Multiport DC-DC Interleaved Boost Converter Fed to Induction Motor using Hybrid Different Capacities of PV/Battery Power System

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Abstract: **Contained a multiport DC-DC converter fed to three phase induction motor using by a Hybrid Distributed Generation System (HDGS). The HDGS is consists of two different capacities of photovoltaic (PV) module and one battery to supply a fixed power for driving a three phase induction motor. Amultiport interleaved DC boost converter utilizing DG sources of HDGS in a unified structure .In this structure, each switching cycle of proposed interleaved boost converter is divided into five switching periods that introduce five different duty ratios. Utilizing these duty ratios result in regulating the PV/battery powers and constant electrical power for the three phase induction motor is achieved. Due to constant the power three phase induction motor will be able to run at its nominal power in different environmental conditions. Incremental conductance algorithm (IC) has been used to regulate the PI parameter of speed controller in order to realize better dynamic response. Reducing ripple content in multiport converter interleaved switches is used. The proposed system is suitable for application of agricultural water pumping systems.**

Keywords: **Battery, Hybrid Distributed Generation System (HDGS), Incremental conductance (IC), Interleaved Boost Converter, Multiport DC-DC converter, MPPT Tracking controller, Photovoltaic Module, Three Phase Induction Motor load.**

I. INTRODUCTION

Nowadays renewable energy sources such as fuel cells, photovoltaic (PV) arrays are increasingly being used in automobiles, residential and commercial buildings. Because of the renewable energy, sources are truly a clean, emission-free electrical generation technology with high reliability. Future power systems will require interfacing of various distributed energy systems. To enable interface hybrid distributed energy systems or multi-source technology, a multiport converter was used for accommodate a variety of sources to increase reliability and maintain fixed power utilization of sustainable sources.

To applicable Hybrid Distributed Generation Systems (HDGS) separate inverters for the input sources and separate DC boost converters for each DG sources are create some of shortcomings for maintaining fixed power. In addition that requires costly topologies and complicated control system which makes high losses, poor efficiency and inferior time response. For improvement their efficiency of these system essential high costs. The multi-port structure is promising from the viewpoints of low cost, centralized control and compact packaging. However, a multiport converter is complex and there are more design challenges, e.g. The control structure.

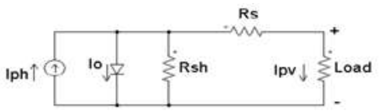
The advantages of using multi-port structure is that the primary source only needs to be sized according to the average power consumed by the load for a specific application, not necessarily to the peak power. Such operation would avoid over sizing of the primary source and is economically beneficial. Moreover, with the auxiliary storage, not only the system dynamics can be improved, but also the storage acts as a backup energy source in the absent of a main source event.

Multiport DC-DC converters are the perfect solution in all applications where complex energy distribution tasks must be solved. The proposed Multiport DC-DC Converter is able to control three independent boost DC-DC converters within a single housing at low cost (minimum ceramic capacitors, cost efficient silicon technology – IGBTs and diodes, no external current sensors) but nevertheless with a high power density what means it is ideally suited for automotive applications. Each low voltage side port can be voltage, current or power controlled by control algorithm and switching state.

Individual interleaved power stages for each port allow low voltage and current ripples also when only a single port is used. In this paper, the interleaving topology of multiport boost converter is proposed with power management and control system for hybrid system of different capacities of photovoltaic module and battery system. It allows bidirectional voltage conversion with high power density. It has an advantage of simple topology, reduced devices and single stage conversion with control power flow between sources and load .Using this converter maximum power point tracking control will be applied for hybrid distributed system of different capacities of photovoltaic panels and battery. The proposed interleaving high step up multiport DC-DC converter offer alternate solutions for renewable power systems with multi-input renewable sources, with storage backups.

II. DC-DC CONVERTER INTERFACING WITH HDGS CONTAINS OF PV MODULE/BATTERY

Photovoltaic (PV) sources are one of the significant players in the world's energy portfolio and will become the biggest contributions to the electricity generation among all renewable energy sources. The electromagnetic radiation of photovoltaic energy can be directly converted to electricity



through photovoltaic effect. The equivalent circuit of a PV cell is as shown in Figure 1.

Fig. 1. Equivalent circuit of PV panel

The current source I_{ph} represents the cell photocurrent. Where, R_{sh} are intrinsic shunt resistances and R_s are the series resistances of the cell, correspondingly. Regularly the rate of R_{sh} is very large and that of R_s is very small for simpler the analysis. Cells of PV are grouped in larger units called PV modules which are further interconnected in a parallel-series configuration to form PV arrays. For interfacing the photovoltaic panel and the load. The DC-DC converters are widely used in photovoltaic generating systems, which allows the follow-up of the maximum power point (MPP).To extract the maximum power from the solar panel, you must adjust the load to match the current and voltage. The converter is designed to be connected directly to the photovoltaic panel and perform operation to search the maximum power point (MPPT).Battery is a portable container of an electrically charged cell or cells as a source of current. The batteries respond faster than a PV and PV life cell for a fast step increase and decrease in power demand, using this energy storage in such hybrid systems improves performance. DC-DC converters are used in applications where an average output voltage is required, which can be higher or lower than the input voltage. The selection of the DC-DC converter for the implementation of MPPT system is based on three basic topologies of DC-DC converters and MPPT tracker, for that we require the characteristics and properties of DC-DC converters, mainly as regards the input impedance that they present under certain operating environment.

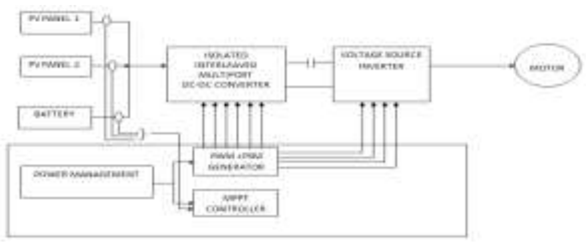


Fig. 2.Block diagram of DC-DC Converter interfacing with load

While using buck converter in MPPT controller it has a maximum power point at minimum irradiation hours. Also buck DC–DC converter has a discontinuous input current and a continuous output current. So, buck topology requires a large and expensive capacitor to smooth the discontinuous input current from the photovoltaic module and to handle significant current ripple. On contrary, the boost converter has a continuous input current and a discontinuous output current. The photovoltaic current in the boost converter is as smooth as its inductor current, lacking any input capacitor but the ripple content is high due to the usage of power electronic switches and inductor. In proposed

DC-DC converter is a boost converter with an interleaved topology to reduce the ripple current, improve reliability and increase efficiency.

III. MPPT TECHNIQUES USED IN DC-DC CONVERTER

The major challenge of designing a boost converter for high power application is how to handle the high current at the input and high voltage at the output. A boost interleaved dc-dc converter is a suitable candidate for current sharing and stepping up the voltage on high power application. In the boost interleaved converter topology, one important operating parameter is duty cycle. The ideal duty cycle is the ratio of voltage output and input difference with output voltage. In this paper, a multiport interleaved boost converter is considered. As known, the input current and output voltage ripple of interleaved boost dc-dc converter can be reduced by virtue of interleaving operation. In addition, the converter input current can be shared among the phases, which is desirable for temperature dissipation.

Therefore, the converter reliability and efficiency can be improved significantly. In proposed system the interleaved boost converter is supplied by different DG sources such as different capacities of PV module/battery system. The interleaved boost converter is responsible to extract maximum power of PV array and charge/discharge of battery by adjusting duty ratios. For adjusting duty ratios the incremental conductance MPPT algorithm, is used to find the global optimal solution for a nonlinear problem. In this each switching cycle of the converter is divided in to five switching periods which define five duty ratios.

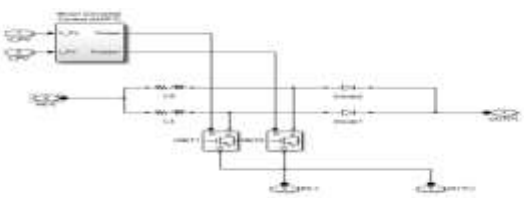


Fig. 3.Schematic diagram of proposed converter

By regulating these duty ratios, the structure enables to provide optimal operating points of DG sources. All possible switching periods corresponding to its duty ratio are shown in table 1.

OCM	T	T1	T	T	T
MPPT	D	1	0	1	0
FC	D	0	1	0	1
Battery	D	0	1	1	0
Battery	D	1	0	0	1
No	D	0	0	0	0

Table: I Switching table for duty ratio control

The incremental conductance method was used, which tracks the MPP by changing the voltage and current supplied to the load and measuring the instantaneous and incremental conductance periodically to reach the minimum value of the two parameters. Incremental Conductance method is based on the differentiation of power with respect to voltage, due to this value in maximum power point is equal to zero. Besides, $\frac{\mathrm{Ipv}}{\mathrm{Vpv}}$ is called instantaneous conductance and $\frac{\mathrm{dIpv}}{\mathrm{dVpv}}$ is incremental conductance, the place where these two values are the same the MPP will be there.

$$\frac{\mathrm{dPpv}}{\mathrm{dVpv}} = \frac{\mathrm{d(Ipv \times Vpv)}}{\mathrm{dVpv}} = \mathrm{Ipv}\frac{\mathrm{dVpv}}{\mathrm{dVpv}} + \mathrm{Vpv}\frac{\mathrm{dIpv}}{\mathrm{dVpv}} = 0 \qquad (1)$$

$$\frac{\mathrm{dIpv}}{\mathrm{dVpv}} = -\frac{\mathrm{Ipv}}{\mathrm{Vpv}} \qquad (2$$

Thus, meeting the MPP requires checking the operating point in each sample; generally operating points in a P-V curve are classified into three groups:

$$\frac{\mathrm{dPpv}}{\mathrm{dVpv}} > 0 \rightarrow Vpv < Vmpp,$$

$$\frac{\mathrm{dPpv}}{\mathrm{dVpv}} = 0 \rightarrow \mathrm{Vpv} = \mathrm{Vmpp},$$

$$\frac{\mathrm{dPpv}}{\mathrm{dVpv}} < 0 \rightarrow Vpv > Vmpp$$

Besides, the incremental variations can be stated approximately due to subtracting of actual value of VPV and IPV in two following sampling time.

$$dIpv = \Delta Ipv = Ipv(t1) - Ipv(t2) \quad (3)$$

$$dVpv = \Delta Vpv = Vpv(t1) - Vpv(t2) \quad (4)$$

Analysis of data values is much easier with this approximation. Algorithm flow chart of Incremental Conductance method has been drawn in Figure 4.

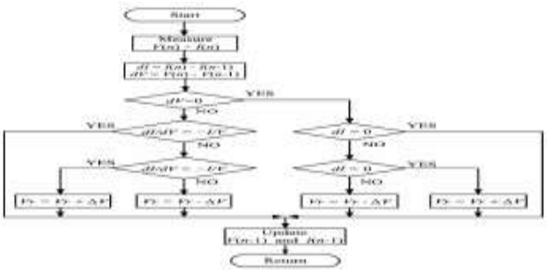


Fig. 4. Flow chart for Incremental Conductance algorithm

IV. SIMULATION RESULTS

The MATLAB/Simulink software is used to simulate the multiport interleaved boost DC converter with Incremental Conductance based MPPT control methods to track maximum power point from photovoltaic module/battery system.

Source 1-PV panel:	Open circuit	64.2
	Short circuit	5.96
Source 2-PV panel:	Open circuit	64.2
	Short circuit	5.96
Source 3-Battery:	Maximum	10.7
	Fully charged	58.8
	Nominal	2

Table : II The overall MATLAB simulation diagram for proposed concept

In addition, this converter uses less number of switches to each source port and as a result that requires less duty ratio signals and makes comfort for each port to eliminate ripples producing in converter and by decreasing ripple losses that maintain fix output power to the three phase induction motor according to the switching states. Thus verified in below simulation shown in Figure 5.

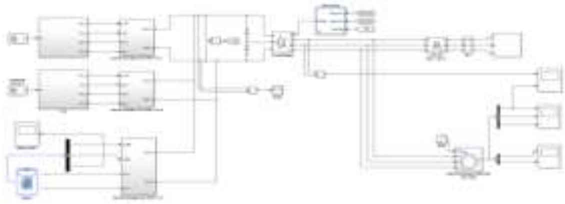


Fig. 5. Overall simulation diagram

In this case study the three phase induction motor is drive through the three level voltage source inverter respectively connected in parallel to grid. The parameters used for simulating the proposed algorithm. The simulation results are obtained as follows in Figure .6,7,8,9.

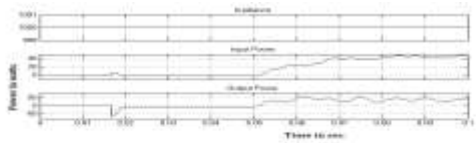


Fig. 6. Irradiance, Input & Output power graph for PV panel

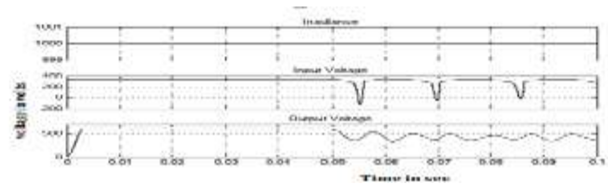


Fig. 7. Irradiance, Input & Output Voltage graph with time in seconds

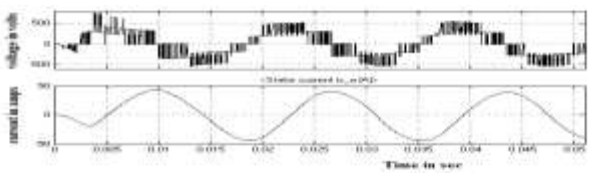


Fig. 8.Input voltage and current for motor with time in seconds

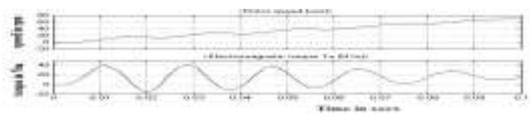


Fig.9.Characteristics of motor speed and torque

V. CONCLUSION

Utilizing a hybrid distributed generation system using multiport DC-DC converter in optimal performance fed to an induction motor has been proposed. The proposed interleaving multiport converter topology allows the voltage conversion in bidirectional manner with high power density. It consists of one control input for each traditional two-input port converter, which means it contains two inputs with different capacities of PV panels, battery storage and single output port. As that N-port converter switch has N+4 control switches is designed, with simple topology, reduced devices and single stage conversion with high-frequency link to control power flow between batteries, load and photovoltaic panels. This multiport DC-DC converter provides fix power in different conditions to the induction motor to enhance the system reliability. The power management and control system is designed to adjusting duty ratios by the incremental conductance MPPT algorithm and to find the global optimal solution for a nonlinear problem. By this it can enable to provide optimal operating points of DG sources. According to the solution, each power management switching cycle of the converter is selected and it is divided into five switching periods which gives five duty ratios for multiport DC-DC converter. The simulation results verify the performance of hybrid system multiport DC-DC converter and three phase induction motor efficiency in operating conditions. This proposed multiport converter is be offers a advantage in satellites ,pumping applications electric vehicles, or stand-alone micro-grid.

VI. REFERENCES

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