International Journal of Applied Engineering and Technology ISSN: 2277-212X (Online)
Online International Journal Available at http://www.cibtech.org/jet.htm
2020 Vol. 10, pp.248-253/Anbalagan et al.
***Research Article** (Open Access)*

REGENERATIVE BRAKING IN SOLAR E-BICYCLE

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ABSTRACT
This paper proposed with a purpose of invoking Regenerative Braking System for E- Bicycle. Ensuring that the maximum energy is utilized by charging the battery using Regenerative Braking system. RBS involves converting mechanical energy into Electrical energy during braking action. Basic idea of RBS is that energy lost while applying Frictional Braking is utilized by replacing it with an electrical braking with a control strategies. Using RBS the endurance of E-vehicle can also be increased. A solar panel module is also used to further reduce the fuel cost considerably. Major component of this project are BLDC motor, battery pack of required capacity depend on our speed and distance requirement, speed controller circuit, a light weighted frame, and also a power meter to make sure power is properly utilized between battery and motor.

Keywords: *BLDC Motor ,RBS, Braking E-Bicycle.*

INTRODUCTION
We are in the world of development. In were which the most of the development depending on electricity so there is a requirement for producing more electricity. We are producing electricity through renewable and non-renewable resources. In which everyone is preferring for renewable resources because they are naturally available and which will not affect the environment by polluting. So now-a - days transportation were changing to renewable resource powered locomotives in which solar power were the most advanced and highly effective resources used or preferred. The E-bike were developed and used for pollution free transportation. However they are pollution free but the short driving range is not appealing for its users. Overcoming this limitation is an achievement of this E-world era.

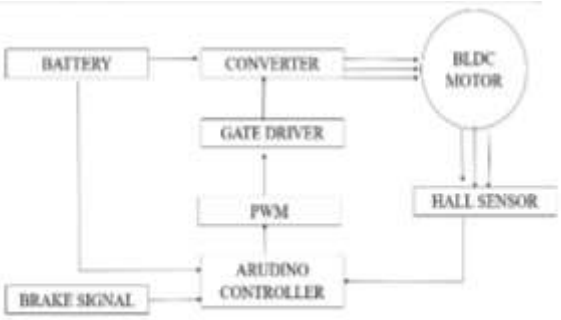


Figure: circuit diagram

How we were going to increase the driving endurance is the most important issue. Due to this reason that electric cars were less popular. The other major point to consider is the charging technology the charging is depends on the battery we are using to run our vehicles. The most cheap battery available in the market are lead-acid battery which is used to sale major e-cycle in low cost.

There are some other battery also available like lithium ion battery which is mainly used in low power applications, because they are costly and difficult to manufacture in huge capacity for e-cars. So to use electricity efficiently our time can be invested on such revolutionary methods. Thus our paper is proposed on regenerative braking controller. Which help in converting the kinetic energy into electrical charge and stored using a battery while applying brakes, thus it will improve the range we travel, along with improved performance of E-bicyle.

There are different method available for regenerative braking .Most commonly method of applying RBS is through adding an extra converter circuit along with super capacitor banks. but this kind of circuit didn't required any dc-dc converter instead of that capacitor voltage sensing sensor are required this lead for more cost investment. In advanced research sensor less ultra capacitance voltage measure is been introduced but the strategy was so complex to understand reproduced it.

The main idea of this paper is converting the kinetic energy produced while applying the brake into Re- usable Energy (electrical energy).which is stored in Battery, It increase the driving endurance of electric bicycle. This convertion is processed by a control unit when brake is applied the brake signal is received by controller and motor can work as generator and energy generated can be stored in battery. Other process or the experiment and results were followed in next sections.

BLOCK DIAGRAM

The 24v dc supply is given to the converter circuit which is nothing but Three phase inverter circuit with six MOSFET as switches and which is triggered using gate triggering circuit and the fed to BLDC motor

The T1~T6 Mosfetused as power switches and the E1,E2,E3 are the equivalent BACK-EMF of the phase 1,2&3 respectively with i1,i2,i3 as current. There are several modes of operation Normal mode , Regeneration mode.

DIFFERENT TYPES OF MODE:

MOTOR MODE:

In the motoring mode ,the power MOSFET T1~T6 were used as a three phase inverter switches, were the supply is through battery to drive motor. Were as in three phase inverter mode there are several switching operation done to drive the motor.

TheT1&T4were tuned ON at the same time in which the energy form battery fed through T1-T6 to motor at the same time at this point the energy is stored in the motor armature inductor. Which lead for the increase in current in the inductance and due to this the back EMF will also be increased .which affect in the generating mode to charge battery, to over come this effect t1 is switched off.

Similarly the other MOSFET were turned on and the inductor is energised and led for motoring operation. The position of motor is sensed through hall sensor. The main point in inverter operation is the same leg should not be operated at the same time which lead for short circuit and there is a need for replacement of entire controller kit.

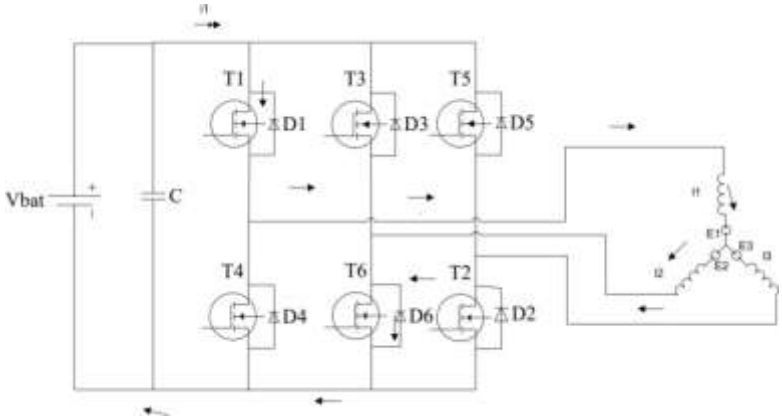
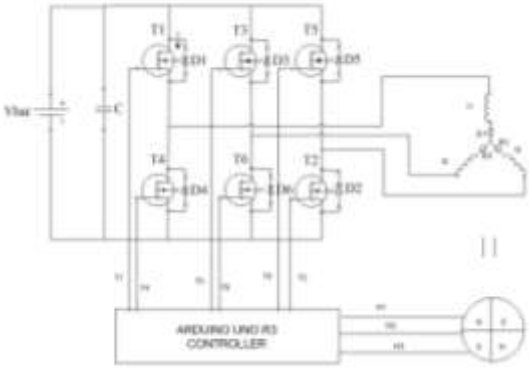


Figure: motoring mode

Regeneration mode



This is the mode were motor operate as a generator. This mode is activated when the barking signal is received by the controller the switch over's to generating action. This mode the energy form the BLDC motor back EMF is been the voltage source to charge battery. Even though the maximum BACK- EMF will be lesser then the battery even at motor highest speed .And the motoring action

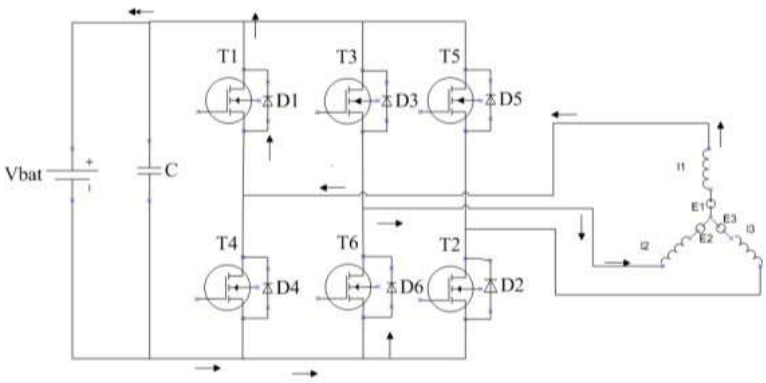


Figure: regenerative mode

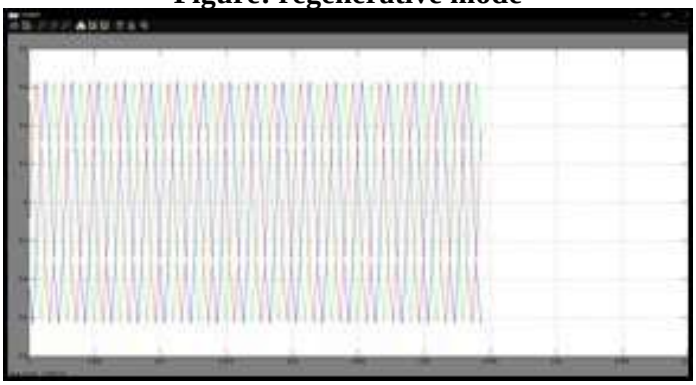


Figure: inverter circuit with motor in matlab

though switching increases the energy stored in the armature inductor of the motor.
When T1&T6 were tuned ON at the same time in which the energy form battery fed through T1-T6 to motor at the same time at this point the energy is stored in the motor armature inductor. Which lead for the increase in current in the inductance and due to this the back EMF will also be increased.

At the time the brake is applied at this point the motor voltage is higher then the battery voltage,T1 will be turned off and the brake energy will charge the battery through D6 and D1.
Similarly the other mode conduction at the point of braking the right diode is get conducted and energy is stored in the battery.

EXPERIMENTAL RESULT ANALYSIS

The experiment is done using some specified bldc motor
Motorvoltage 24v
MotorRated current
16amps Motor Watts250w
Motor Rmp 300 Motor Troque 5Nm
Battery lithium ion 24
As before going into the motor experiment some simulation as been simulated.
The inverter circuit is simulated with plus generator with the BLDC motor(in simulation sync - permanent magnet motor with trapezoidal back-emf)
The mode of operating is manually assigned and the output of inverter circuit is verified. The motor which is used here is 24V/16A 250W brushless dc motor which as the no load current 2.2A which operate at the 300rpm the Back-EMF which is to be trapezoidal

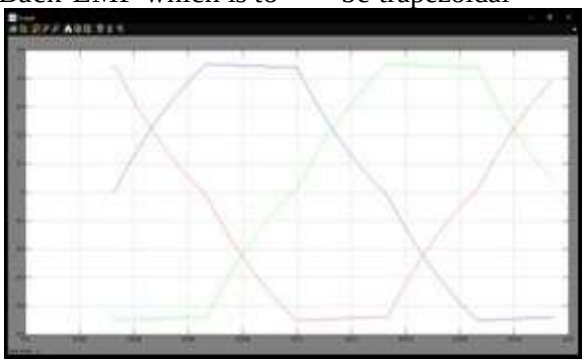


Figure: back-EMF form bldc motor

The controller which consist of six Mosfet (IR5400n) three gate driver (TLP250) and the arduino uno r3 which as ATmega328p microcontroller in which the comparator program is to be written and they should perform the speed variation in the bldc motor

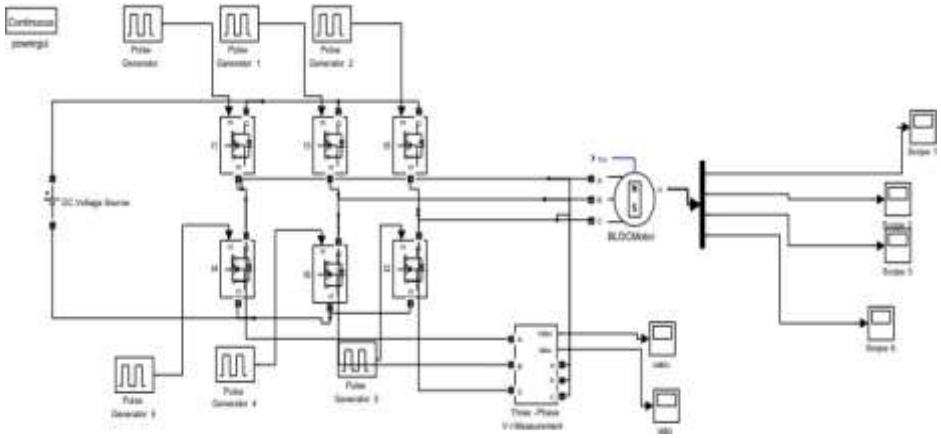
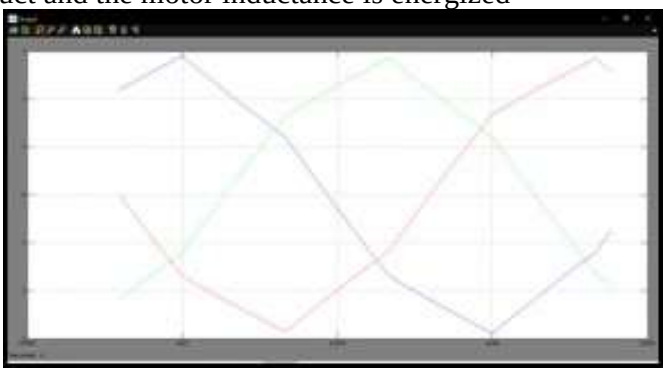


Figure: waveform of back emf voltage

Through which only the motoring and regenerative braking system mode is activated and performed .the arduino generate the PWM. This signal is fed to gate driver and theMosfet driver fed to the Mosfet and which conduct and the motor inductance is energized



The position of the motor is sensed by the hall sensor and the signal is given to the controller and the brake signal is also signalled to the controller then both the signal compared and the required PWM signal is generated.

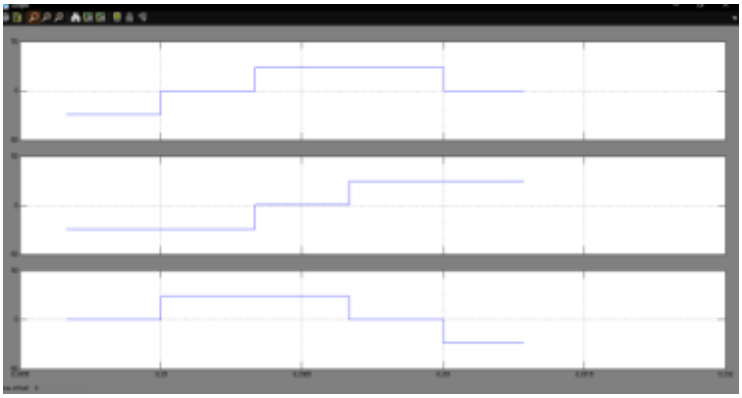


Figure: triggering signal

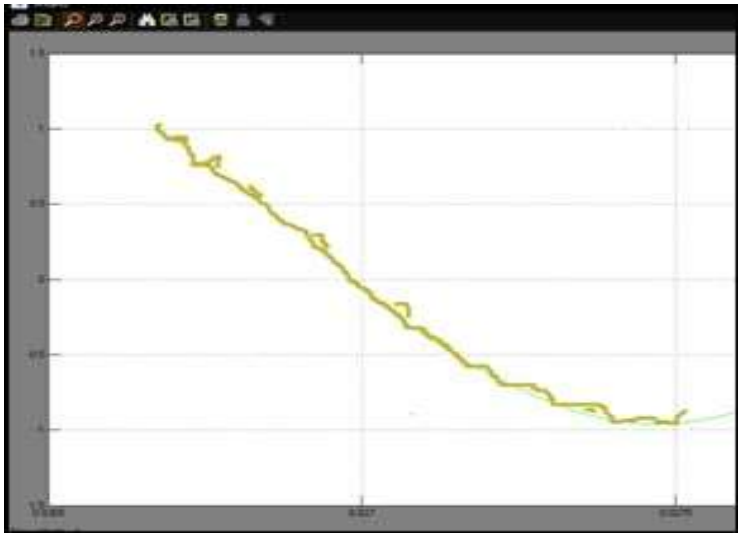


Figure: regenerative braking current

The triggering signal is given in the regular interval the Mosfet is conducting period. Through the experimental results the regenerative braking is high at the continuous and regular interval braking .Mostly the regenerative braking is full effective in downhill.
Regenerative current is fully depend on how long the bake is been applied and the kinetic energy is converted and stored in the battery.

CONCLUSION

In this paper is prepared with the idea of effective braking and kinetic energy stored while applying brake is converted intoelectrical energy and stored in battery.Whichis recovered with the same 3inverter circuit by sensing brake signal and the controllerturn off the switches and the energy is recovered. There is no need of external circuit or any other component like supercapacitors.Through this energy recovery system the endurance of E-bicycle can beimproved.

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