Implementation of Bi-directional Capabilities of Batteries for using Quadratic Buck-Boost Converter

Vinoth Kumar K*[1], K. Ranjith Kumar[2], R. Vishnu[3]
[1,3]PG Scholar, Department of EEE, Government College of Technology, Coimbatore, India
[2]Associate Professor, Department of EEE, Government College of Technology, Coimbatore, India
****Corresponding Author***
E-Mail Id: guruvinoo@gmail.com

ABSTRACT
Energy storage devices are essential to provide voltage and frequency stability in renewable energy sources, such as solar and wind. In this paper is used to distribute generating system like batteries super capacitors or discharging mode operating condition. In this paper, a new non- isolated bidirectional quadratic converter characterized by high voltage gain in both step-down (Buck) and step-up (Boost) operation modes is proposed. It is used to reduce ripple in distributed system. All these types permit an optimized operation among the DC bus and the storage devices. The bidirectional converter proposed in both condition modes step up and step down. The controller design as the fuzzy logic condition and performance of the proposed converter through simulation and experimental results.

Keywords: *Energy storage devices, quadratic converter, high voltage gain*

INTRODUCTION

The role of Energy Storage Devices (*ESDs*) in the increasing penetration of renewable and sustainable energy sources is widely recognized [1-3]. Such devices are considered one of the key technologies for emerging markets in the use of more renewable energy sources, in order to minimize fossil fuel consumption and appropriate integration of clean energy sources in off-grid [4.5] and in-grid applications [6,7]. Undesirably the floating nature of most renewable energy facilities, such as solar and wind, makes them unsuitable for standalone operation since they are strongly affected by weather conditions, causing energy variations and stability problems in the power network [8-10]. Several measures can be adopted to deal with this problem but are generally dependent on the existence of some type of *ESD*. One possible measure is to provide overcapacity, i.e. increase the amount of renewable generation installed in order to ensure that even in worst conditions there is enough energy to provide a stable grid connection. Another measure is to spread the installations of renewable generators over a wide region, to take advantage of weather conditions changing from place to place and of smoothing effects expected from the complementarity of wind and solar energy [11-13].

Since the invention of the alternating current (AC) generation, fossil fuels had become the main energy source of electricity generation. The types of fossil fuel that are typically used in the generation of electricity include coal, diesel and natural gas. Over the past few years, the demand of electricity has been ramping up high due to the increasing world population and development of more urban cities. The subsequent direct effect imposed is the significant increase in the consumption of fossil fuel from years to years and yet, the cost of fossil fuels has been fluctuated from years to years and the overall effect is the increase in the cost of fossil fuel. This problem leads to the fact that fossil fuel may not be the economical energy source for electricity generation in the future. Moreover, one of the major problems faced with the extended usage of fossil fuel is the depletion of its limited available resources on the earth. Another downside of electricity generation using fossil fuel is the emission of greenhouse gases which contributes to the environmental pollution issues and health related issues.

Studies and developments on renewable energy have been initiated with great effort in the past few years to address the various issues in the electricity generation using fossil fuels. Renewable energy is defined as the energy source that exists naturally and sustainably on the Earth and it typically includes the solar energy, wind energy, biomass energy and geothermal energy. Nowadays, there is a positive growth in the usage of renewable energy and many countries have integrated renewable energy sources into the electrical grid network in the form of distributed generation (DG).

Energy storage system nowadays plays a significant role in the field of renewable energy. One of the applications of energy storage system is to solve intermittency issues caused by the renewable energy sources by interconnecting the energy storage system to the electrical grid. However, energy storage system which consist stack of batteries generally has low voltage and this imposes a difficulty in connecting the energy storage system to the electrical grid. Hence, the lower voltage at the energy storage system side has to be stepped up to discharge the energy stored in batteries to the grid and the higher voltage at the electrical grid side has to be stepped down to charge the batteries.

It consists of a simple circuit composition. Both windings of the proposed converter consist of a coupled inductor with identical winding turns. The windings of the coupled inductor are operated in parallel charge and series discharge to achieve high step-up voltage gain in step-up mode. As a result, the proposed converter has superior step-up and step-down voltage gains than the predict able bidirectional DC-DC buck-boost converter. The average value of the switch current in the projected converter is not as much of the conservative bidirectional boost/buck converter.

PHOTOVOLTAIC SYSTEM

General

Solar energy is a large renewable energy source. Solar energy consists of multiple photovoltaic modules referred to as solar panels to current sunlight to direct current. It is used to residential, Commercial or industrial, water pumping, solar hybrid vehicles. A solar panel cell is PN junction PV cell converts the sunlight into the Dc by the PV effect. It requires the little maintenance initial cost is high and no environmental pollution. PV module normally comprises of a number of PV cells in series. Two types of topology that employed solar energy normally solar to thermal and solar energy.

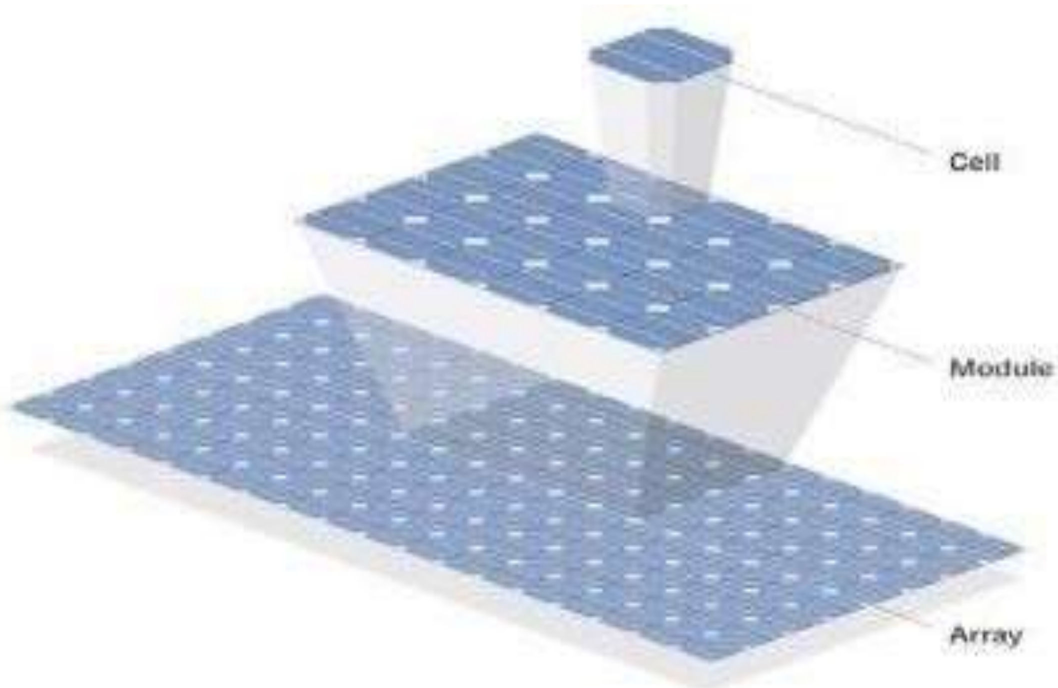

Fig. 1: *Photovoltaic System.*

Basics of Photovoltaic Array

The basic criteria about photovoltaic system with the formulation of PV array and the Generation of electricity from PV system are discussed below.

Photovoltaic array

Due to the low voltage of an individual solar cell (typically 0.5V), several cells are wired (Copper in photovoltaic power systems) in series in the manufacture. The laminate is assembled into a protective weather proof enclosure, thus making a photovoltaic module or solar panel. Cross section model of this is shown in figure 2.

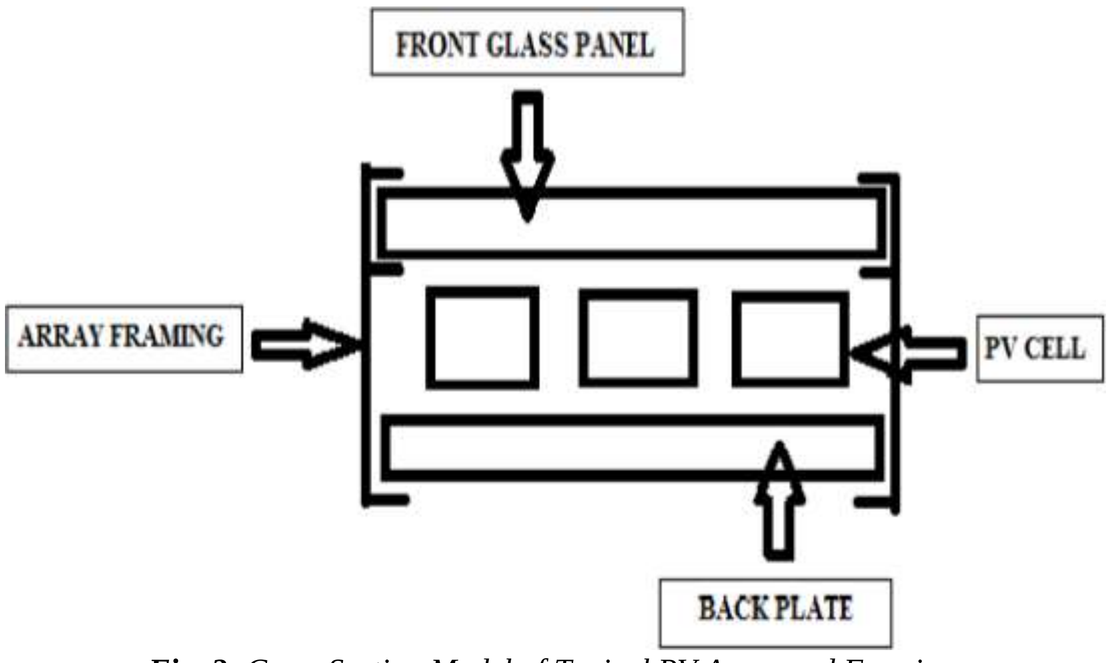

Fig. 2: *Cross Section Model of Typical PV Array and Framing.*

BIDIRECTIONAL BUCK BOOST CONVERTER

Step-Up Mode of the Converter

In the step-up mode, the equivalent circuit of the converter is shown in Figure 3. The continues pulse technique is used to control the switches M1. In this mode of operation MOSFET M1 is gating gate pulse for triggering the switch. When MOSFET is trigger at the same time diode D1 also conducting and inductor L storage energy during this time capacitor C2 is discharging. When switch not conducting then whole power from battery and energy storage by inductor L will supply the power at input side of inverter, at the same time diode D4 is conducting. Equivalent circuit for mode of operation and waveform is shown in figure 3

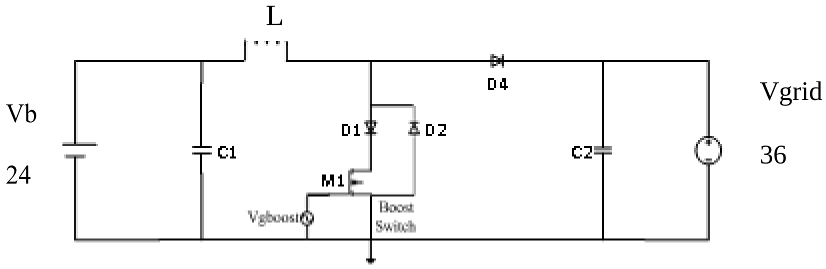

Fig. 3: *Equivalent Circuit of Step up Converter.*

Step-down mode of the converter

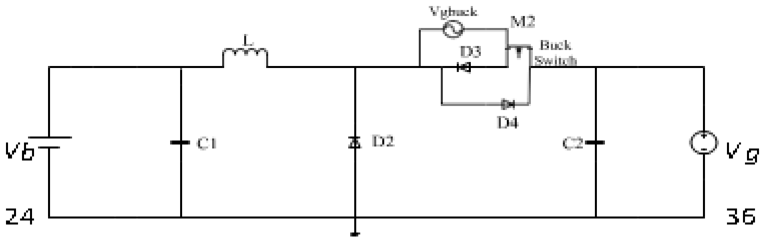

Fig. 4: *Buck Equivalent Model.*

Circuit diagram of buck converter using MOSFET is displayed. The direction of current flow from the high voltage 36V DC to the low voltage 24V DC sources is called "buck" or charging mode.

Its operation is divided into two modes. Mode1:- It begin when MOSFET (M2) is switch on at t=0. The input current I_S (t), which rise flows through inductor L, capacitor C, and battery. Mode 2:- It begins when MOSFET (M2) is switch off at t=t1. The freewheeling diode D2 conducting due to energy stored in the inductor; and the inductor current continues to flow through L, C1, battery and diode D2. The inductor current fall until MOSFET (M2) is switch on again in the next cycle. The equivalent circuits for the modes of operation are shown in figure 3. The wave form for the voltage and current are shown in figure for a continuous current flow in the inductor L. It is assumed that the current rise and falls linearly. In practical circuits, the switch has a finite, nonlinear resistance. Its effect can usually be slight in various applications.

PROPOSED MODEL

In this proposed system for a solar based system that user's fuzzy logic algorithm. The solar photovoltaic is an electronic device that the light into electric energy. The photons absorbing semiconductor material need conversion, the controller design as a fuzzy-logic algorithm, in the proposed design using membership function. The fuzzy-logic control proposed a three steps namely fuzzifications, Interference, and defuzzification.

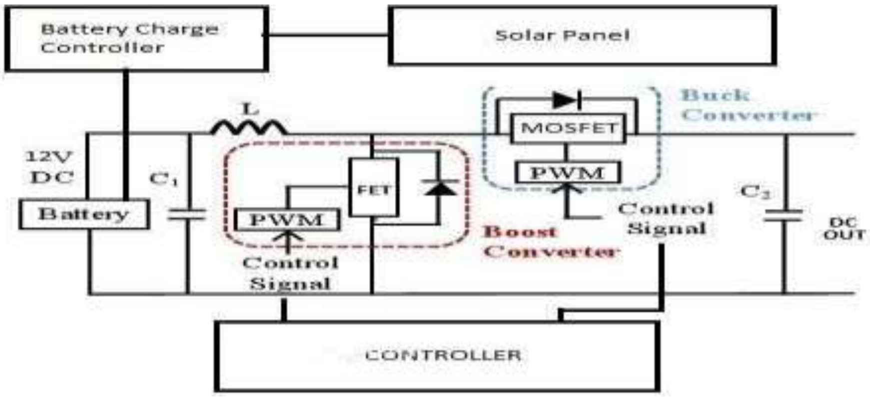

Fig. 5: *Proposed Model.*

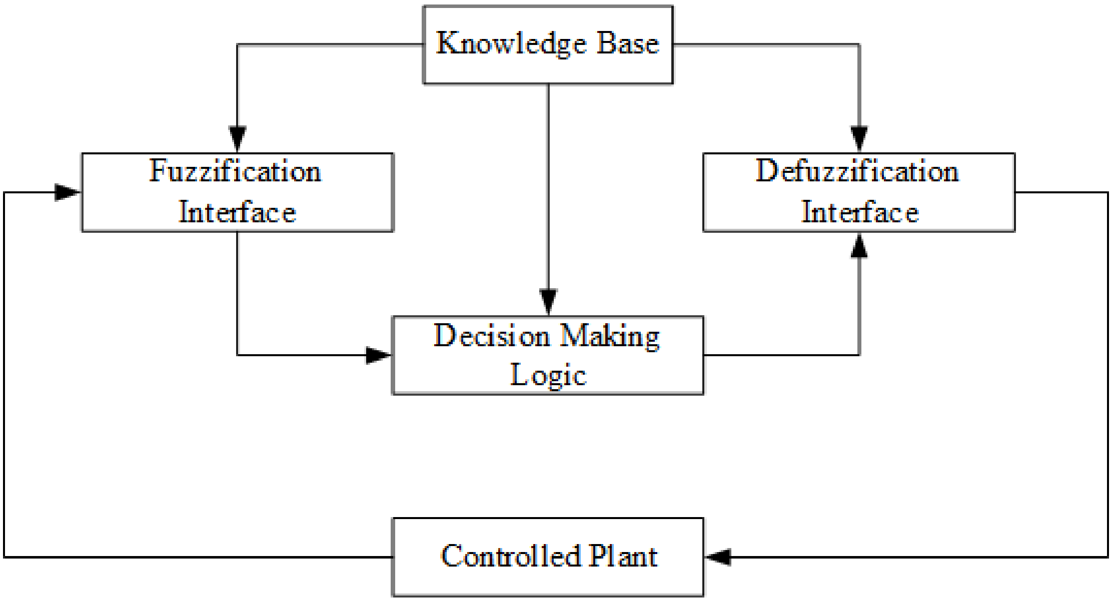

Fig. 6: *The General Structure of a Fuzzy Logic Controller.*

BOOST CONVERTER

A DC-DC buck boost converter has been designed by Derik Towler and Bret Whitaker in the project "Bi- Directional Inverter and Energy Storage System". The DC-DC boost converter plays an important role in the project to boost the output voltage level of the lead-acid batteries to inject the power into AC system grid in the discharging mode (Trowler and Whitaker, 2008). Since the voltage level of the AC grid fluctuates all the time, proportional-integral (PI) strategy was proposed by Trowler and Whitaker to control the duty cycle of the boost converter to make necessary adjustment on the output voltage.

In the charging mode, the DC-DC buck converter is responsible for stepping down the voltage of AC grid to the voltage level of the batteries. According to Trowler and Whitaker, the DC-DC buck converter can be designed in such a way that by adding an additional switch to the DC-DC boost converter, thus forming a DC-DC buck-boost. The schematic diagram of the bi-directional DC-DC buck-boost converter is as shown in Figure 4 (Trowler and Whitaker, 2008).

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SIMULATION AND RESULTS

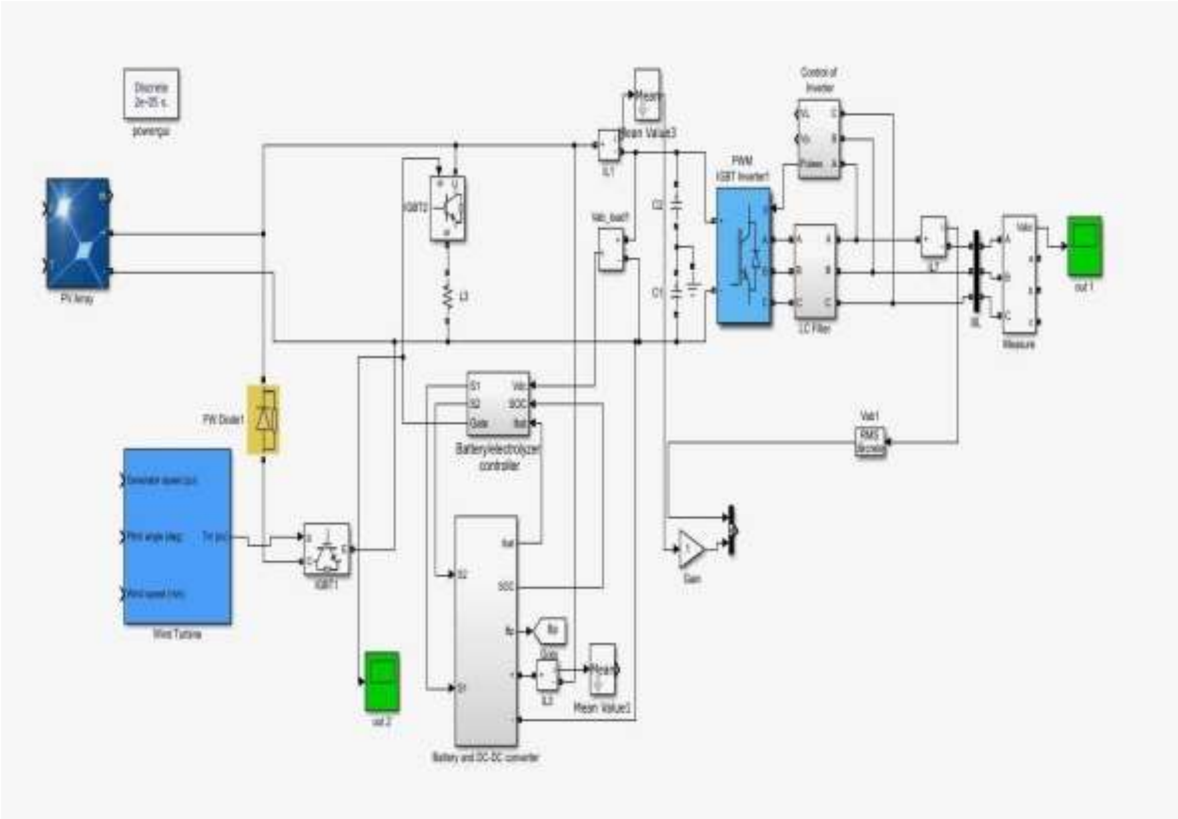

Fig. 7: *Simulation Diagram of Bidirectional Converter.*

Fuzzy Logic Control

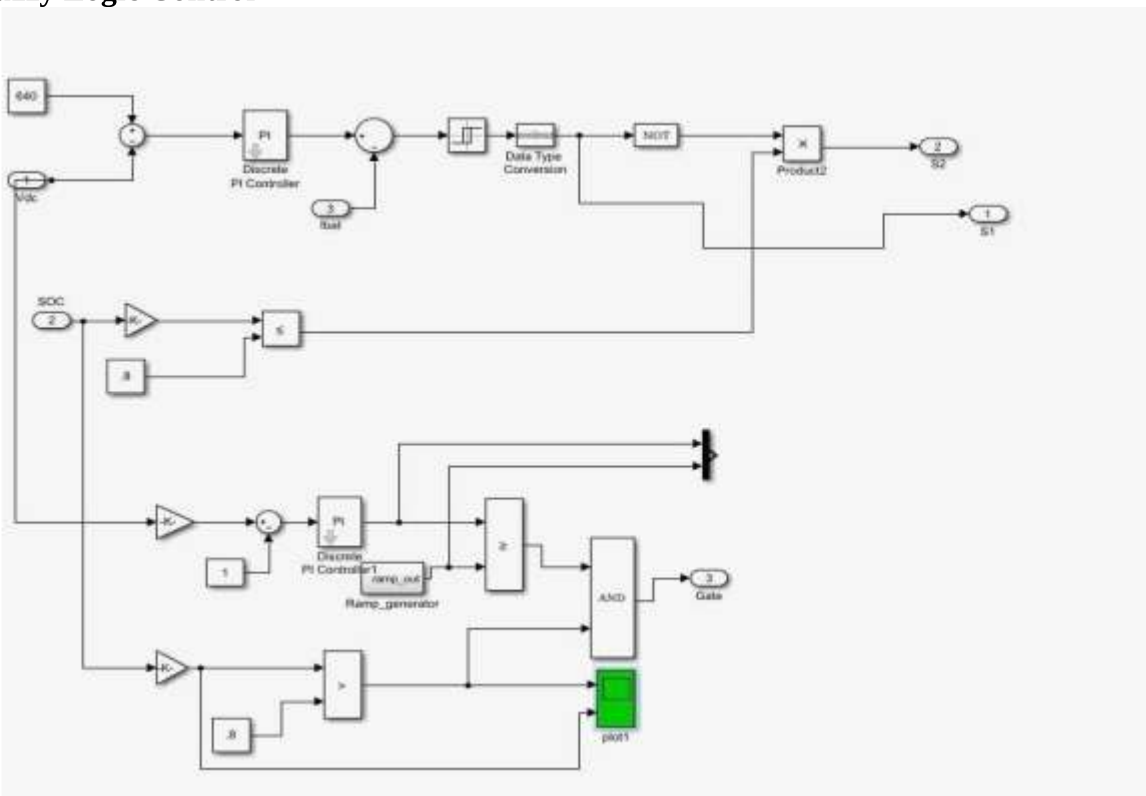

Fig. 8: *Fuzzy Logic Control Block.*

The figure 9 shows the output waveform of charging mode operation

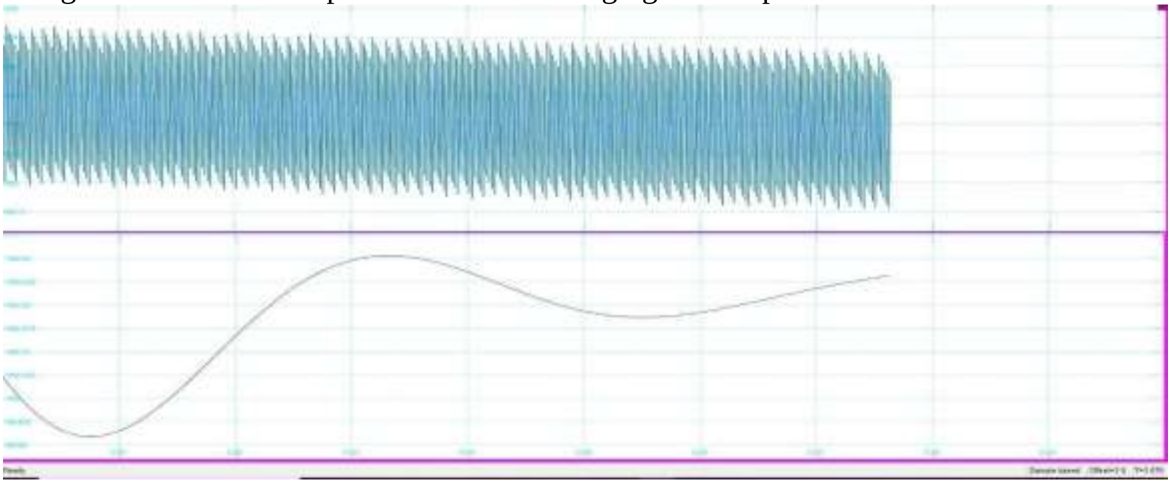

Fig. 9: *Charging Mode Operation.*

The figure 10 shows the output waveform of discharging mode operation

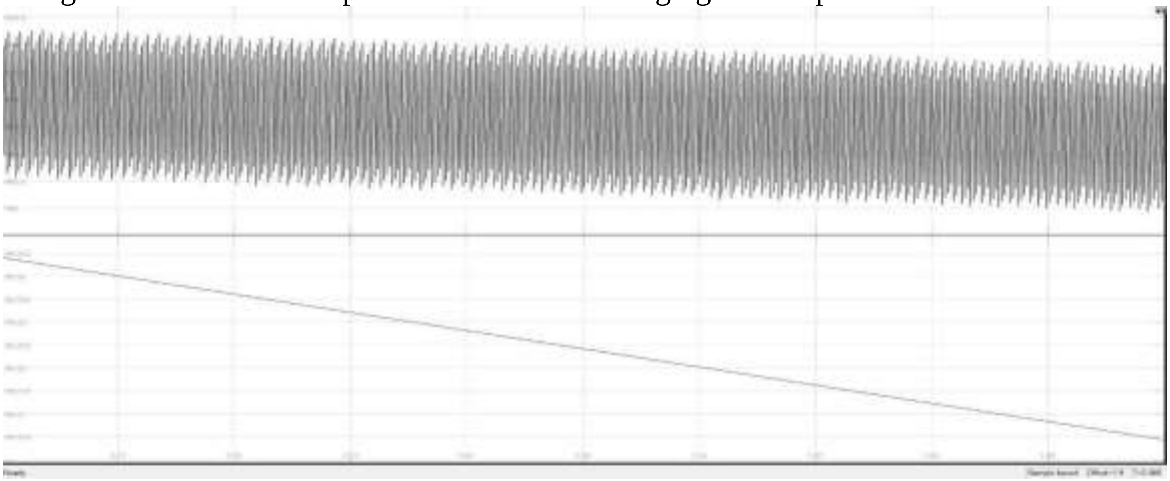

Fig. 10: *Discharging Mode Operation.*

The figure 11 shows the output waveform of load

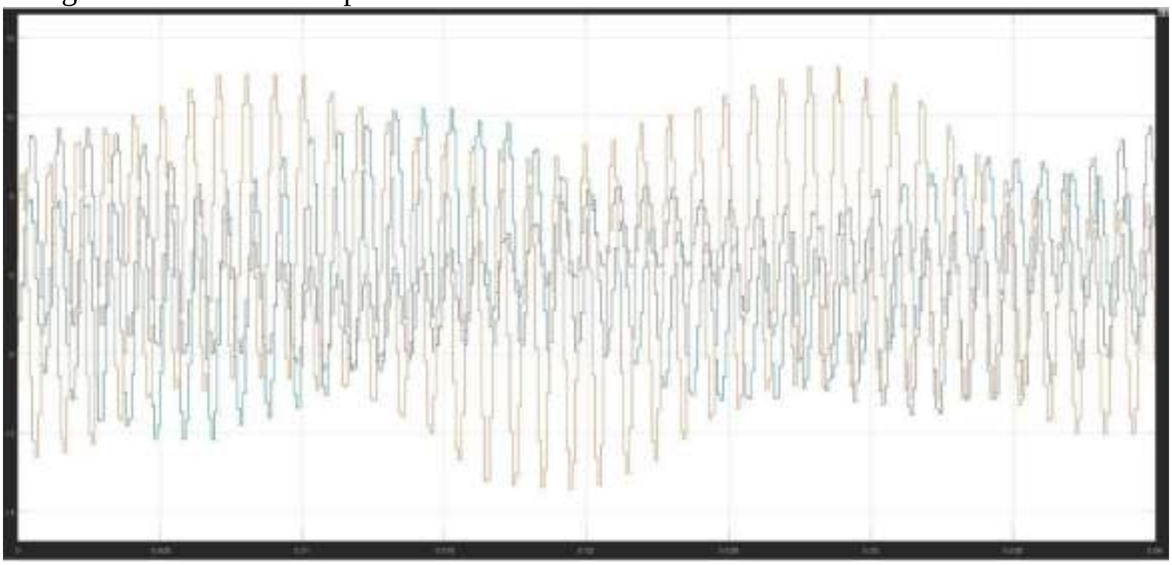

Fig. 11: *Output Voltage.*

Hardware Implementation

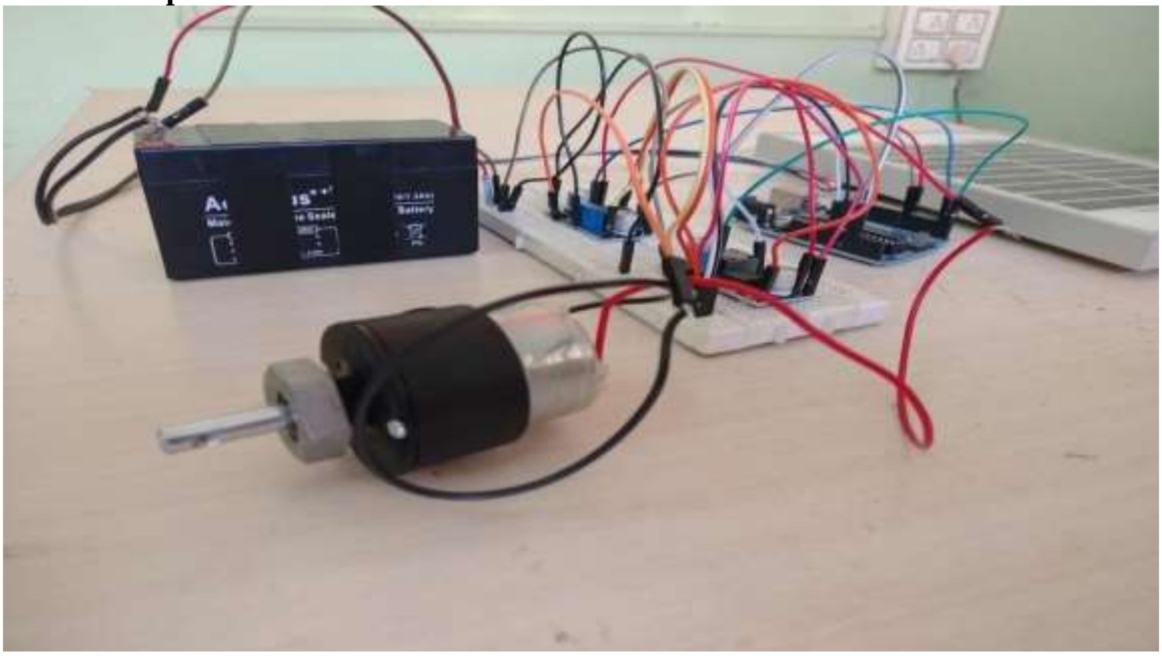

Fig. 12: *Bidirectional Converter with Load.*

The bidirectional capabilities for batteries using quadratic buck-boost converter was implemented in hardware setup. Output voltage has opposite polarity to that of the input voltage. The photovoltaic array to collect the energy from the solar energy, the solar PV cells to collect the solar energy. The converter has to been stored electrical energy in battery energy storage device. Whenever to disconnect the power supply unit, to operate the converter reverse operation to discharge the power from battery.so the battery operate the load. In proposed prototype system source are used solar energy or using energy with help of dynamo the wind energy is generated. The generated energy from the solar energy from the solar panel is given to the bidirectional buck-boost converter. The 12V from the source is given to the power supply. This 12V is fed to MOSFET gate terminal.

CONCLUSION

In this project, a DC-DC boost converter has been successfully developed to step up the low voltage of the energy storage system which consists of four series-connected lead-acid batteries to a higher DC voltage. Through multiple experiments, it is proved that the developed boost converter can achieve efficiency above 90 % when operating under certain load conditions, duty ratios and switching frequencies. Besides, a buck converter is developed in this project to charge the lead-acid battery. The buck converter is also able to achieve a high efficiency when charging the lead acid battery.

Apart from the advantage of higher efficiency achieved by implementing Fuzzy based Bidirectional buck boost converter, the mentioned topology provides an extra benefit of multiple outputs, thus reducing the complexity as well as the expense of the circuit. The waveforms corresponding to closed loop and open loop circuit has been mentioned in the above sections. The closed loop circuit has been simulated for a 15% of load change. As discussed earlier multi output converters are capable of supporting two different applications simultaneously as well as for applications which require two different voltage levels multilevel converters

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