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Simple Phase Shift Controlled DC-DC Converters for High Voltage Applications

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ABSTRACT

With rapid development of renewable energy there is a rise in utilization of isolated DC-DC converters for applications like smart grid and electric vehicles. High efficiency, high gain and high power density are the parameters expected from a normal DC-DC converter, but when it comes to the output voltage, it will be of poor quality. The use of a transformer in the above system can correct this fault. This transformer isolates the Active Boost Rectifier (ABRs) which is composed of a traditional diode rectifier and a switch along with a Voltage Doubler (VD). Replacing inverter with an interleaved DC-AC converter on the primary side helps to generate a voltage from equal or lower input supply. This system can be useful anywhere where one does not have access to mains outlet for example a car, trailer or cottage. It can power appliances like radios, tape recorders, televisions, electric shavers, fluorescent lamps or cell phone charger. A voltage multiplier if implemented instead of the ABR-VD produces high voltage gain and can be used for high voltage applications , this is realized using fast switching diodes with addition of a phase shift control which provides gate pulses for switches on the inverter side by shifting phase angle and producing delay in pulses. This technique if utilized gives better performance parameters for DC-DC converter such as voltage gain, low voltage stress and soft switching behaviour. Various control strategies to suit high voltage low current application is consideredgiving more importance to phase shift control scheme and implementing it with a suitable closed loop controller for complete control is done and this work is studied alongside an interleaved configuration which can be used for same application with similar results.

INTRODUCTION

DC-DC converters are important in most of the portable electronic devices and are employed in variety of applications including supply for personal computers, office equipment, spacecraft power systems, laptops, telecommunication equipments as well as DC motor drives which are very much useful to people . The input to a basic DC-DC converter is a DC voltage say Vin and the converter produces a regulated output voltage say Vout which is having a magnitude and sometimes polarity that differs from that of the input . The ideal DC-DC converter exhibits 100% efficiency but in practice efficiencies of 70% to 95% are obtained as maximum , this is achieved using switched mode or chopper circuits whose elements dissipate negligible power. Different techniques allows control and regulation of the total output voltage. This controlling approach is employed in applications involving alternating current, including high efficiency DC-AC inverters, AC-AC power converters and some AC-DC power converters (low harmonic rectifiers). In most of applications it is desired to incorporate a transformer into the switching converter, to obtain dc isolation between the input and output. In off-line power supply applications, isolation is usually required by regulatory agencies. This isolation can be attained by simply connecting a 50 Hz or 60 Hz transformer at the power supply AC input terminals. However, since transformer size and weight vary with regards to the value of frequency, incorporationof the transformer into the converter can make significant improvement. When large conversion ratio is required, the use of a transformer can allow great converter optimization. By making a proper choice of the transformer turns ratio the voltage or current stresses imposed on the transistors and diodes can be reduced, leading to improved efficiency and lower cost. The ratio of turns on primary side to secondary side of a transformer is same as the ratio of voltage at primary to that of secondary but inverse of current value of primary to Secondary.

Generally, some additional components are introduced to suppress the circulating currents and alleviate the reverse-recovery problem. For instance, an auxiliary inductor, a transformer, or a winding is introduced to recycle the energy in . In, two active switches are introduced to the secondary-side rectifier to solve the reverse-recovery problem, but the penalty is an additional conduction loss. Recently, the dual active bridge topology attracts great interest because it can realize ZVS for all the power switches . But the limited ZVS range and high circulating currents at light load make this converter unsuitable for wide voltage/load range applications. Another attractive solution for the isolated dc–dc power conversion is the LLC resonant converter . By designing and selecting a proper operation region, soft switching of all the active switches and rectifier diodes over a wide load range can be achieved with the LLC resonant converter. However, frequency modulation makes the accurate modeling of the LLC converter difficult to achieve, and also complicates the design of magnetic components. Besides, the resonant tank in the LLC converter should be designed carefully as well to achieve high efficiency, which remains a challenge for this type of converter.

On the other hand, the duty cycle of a dc–dc transformer, which is an open-loop controlled isolated dc–dc converter, is fixed at 50%. As a result, soft switching of all the power switches can be always achieved by utilizing the leakage or magnetizing inductance . Therefore, high efficiency and high power density can be easily achieved. However, the output voltage/power of a dc–dc transformer cannot be regulated. If the output voltage of a dc–dc transformer can be regulated, high efficiency may be easily achieved. To achieve the goal mentioned previously, this paper proposes the active-boost-rectifier (ABR) concept. The ABR circuit is introduced to the dc–dc transformer topology to implement output voltage/power regulation. As a result, a family of wide-range soft-switching isolated dc–dc converters X. Pan and A. K. Rathore presented a novel interleaved soft-switching bidirectional snubberless current-fed full-bridge voltage doubler (dc/dc converter) for an energy storage system in fuel cell electric vehicles. A novel secondary modulation technique was also proposed to clamp the voltage across the primary-side switches naturally with zero-current commutation. It, therefore, eliminates the necessity for an external active-clamped circuit or passive snubbers to absorb the switch turn-off voltage spike, a major challenge in current-fed converters. Zero-current switching of primary-side devices and zero-voltage switching of secondary-side devices are achieved, which significantly reduce switching losses. An interleaved design is adopted over a single cell to increase the power handling capacity obtaining merits of lower input current ripple, reduction of passive components' size, reduced device voltage and current ratings, reduced conduction losses due to current sharing, and better thermal distribution. Primary device voltage was clamped at rather low-reflected output voltage, which enables the use of low-voltage semiconductor devices having low on-state resistance. Considering input current was shared between interleaved cells, conduction loss of the primary side, a considerable part of total loss, was significantly reduced and higher efficiency can be achieved to obtain a compact and higher power density system. Steady-state operation, analysis, and design of the proposed topology have been presented.

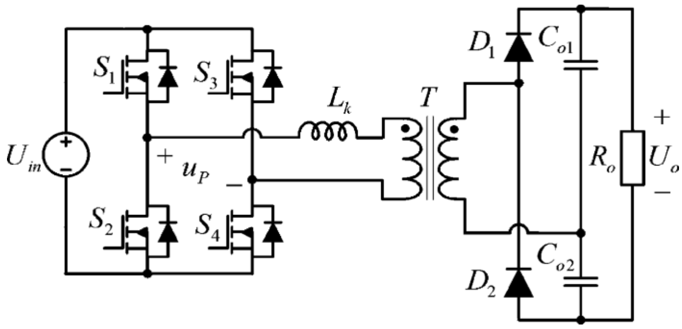
PROPOSED SYSTEM

The proposed system block diagram is shown in figure1. In the proposed system we have used the fuzzy logic controlling technique to improve the efficiency of the system. The system circuit diagram and operation of the proposed system is discussed below.

THE FBC WITH VOLTAGE-DOUBLER ABR:

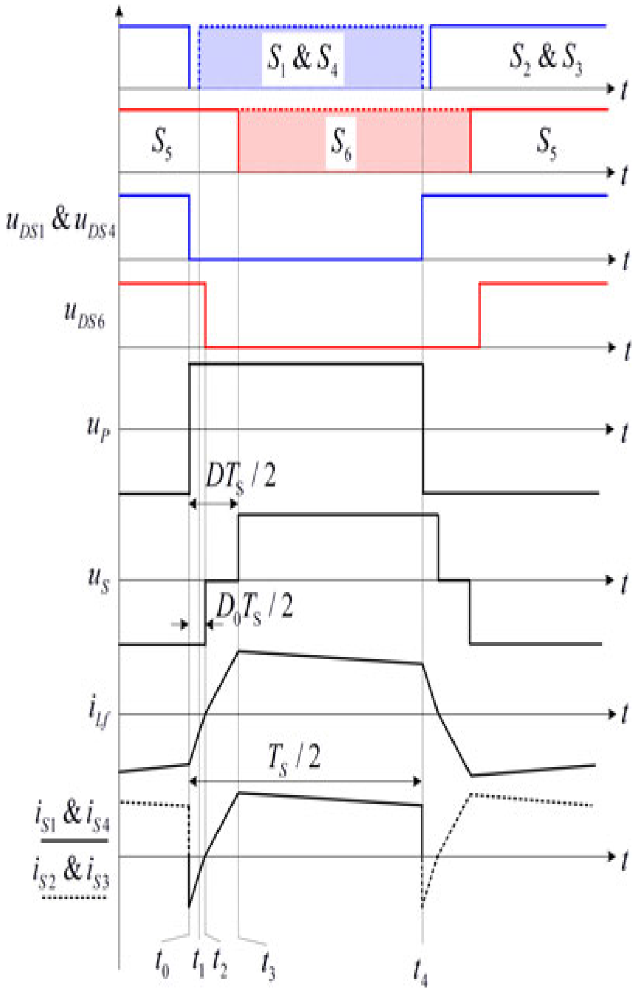
The FBC-VD-ABR is redrawn in Fig.2, where all the switches on the primary and secondary sides have a constant duty cycle of 0.5. S1 and S4 are always turned-

ON/OFF simultaneously, and the same with S2 and S3. A phase-shift angle between the primary- and secondary-side active switches is employed to regulate the output power and voltage. Lf stands for the total of the transformer leakage inductance and external inductor. The output series capacitors Co1 and Co2 have the same capacitance and are large enough to clamp the voltage stresses of the secondary-side switches and diodes to half of the output voltage. uDS1, uDS4, and uDS6 are the drain to source voltages of S1, S4, and S6, respectively. uP and uS are the voltages on the primary side and secondary side of the transformer. And iLfis the primary current flowing through the transformer with the positive direction shown in Fig.2. A proper dead time is necessary for the primary-side switches to achieve ZVS and avoid shot-through of the switching bridges. To simplify the analysis, the parasitic capacitance of MOSFET is ignored and the transformer is assumed to be ideal.

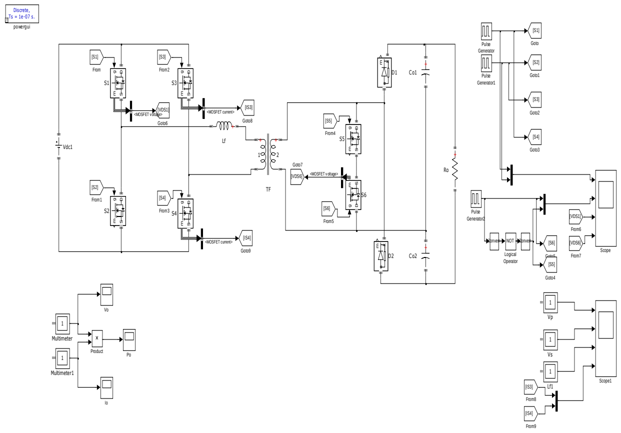


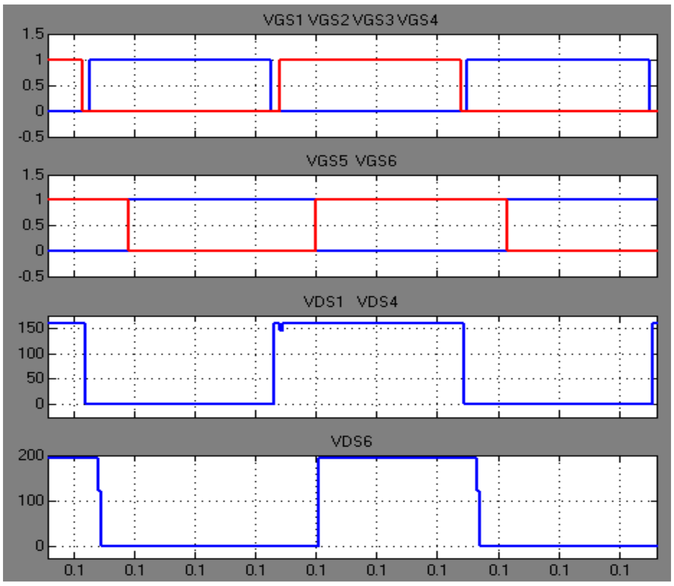
ANALYSIS ON THE FBC WITH VOLTAGE-DOUBLER ABR

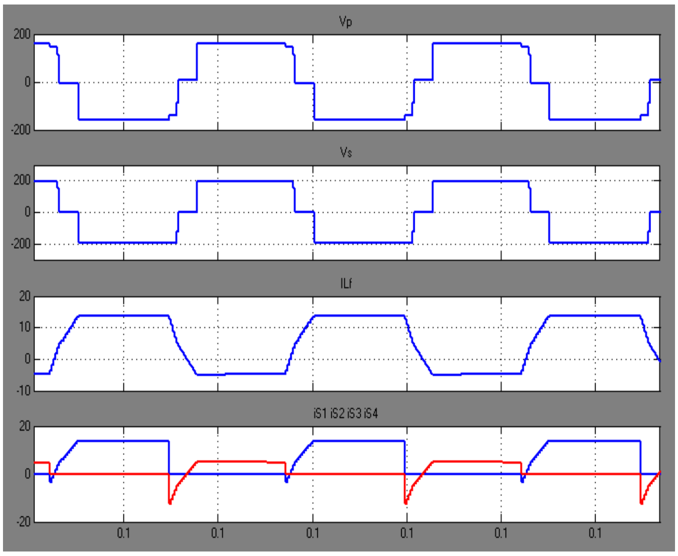
where all the switches on the primary and secondary sides have a constant duty cycle of 0.5. S1 and S4 are always turned-ON/OFF simultaneously, and the same with S2 and S3. A phase-shift angle between the primary- and secondary-side active switches is employed to regulate the output power and voltage. Lf stands for the total of the transformer leakage inductance and external inductor. The output series capacitors Co1 and Co2 have the same capacitance and are large enough to clamp the voltage stresses of the secondary-side switches and diodes to half of the output voltage. uDS1,uDS4, and uDS6 are the drain to source voltages of S1,S4, and S6, respectively. uP and uS are the voltages on the primary side and secondary side of the transformer. And iLf is the primary current flowing through the transformer with the positive direction shown in Fig. 11. A proper dead time is necessary for the primary-side switches to achieve ZVS and avoid shot-through of the switching bridges. To simplify the analysis, the parasitic capacitance of MOSFET is ignored and the transformer is assumed to be ideal. The phase shift ϕ is defined as the phase difference between S1 gate signal and S6 gate signal. Because this phase shift serves the same function as duty cycle in a PWM converter, we define duty cycle D According to the waveforms of the primary-side current, the converter has three operation modes, namely secondary-side soft-switching continuous-conduction mode (SS-CCM), secondary-side hard-switching continuous-conduction mode (HS-CCM), and discontinuous conduction mode (DCM), respectively.

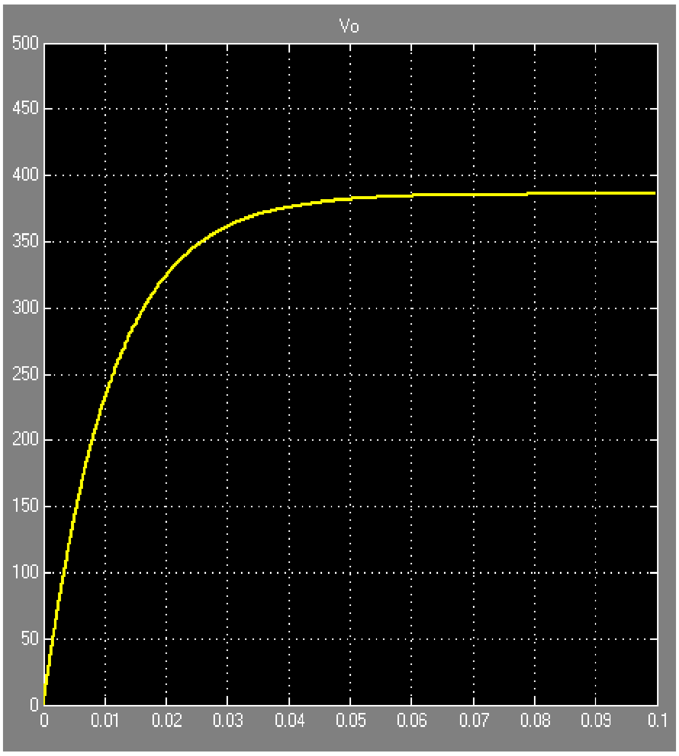


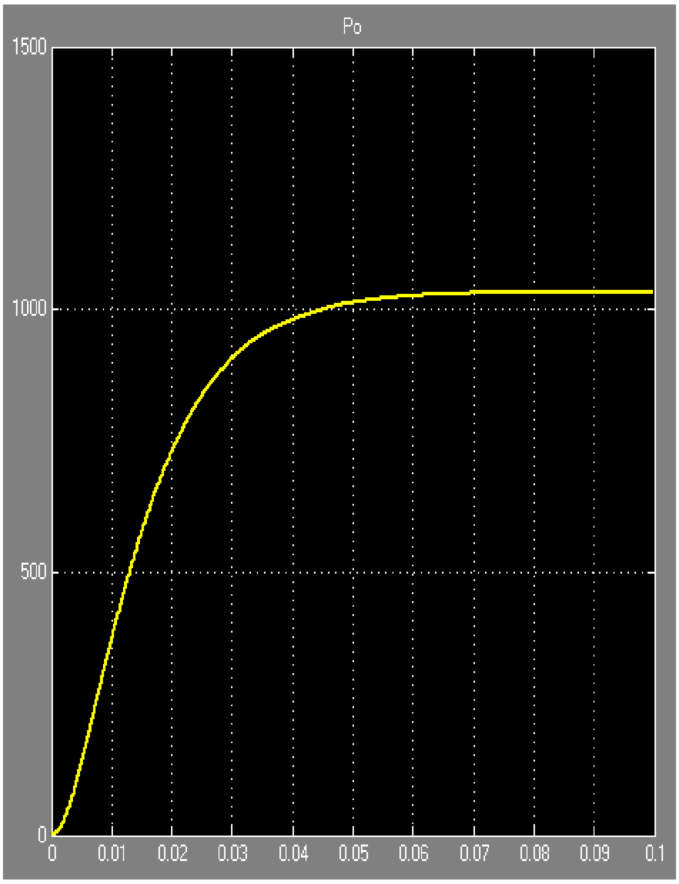
SIMULINK RESULTS AND OUTPUTS











CONCLUSION

In this paper, a soft-switching dc–dc converters has been presented for high-efficiency applications based on the proposed fuzzy controlled ABRs. The optimization of problems is achieved using fuzzy logic technique, the output voltage regulation is achieved by adopting phase shift control between the primary and secondary-side switches. ZVS performance has been achieved for both the primary- and secondary-side switches in a wide voltage and load range. Furthermore, the reverse-recovery problems associated with the rectifier diodes are alleviated. Therefore, the switching losses of the proposed converters can be reduced, which is important for high-frequency, high-efficiency, and high-power density applications. Moreover, the leakage inductance of the transformer has been utilized as the energy transfer inductor, and all the devices voltages are clamped to the input or output voltage. Thus, the voltage overshoots on the devices are effectively suppressed.

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