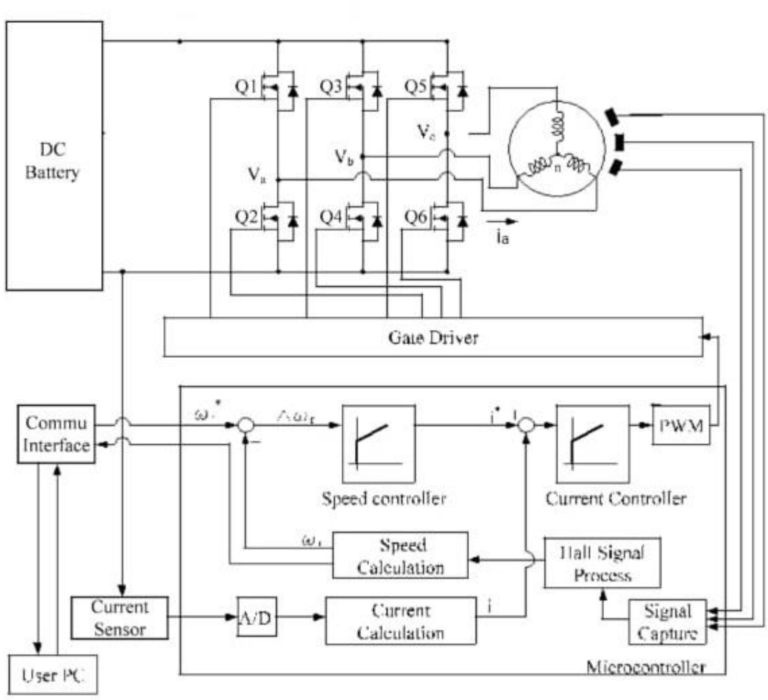

Fig 2- The system structure of electric bicycle

3.2 PID Controller

A proportional–integral–derivative controller (PID controller or three-term controller) is a control loop feedback mechanism widely used in industrial control systems and a variety of other applications requiring continuously modulated control.

In practical terms it automatically applies accurate and responsive correction to a control function. An everyday example is the cruise control on a car, where external influences such as hills (gradients) would decrease speed. The PID algorithm restores from current speed to the desired speed in an optimal way, without delay or overshoot, by controlling the power output of the vehicle's engine.

The first theoretical analysis and practical application was in the field of automatic steering systems for ships, developed from the early 1920s onwards. It was then used for automatic process control in manufacturing industry, where it was widely implemented in pneumatic, and then electronic, controllers. Today there is universal use of the PID concept in applications requiring accurate and optimized automatic control.

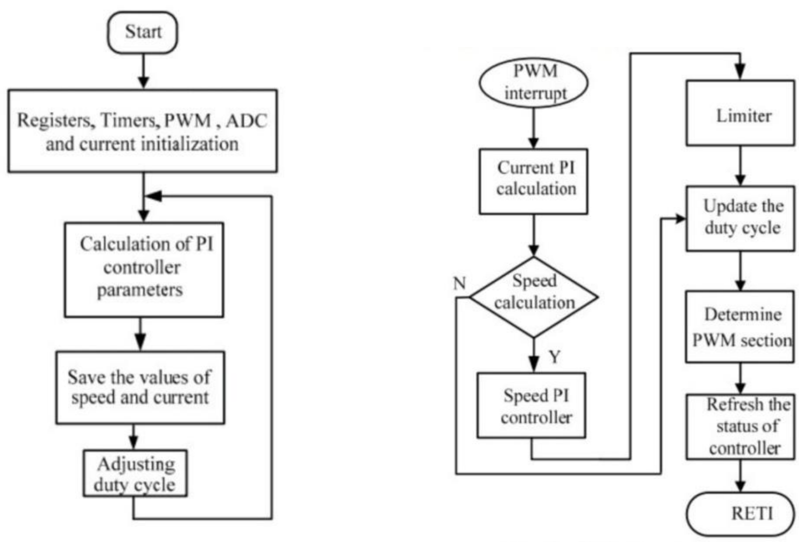

Fig 3- Flow chart for working of PI controller

IV. COMPONENT DESCRIPTION

4.1Brushless DC electric motor

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors), or synchronous DC motors, are synchronous motors powered by DC electricity via an inverter or switching power supply which produces an AC electric current to drive each phase of the motor via a closed loop controller. The controller provides pulses of current to the motor windings that control the speed and torque of the motor.

The construction of a brushless motor system is typically similar to a permanent magnet synchronous motor (PMSM), but can also be a switched reluctance motor, or an induction (asynchronous) motor.

The advantages of a brushless motor over brushed motors are high power to weight ratio, high speed, and electronic control. Brushless motors find applications in such places as computer peripherals (disk drives, printers), hand-held power tools, and vehicles ranging from model aircraft to automobiles.

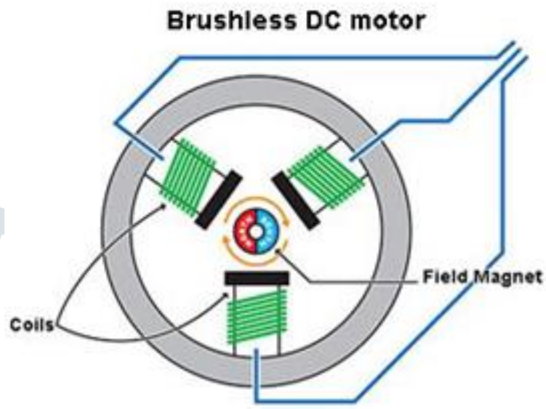

Fig 4: Brushless DC motor

4.2 Batteries

E-bikes use rechargeable batteries, electric motors and some form of control. Battery systems in use include sealed lead-acid (SLA), nickel-cadmium (NiCad), nickel-metal hydride (NiMH) or lithium-ion polymer (Li-ion). Batteries vary according to the voltage, total charge capacity (amp hours), weight, the number of charging cycles before performance degrades, and ability to handle over-voltage charging conditions. The energy costs of operating e-bikes are small, but there can be considerable battery replacement costs. The lifespan of a battery pack varies depending on the type of usage. Shallow discharge/recharge cycles will help extend the overall battery life.

Range is a key consideration with e-bikes, and is affected by factors such as motor efficiency, battery capacity, efficiency of the driving electronics, aerodynamics, hills and weight of the bike and rider. Some manufacturers, such as the Canadian BionX or American Vintage Electric Bikes, have the option of using regenerative braking, the motor acts as a generator to slow the bike down prior to the brake pads engaging. This is useful for extending the range and the life of brake pads and wheel rims.

4.3 List of components required

Table 1: list of components

SL.NO	Components name	Rating
1.	Cycle body	
2.	Hub motor	250W,60V, 18Amps
3.	Li-Ion Battery	60V,18Amps
4.	MOSFET Drive and Controller	90V,30Amps
5.	Throttle and cable set	
6.	Speedometer	
7.	LEDs	3.5V

V. ADVANTAGES

1. More efficient compared to regular DC motor driven bicycle
2. Eco friendly and better option to reduce fossil fuel consumption
3. Economical when compared to fueled vehicles
4. Power on demand makes it more flexible
5. Maintenance is less frequent and less expensive
6. They are very quiet
7. You will get tax credits
8. Speed up to 40kmph can be achieved with load up to 100kg

VI. DISADVANTAGES

1. Complex driver design compared to DC drive
2. BLDC motor requires high initial investment
3. Pretty short range
4. Recharging can take a while
5. Not much charging stations are available

VII. RESULTS AND DISCUSSIONS

Every proposed project has a thought or purpose behind it. The major objective of this project is to design and to implement a boost converter and also BLDC motor drive board applied for electric bicycle. The proposed converter, which integrates motor driver and battery charger to improve system performance, but also reduce component count to reduce the overall cost. And then, a driving, charging and electric capacity estimation strategies are all embedded in proposed the system to promote system reliability.

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