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RENEWABLE ENERGY BASED INTERLEAVED BOOST CONVERTER FOR THE APPLICATION OF BLDC MOTOR

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Abstract- *To increases the power generation capacity as the electrical energy consumption is increasing day by day. As non-renewable fuels are going to extinguish, that's why we are focused toward renewable energy which is the best option now a days. There are so many options to produce electrical energy using renewable energy such as solar, wind and tidal, etc. from this the best form of energy is solar energy. Solar energy is available abundant form and free in nature. But the renewable energy is irregular because of which its output and efficiency as compared to non-renewable energy. So we have provide the proposed method to increase the renewable energy i.e. solar energy by means of interleaved boost converted (IBC), by connecting two identical boost converters in parallel which has same switching frequency and phase shift. As a result the interleaved method use increases output voltage along with efficiency, improve reliability, reduce current peak value, reduces ripple and have good current sharing characteristics. To show the application of IBC here BLDC motor is used whose speed is controlled by using ESC and micro-controller. The proposed method is successfully verified along with hardware implementation.*

***Key Words*: Solar panel, IBC, Battery, ESC, Arduino Uno, Potentiometer, BLDC motor**

1. INTRODUCTION

The demand for power generation capacity is increasing day by day; to meet this demand without harming the environment can be done by means of renewable energy source due to their effective operation and no pollution. Since the output of renewable energy i.e. solar energy is less we cannot fulfil the demand. If we want to fulfil the demand then number of panels are required, large area is required for installation, complexity is increased in operation and cost also increases which ultimately make it uneconomical to install in commercial and domestic level. Hence to fulfil this demand and overcome above disadvantages, by connecting an IBC to the solar panels. The solar energy gives output voltage and interleaved method will boost up this output voltage level and efficiency is also increased. By using two boost converter the level of both voltage and current is increased, the IBC consist of MOSFET's which has same frequency and phase shift due to number of phases having less output current and it depends upon duty ratio.

2. LITERATURE SURVEY

1. Kachare Vishal Vilas (14EE16), Yesade Vivek Dhanaji (14EE46), Karel Ubaid Akhalakh Ahmed (14EE47), Khalfay Aaimaan Nisar (15DEE32) "Renewable Energy Based Interleaved Boost Converter" AIKTC, University of Mumbai, 2017-2018 in this paper there is a demand to increase the power generation capacity because of steadily rising electrical energy consumption. In order to achieve this, renewable energy sources are the best option. Among all the renewable energy sources, solar power generation system tops the list. For increasing the output of these sources we need a suitable boost converter. Interleaved boost converter (IBC) is one of such converter which consists of several identical boost converters connected in parallel and controlled by interleaved method. IBC is more advantageous over conventional boost converter. The proposed method provides the increased output voltage along with efficiency. Here, in this work we have also shown the application of IBC in running BLDC motor. The proposed strategies have been verified with the help of MATLAB/SIMULINK along with the hardware implementation.

2. Pradeeppakumara V., Nagabhushan Patil "Renewable Energy Based Interleaved Boost Converter" International Research Journal of Engineering and Technology (IRJET), volume 3, issue 7, july-2016 in this paper to meet the demand of increase power generation capacity, renewable energy power generation is used as it does not harm the environment. For this solar energy source is used but the energy is obtain in irregular form. For increasing the output of these sources Interleaved boost converter (IBC) is used which is one of such converter, which consists of several identical boost converters connected in parallel and controlled by interleaved method. IBC is more advantageous over conventional boost converter. The proposed method provides the increased output voltage along with efficiency. Here, in this work we have also shown the application of IBC in running BLDC motor. The proposed strategies have been verified with the help of MATLAB/SIMULINK along with the hardware implementation.

3. PROPOSED METHODOLOGY

The basic proposed method of this project is to increase the output power and efficiency of renewable energy that is solar energy. We have implemented our project by connecting a battery between IBC and ESC which controlled BLDC motor and makes the project to a boost up level than the previous proposed work implemented on this project. Due to this implementation on this project we have increased the output voltage to a very high level also by connecting a Arduino Uno we have dumped a programming to control the speed of motor. The programming is dumped in Arduino which has inbuilt microcontroller (ATMEGA328p) in it. The Arduino reduces the complexity. The fluctuating voltage at different level is considered and the result will be obtained which has maximum efficiency as output voltage is increases.

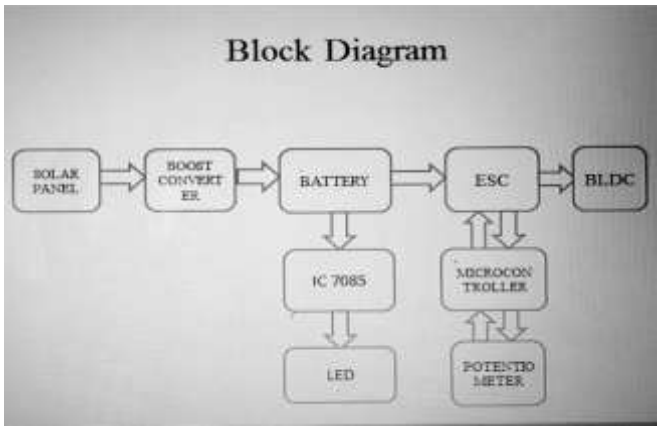

Fig.3.1. Block Diagram of Renewable Energy Based Interleaved Boost Converter for the Application of BLDC motor

The working of project can be divided into 4 parts. One part is the renewable energy that solar where solar panel is used. Second part is power station where battery is used, Third part is the controlled unit IBC, ESC, microcontroller and potentiometer, and fourth part is the load where BLDC motor is used. The Solar panel used in the project can provide the voltage at a range of 1.3V to 3V and current in milli ampere. This input voltage is feed to boost converter, here two boost converters are used to form interleaved boost converter. The interleaved boost converter will boost up the voltage as well as the current to the range of 5v to 35v and 2A. This power is feed to power station. Where three batteries are used in series of 4 to 4.5V forms a voltage range of 12 to 13V and the battery gets charges through IBC. When IBC Switch is ON and the battery will feed the power to ESC (Electronic Speed controller). Here a switch is used to turn ON /OFF microcontroller ATMEGA328p which is embedded in arduino Uno. The 12V provided to ESC is feed to arduino, to provide supply to the microcontroller. A programming is dumped in ATMEGA328p for controlling the speed BLDC motors which is of 1000KV. As soon as the switch of arduino in ON, the programming dumped will compare the speed of BLDC motors and variation input is provided by potentiometer. So by varying potentiometer we can control of BLDC motors. Here an LED is used for indication proposed to show whether the power station is connected to system of not for that a 7805 IC is used connected with battery (8V) and LED. The LED glows when the power station is connected.

3.1 Components and Description

A. Solar Panel

Photovoltaic comes from the words photo, means light and volt, a measurement of electricity. Solar cells are made up of silicon, the same substance that makes up sand. Silicon is the second most common substance on earth. Photovoltaic solar panel absorbs sunlight as a source of energy to generate direct current dc electricity. The action of the electrons starts to flow an electric current. A photovoltaic module is a packaged, connected assembly of PV solar cells available in different voltages and wattages. PV modules constitute the PV array of a PV system that generates and supplies solar electricity in commercial and residential application. The solar panel used in our project is of mono-crystalline. These types of panels are made up of silicon wafers. To build them wafers are assembled into rows and columns to form a rectangle which is covered with a glass sheet and framed together. In these types of panel's solar cells are made from cut of a single pure crystal of silicon. The panel used is of ratings 1.3W, 1.3V to 3Vand current in milli-ampere. The advantages of these panels are require less space for installation, higher efficiency of 19% than other panels to maximize the energy bill saving.

Fig. A. Solar Panel

B. Interleaved Boost Converter

Interleaved boost converter (IBC) is one of such converter which consists of several identical boost converters connected in parallel and controlled by interleaved method, which has same switching frequency and phase shift. The advantages of using IBC over conventional boost converter are increased efficiency, improved reliability, reduced current peak value and these converter cells have good current sharing characteristics. The boost converter consists of inductor of 470mH, capacitor of 220micro-F in input side and 100micro-F in

output side, potentiometer of 10Kohm, and MOSFET XL6009.

The single boost converter will boost up the voltage at the range of 5V to 35V but the current will get reduced, hence to increase the current level another boost converter is connected in parallel which provide a 2ampere current in output. This method of connecting number of boost converters in parallel is called as interleaved method. The XL6009 regulator is a wide input range, current mode, DC/DC converter which is capable of generating either positive or negative output voltages. It can be configured as boost, fly back, SEPIC or inverting converter. The XL6009 built in a N-channel power MOSFET and fixed frequency oscillator, current-mode architecture results in stable operation over a wide range of supply and output voltages. The XL6009 regulator is special design for portable electronic equipment applications.

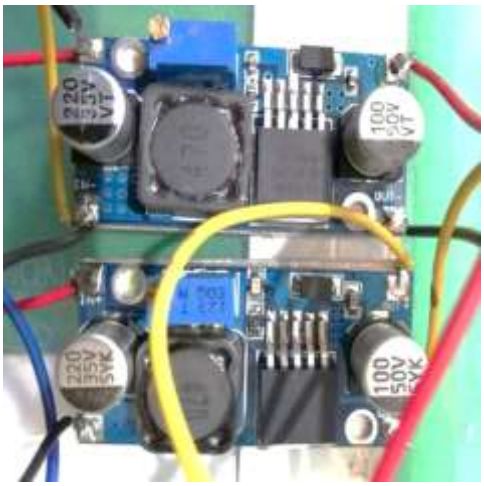

Fig. B. Interleaved Boost Converter

C. Battery

The battery used in this project is sealed lead –acid rechargeable battery of 4 volt and 1.0Ah. The battery is used to store the energy in the form of electrochemical energy. According to the construction of battery the liquid electrolyte is gelled into moistened separators and the enclosure is sealed. Safety valves allow venting during charge, discharge and atmospheric pressure changes. A battery consists of two voltaic cells. Each cell consist of two half cells connected in series by a conductive electrolyte containing metal cations. One half cell includes electrolyte and negative electrode that is anion which is negatively charged ions and the other half cells includes electrolyte and the positive electrode which is cations that is positively charged ions. Each cell has an electromotive force in it. The optimum operating temperature for lead-acid battery is 25^0C and it has a life of 5years.

Fig. C. Battery

D. Electronic Speed Controller

An electronic speed controller or ESC is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor and dynamic braking. Most modern ESC contains a microcontroller interpreting input signal and appropriately controlling the motor using a built – in program or firmware. This is done generally to adapt the ESC to a particular application. ESCs are normally rated according to maximum current here in this project we are using 30A ESC. An electronic speed controller follows a speed reference signal it can be a manual input and varies the switching rate of a network by field effect transistors (FETs). By adjusting the duty cycle or switching frequency of the transistors, the speed of the motor is changed. The speed of the motor is varied by adjusting the timing of pulses of current delivered to the several windings of the motor. Brushless ESC systems basically create three phase ac power to run the motor. The correct phase varies with the motor rotation, which is to be taken into account by the ESC; basically back emf from the motor is used to detect this rotation. Computer-programmable speed controls generally have user-specified options which allow setting low voltage cut-off limits, timing, acceleration, braking and direction of rotation.

Fig. D. ESC

E. Arduino Uno

Arduino circuit board with arduino IDE are capable of reading analogy or digital input signal from different sensor, activity the motor, turning LED ON/OFF and do many other such activities. The arduino Uno performs all the functionalities by sending a set of instructions to the ATMEGA328pmicrocontroller which is the main microcontroller and the software used for dumping the programming is arduino IDE. The arduino board includes power USB, Voltage regulator, crystal oscillator, The

voltage Pin (3.3V,5V,gnd,Vin),A0 to A5 analog pins ices pin, power led indicator, Tx & Rx led's , 14 digital input/output pins, Aref, and Arduino reset. From this pins two gnd, 5V, A_0, D_9 pins are used in the project to take input from potentiometer and take and provide control on ESC.

Fig. E. Arduino Uno

F. Potentiometer

A potentiometer is a three terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat here the potentiometer used is of rating 47Kohm and it is a type of slider pot which is adjusted by sliding the wiper left or right. In the construction of potentiometer consist of a resistive element, a sliding contact i.e. wiper that moves along the element, making good electrical contact with one part of it, electrical terminals at each end of the element, a mechanism that moves the wiper from one end to the other, and a housing containing the element and wiper. The resistive element is made up of graphite. Potentiometer can be used as position feedback devices in order to create closed loop control. This method of motion control used in the dc motor is the simplest method of measuring speed angle and displacement.

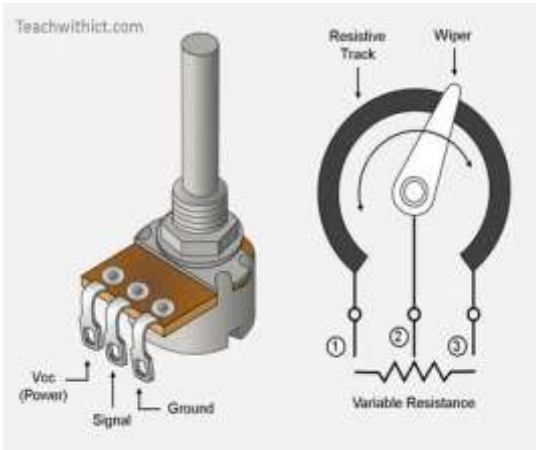

Fig. F. Potentiometer

G. Brushless DC Motor

A brushless DC motor also known as BLDC motor is an electronically commutated DC motor which does not have brushes having ratings:-1000KV, 150W and 12000 rpm. The controller provide pulses of current to motor winding which controls speed and torque of synchronous motor. These types of motors are highly efficient in producing a large amount of torque over a vast speed range. The BLDC motor consists of two main parts stator and rotor. Stator is a stationary parts contains stator winding and rotor consist of rotating part having permanent magnet. The working of BLDC motor is same as that of Permanent Magnet Synchronous Motor (PMSM). In BLDC, permanent magnets are attached in rotor and move the electromagnet to the stator. The high power transistors are used to activate electromagnets for shaft turns. The controller performs power distribution by using a solid state circuit. In our project the BLDC motor is of Inner Rotor Design. As rotor is located in core, rotor magnets do not insulate heat inside and heat get dissipated easily. Due to this, motor produces a large amount of torque.

Fig. G. Brushless DC Motor

3.2 Circuit Diagram

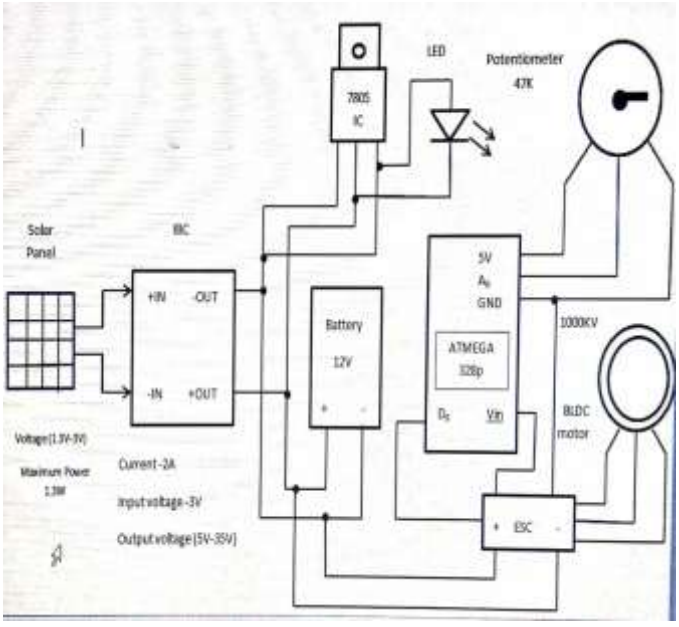

Fig.3.2: Circuit diagram of Renewable Energy Based Interleaved Boost Converter for the Application of BLDC Motor

The solar panel of 1.3V-3Vtwo terminals are connected to input terminals of IBC i.e. +IN and -IN terminal of IBC. In IBC the input power is boosted up and the output of IBC is provided to battery through output terminals +OUT and –OUT, to S positive and negative terminal of battery. The output voltage range of IBC is 5V to 35V, but the requirement of battery is only 12V-13V, for that potentiometer (10K) of IBC is adjusted to the required voltage. The battery positive and negative terminal is connected with ESC as well as IC 7805.

The ESC is connected with microcontroller and BLDC motor. Microcontroller ATMEGA328p consist of 28 pins from that digital 9 pin (D_9) is connected with ESC for controlling the speed of BLDC motor according the programming dumped, the analog 0 pin (A_0) is connected to potentiometer signal pin, Vin and gnd is connected to ESC for supply and the 5V and gnd is connected with positive and ground terminal of potentiometer. The output of ESC is provided to three terminals of BLDC motor.

For the power supply indication of 5V LED of multicolour is used, it is fed by 5V from 7805 IC. The 7805 IC has three terminals input, ground and output. The positive terminals of battery is provided to input and output terminals of 7805 IC and the negative terminal of battery is connected to ground terminal of 7805 IC. The LED anode terminal is connected with output terminal of 7805 IC and cathode is connected with ground terminal.

3.3 Software and Programming

The software used for dumping the program in the microcontroller ATMEGA328p is Arduino IDE and for controlling the speed of motor Embedded C programming is used.

```
/*
Controlling a servo position using a potentiometer
(variable resistor)
 Efficiency
by Michel Rinott <http://people.interaction-
ivrea.it/m.rinott>
Modified on 8 Nov 2013
by Scott Fitzgerald
<http://www.arduino.cc/en/Tutorial/Knob>
*/
#include <Servo.h>
Servo myservo;     // create servo object to control a servo
int potpin=0;    // analog pin used to connect the
potentiometer
int val;    // variable to read the value from the analog pin
void setup ( )
{
 myservo.attach (9);    // attaches the servo on pin 9 to the
                          servo object
}
void loop ( )
{
 val = analogRead(potpin);    // read the value of the pot (0
                                and 1023)
 val = map (val, 0, 1023, 0, 180);    // scale it to use it with
                                        the servo (value between 0 and 180)
 myservo.write (val);    // sets the servo position according
                           to the scaled value
delay (15);    // waits for servo to get there
}
```

4. EXPERIMENTAL RESULTS

The experimental result is shown between output voltage and efficiency. The below figure 4.1 shows the table and graph representation of output voltage versus efficiency and the graph is a straight line.

Table-1: For different values of output voltage, efficiency is as given below

OUTPUT VOLTAGE(V)	2	4	6	8	10	12
EFFICIENCY (%)	0.2	0.4	0.6	0.7	0.8	0.89

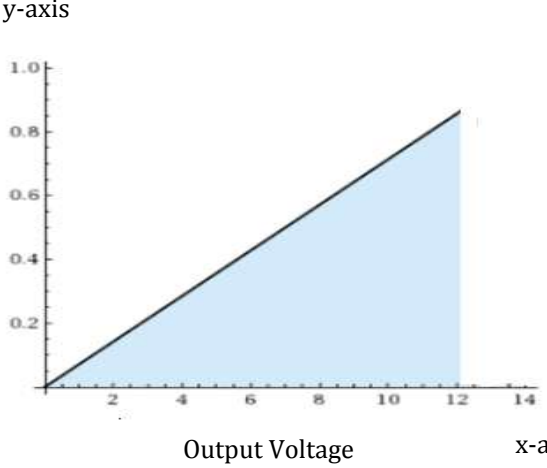

Chart-1: Graphical representation of output voltage versus efficiency.

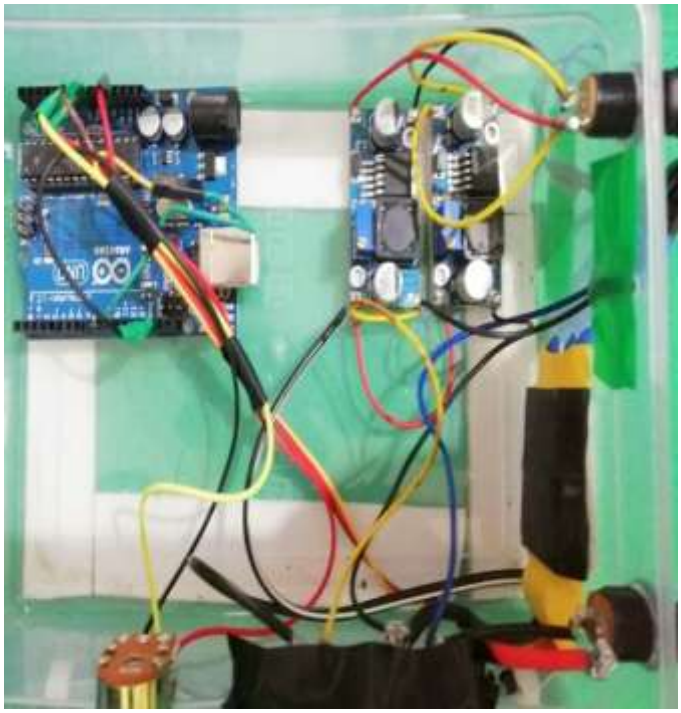

Fig.4.1.Control Unit

The above figure 4.1 shows hardware implementation of interleaved boost converter, Arduino Uno, ESC, potentiometer connections are shown. The figure 4.2 shows the hardware implementation of Renewable Energy Based Interleaved Boost Converter for Application of BLDC Motor.

Fig.4.2. Hardware Implementation of Renewable Energy Based Interleaved Boost Converter for the Application of BLDC Motor

5. CONCLUSION

The project work shows the implementation of IBC for increasing the power and efficiency of solar panel and the application of it are shown by running a BLDC motors. The IBC is more advantageous than conventional boost converter like improved efficiency, less ripple, reduced inductor, pick current, improve reliability, good current sharing characteristics, higher boosting capacity etc. The BLDC motors speed is controlled by ESC with the help arduino Uno and potentiometer. The graph obtained between output voltage and efficiency is a straight line. Hence from the result it is found that though the input voltage is less but output voltage is more and hence efficiency obtain is also more. The hardware implementation of the project is also shown.

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