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Multiport Semi-Dual Active Bridge Converter

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ABSTRACT: A new soft switching circuit topology is derived from semi dual active bridge converter which is proposed for applications requiring only unidirectional power flow such as the dc–dc stage of a photovoltaic power converter, and battery charger for electric vehicles. The proposed converter consists of three ports,two bidirectional ports and one output port.It is similar to semi dual active bridge converter, no additional switches are used.The energy stored in the leakage inductance of the transformer is utilized to achieve zero-voltage switching for all the primary-side switches. The topology offers several other advantages including extended zero-voltage switching (ZVS), and smaller output filter requirement. MATLAB/SIMULINK is used for the system.

KEYWORDS: DC-DC Converter, Photo voltaic conversion, softswitching, unidirectional application.

I.INTRODUCTION

Renewable energy is generally energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain etc. which are found in many applications such as hybrid electric vehicles,traffic light etc.since the output is power of renewable sources is stochastic and the sources lackenergy storage capabilities, energy storage systems such as a battery or a supercapacitor are required to improve the system dynamics and steady-state characteristics. A three-port converter (TPC), which can interface with renewable sources, storage elements,and loads, simultaneously, is a good candidate for a renewable power system and has recently attracted increased research interest. Compared with the conventional solutions that employ multiple converters, the TPC features single-stage conversion between any two of the three ports, higher system efficiency, fewer components, faster response, compact packaging, and unified power management among the ports with centralized control. Power flow control and zero-voltage switching (ZVS) are achieved with phase-shift control between different switching bridges, whose principles are the same as the dual active- bridge (DAB) topology. Isolation and bidirectional capabilities can also be achieved with these topologies.This paper proposes the multi-portsemi dual-active-bridge (S-DAB) converter for the unidirectional power flow applications. Here, the active H-bridge on the source side (primary) is divided in to two with a transformer, but the load side (secondary) H-bridge is replaced by a semi active bridge with two switches and two diodes. In addition to reducing the number of switches, it alters the operating characteristics leading to advantages similar to PWM control of DAB. It may be noted that the primary H-bridge may also be replaced by a half bridge for lower power applications.

II. LITERATURE SURVEY

Thecurrent-voltage-fed bidirectional DC–DC converter, which refers to a current-fed inverter at low voltage side and a voltage-fed inverter at high voltage side, can realize Zero Voltage Switching (ZVS) for the switches with the use of Phase-Shift (PS) technology. All switches realize ZVS in a wide range of load variationwhile input or output voltage varies. The PS plus PWM control reduces the circulating current. The converter avoids the voltage spike of switches with the use of an active clamping branch. The control strategy realizes energy conversion freely, which has high steady and dynamic performance.Dual-Phase-Shift (DPS) control strategy for a dual-active-bridge isolated bidirectional DC–DC converter also studied. The proposed DPS control consists of a phase shift between the primary and secondary voltages of the isolation transformer and a phase shift between the gate signals of the diagonal switches of each H-bridge. The DPS control can eliminate reactive power in isolated bidirectional DC–DC converters. In addition, the DPS control can decrease the peak inrush current and steady-state current, improve system efficiency, increase system power capability and minimize the output capacitance as compared to the traditional phase-shift control.A Dual-Active-Bridge (DAB) and a half-bridge inverter, which are integrated back-to-back for a converter/inverter system.The power source is isolated by a high frequency transformer, and a 60Hz inverter is directly connected to the secondary side of the converter via DC link capacitors. Thus, the proposed converter-inverter topology greatly reduces the size and the

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number of parts count, while providing isolation.But, the inverter causes the DC link voltage unbalance, leading to coupled dynamics between converter and inverter**.** An asymmetrical duty control method is proposed to counter attack the capacitor voltage unbalance and fluctuations. At the same time, the average DC link voltage is controlled mainly via the traditional phase-shift control.

II.CIRCUIT TOPOLOGY AND OPERATION

A DC/DC multi input converter is used for the unidirectional power flow applications.The proposed converter consists oftwo sections, primary and secondary. primary side consist of four MOSFET's and secondary side consist of 2 MOSFET and two diodes The diodes for the upper switches of secondary bridge limit the power flow to be unidirectional from the source connected to the active bridge to the load connected to the semi active bridge. The two bridges are connected by a transformer that provides galvanic isolation and voltage step-up or step-down functions.Analysis of the S-DAB converter can be simplified by referring the entire model to the primary of the transformer such that the two bridges are linked by the leakage inductance of the transformer.Similar to the DAB, the leakage inductance is a key element in determining the power handling capacity of the S-DAB converter. The high-frequency transformer in the DAB or S-DAB is fabricated with high leakage inductance. The inductance is either implemented as an integrated magnetic structure or as an external component to achieve the desired value. The switches in HB1 and HB2 are typically driven by square waveforms of 50% duty cycle and the power flow is controlled by varying the phase-shift angle φ between the bridges. Resistances of the transformer and semiconductor switches and the threshold voltages of diodes and MOSFETs are neglected in this analysis.

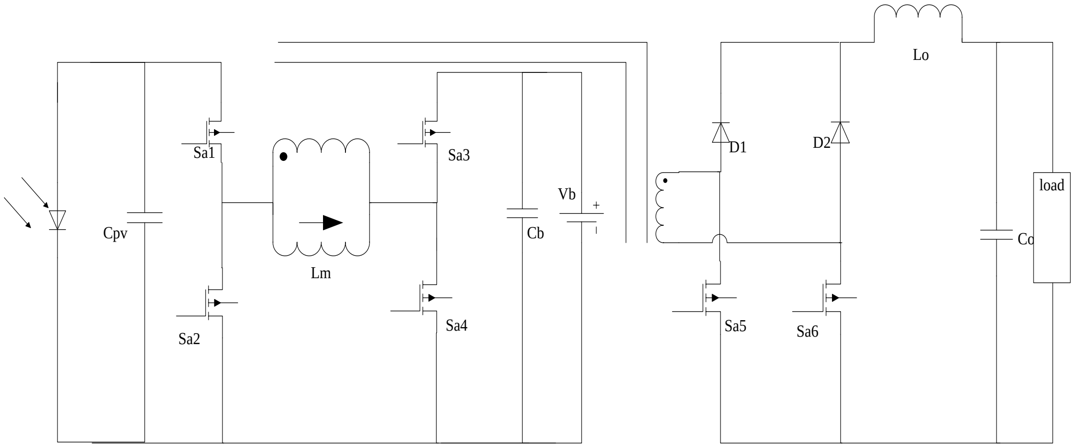

Fig.1: proposed converter

The primary side bridge HB1 produces a square wave voltage waveform at constant frequency indicated asv_p. The voltage produced by the secondary bridge indicated asv_s,has a quasi-square waveform with the pulse width determined by the operating conditions, in particular by the conduction of the diodes in the secondary bridge. The control of the converter is achieved by phase shifting (delaying) the rising edge ofv_s with respect to the rising edge ofv_p. Shifting the phase of the secondary bridge by an angle changes the effective voltage across the leakage inductance there by controlling the current through the transformer. The net power always flows from the leading (primary) to the lagging (secondary) bridge. Similar to the DAB, many of the converter waveforms depend strongly on the voltage ratio, *m*, where $m=v_0/nv_n$ and*n* is the secondary to primary turns ratio of the transformer. Unlike in the DAB, the operation here involves inherent freewheeling of the secondary winding for an angle $\alpha_s$as the diodes on the upper section of each leg in the secondary bridge prevent reverse current flow. Some of the disadvantages of the DAB topology include limitedZVS range with a strong dependence on the voltage conversion ratio and load, relatively higher root-mean-square (rms) currents through the transformer and semiconductor devices due to circulating currents, and a negative pulse in the input and output currents with the duration dependent on the phase shift leading to higher capacitor rms currents are rectified in this converter.

Figure 1 sows the proposed converter that is multi-port semi dual active bridge converter. The unique characteristics of the semi bridge multiport converter are analyzed and summarized as follows.
1) The SB-TPC has two unidirectional ports and one isolated output port. Single-stage power conversion between any two of the three ports is achieved. The SB-TPC is suitable for renewable power systems and can be connected with an input source and an energy storage element, such as the photovoltaic (PV) with a battery backup, or with two energy storage elements, such as the hybrid battery and the supercapacitor power system.
2) A buck-boost converter is integrated in the primary side of the SB-TPC. With the integrated converter, the source VoltageV_{sa}can be either higher or lower than V_{sb}, and vice versa. This indicates that the converter allows the sources' voltage varies over a wide range.
3) The devices of the SB-TPC are the same as the Semi dual active bridge converter and no additional devices are introduced which means high integration is achieved.
4) The following analysis will indicate that all four active switches in the primary side of the SB-TPC can be operatedwith ZVS by utilizing the energy stored in the leakage inductor of the transformer, whose principle is similar to the phase-shift semi dual active bridge converter.
There are three power flows in the standalone PV power system: 1) from PV to load; 2) from PV to battery; and 3) from battery to load. As for the SB-TPC, the load port usually has to be tightly regulated to meet the load requirements, while the input port from the PV source should implement the maximum power racking to harvest the most energy. Therefore, the mismatch in power between the PV source and load has to be charged into or discharged from the battery port, which means that in the multiport semi dual active bridge, two of the three ports should be controlled independently and the third one used for power balance. As a result, two independently controlled variables are necessary.

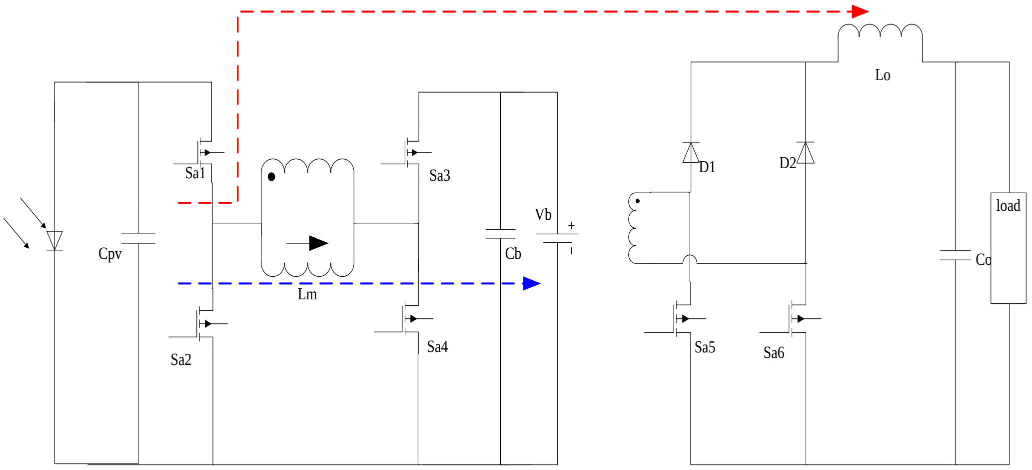

Fig.2: power flow direction in DI mode

Figure 2 shows the power flow direction of dual input operating mode of semi dual active bridge converter. There are mainly 3 directions such as dual input mode (DI), dual output mode (DO) and single input single output mode (SISO).In DI mode power of PV is greater than or equal to output power.

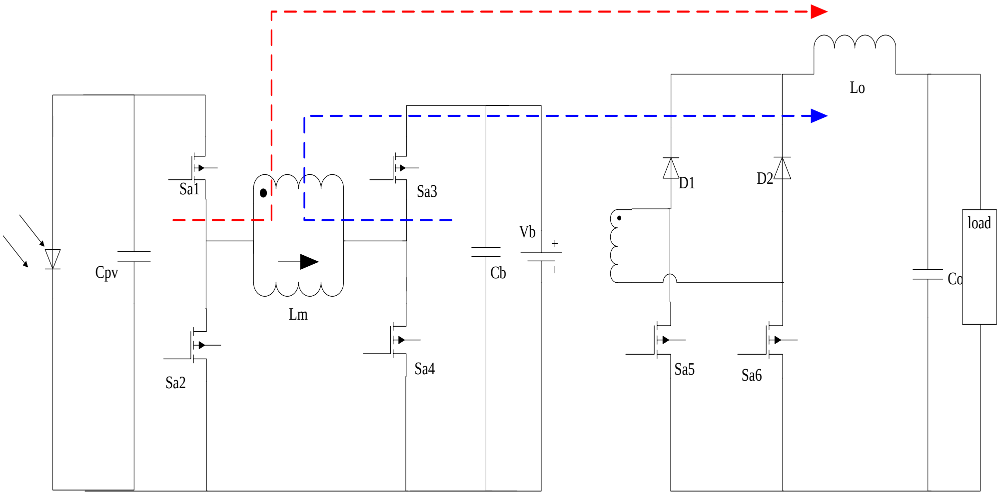

Fig.3: Power flow direction in DO mode

Figure 3 shows the power flow direction of dual output operating mode of semi dual active bridge converter.In DO mode the output power is greater than PV power, because the battery is discharging on this mode.

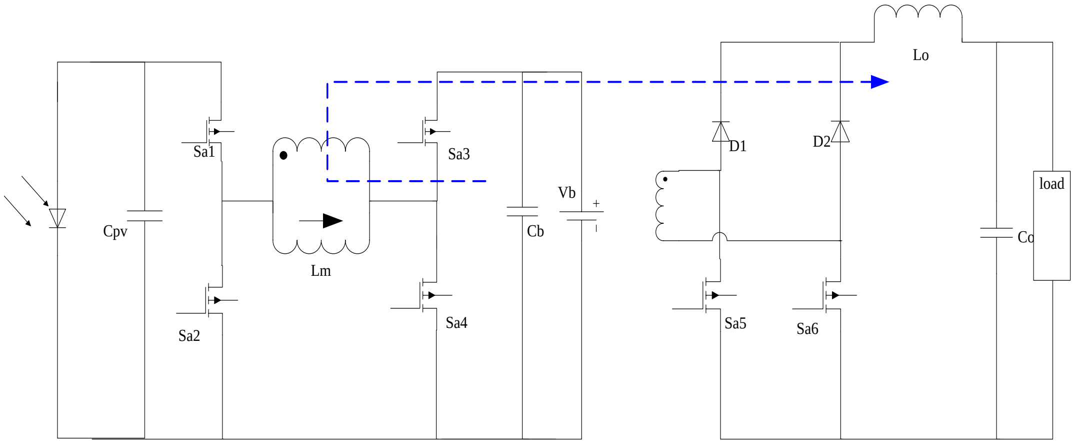

Fig.3: power flow direction in SISO mode

Figure 4 shows the power flow direction of single input single output operating mode of semi dual active bridge converter.In SISO mode the power of PV will be zero.

As for the semi dual active bridge-TPC, the load port usually has to be tightly regulated to meet the load requirements, while the input port from the PV source should implement the maximum power tracking to harvest the most energy. Therefore, the mismatch in power between the PV source and load has to be charged into or discharged from the battery port, which means that in the SDBTPC, two of the three ports should be controlled independently and the third one used for power balance. The switching states in different operation modes are the same and the difference between these modes are the value and direction of i_{Lm}, as shown in Fig. 1, which is dependent on the power of $p_{pv}$and p_o. In the DO mode, $i_{Lm}$is positive, in the SISO mode, $i_{Lm}$is negative, and in the DI mode, i_{Lm}can either be positive or negative. Take the DO mode as an example to analyze.

For simplicity, the following assumptions are made: 1) C_{pv} , C_b, and $C_o$are large enough and the voltages of the three ports, V_{pv} , V_b, and V_o, are constant during the steady state; and 2) the $V_{pv}>V_b$case is taken as an example for the switching state analysis. There are four switching states in one switching cycle. This four states explain us how the three port converter works and which are the switches that conduct on particular states

State 1 (t_0-t_1):Before t_0 switches S_{a2} and $S_{a4}$are on, S_{a1} and S_{a3} are off.i_{Lm} freewheels through S_{a2} and S_{a4}.At $t_0$$S_{a1}$turns on and S_{a2}turns off.
State 2(t_1-t_2): At t_1 S_{a4} turns off and S_{a3} turns on.A positive voltage is applied on the primary winding.
State 3 (t_2-t_3): At t_2 S_{a1} turns off and S_{a2} turns on.A negative voltage is applied on the primary winding.
State 4(t_3-t_4): At t_3 S_{a3} turns off and S_{a4} turns on.The voltage across the primary winding is clamped at zero.i_{Lm} free wheels through S_{a2} and S_{a4}.

III.SIMULATION DIAGRAM

MATLAB Simulink model of three port semi dual active bridge converter is shown in fig.5.consisting of a PV, battery source, six MOSFET switches etc. Thegatingsignals for all the switches are given by the PWM technique which helps to improve the efficiency of the converter by reducing the loss.

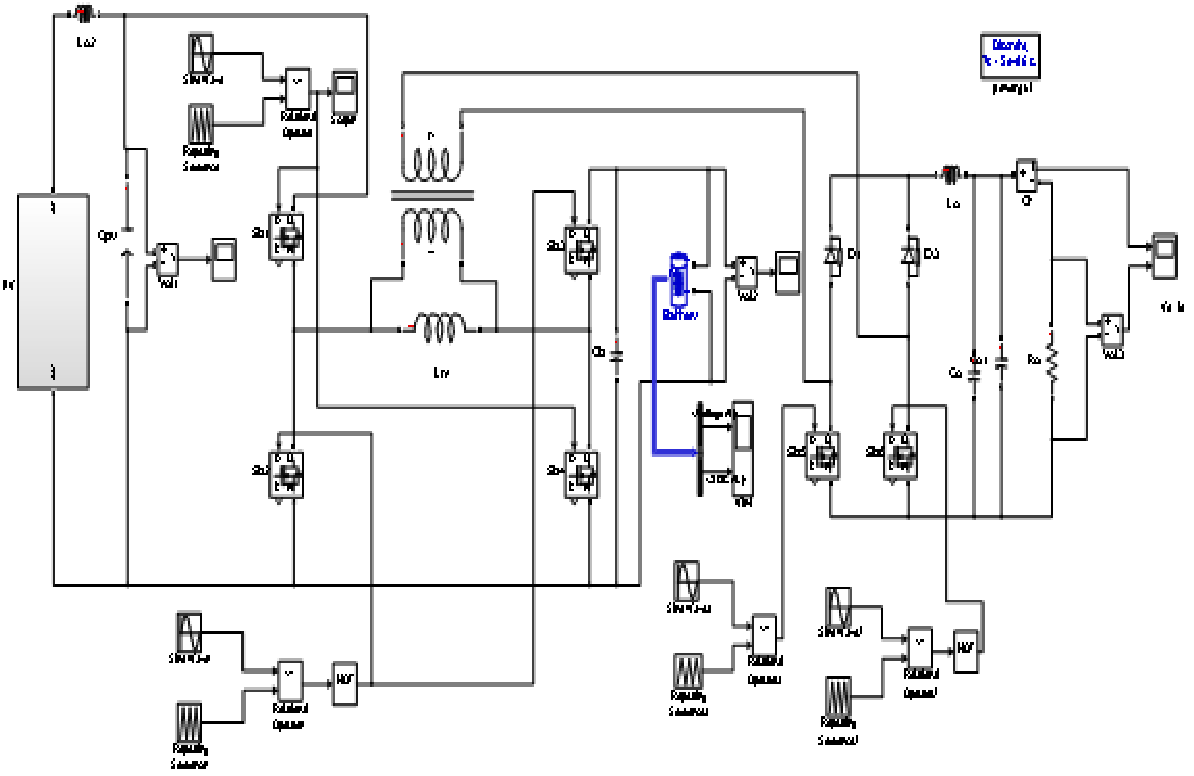

Fig.5: simulation diagram of proposed converter

fig.6 shows the Simulink model of solar panel which is given for the PV analysis.PV cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whoseelectrical characteristics, such as current, voltage, or resistance, vary whenexposed to light.

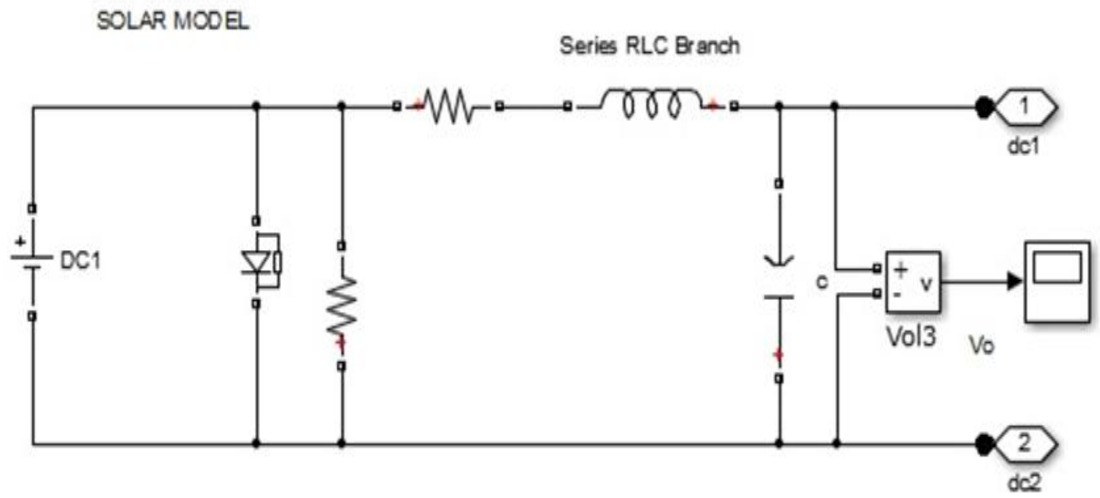

Fig.6: simulation diagram solar model

The basic solar model consists of DC source, RLC branch, diode and two resistors. These all elements are connected and then its voltage is measured. This voltage is applies as one source.

IV. SIMULATION RESULT

Simulation of proposed semi dual active bridge three port converter is performed using MATLAB. The output waveforms of proposed converter are given. All input DC sources are equal. MATLAB 7.10.0(R2010a) is used for simulation part of the project.

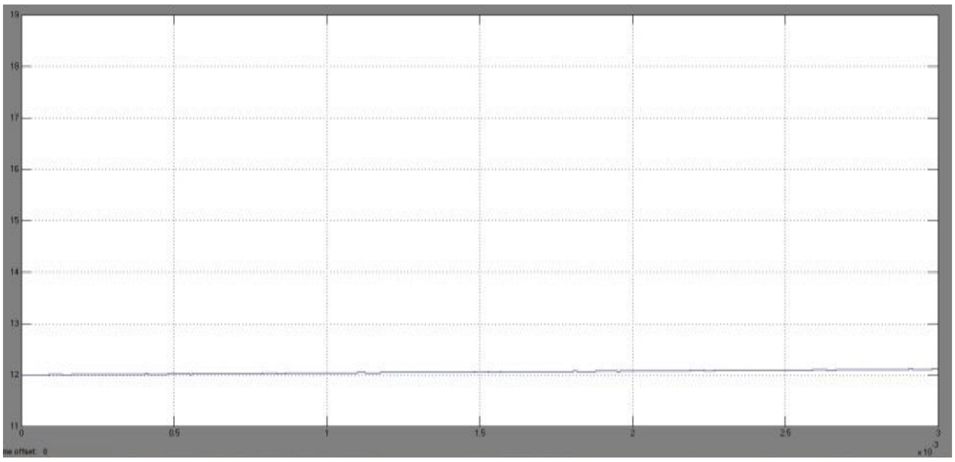

Fig.5: output waveform of solar panel

Figure 5 shows the output waveform of solar panel, which is obtained by connecting the parameters in MATLAB. This gives an output of 12v with simple circuit parameter.

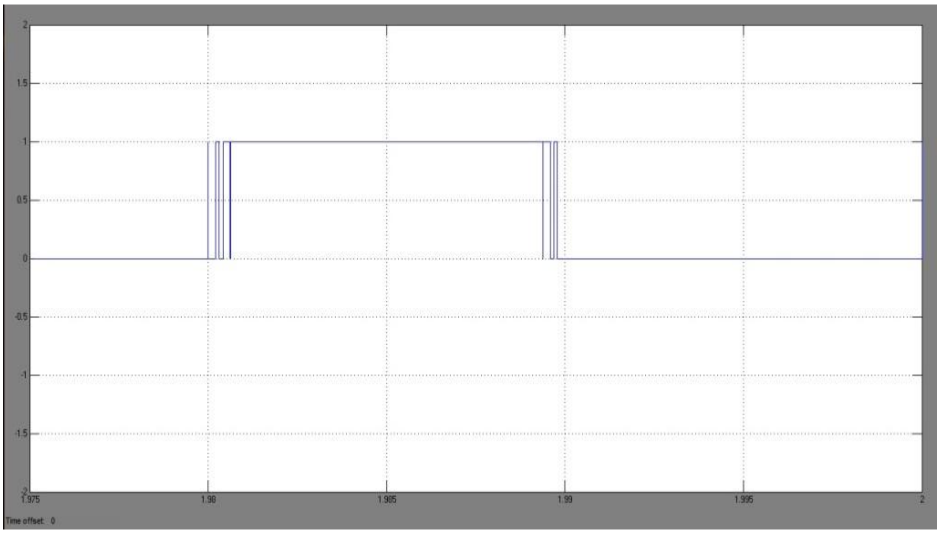

Fig.6: PWM output

Figure 6 shows the output waveform of PWM method. Sinusoidal pulse width modulation method is used here for better efficiency. By using PWM technique losses also reduced.

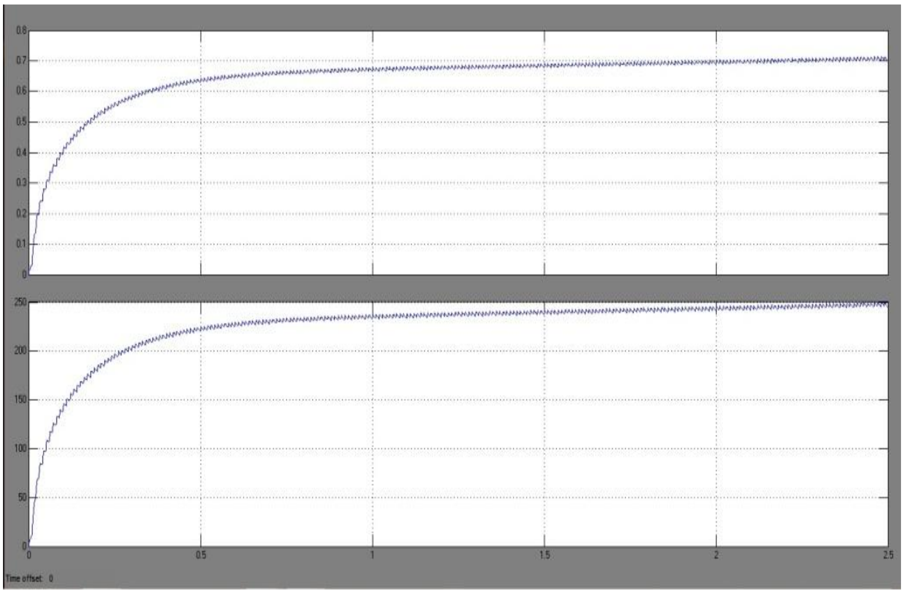

Fig.7: output waveform of converter

Figure 7 shows the output waveform of the proposed converter. From this converter we get an output around 250v for a 24v input and its gain is near to 10%.for a small input we can vary the output over a wide range.

V.CONCLUSION

Novel SB-TPCs have been proposed and investigated in this paper. The SB-TPCs are rooted in the semi dual active bridge and generated by splitting the two switching legs of the converter into two switching cells, connecting the two cells to different sources, and utilizing the magnetizing inductance of the transformer as a filter inductor.ZVS has been achieved for all the primary-side switches by utilizing the energy stored in the leakage inductance of the transformer. This results in high conversion efficiency.S-DAB is suited for unidirectional power flow applicationssuch as the dc–dc stage of a PV power conversion system, chargers for electric vehicles, and other dc–dc converters requiring multiple, regulated outputs. It retains all the advantages of the popular DAB (except bidirectional power flow) including ZVS, high power density, high efficiency, and simple control..Energy can be stored in the leakage inductance of the transformer resulting ZVS.Some of the characteristics of S-DAB are similar to those obtainable using DAB with PWM control of the secondary side bridge, but here the advantages are obtained with reduced number of active switches. The operating principles, analysis and performance improvement have been presented in detail supported by simulation results. Three port semi dual active bridge converter is drawn using MATLAB. This three port converter consists of advantages such as high gain, reduced number of switches with simpler gate drive etc.

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