DC TO DC CONVERTER WITH EXPANSIVE SOFT SWITCHING RANGE AND LESS LOSSES FOR RENEWABLE ENERGY SOURCE APPLICATIONS

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ABSTRACT:

This paper presents dc to dc converter to eliminate the problems associated with traditional converters, they are voltage oscillation in the rectifier diodes, freewheeling period circulating losses, narrow zero voltage (ZVS) and zero current (ZCS) soft switching range. The proposed converter consists of series capacitor connected with dc to dc converter; this capacitor is used to diminish the voltage stress in the semiconductor switches, zero voltage and zero current switching can be obtained. And the asymmetric pulse width modulated (APWM) scheme is utilized in this converter to reduce the switching losses and wide soft switching can be obtained. The switching losses when turned OFF can be reduced and the energy required for commutation system also minimized by utilization of reduced voltage applied to the power switches. For load power and variable input voltage, wide soft switching range is obtained. The oscillation of the voltage output is minimized by using the auxiliary circuit on the output side of the transformer, Zero current switching for the lagging switches could be achieved and circulating losses are eliminated. In this paper gives the principle of operation, configuration of the circuit, result analysis of the proposed converter, and design example are discussed. The results are checked and validated experimentally with prototype of 500watts, 420v/12v.

Key words:

Phase shift full-bridge converter, circulating loss, Asymmetric pulse width modulation (APWM), ZCS, ZVS, soft switching,.

I. INTRODUCTION

The dc-dc power converters used in many applications, such as renewable energy resources, distributed power system; and Automobile battery charging system and switch mode power supply system.

The zero current switching (ZCS) and zero voltage switching (ZVS) techniques are introduced to mitigate the electromagnetic interference problem and get better efficiency of dc to dc converters. Hence, power density can be increased by increasing the switching frequency of the converter.

The resonant converter topology is the most popular to attain the power electronic switches in soft switching operations.

The variable switching frequency control method is used to shaping sinusoidal voltage and current across all the power electronic switches; this achieves the ZCS and ZVS operation of switches. Though, broad switching frequency range is necessary to adjust the voltage output of resonant converters, and the design of capacitive and inductive elements of resonant converter is difficult. This article proposes the capacitor based dc to dc converter.

The fig.1 represents the proposed series capacitor based dc to dc converter.

The stress voltage for the power electronic switches is reduced the half of value by introducing series capacitor in the converter circuit. The voltage stress across all the power switches are minimized fifty percentage of the input voltage, this expand the soft switching range, and reduces the energy required to turn off process of the power switches.

The ZVS and ZCS operation of all the power switches are obtained by using pulse width modulated method (APWM) to the series-capacitor-based dc to dc converter. The transformer leakage inductor gives flux balance and not required for blocking capacitor.

The stress voltage in the bridge rectifier is clamped and minimizes the voltage oscillation by using small auxiliary circuit in the transformer secondary side.

At the time of wheeling period, minimized the circulating losses, primary current is reduced to zero, ZCS operation in switches S_{a2} and S_{b2}.

The circuit diagram and working principle of the proposed converter are presented in section II.In the section III presents the performance analysis of the proposed converter; the practicability of the converter is confirmed by the experimental results are discussed in the section IV.Finally concluded in section V.

II. WORKING PRINCIPLE

In the anticipated converter, the secluded transformer is connected with series capacitor buck converter, Designed from [1] and [2], the capacitor C_1 is linked between switches Sa_1 and Sa_2, and it brings down the stress voltage across the power semiconductor switches Sb_2, Sa1, and Sa_2, and also the voltage for power semiconductor switch Sb_1 acts stair-wave waveform. Hence the stress voltage across the power semiconductor switch Sb_1 can also be minimized.

The diodes D_1, D_2, D_3 and D_4 are connected in the output side of the transformer, the inductor Lo is named as output inductor, and this inductor used to minimize the ripples in output current. Furthermore, the diodes Dc_1,Dc_2 and capacitor Cc are connected with the output of diode rectifier circuit, this circuit named as auxiliary circuit. The fig.2 indicates the rectifier voltage output and capacitor current wave forms of the proposed converter.

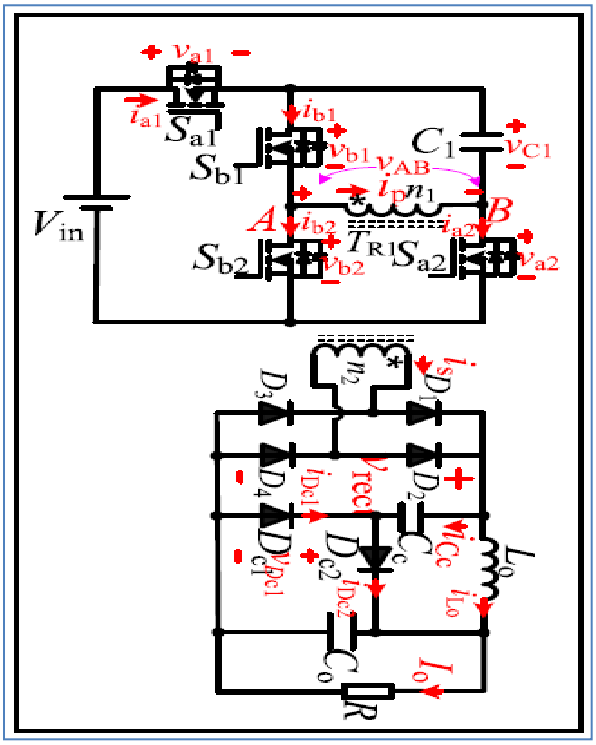

Fig. 1.Proposed isolated transformer and series capacitor based dc to dc converter.

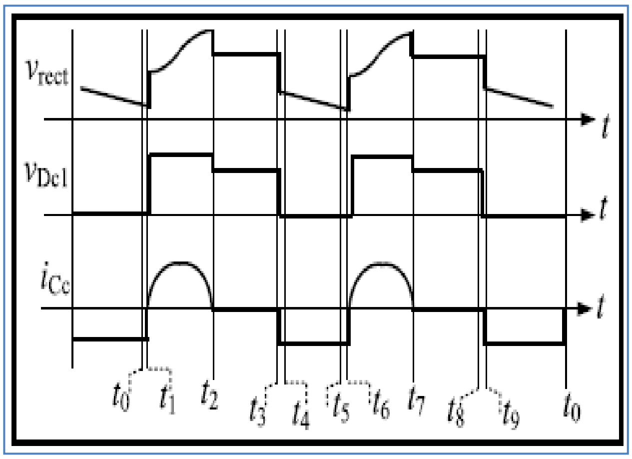

Fig.2.Rectifier voltage output and capacitor current wave forms of the full bridge converter

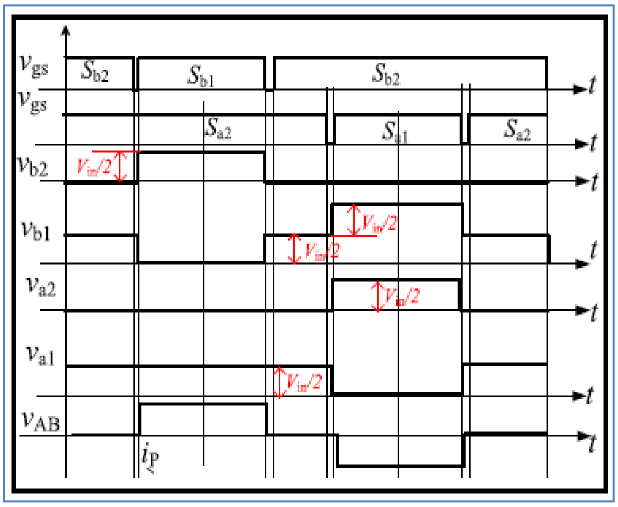

Fig.3. Gate voltage and other voltages across power electronic switches

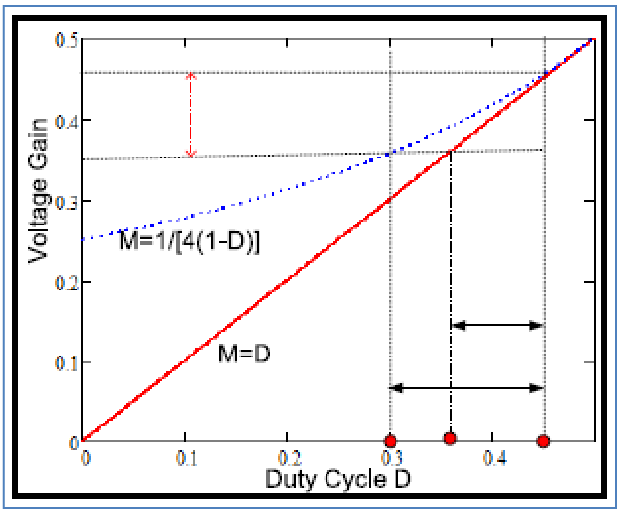

Fig.5.Voltage gain versus duty cycle characteristics.

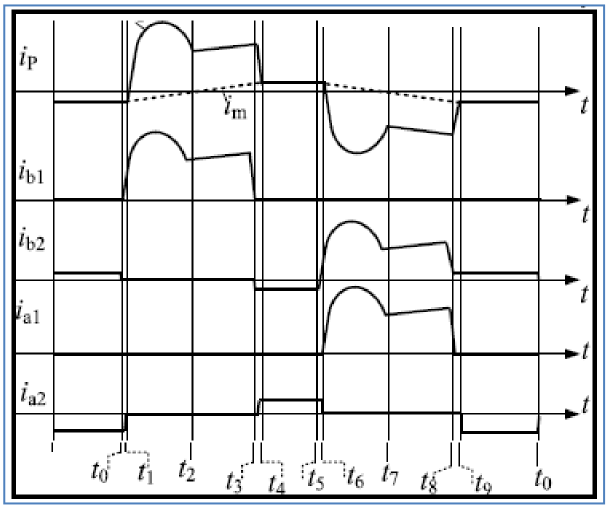

Fig.4.Current in power semiconductor switches

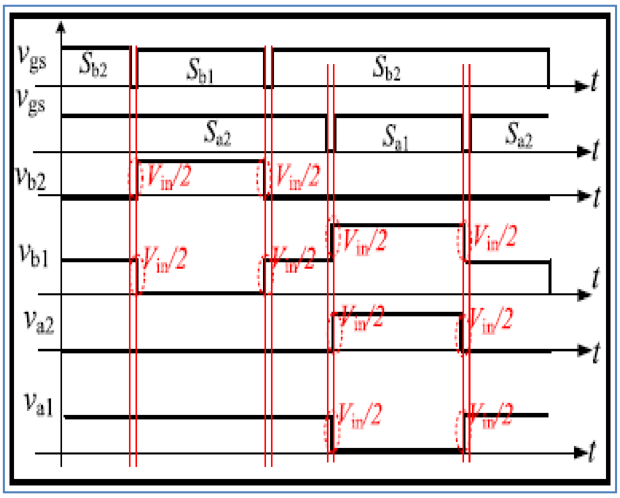

Fig .6.Gate pulse and voltage waveforms of the proposed converter

The fig.3. Represents the various gate voltage and voltage across power semiconductor switches, and the fig.4.indicates various currents in power switches.

III. PERFORMANCE ANALYSIS

A. Voltage Gain

The fig.2 shows the rectifier output voltage and capacitor current wave forms of series capacitor connected full bridge converter, and the fig .3 denotes the gate voltage and voltage across power semiconductor switches, Based on the fig.2 and 3 the commutation process of this converter is very small time period in mode 1, 4, 6 and 9, hence it can be neglected.

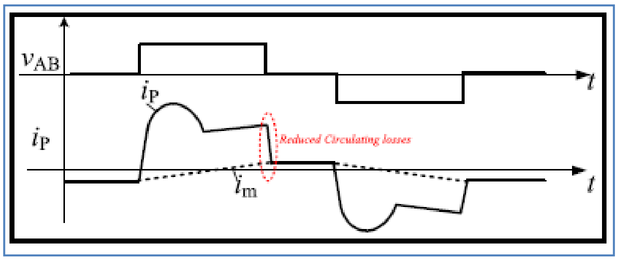

Fig.7.voltage across A and B terminals and primary current in the transformer

The fig.5.indicates voltage gain versus duty cycle characteristics and the fig .6.represents the gate pulse and voltage waveforms of the proposed converter. The fig.7 voltage across A and B terminals and primary current in the transformer.

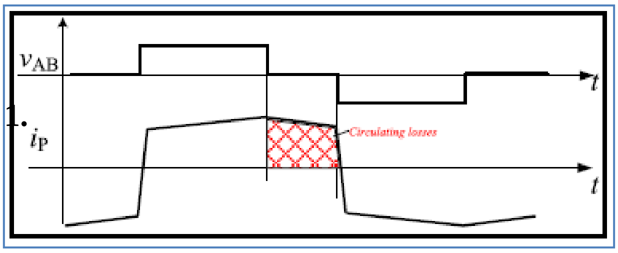

Fig.8. Voltage across the transformer primary (V_{AB}) and primary current (i_p) with circulating current losses.

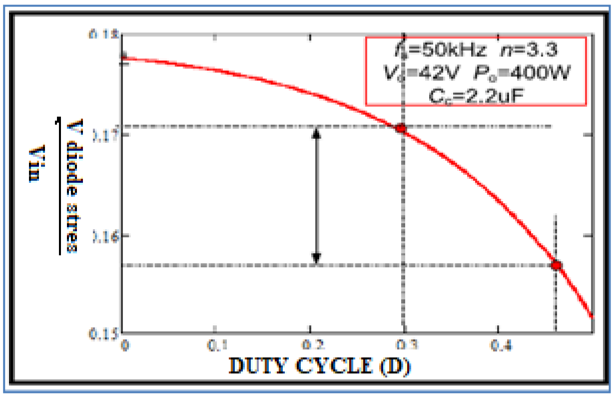

Fig.9.The characteristic curve between duty cycle (D) and voltage stress across diodes

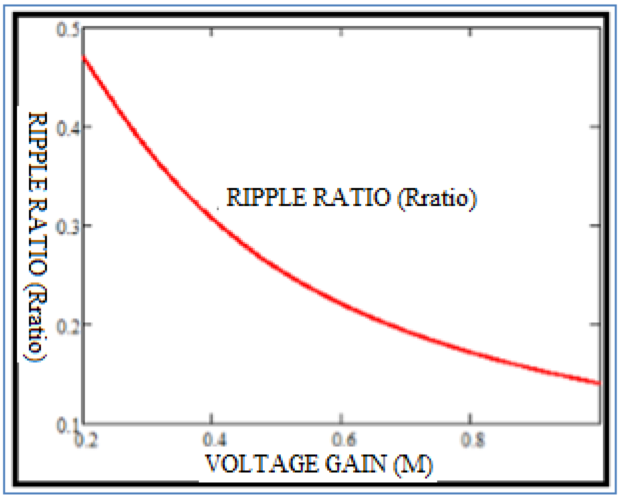

Fig.10.Voltage gain (M) versus Ripple ratio (R_{ratio}).

The fig.8.indicates the voltage across the transformer primary (V_{AB}) and primary current (i_p) with circulating current losses. And the fig.9.indicates the characteristic curve between duty cycle (D) and voltage stress across diodes. Voltage gain (M) versus Ripple ratio (R_{ratio}) is denoted in the fig.10.

IV.LOSS ANALYSIS

The switching losses and conduction losses of the proposed converter are analyzed for further improvement. The fig.11 indicates the loss comparison between the proposed converter and conventional converter. The table i shows the circuit parameters for analyzing the performance of the proposed converter.

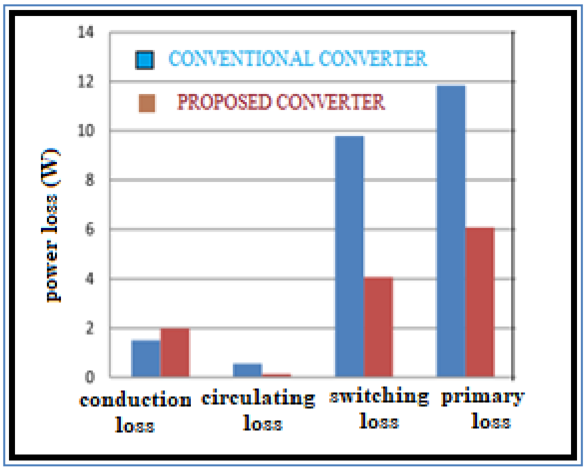

Fig.11.Loss comparison of the proposed converter versus conventional converter

TABLE I
CIRCUIT PARAMETERS

Power output	500W
Input voltage	300 - 420V
Output voltage	42V
Switching frequency	60kHz

V. EXPERIMENTAL RESULTS

The specification details of the series capacitor based full bridge converter are shown below;

i.Switching frequency fs = 60 kHz.
ii.Input voltage Vin = 300–480 V,
iii.Output voltage Vo = 42 V,
iv.Output power Po = 500 W,

The table ii indicates the specification details and circuit parameters of the proposed converter.

TABLE II
SPECIFICATION DETAILS OF CIRCUIT ELEMENTS

CIRCUIT ELEMENTS	PARAMETERS
Output inductor	100µH
Output capacitor	100µF
Rectifier diode	DSA90C200HB
Auxiliary diode	MBR20H200CT
Main switches	SPW11n60s5
Capacitor	2.2µF/ 600V CBB

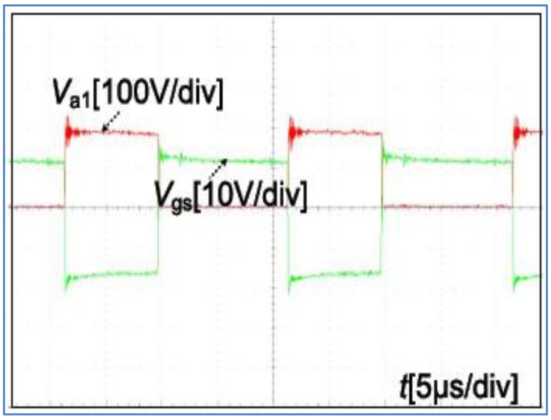

Fig. 12.Voltage across switch (Va_1) and gate voltage (Vgs)

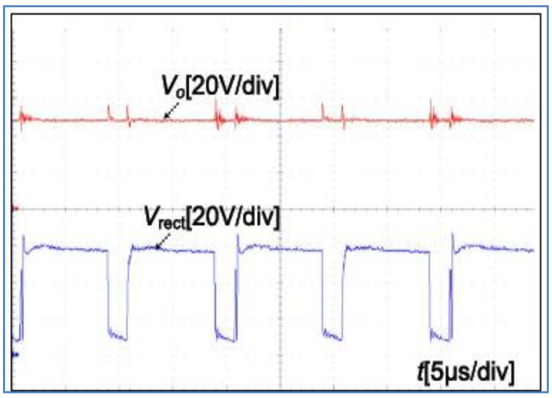

Fig.13. Output voltage (Vo) and rectifier output (Vrect)

The fig. 12.indicates Voltage across switch (Va_1) and gate voltage (Vgs) with full load, and the fig.13 denote Output voltage (Vo) and rectifier output (Vrect).

The figure 14 indicates the driver circuit of the proposed converter and the fig. 15.indicates the power loss distribution of the converter.

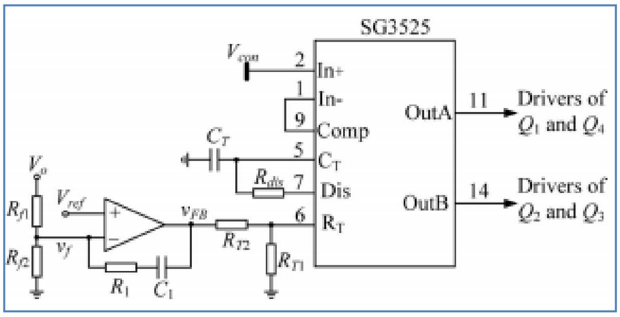

Fig 14.driver circuit

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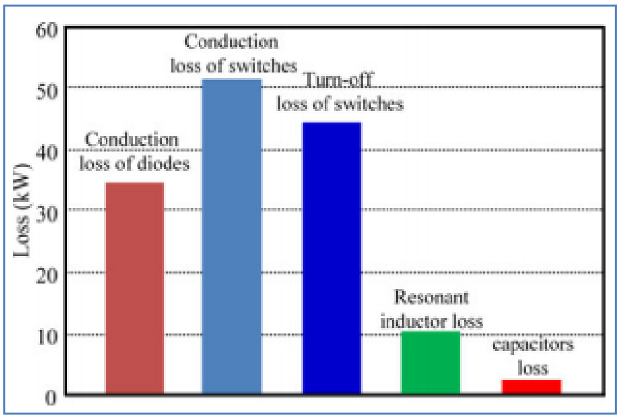

Fig. 15. Power loss distribution of the converter

VI. CONCLUSION

The full bridge converter with isolated series capacitor is discussed in this article. The working principle and performance characteristics of the converter are discussed in this article. Furthermore, inductor filter in output, stress voltage in the rectifier diode, power electronic switch ZVS and ZCS working and transfer gain of voltage are also studied in this article. The proposed converter topology is validated by practically, the practical results shows the minimized circulating conduction losses, wide range of soft switching and minimized the stress voltage across the power electronic switches. The practical model developed and result are anayized, the all the results represents the wide soft switching range, less conduction losses and minimized the stress voltage across the power electronic switches are reached in this converter topology. The efficiency of this converter in light load condition is higher compared with traditional converters; hence the proposed converter is apt for function in renewable energy sources, distributed power supply system, battery charging system in automobiles and switch mode power supply system.

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