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Control of Segway Personal Transporter for Emission Reduction using BLDC Motor-Spindle Dynamo System

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ABSTRACT

In recent days, utilization of electric vehicles has been emphasized in transport systems, where regenerative braking is possible. Further, existing brushed dc motor based transport systems have various drawbacks such as regular maintenance, low efficiency and produce sparks in brushes. It is known that the brushless direct current (BLDC) motor have smooth speed control, high power density, less maintenance, less complexity in power converter and its associated controllers. Hence, in this paper, the BLDC motor based Segway personal transporter system has been proposed for reducing carbon emission and also to accomplish regenerative braking. The proposed system consists of a BLDC motor, Spindle dynamo, Power Converters and digital controllers. The power circuit of the system has been designed using power electronics switches along with the gate driver circuits. The battery charging and discharging has also been incorporated using semi-conductor switches and hence the efficiency of the system has been improved.The overall control strategy has been implemented using ATMEGA8 digital controller. The performance of the proposed system has been analyzed, simulated and various modes of operation results have been clearly brought out in this work.

Key words: *ATMEGA8 digital controller, brushless direct current (BLDC) motor, Power Converters, Segway personal transporter, Spindle dynamo.*

I. INTRODUCTION

A Brushless Direct current (BLDC) motor consists of three-phase concentrated windings on the stator and permanent magnets on the rotor [1-7]. Lhommeet *al.* have proposed a system consists of various components such as Battery, Dynamo as a wind generator, the BLDC engine, controller, charging framework and sun oriented board for traction applications [8]. Kim and Choi have proposed a system for development of electric vehicle. The rate of improvements in technologies is at an exponential level despite that the electric bicycle is a concept that has been very feasible for years but has not been fully explored [9]. Khaligh and Li have proposed a system based on the charging arrangement on the e-bike. The motor is use the electric energy from battery and battery can receive electric energy from dynamo [10]. The system description of the proposed system is given in Section II. Further hardware description and results are presented in succeeding sections.

II SYSTEM DESCRIPTION

Fig.1 shows the block diagram of the proposed system. It consists of a dynamo, boost converter, switching device, battery, three-phase inverter and BLDC motor. During starting condition power supply of the motor is taken from the battery. After the motor picks up the speed (25% of rated speed) the power supply is taken from the dynamo for motor operation. If the power from the dynamo is less than the rated power of the motor then motor is powered through the battery.

Initially 12 V AC is step down to 6 V using transformer and its given to the bridge rectifier. The output from the bridge rectifier is regulated to 5 V and it is used as a supply for ATMEGA8 controller.

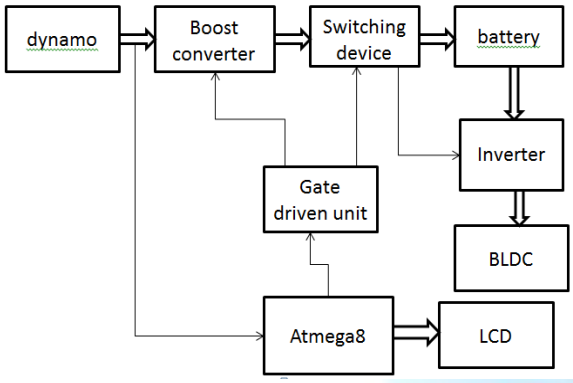

Fig 1 Block diagram

III MODES OF OPERATION

Depends on the ATMEGA8 feedback signal, the operation of the circuit can be explained in two modes.

3.1 Mode 1

At the time of starting, the motor is supplied from the battery. When the motor reaches its 25% of rated speed, the coupled dynamo is generated the power and the generated power output from dynamo is goes to boost converter. Later boost converter voltage is boosted and is given to the microcontroller as a feedback signal. ATMEGA8 controller checks whether the power generated from the dynamo is sufficient to run the motor then the power goes to S2 MOSFET switch, PWM inverter and run the motor.

If it is not sufficient power from the generator-dynamo then the motor enters into mode 2 operation.

3.2 Mode 2

When the developed voltage from the dynamo is insufficient, the controller is cut off the S2 MOSFET switch. Then turn ON switches S1 & S3 and hence the boost converter output is goes via S1 & S3 switches. The output power/voltage is added with battery power and this S3 output power is sufficient to run the motor and this operation continues till the mode 2 condition exists.

IV HARDWARE DESCRIPTION

Fig. 2 shows the photograph of the power circuit.

4.1 ATMEGA8

The ATMEGA8 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density non-volatile memory technology and is compatible with the industry-standard 80C51 instruction set and pinot. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

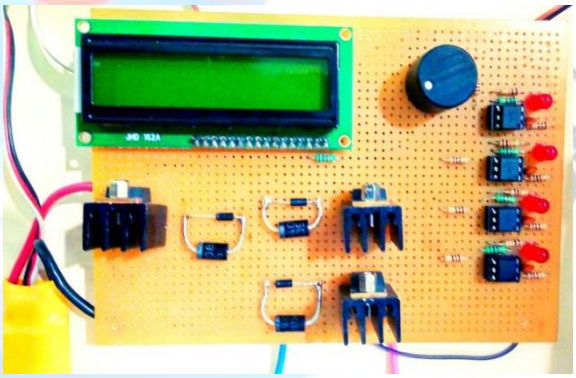

Fig. 2. Photograph of the power circuit

4.2 BLDC

The rotor is the rotational part of the motor while the stator is the stationary part. Structurally the stator assembly surrounds the rotor. Embedded into the side of the rotor are permanent magnets, external is the fan propeller blade. The motor coil is part of the stator assembly, and is placed inside the rotor. Brushless DC motor utilizes hall-effect sensors to provide positional and rotational information, which informs the logical inverter to drive the motor coil. Brushless dc motor usually come in fixed voltage type ,such as 5 V, 6 V ,12 V, 24 V, 48 V etc, with one of the most common ones in use being the 12 V type. When the rated voltage

is applied to the motor it will rotate with maximum speed, but by changing this applied voltage the motor speed can be controlled naturally, the voltage is higher and then speed is higher and vice versa. The brushless DC motor is essentially configured as a permanent magnet rotation past a set of current carrying conductors.

In brushless DC motor, the polarity reversal is performed by power MOSFET's, which must be switched in synchronism with the rotor position. The stator is normally 3- phase star connected. Each commutation sequence has one of the winding energized to positive power (current entering into the winding) and the second winding energized to negative power (current exits the winding) and third winding non- energized. Torque is produced by the interaction of the magnetic field produced by the stator winding and the permanent magnets. To build a brushless motor, the current-carrying coils must be taken off the rotating mechanism. In their place, the permanent magnet will be allowed to rotate within the case. The current still needs to be switched based on rotary position

4.3 Dynamo

A vehicle dynamo is a type of generator attached to a Vehicle to produce electricity for the vehicle's lights. The Top of the dynamo touches the tire's rim, which spins when the vehicle starts moving. Currently, the term dynamo refers to mechanisms that are capable of producing direct current, Such as the small devices fitted to vehicles to generate Power for the lights. The Device consists of a stationary part called a stator and a Rotating part called an armature. When the coil spins in the Magnetic field created by the magnets, the magnetic flux Begins to change trough the coils, resulting in an electric Field that generates the charge carriers through the wire. This process produces an electric current. Fig. 3 shows the view of spindle dynamo and Fig. 5 shows the photograph of prototype model developed in the laboratory.

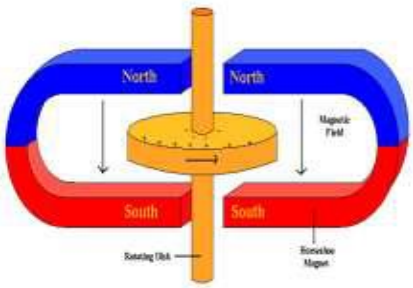

Fig. 3. View of Spindle Dynamo

4.5 Battery Specifications

Table 1.Shows the specifications of lead-acid battery.

Specifications	Ratings
Model number	OPTI 7
Voltage	12 V
Current	7 AH
Charge settings	25°C

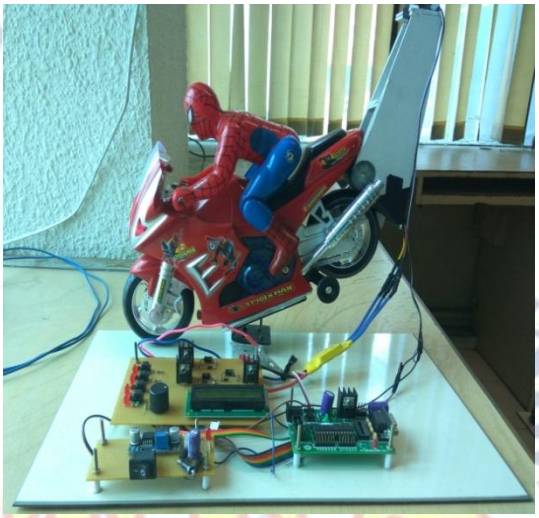

Fig. 4. Photograph of prototype model

V CONCLUSIONS

A new configuration of dynamo coupled BLDC motor has been proposed for E-vehicle personal segway transporter systems. The speed control of the BLDC motor has been achieved by Hall-effect sensor. This has facilitated the operation of dynamo to generate the power by using the switching mode. The dynamo has been designed along with BLDC motor to accomplish regenerative breaking mode of operation. ATMEGA8 digital controller has been deployed for implementing the closed loop control strategy.

The proposed BLDC-Dynamo system has been implemented for E-vehicle transporter applications for reducing carbon emissions. The results obtained on the proposed system further demonstrate the successful working and usefulness of its application for personal transporter systems using BLDC-Dynamo system.

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