BI-DIRECTIONAL DC-DC CONVERTER FOR ENERGY STORAGE IN SOLAR PV SYSTEM

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Abstract

A Bi-Directional DC-DC Converter (BDC) which has two input sources a Solar PV system and a battery which will operate in two modes of operation under certain conditions when solar PV supplies the battery will get charged and also the power flow to load and in other mode when Solar PV fails the battery will discharge and the power flow will be from the battery to load. The basic idea of this project is to observe the battery state of charge (soc) and operate the BDC in two modes of dc-dc converter operation. The simulation is done using MATLAB/SIMULINK software and also a hardware prototype has been done for 100 watts solar panel the results are provided. The result shows that the DC-DC
converter is best for PV power system because of its better efficiency and energy storage process.

**Keywords:** BDC (Bi-Directional converter), SoC (state of charge), Isolation transformer.

# 1 INTRODUCTION

The population in our world is increasing day by day and the demand for energy is increasing accordingly. Since oil, gas and coal are getting exhausted and it cannot be refilled, we opt for an alternative source of energy. Renewable energy is derived from natural processes that are replenished constantly such as sun, wind, tides, waves and geothermal heat which are inexhaustible. From these solar energy is quite simple that energy is derived directly from the sun.

![Figure-1. Conventional Bi-directional Converter](image)

As far as Renewable energy systems are concerned, the Power Management is an essential aspect in order to feed the Load Demand. Even though renewable energy sources have high fluctuations that affects the grid system its battery storage system diffuse the importance of renewable energy sources [1],[2],[3]. So, choosing a suitable Bidirectional DC-DC Converter which does the proper function of the Battery Charging as well as extracting the energy to the maximum extent from a PV Array giving a constant supply to the load is required. By using this system a huge amount of energy is being saved and a constant supply to the load is given in order to protect the load from damage. In this paper a Bi-directional DC-DC converter for energy storage process is simulated and also a hardware prototype for a 100
watts solar panel is done and the results are provided. The hardware prototype consists of a solar panel, battery, converters, isolation transformer, rectifier and an inverter to the load\cite{4,5}. The windings of the isolation transformer are of ratio 1:3 which boosts up the input voltage thrice and feeds the load. The converter has a bidirectional path which is used to charge the battery and to feed the load.

2 BI-DIRECTIONAL DC-DC CONVERTER FOR SOLAR PV SYSTEM

Figure-2. Bi-Directional DC-DC Converter

Fig-2. Shows the circuit diagram of Bi-directional DC-DC Converter for energy storage in solar Pv system as it mentioned earlier it clearly shows the two input sources and during day times the solar power is high and hence it charges the battery as well as supply the load and when Pv system fails the battery discharges and feed the load.
3 BI-DIRECTIONAL DC-DC CONVERTER

A Bi-Directional DC-DC Converter (BDC) is a type of dual active full bridge converter which provides nearly square wave ac voltage with 180 degrees phase shift between two legs [5],[6],[7],[8].

Figure-3. Dual active full bridge converter

It has great efficiency and used for energy storage in renewable energy sources. It consists of four switching devices will act as full bridge converter. This type of BDC will always have an isolation transformer to isolate the input side and load side[9]. Based on the requirement of load the winding of isolation transformer is constructed. The average power transferred can be obtained by calculating the average ac power at the transformer terminals. This module will operate in two modes of operation one when the solar Pv supplies and the other when solar Pv fails and the battery supply mode.
4 MODES OF OPERATION

Mode I (Solar power > Load power)

In this mode Fig.4. of operation the power produced by the Solar PV is higher than the power required by load. The PV array produces excess power. This excess power produced by the PV array is pumped to the battery through the bidirectional DC/DC converter and also connected to the load.

Mode II (Solar power < Load power)

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Figure-5. Mode 2
In this mode Fig.5, the power produced by the Solar PV is less than the load power. Once the DC link voltage demands the solar power, the additional power is pumped from the battery via bidirectional DC/DC converter.

5 HARDWARE RESULTS

The bidirectional DC-DC power converter circuit is designed for 100W. The design includes the isolation transformer, switching devices, switch gate drive circuit, and battery selection.

![Figure-6. Hardware Setup](image)

Figure-6. Hardware Setup

The Fig-6. shows the hardware arrangement of Bi-directional DC-DC converter.

6 RESULTS OF MODE 1

During Mode 1 i.e. (when the solar panel supplies more power during day times) is shown in Fig.7. At this mode the solar PV charges the battery through the flux induced in the transformer and also leads the power to flow through the load. The battery charging profile is shown in Fig.7.
7 RESULTS OF MODE 2

During the operation of Mode 1 the battery is getting charged and when the solar PV fails or at night times, the battery discharge and feeds the load and thus process is said to be operation of Mode 2 or battery Mode. The battery produces a constant input voltage of 12v at 1.3Ah and the output voltage obtained is about 36v after it is being fed into the transformer, rectifier and inverter. The inverter output and discharging profile of battery is shown in Fig.8. Fig.9.
8 CONCLUSION

This paper is presented with the experimental results for bidirectional DC-DC converter. The hardware is designed and
built for 100W power. The Bi-Directional DC-DC Converter used in this system has more efficiency compared to other converters. The high frequency isolation transformer reduced the size and cost. The hardware prototype output shows that the output voltage is increased thrice the input voltage.

References


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