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Implementation of Three Port dc-dc Converter Interface with Renewable Energy for High Power Application

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Abstract: **-- In this paper, multiport converters can be used for relatively high-power applications. Due to the advantages of multiport converter, recently there have been extensive researches that result in a wide variety of topologies. 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. One simple approach is to interface several converters stages to a common dc bus with independent control for each converter stage. This project presents the control strategy and power management for an integrated three-port converter, which interfaces one solar input port, one battery port, and an isolated output port.**

I. INTRODUCTION

The integrated multiport converter, instead of several independent converters, has advantages such as less component count and conversion stage because resources like switching devices and storage elements are shared in each Switching period. As a result, the integrated system will have a lower overall mass and more compact packaging. In addition, some other advantages of integrated power converters are lower cost, improved reliability, and enhanced dynamic performance due to power stage integration and centralized control. Besides, it requires no communication capabilities that would be necessary for multiple converters. Therefore, the communication delay and error can be avoided with the centralized control structure. Instead of one control input for traditional two-port converter, N-port converter has N-1 control inputs, which requires more modeling effort.

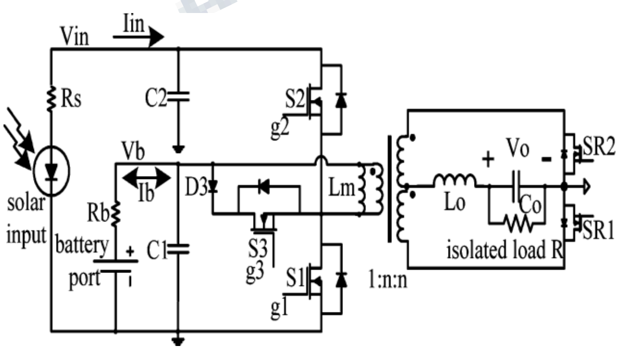

Fig 1.

Moreover, since the multiport converter has integrated power stage and, thus, multi-input multi-output (MIMO) feature, it necessitates proper decoupling for various control-loops design. Table I gives a comparison of the two different system structures. A buck-based topology was used to interface spacecraft front-end power systems. But the battery port is unidirectional and cannot be charged from solar port. But plenty of interacting control loops were neither analyzed nor decoupled. A multi input buck–boost-topology-based converter was proposed to accommodate various renewable sources. But there is neither bidirectional port nor isolated power port to interface battery and comply with safety requirement for certain applications. Another half-bridge-based topology has also been proposed for vehicle application. It has three fully isolated power ports, but conditions. utilizes six switches and many components, which is overqualified for our application that requires only one isolated port. Similarly, isolated-bidirectional multiport converters can also be constructed out of full-bridge topology for relatively high-power applications, since they apply full voltage to the transformer and adopt more switches to process power. But full-bridge-based topologies utilize a lot of switches with complicated driving and control circuitry that counteracts the size benefit of integrated topologies.

Recently, a three-port topology with only one middle branch added to the traditional half-bridge converter has been reported, which can achieve zero-voltage switching (ZVS) for all three main switches,

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adopts a high-frequency transformer to interface an isolated distribution bus, and has a Bi-directional port to interface battery.

To sum up, the multiport topologies can be classified into two categories: non isolated topologies and isolated topologies. Non isolated multiport converters usually take the form of buck, boost, buck–boost, etc., featuring compact design and high-power density; isolated multiport converters using bridge topologies have the advantages of flexible voltage levels and high efficiency since high-frequency transformer and soft-switching techniques are used; besides, isolation may be required for certain critical applications.

However, most reports focus on converter's open-loop operation and lack of investigation on control strategy such as system-level power management for different operational modes and various interacting control-loops' design, which are unique features of multiport converters and difficult to be dealt with. Therefore, it is interesting to solve problems like how to deal with different operational modes and let them transit between each other smoothly and seamlessly, and how to decouple control loops and design optimized compensators to minimize interactions of the MIMO converter

II.THE PROPOSED CIRCUIT OPERATION STAGES

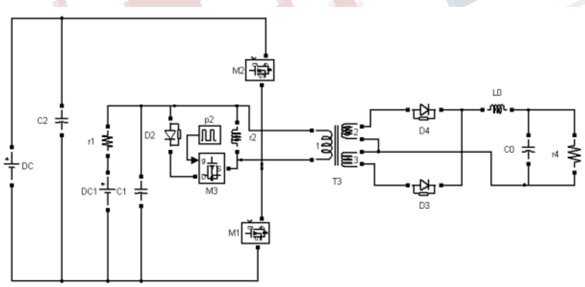

Fig 2. Circuit diagram

This section introduces the three-port topology and control structure. As shown in Fig. 1, it variables, namely, duty-cycles *d*1 and *d*2 that are used to control S1 and S2, respectively. This allows tight control over two of the converter is a modified version of pulse width-modulated (PWM) half-bridge converter that includes three basic circuit stages within a constant-frequency switching cycle to provide two independent control ports, while the third port provides the power balance in the system. The switching sequence ensures a clamping path for the energy of the leakage inductance of the transformer at all times. This energy is further utilized to achieve ZVS for all primary switches for a wide range of source and load

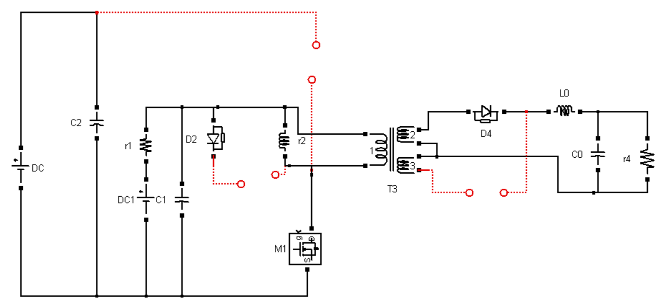

Fig 2(a) mode 1

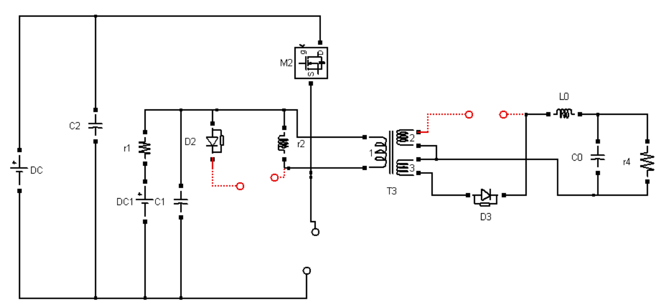

Fig 2(b) mode 2

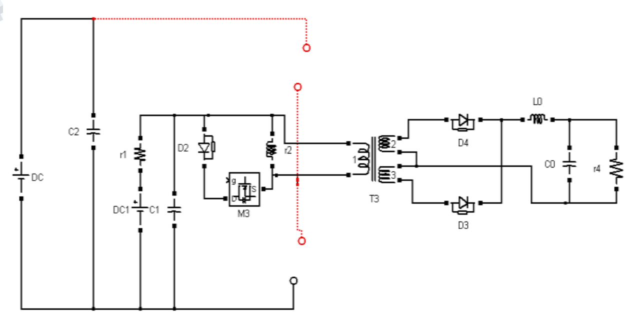

Fig 2(c) mode 3

II. MODES OF OPERATION

The operating principle of this converter can be divided into thre intervals. the following assumption is made.

- All switching devices and passive elements are ideal.

***Mode 1*:**

In stage I, S1 is gated ON, applying a positive voltage to the transformer primary side, while output inductor is charging. Synchronous diode is ON to allow current flow through output inductor Lo . Current of battery-port filter capacitor is equal to the sum of battery current, transformer magnetizing inductor current, and reflected secondary-side current. The state equation in this stage is as

$$\frac{C_1 dvc_1}{dt} = \frac{-vc_1}{R_b} + iL_m - ni_{L_{O,}}$$

$$\frac{L_m diL_m}{dt} = -v_{c_1},$$

$$\frac{L_O di_{L_o}}{dt} = v_{c_1} n - v_{0,}$$

$$\frac{C_o dv_o}{dt} = iL_o - \frac{v_o}{R}$$

Mode 2:

In stage II, S2 is gated ON, a negative voltage is applied to the transformer primary side, and output inductor is still charging. Synchronous diode is ON to allow a current flow path through Lo. The transformer primary voltage is the input voltage that subtracts battery voltage, and thus, output inductor charging rate changes accordingly. The state equation in this stage is as follows:

$$\frac{C_1 dvc_1}{dt} = \frac{-vc_1}{R_b} + iL_m + ni_{L_{O,}}$$

$$\frac{L_m diL_m}{dt} = v_{c_2} - v_{c_1},$$

$$\frac{L_O di_{L_o}}{dt} = (v_{c_1} n - v_{c_1}) n - v_{0,}$$

$$\frac{C_o dv_o}{dt} = iL_o - \frac{v_o}{R}$$

Mode 3:

In stage III, S3 is gated ON, zero voltage is applied to the transformer primary side due to middle branch (S3 and D3 path)'s clamping, and output inductor is discharging. This allows both the magnetizing and output inductor currents to free-wheel. Both D3 and D4 are turned on, thus output inductor current distributes into both of rectifying paths. The state equation in this stage is as follows

$$\frac{C_1 dvc_1}{dt} = \frac{-vc_1}{R_b},$$

$$\frac{L_m diL_m}{dt} = 0,$$

$$\frac{L_O di_{L_o}}{dt} = -v_{0,}$$

$$\frac{C_o dv_o}{dt} = iL_o - \frac{v_o}{R}$$

III. BASIC BLOCK DIAGRAM OF PROPOSED CIRCUIT

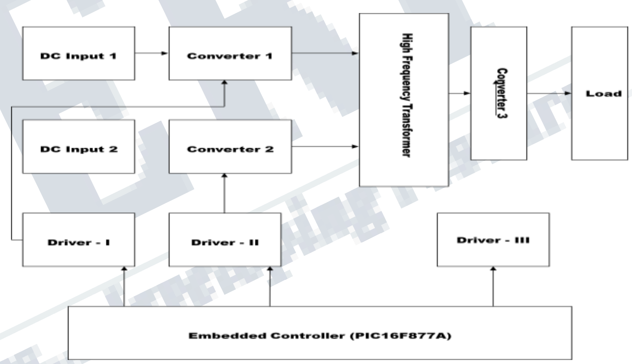

Figure 3. Block diagram of Proposed Circuit

Dc source is the first stage of this project. So it is give the dc supply to Inverter. The dc source may be Battery or fuel cell or rectified from ac source Converter 1 and converter 2 is used to convert dc to ac voltage in forward mode .the phase shift pulse width methosd is used to control the inverter as a result to achieve the ZVS.in reverse mode converter act as arectifier .so the power flow in both direction. 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-3 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. Rectifier converts ac to dc. This output has ripples. It is filtered with a help of Capacitor filters.

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The output has DC output votlage. It is 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. Micro controller have more advantage compare then analog circuits and micro processor such as fast response, low cost, small size and etc.

Drivers are also called as power amplifier because it is used to amplify the pulse output from micro controller. It is also called as opto coupler IC. It provides isolation between microcontroller and power circuits.

RPS give 5V supply for micro controller and 12V supply for driver. It is converted from AC supply. AC supply is step down using step down transformer

IV. EXPERIMENTAL RESULT

Below Figures shows experimental waveforms for the proposed converter

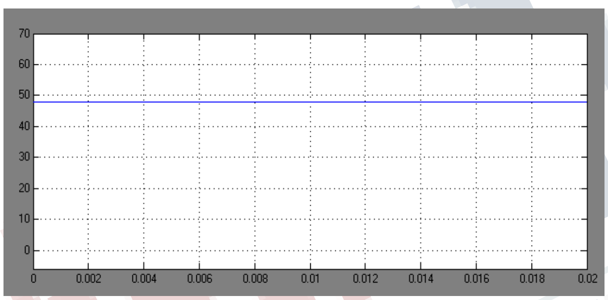

Fig 3.1 Solar input voltage

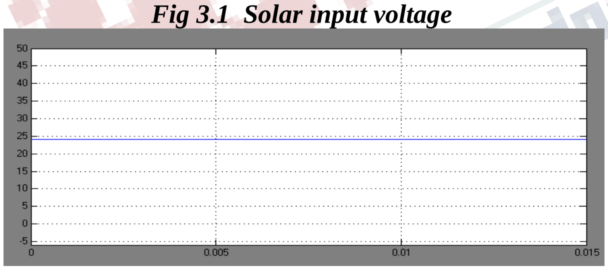

Fig 3.2 Battery voltage

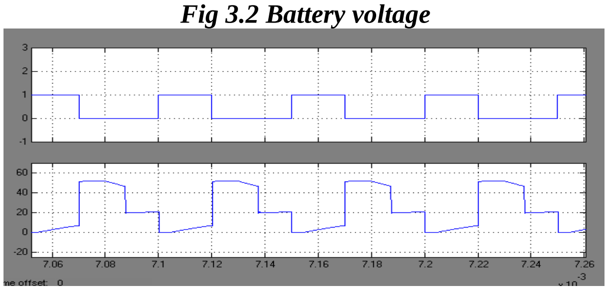

Fig 3.3 VGS and VDS across switch1

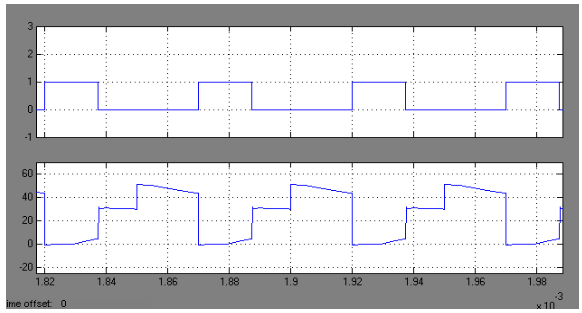

Fig 3.4 VGS and VDS across switch2

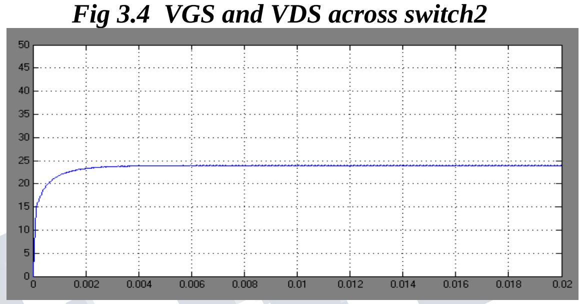

Fig 3.5 DC Output Voltage

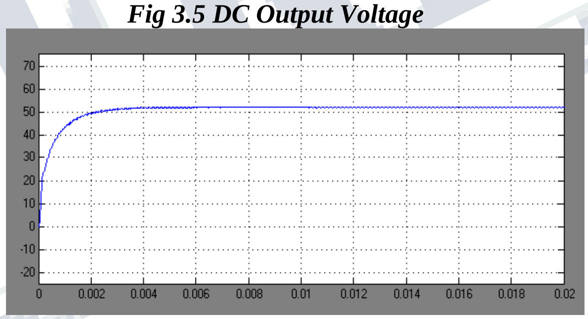

Fig 3.6 DC Output Power

V.CONCULSION

This paper deals with control strategy and modeling of the three-port dc/dc converter for high power application that interfaces a solar input panel,a rechargeable battery port, and an isolated output port were presented in this paper. The converter has three circuit stages to allow two control inputs that are used to regulate two of the three ports. The output voltage is regulated at any given time,but either input port or battery port can be regulated depending on which is most urgently needed according to available solar power and battery state of charge. The control design for multiport converter is challenging and needs to manage power flow under various operating conditions.

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