A FOUR PORT DC-DC CONVERTER FOR RENEWABLE ENERGY SYSTEMS

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Abstract: *Multiport converters can be used for relatively high-power applications. Three port Full-bridge-based topologies utilize a lot of switches with complicated driving and control circuitry. Due to this reason overall cost and size are high. This paper presents the control strategy and power management for an integrated Four-port converter, which interfaces one wind energy port ,one solar input port, one battery port and an isolated output port. A competitive method is used to realize smooth and seamless mode transition. Multiport converter has plenty of interacting control loops due to integrated power trains. The integrated system will have a lower overall mass and more compact packaging. And also has lower cost, improved reliability and enhanced dynamic performance due to power stage integration and centralized control. The circuit is simulated using MATLAB. The simulation results are presented in this paper.*

Key Terms: *Multiport Converter, DC-DC converter, Renewable Energy Sources, Four Port Converter*.

I. Introduction

As interest in renewable energy systems with various sources becomes greater than before, there is a supreme need for integrated power converters that are capable of interfacing, and concurrently, controlling several power terminals with low cost and compact structure [16]. Meanwhile, due to the intermittent nature of renewable sources, a battery backup is normally required when the ac mains is not available [1],[15].This paper proposes a new four-port-integrated dc/dc topology, which is suitable for various renewable energy harvesting applications. An application interfacing hybrid photovoltaic (PV) and wind sources, one bidirectional battery port, and an isolated output port is given as a design example. It can achieve Maximum power-point tracking (MPPT) for both PV and wind power simultaneously or individually, while maintaining a regulated output voltage. Compared to the effort spent on the traditional two-port converter [8],[9], less work has been done on the multiport converter . But, due to the advantages like low cost and compact structure, multiport converters are reported to be designed for various applications, such as achieving bus voltages of 14 V/42 V. (high voltage of around 500 V) in electric vehicles [6] or hybrid electric vehicles interfacing the PV panel and a battery to a regulated 28-V bus in satellite platform power systems PV energy harvesting with ac mains or the battery backup, hybrid fuel cell and battery systems and hybrid ultra capacitor and battery systems. From the topology point of view, multi input converters based on buck, boost, and buck–boost topologies have been reported in. The main limitation of these configurations is the lack of a bidirectional port to interface storage device [10]. Multiport converters are also constructed out of a multi winding transformer based on half-bridge or full bridge topologies [12]. They can meet isolation requirement and also have bidirectional capabilities. However, the major problem is that they use too many active switches, in addition to the bulky transformer, which cannot justify the unique features of low component count and compact structure for the integrated multiport converter. The proposed four-port dc/dc converter has bidirectional capability and also has one isolated output. Its main components are only four main switches, two diodes, one transformer, and one inductor. Moreover, zero-voltage switching (ZVS) can be achieved for all main switches to allow higher efficiency at higher switching frequency, which will lead to more compact design of this multiport converter. The control design is also investigated based on the modeling of this modified half-bridge topology. In addition, a decoupling network is introduced to allow the separate controller design for each power port. The simulation results for the proposed converter are presented in this paper.

II. Circuit Description

The block diagram in Fig.1, presents the control strategy and power management for an integrated four-port converter, which interfaces one wind energy port, one solar input port, one battery port, and an isolated output port. The DC source may be Battery or fuel cell or rectified from AC source. Three port converters has one bi-directional input, one solar input and one wind energy based source so it is called four port circuit. Input side has three inputs and output side has one output. The input is from different sources such as solar, battery and wind. It is converted into high frequency AC with help of inverter. High Frequency Transformer is used for step down purpose. It is also used for isolation purpose. The transformer size should be small due to high frequency. Converter-2 is used to convert DC to AC voltage in reverse mode. In forward mode converter act as a rectifier .so the power flow in both direction. Filter Rectifier converts AC to DC. This output has ripples. It is filtered with a help of Capacitor filters. The output is DC voltage which can be used to run the motor, battery charging and telecommunication applications. Micro controller is used to generate triggering pulse for MOSFETS. It is used to control the outputs.

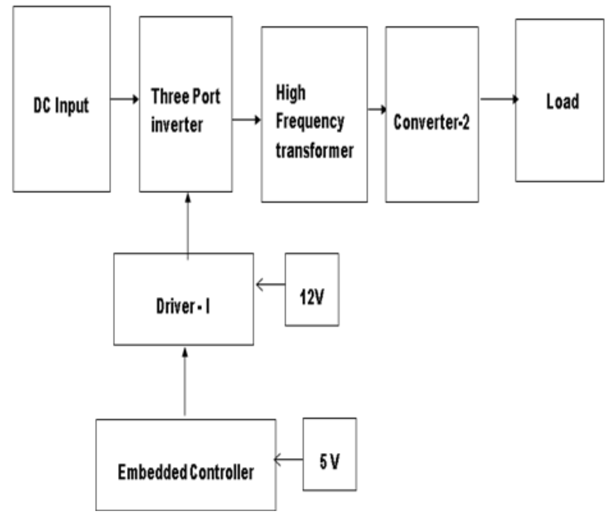

Fig.1 Block diagram of Four Port DC/DC Converter

III. Simulation Results

The simulation circuit diagram of proposed converter is shown in Fig.2.

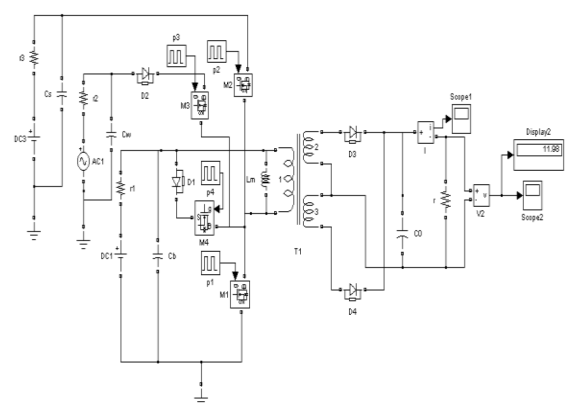

Fig.2 Simulation Model of Four Port DC-DC Converter

There are three voltage sources Solar Input Voltage (DC1), Rectified output from wind energy source (DC2) and Battery Input Voltage (DC3) shown in Fig.3, Fig.4 and Fig.5 respectively.

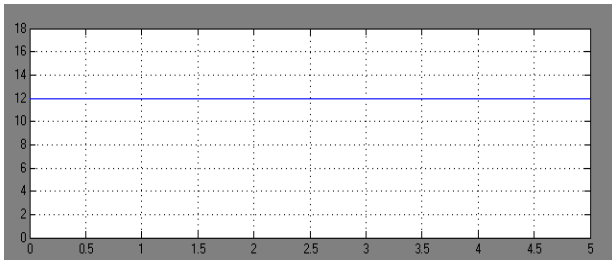

Fig.3 Solar Input Volatge-DC1

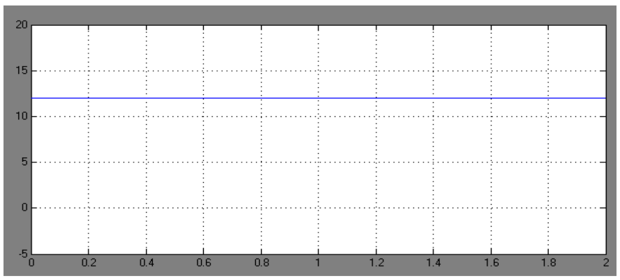

Fig.4 DC Input Voltage-DC2

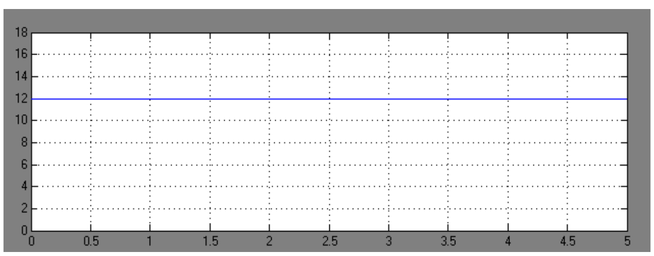

Fig.5 Battery Input Volatge-DC3

The switching pulses and voltage across MOSFETs are shown in Fig.6, Fig.7, Fig.8 and Fig.9 for MOSFETs M1, M2, M3 and M4 respectively.

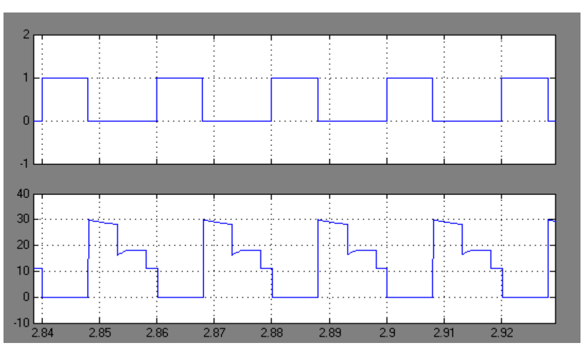

Fig.6 Switching pulse and voltage across S1

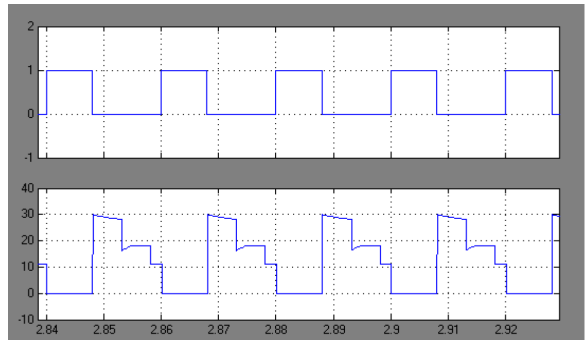

Fig.7 Switching pulse and voltage across S2

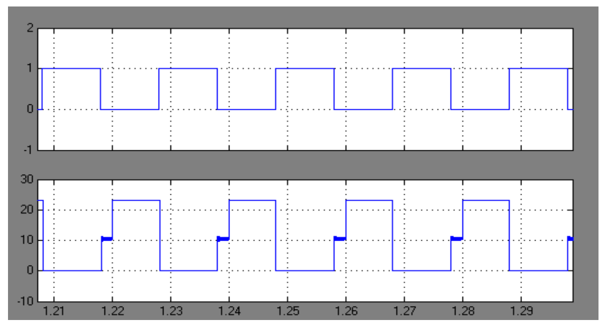

Fig.8 Switching pulse and voltage across S3

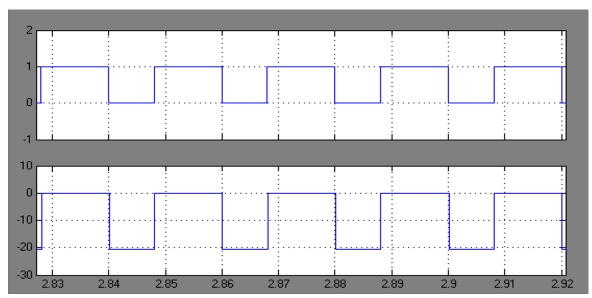

Fig.9 Switching pulse and voltage across S4

Transformer Primary and secondary voltages are shown in Fig.10 and Fig.11 respectively. The inverter output voltage is shown in Fig.12. The Output DC voltage and DC currents for R load are shown in Fig.13 and Fig.14 respectively.

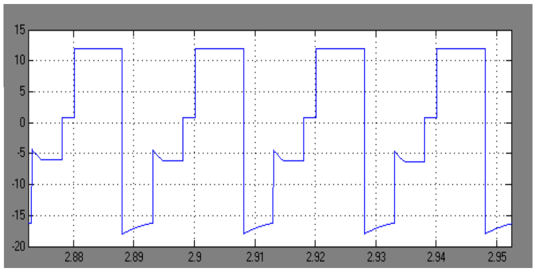

Fig.10 Transformer Primary Side Voltage

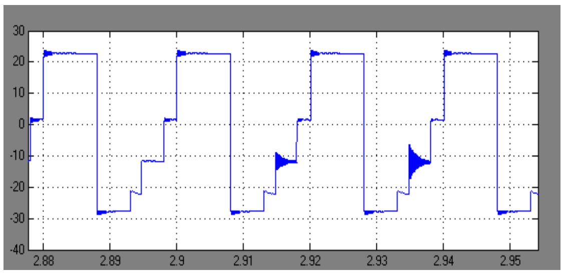

Fig.11 Transformer Secondary Side Voltage

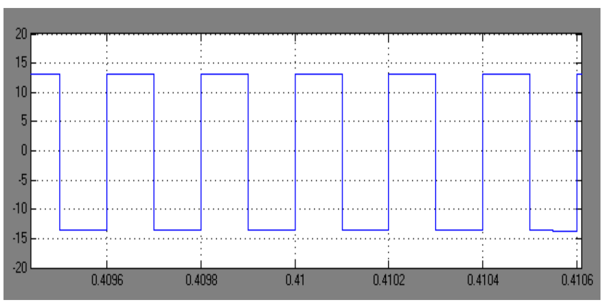

Fig.12 Inverter Output Voltage

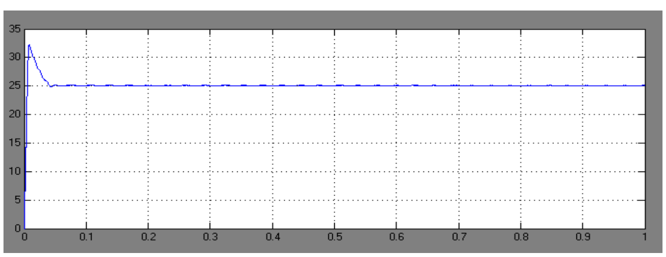

Fig.13 DC Output Voltage

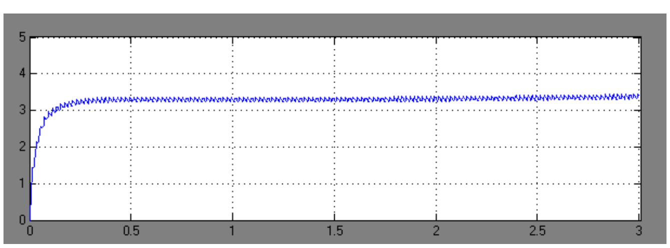

Fig.14 DC Output Current

IV. Conclusion

A novel DC/DC converter topology capable of interfacing four dc power ports is proposed. It has two input source ports a bidirectional storage port, an isolated loading port. The converter features low component count and ZVS operation for all primary switches. As observed from Fig.13, The voltage sharing is done between the sources.

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