

SOFT SWITCHED MULTI PORT BIDIRECTIONAL CONVERTERS

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ABSTRACT

A four-port converter with three active full bridges, two series-resonant tanks, and a three-winding transformer is proposed. It uses a single power conversion stage with high-frequency link to control power flow between batteries, load, and a renewable source such as fuel cell. The converter has capabilities of bidirectional power flow in the battery and the load port. Use of series-resonance aids in high switching frequency operation with realizable component values when compared to existing four-port converter with only inductors. The converter has high efficiency due to soft-switching operation in all three bridges. Steady-state analysis of the converter is presented to determine the power flow equations, tank currents, and soft-switching region. Dynamic analysis is performed to design a closed-loop controller that will regulate the load-side port voltage and source-side port current.

Keywords: four port converter, bidirectional converter, soft switched.

1. INTRODUCTION

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[1-5]. 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[6-11]. 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[12-18]. 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[19-24], battery charging and telecommunication applications. Micro controller is used to generate triggering pulse for MOSFETS. It is used to control the outputs.

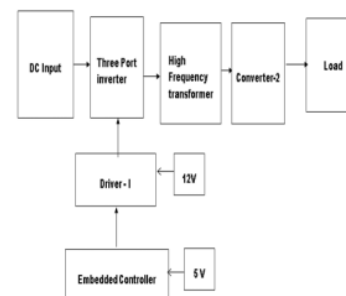


Fig.1 Block diagram of Four Port DC/DC Converter

2. PROPOSED METHOD:

A four-port series resonant converter operating at constant switching frequency and retaining all the advantages of a four-port structure is proposed in this project[25-30]. The series-resonant four-port converter proposed in this project uses a similar phase shift control but between two different sources. The phase shifts can be both positive and

negative, and are extended to all bridges, including the load-side bridge along with bidirectional power flow. In this project, a four-port converter with three active full bridges, two series-resonant tanks, and a three-winding transformer is proposed. It uses a single power conversion stage with high-frequency link to control power flow between batteries, load[31-36], and a renewable source such as fuel cell. The converter has capabilities of bidirectional power flow in the battery and the load port. Use of series-resonance aids in high switching frequency operation with realizable component values when compared to existing four-port converter with only inductors[37-40]. The converter has high efficiency due to soft-switching operation in all three bridges. Steady-state analysis of the converter is presented to determine the power flow equations, tank currents, and soft-switching region. Dynamic analysis is performed to design a closed-loop controller that will regulate the load-side port voltage and source-side port current.

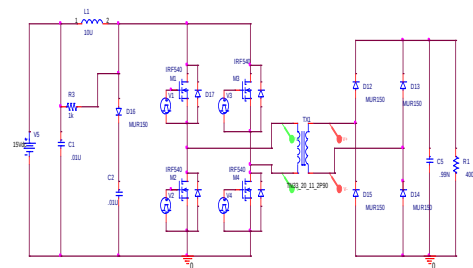
In this project, a four-port bidirectional series-resonant converter is proposed with the following features:

- 1) All ports are bidirectional, including the load port for applications, such as motor loads with regenerative braking.
- 2) Centralized control of power flow by phase shifting the square wave outputs of the three bridges.
- 3) Higher switching frequencies with realizable component values when compared to four-port circuits with only inductors.
- 4) Reduced switching losses due to soft-switching operation.
- 5) Voltage gain increased by more than two times due to the phase-shifting between input and

output bridges as opposed to a diode bridge at the load side.

In this project, a four-port series resonant converter is introduced to interface renewable energy sources and the load, along with energy storage[41-45]. It was proven by analysis and experimental results that power flow between ports can be controlled by series resonance and phase-shifting the square wave outputs of the three active bridges. The converter has bidirectional power flow and soft-switching operation capabilities in all ports. Dynamic model and controller design is presented for centralized control of the four-port converter. A design procedure with normalized variables, which can be used for various power and port voltage levels, is presented.

CIRCUIT DIAGRAM of conventional method



FULL BRIDGE BI-DIRECTIONAL CONVERTER - FORWARD MODE

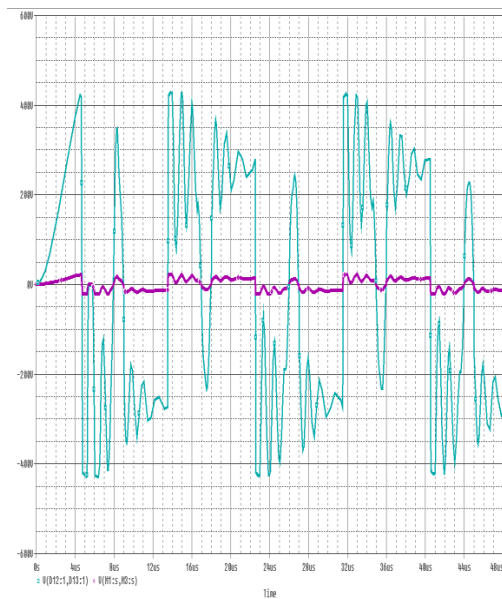
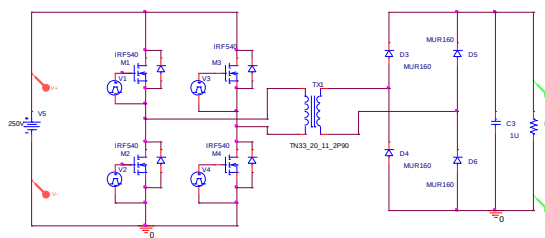
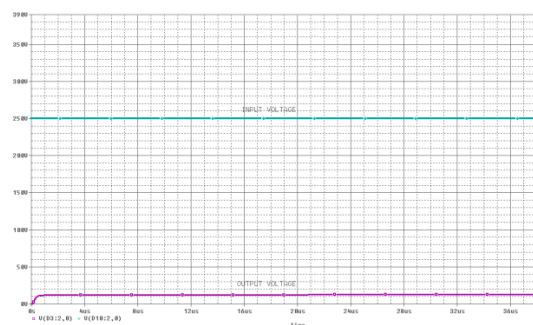


Fig.2. Primary and secondary of transformer



FULL BRIDGE BI-DIRECTIONAL CONVERTER -REVERSE MO

Fig 3 Full bridge bi-directional converter – Reverse mode



PROPOSED METHOD CIRCUIT DIAGRAM

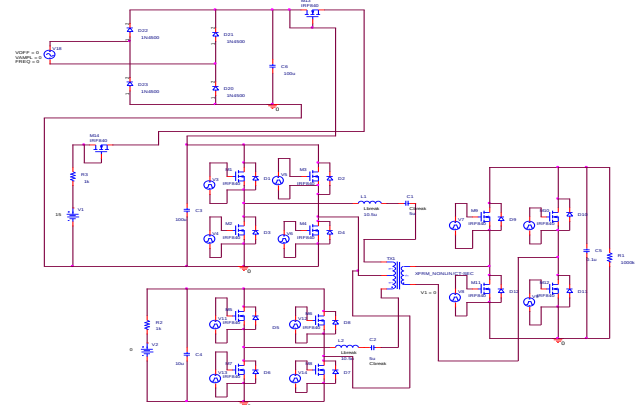


Fig.4 circuit diagram of proposed method

3. NEW PROPOSED METHOD:

- Changing the phase shift inverter as PWM inverter
- Elimination of series resonance.
- Designing hardware for motor load instead of resistive load.

Pulse Width Modulation or PWM technology is used in Inverters to give a steady output voltage of 230 or 110 V AC irrespective of the load. The Inverters based on the PWM technology are more superior to the conventional inverters. The use of MOSFETs in the output stage and the PWM technology makes these inverters ideal for all types of loads. In addition to the pulse width modulation, the PWM Inverters have additional circuits for protection and voltage control.

Circuit diagram

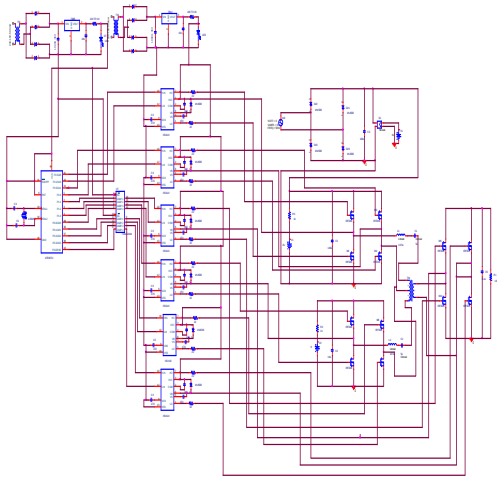


Fig 5.circuit diagram of new proposed converter

The quality of the output wave form (230 / 110 volt AC) from the inverter determines its efficiency. The quality of the inverter output wave form is expressed using **Fourier analysis data** to calculate the Total Harmonic Distortion (THD). THD is the square root of the sum of the squares of the harmonic voltage divided by the fundamental voltage.

$$\text{THD} = \sqrt{V_2^2 + V_3^2 + V_4^2 + \dots + V_n^2} / V_1$$

Based on the output waveforms, there are three types of Inverters. These are Sine wave, Modified Sine wave or Quasi sine wave and Square wave inverters.

4. Operation of the converter

To design an Inverter, many power circuit topologies and voltage control methods are used. The most important aspect of the Inverter technology is the output waveform. To filter the waveform (Square wave, quasi sine wave or Sine wave) capacitors and inductors are used. Low pass filters, are used to reduce the harmonic components. Resonant filter can be used if the Inverter has a fixed output frequency. If the inverter has adjustable output frequency, the filter must be tuned to a level above the maximum fundamental frequency. Feedback rectifiers are

used to bleed the peak inductive load current when the switch turns off.

As per the Fourier analysis, a square wave contains odd harmonics like third, fifth, seventh etc only if it is anti-symmetrical about 180 degree point. If the waveform has steps of certain width and heights, the additional harmonics will be cancelled. If a Zero voltage step is introduced between the positive and negative parts of the square wave, the harmonics that are divisible by three can be eliminated. The width of the pulse should be 1/3 of the period for each positive and negative steps and 1/6 of the period for each of the Zero voltage steps. This leaves on the fifth, seventh, eleventh, thirteenth harmonics etc

The Pulse Width Modulation technology is meant for changing the characteristics of the square wave. The switching pulses are Modulating, and regulating before supplied to the load. When the Inverter requires no voltage control, fixed pulse width can be used.

Advantage due to above changes

1. Harmonic reduction
2. Soft switching
3. Transformer size has been reduced.

4. SIMULATION RESULTS

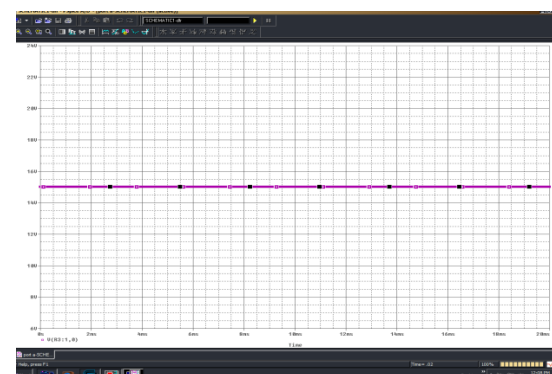


Fig 6. PortA supply voltage

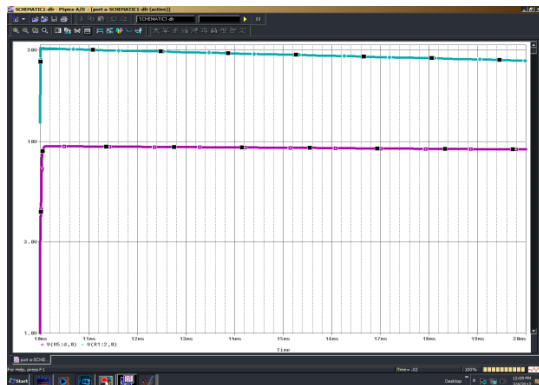


Fig 7 .port B charging, load voltage

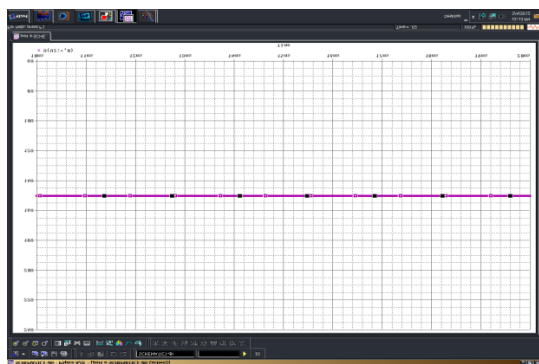


Fig 8 PORT B, SUPPLY VOLTAGE

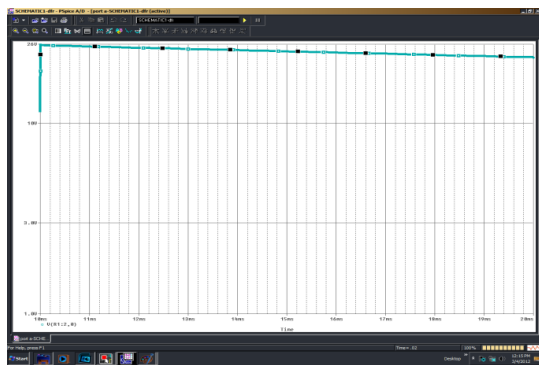


Fig 9 LOAD VOLTAGE

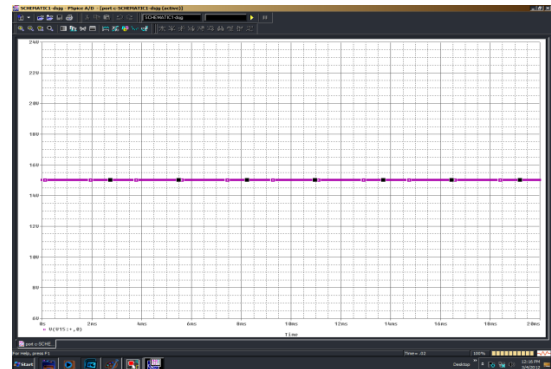


Fig 10 PORT C, SUPPLY VOLTAGE

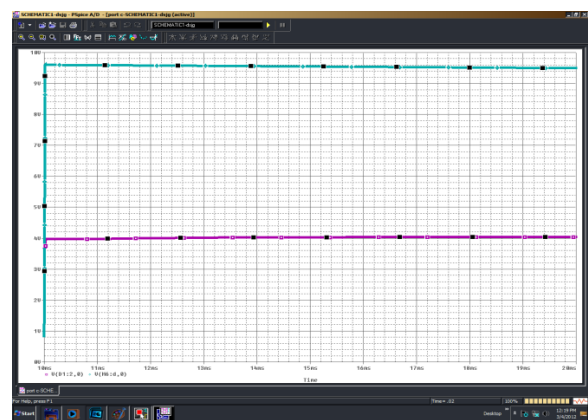


Fig 11 PORT A, PORT B, CHARGING VOLTAGE

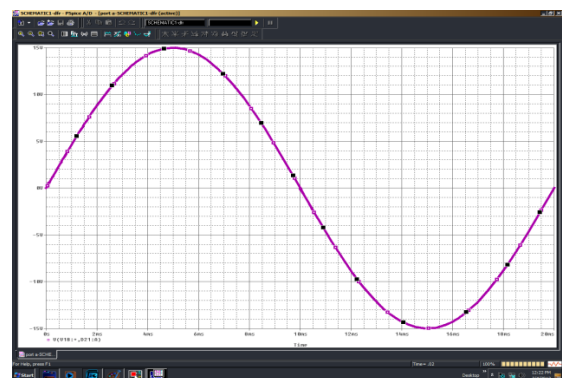


Fig 12 WIND INPUT VOLTAGE

CONCLUSION

This project deals with the implementation of simulation for bidirectional dc-dc converter, which allows transfer of power flow between the two dc sources in either direction. This converter can reverse the direction of flow of current, and thereby power, while maintaining the voltage polarity unchanged. Simulation of charging and discharging mode of bidirectional dc power supply was done successfully and waveforms are obtained. This bidirectional power flow is achieved by using same power components hence will minimize the hardware.

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