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Powerflow Sharing in Bidirectional Three Input Boost Converter for Hybrid Electric Vehicle

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ABSTRACT: The concept of renewable energy is increasing day by day because the electrical applications are moving towards utilization of renewable sources especially in the transport field. Due to this factor electric power is also gaining popularity and new type of converters are modelled in order to get high utilization of renewable sources. Multiport converters, a promising concept for hybrid power sources, have attracted increasing research interest recently. The use of a single power processing stage to interface multiple power inputs integrates power conversion for a hybrid power source. This structure removes redundant power stages that would exist in the conventional approach that uses multiple converters. The multiport structure is promising from the viewpoints of centralized control and compact packaging. This paper is discussing the power sharing between the hybrid sources in the multiport bidirectional boost converters.

KEYWORDS: MULTIPOINT CONVERTER, HYBRID SOURCES, POWER SHARING

I. INTRODUCTION

Hybrid power sources are becoming more and more popular. For example, in renewable energy generation systems the production of electricity from solar sources depends on the amount of sunlight. Like solar energy, the availability of wind energy is also uncertain, heavily relying on the weather. For stand-alone or grid-interactive systems, energy storage is often used to store the captured electrical energy. Power generators like fuel cells(FC) have slow dynamics. A storage element is needed for energy buffering and can therefore improve system dynamics. For Electric Vehicle(EV) applications, transient energy storage is required for acceleration and braking. A multiport interface is useful for those systems since they require energy storage to compensate for the mismatch between the sourcing and loading power patterns. A three-port power converter system can accommodate a main source and energy storage and combine their regenerative advantages while using a single power conversion stage to interface the three power ports. Another advantage of incorporating energy storage is that oversizing of the main source can be avoided. A three-port system can therefore be economically beneficial.

There has been a growing interest in multiport power converters for small generation systems and Electric Vehicles. These applications have in common that the system needs to operate with multiple power inputs and/or outputs. Several converter topologies that can provide multiple interfacing ports have recently been reported in the literature [1], [2], [3], [4], [5], [6], [7], [8], [9], [10].

For hybrid systems, an efficient power flow management and control theory has been suggested in light of the above viewpoints and issues. The AC connect interfacing multiport converters, transfer the real power from renewable energy resources alongwith enhanced features of power quality [11]. An integrated high addition DC-DC converter is used as a tracker for full solar power level. Power management is essential to ensure both effective and economical system operation in integrated use of renewable energy sources. It is made possible for unpredictable weather conditions, day-night conditions and frequent voltage shifts [12,13].

Management of power is important to assure both efficient and economical work of the system in combined means of renewable energy sources usage. Variable factors like day-night conditions, weather conditions and rapid change in

voltages make it necessary to control the power flow management in renewable energy sources. In hybrid renewable system there will be many sources available thus makes the power flow management slightly complicate. This paper made to deliver some clarity regarding the power flow for the three port boost converter.

II. THREE INPUT MULTIPORT BOOST CONVERTER

A three-port converter topology is derived from the full bridge converter. The three port converter interfaces the following ports which include an isolated load port, a bidirectional storage port and unidirectional input port. For the unidirectional input source, we have used a photovoltaic (PV) panel for the bidirectional port and a battery is used as the storage element. The three port converter used is shown in Fig. 1.

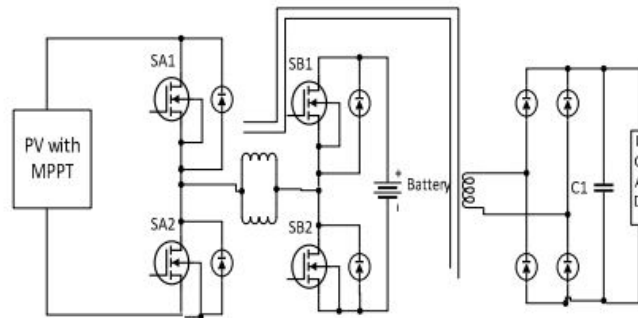


Fig.1 Three input boost converter

The three port converter construction is composed of four switches. Two switches SA1 and SA2 are connected to the unidirectional port where the PV panel is the source and the remaining two switches SB1 and SB2 are for the bidirectional flow where the battery is connected. [14]

A transformer isolates the load and source side, the primary side of the transformer is connected to the sources and the secondary side is connected to the load. At the load side a rectifier made up of four diodes, is connected in such a way to convert the AC voltage to DC voltage. It can be seen from Fig. 1 the transformer primary side is connected to a PV panel with Maximum Power Point Tracking(MPPT). MPPT is added to get maximum power from the PV panel by tracking the sunlight with the help of perturbations and observation algorithm. The battery is connected on the left side between switches SB1 and SB2. The positive of the battery is connected to SB1 and the negative of the battery is connected to SB2. The flow of power from the battery is when SB1 is switched 'ON'. So for control of the battery the SB1 switch plays a vital role.

The three-port converter provides a power flow between the load via the battery or PV panel, they can work together or independently, depending on the available power resources. So it follows that the power to load can be either only by the PV panel or only battery or they both supply power by time sharing of the available sources, which depends upon the conditions. There are three modes of operation for the three-port converter. [12,13]

Mode I:

In this Mode the load must be fed only by the PV panel. Also the battery is charged at the end of each pulse. During this time the switch SB1 is switched 'ON' while SB2 is switched 'OFF'.

Mode II:

In this Mode the PV panel delivers the power to the load and to the battery. When the PV panel voltage is higher than load demand, switch SB1 reaches the maximum value and allows the charging of the battery.

Mode III:

In this Mode the load must be fed by PV panel together with the battery because the PV panel does not produce enough energy. The voltage of PV panel is lower than load demand but not zero, when there is no PV generation then the load must be fed by the battery only, and the switch SA1 reaches the maximum value. [12,13].

Controller design: The controller is designed in MATLAB Simulink 2018 by using the MATLAB function block as shown in Fig. 2. The MATLAB function block is composed of two inputs, input 1 is for the selection of mode I. The selection of mode II or mode III is on the basis of input 2. Input gets the comparison result of the PV panel and the load demand as shown in Fig. 2. If PV panel power is higher than load demand pulses are generated for mode II and if PV panel power is lower than Load demand than mode III pulses are generated. Fig.3 describes the power flow among the three different sources.

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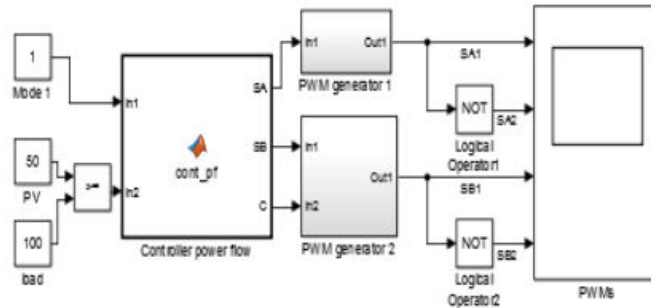


Fig.2 Power flow controller

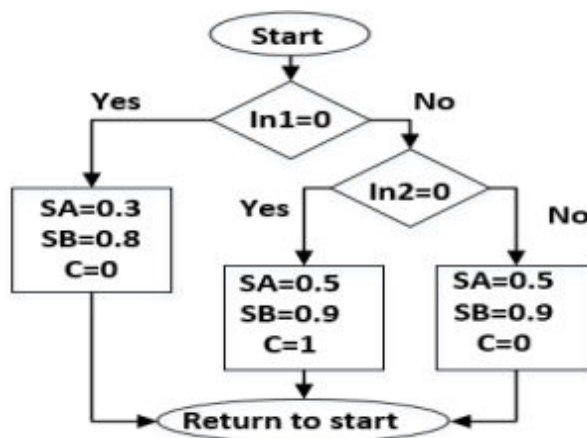


Fig. 3 Power flow control algorithm

III. RESULTS AND DISCUSSIONS

In mode I, the main power flow from PV panel with MPPT to the positive terminal of the switch labeled as SA1 and then to the transformer primary and to the inductor at last it will pass through the switch labeled as SB2 and then back to PV panel via its negative terminal.

The switches SA2 and SB1 are also varied to get pulses because of the transformer and for the transformer separate signal must be generated and in this way the battery is also get charged. The signal should be like pulses otherwise the transformer will not work properly.

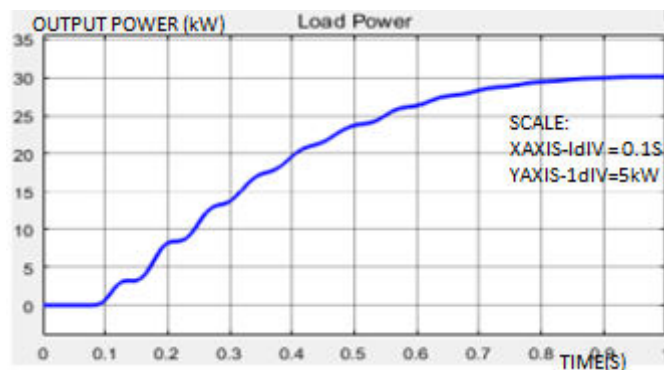


Fig. 4 Power flow during mode I

In mode II, the power flow is given as the power that flows from the PV panel with MPPT positive terminal to switch SA1, then to the transformer primary and inductor. Then it will pass through switch SB1 and will charge the battery. Lastly it will return to the PV panel via the negative terminal. Fig.4 and Fig 5 shows the first and second mode of operation .

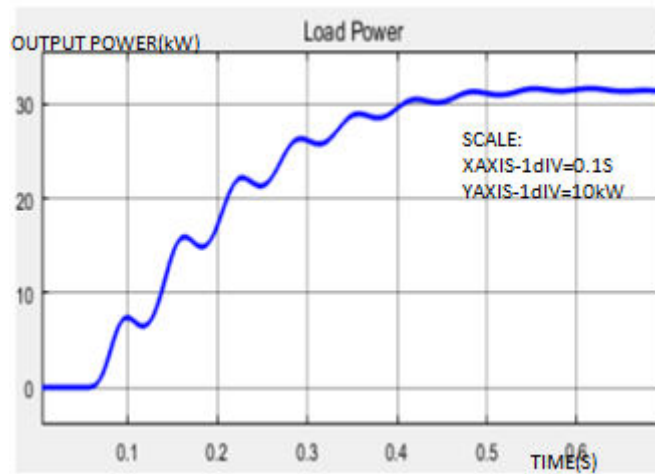


Fig 5. Power flow during mode II

In this mode the power flow is given as the power flows from the battery's positive terminal to switch SB1, then to the transformer primary and inductor. Then it will pass through switch SA2 and hence the circuit is completed in this way to support the PV panel while the switches are changed. Fig.6 shows the third mode of operation.

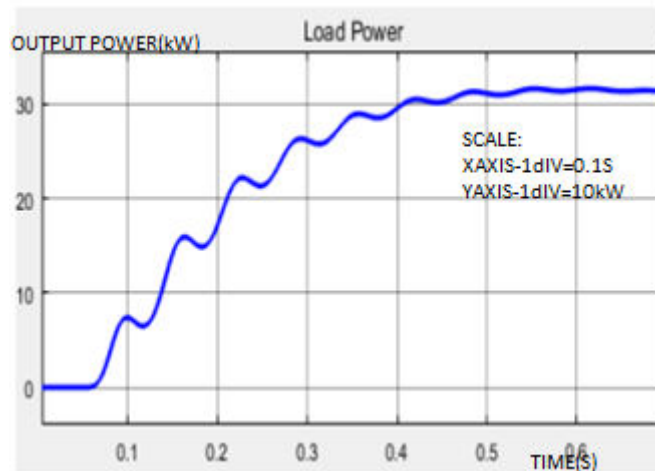


Fig.6 Power flow during mode III

From the above results it can be concluded that there is a proper power flow control maintained among the three sources. The main purpose is to reach maximum power of 35kW for the three modes of operation.

IV. CONCLUSION

In this paper a three-port boost converter is modelled, simulated in order to put in evidence the characteristics of its specific modes of operations. The considered three port boost converter interfaced a PV panel with Maximum Power Point Tracker, a battery and a load, which is isolated by a single phase transformer. The power flow transfer in the converter is controlled by the MOSFETs switches. In this paper three modes of operation have been analyzed. In mode I, the PV panel is delivering power to the load, as well to the battery, for short time in each cycle. In mode II due to the fact that the voltage of PV panel is higher than load demand, the energy access is delivered to the battery, in mode III the load must be fed by both the battery and source. Main advantage of this model for the hybrid system is less complexity, less number of components and controller design is easy compared to the other converters. From the results it is clear that the power flow is properly maintained for the three modes of operation.

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