Closed Loop Control of Bi-Directional DC-DC Converter

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Abstract: This paper presents a closed loop control of isolated boost full bridge DC-DC converter for used in Medium and High power application. Zero voltage switching is applied in all switches. The DC input voltage is stepped up by using a boost converter. It is inverted using a full bridge inverter. The transformer is used to produce a higher voltage in secondary voltage side. The a.c. Voltage is converted into D.C. Voltage with the help of rectifier. The open loop model, there is no possibility of maintaining a constant voltage with a variation of input voltage. In closed loop system is maintaining a constant voltage is applied with various value of input voltage. The Matlab version is used for simulating the open loop and closed loop full bridge DC – DC converter are verified.

Keywords: Bidirectional power flow, zero voltage switching, full bridge, isolated boost converter.

I. INTRODUCTION

Isolated boost full bridge DC-DC converter is used for medium and high power application. It is an alternative source of electrical energy. Fig.1 shows the block diagram of isolated boost full bridge DC-DC converter. The input voltage is applied to the boost converter to boost the voltage. A full bridge inverter is used to convert the DC voltage into AC voltage.

The transformer is used to step up the AC voltage and also isolate the low voltage and high voltage. The rectifier is converted into AC voltage into DC voltage. It is applied to the resistive load. In forward direction the low voltage side to high voltage side the circuit works in boost mode. On reverse direction high voltage side to the low voltage side the circuit works in block mode.

The harmonic current pollution of the AC power systems is being restrained by international standard [1]. A dual active full bridge DC–DC converter for high power, bidirectional application [2]. A dual active half bridge soft switching bidirectional, avoiding voltage spike issue in a current fed inverter [3]. The converter operates in continuous conduction mode with soft commutation of the control switches and constant frequency pulse width modulation [4-7].
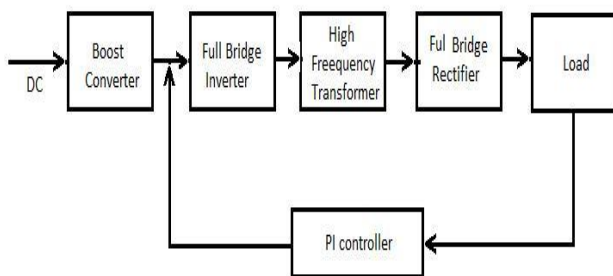

Fig. 1: Block Diagram of Closed Loop Boost Full Bridge DC-DC converter

The duty cycle δ of the two pulse width modulated signals produced by Matlab are synchronized with 180° phase shift [8]. The isolated boost full bridge topology can

converter low input voltage to high output voltage [9]. The simulation of full bridge DC-DC converter using both the control scheme was implemented in Matlab 7.3 version simulation tool and found that phase shifted control scheme is better than the conventional scheme [10-11]. This paper deals with PI controller is proposed the open loop does not maintain the constant voltage with the variation of input. The closed loop system maintains constant voltage with the variation of input voltage.
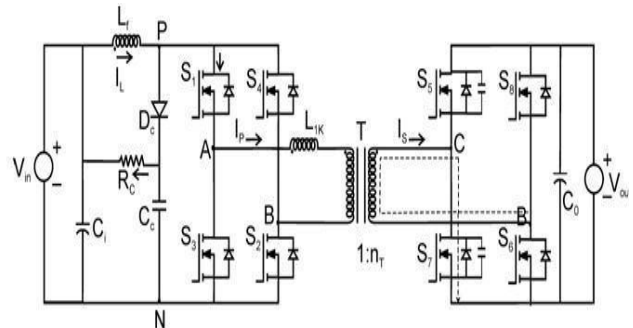

Fig. 2: Isolated Boost Full bridge DC-DC Converter

II. OPERATING PRINCIPLE

The operating principle is divided into two modes i) Energy is storing mode ii) Energy is transforming mode. At initial condition, the input voltage is applied to the inductor energy is stored in the inductor. S_1-S_4 switches are ON condition for the fraction of seconds. In buck mode operation four ON and two OFF switches. The converter operates in two modes in-between the commutating mode is operated.

S_1-S_4 are turned ON. Inductor stores energy corresponding current increases linearly. S_7, D_6 are ON the current through the primary winding of the transformer is short circuited. To create a freewheeling flow part are S_7, D_6. S_6 can be turned ON after zero voltage condition.

S_3, S_4 are turned OFF. The voltage is charged quickly by the balance current up to the active clamping. S_7, D_6 are remains ON.

At the condition I_L–I_P, after commutating ends and the converter is waiting for energy transferring mode. S_7, D_6 are remains ON. The secondary side of the transformer remains ON drops from zero. Energy is stored in inductor again. S_7 is turned OFF D_5 is turned ON. D_5 and S_6 are transferring energy from primary side to the secondary side of the converter. S_5 is ON. Under zero voltage switching and prepares the next commutating modes. $I_s=I_L$, Energy transferring mode ends. S_5, D_8 to create current freewheeling path to change its direction. D_6- S_5 remains ON until it resets to zero. After the resonate period. D_8 forming a freewheeling path and a leakage current path through $S_5 – D_8$. Again the cycle is repeated S_1-S_4 are turned ON.

III.DESIGN GUIDE LINES

Losses

1. The conduction losses in the rectifier are the same for conventional PWM and ZVS PWM. Prect = 4 (Iout / 2 Vf). V_f is the forward drop for the rectifier diodes, assuming that a full bridge rectifier is used.
2. The conduction losses on the primary bridge diodes are PD = Vdiode Iav .V_{diode} is the forward voltage drop on the diodes and I_{av} is the average current.
3. The conduction losses due to channel resistance of the switches can be calculated as $P_Q = R_{on} I_{rms}$ To find parameters.

$$L = V_o\delta / f \, \Delta I$$
$$I_o = V_o / R$$
$$E_1 = 4.44 \, N_1$$
$$\Phi f \, E_2 = 4.44$$

$N_2 \, \Phi f$ Losses:
   Mosfet = 8x2w = 16w
   Transformer = 12 w
   Inductor = 5 w
   Resistor = 10 w

IV.SIMULATION RESULTS

ZVS-PWM D.C. to D.C. converter is simulated using mat lab and the simulation results are presented. The primary side four MOSFET switches and four diodes is used in the secondary side of the transformer. The circuit model of isolated boost ZVS-PWM D.C to D.C. converter is shown in Fig 3. DC input voltage is 15V as shown in fig. 3. The square Pulse width is applied with constant frequency and voltage across M3 are shown in fig 4. and M4 are shown in Fig 5. The inverter output voltage is shown in Fig 6. The transformer is stepped up the voltage and then converted A.C into D.C with capacitor is connected across the load output voltage across load is shown in Fig 7. the four switches at the voltage fed inverter side are also verified under soft switching condition The harmonics across the inverter voltage is shown in Fig 8. The D.C to D.C converter operating in buck mode is shown in Fig 10. The driving pulses for MOSFETS M1 and M2 are shown in fig 11. The dc input voltage is 50 voltages as shown in fig 12. The transformer primary voltage is shown in fig 13.The transformer secondary voltage is shown in fig 14. The Output voltage is shown in Fig 15. Variation of output with input for boost and buck modes are shown in Fig.3g

& fig. 16. The output power with efficiency as shown in fig. 17.

The open loop converter using an input voltage of 12v is simulated under the condition, below

$$V_{IN = 15V}, C_{o =} 300\mu f, V_{o =}58V, \delta = 0.5, C_{c =} 1500 \, \mu f , R_c{=}2000\Omega, L= 350 \, \mu H, f = 55khz$$
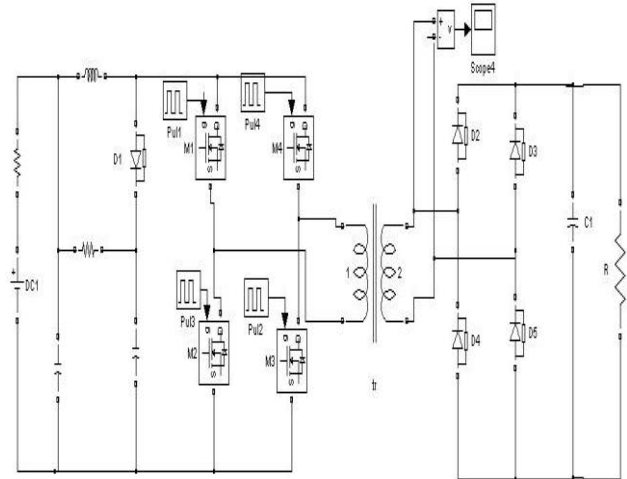
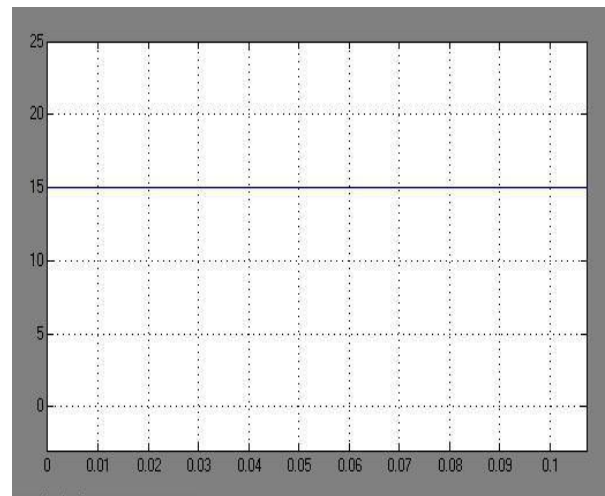**BOOST MODE**

Fig.3: Circuit Diagram
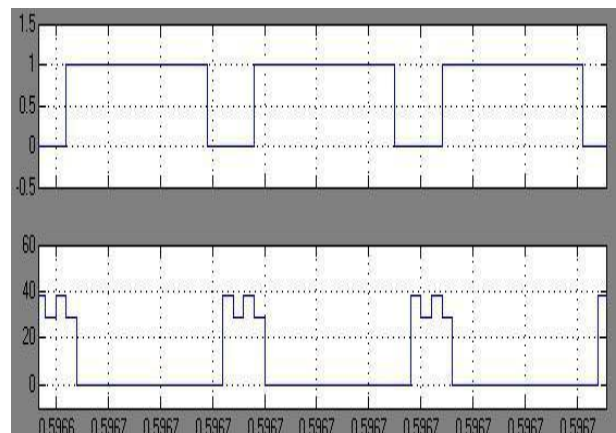

Fig. 4: Dc input Voltage

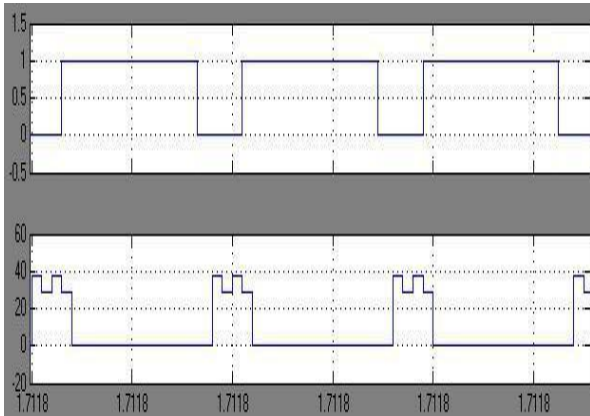**Fig. 5: Pulse and Voltage across M3**

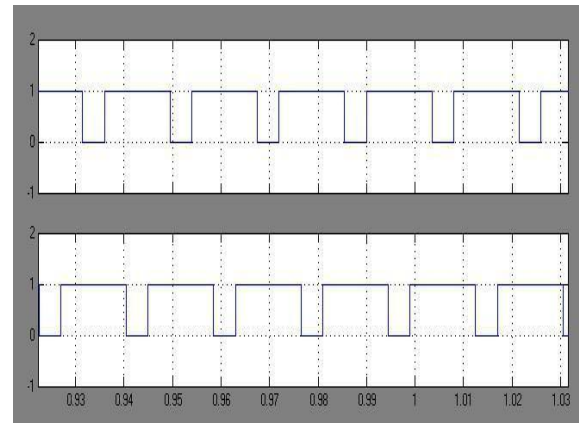**Fig. 6: Pulse and Voltage across M4**
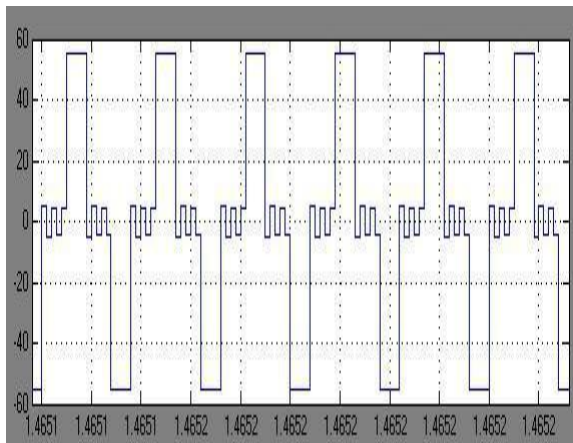
Fig 10: Driving pulses for M1 and M2

Fig.7: Inverter output voltage
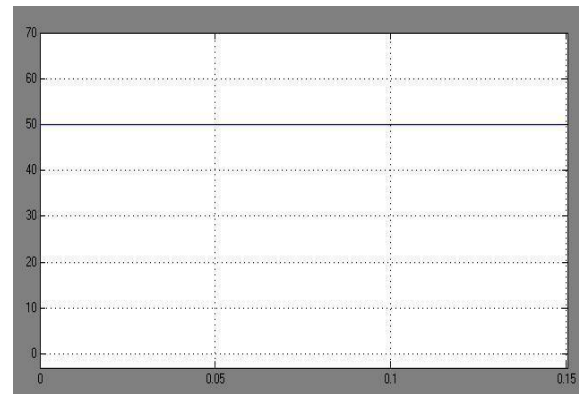
FIG. 11: DC INPUT VOLTAGE

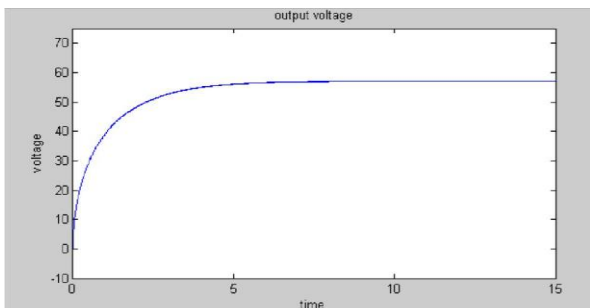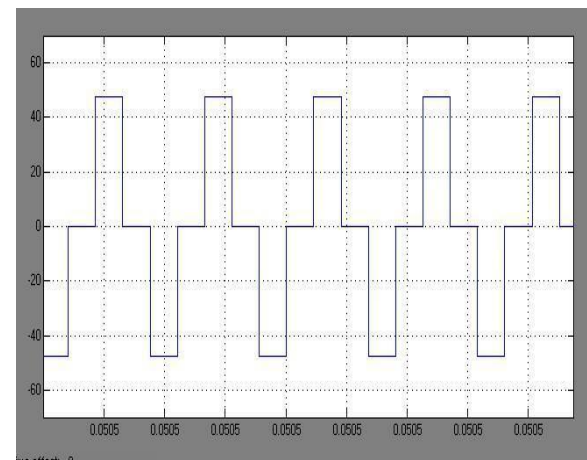**Fig. 8: DC output voltage**
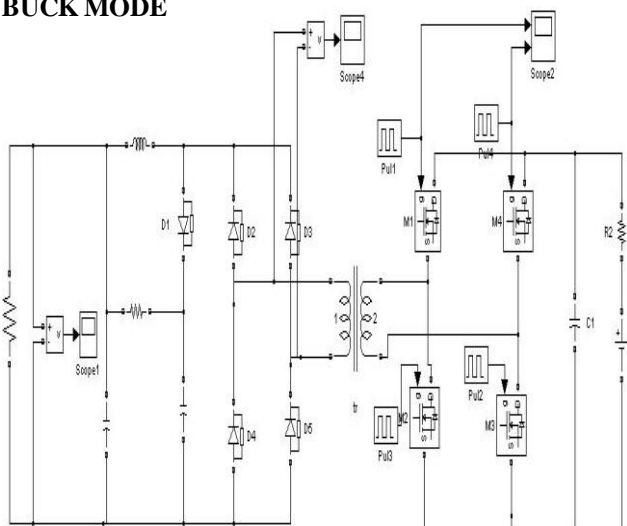
BUCK MODE

Fig. 12: transformer primary voltage
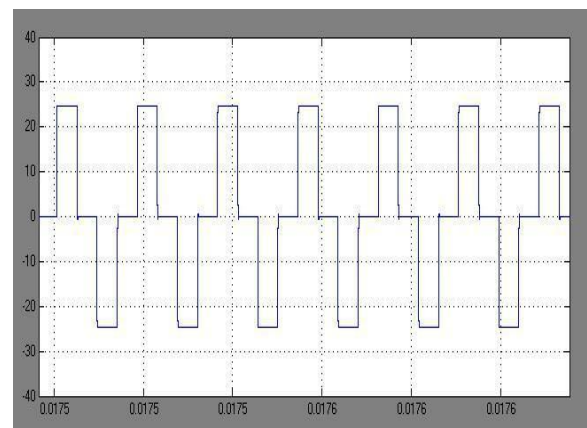
Fig.9: Circuit Diagram

Fig. 13: transformer secondary voltage
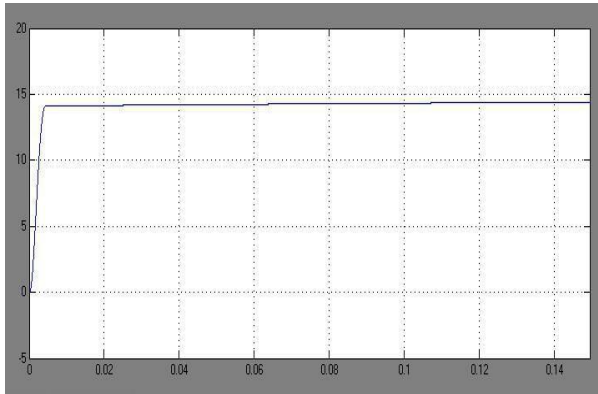
Fig.14: DC Output voltage

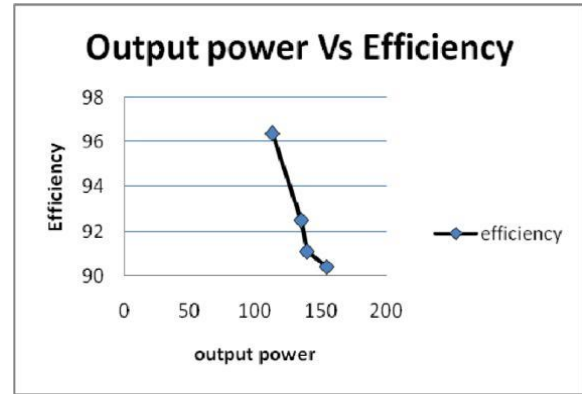**FIG.15: OUTPUT VOLTAGE VS INPUT VOLTAGE**
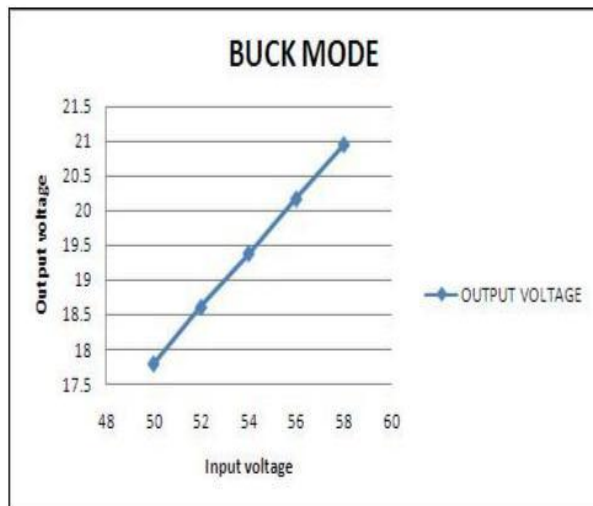
FIG. 16: OUTPUT VOLTAGE VS INPUT VOLTAGE

Output power (W)	efficiency
112.8	96.4
135	92.5
139.3	91.1
154.56	90.4

Table - 1

Fig.17: output power Vs Efficiency

The circuit model of the closed loop system is shown in Fig 19. Output voltage is sensed and it is compared with the reference voltage. The error is applied to a PI controller. The output of PI controller is used to generate proper pulses to drive the MOSFET in the output rectifier. A controlled converter is recommended at the to get a constant voltage across the load. The response of closed loop system is shown in Fig 20. From this figure, it can be seen that the output voltage increases, oscillates and is reduced to the set value of 250V.
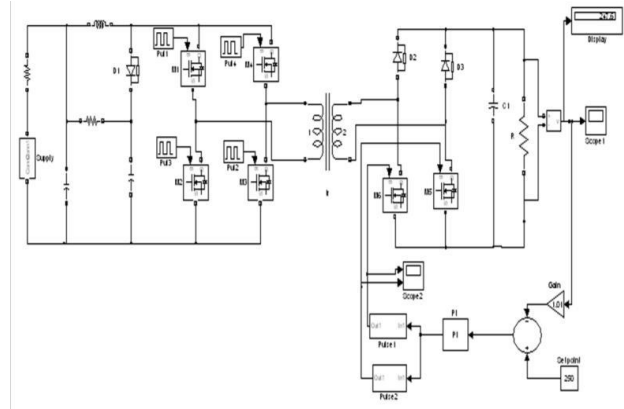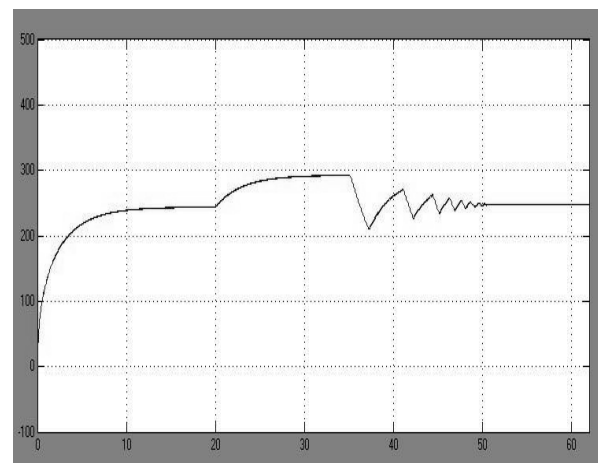

Fig. 18: Closed loop circuit diagram

FIG. 19: OUTPUT VOLTAGE WITH DISTURBANCE

V. CONCLUSION

Bidirectional power flow control and conversion capability and with electrical. Isolation between the two

sides through a transformer are evaluated for medium and high power application with consideration of device availability and a preliminary design study, a circuit configuration with the current fed converter on the LV low side and the voltage fed converter on the HV side is arranged the peak charging mode efficiency reaches 96% with full bridge version, but only 90% of full bridge converter is more efficient because it allows lower voltage devices to be used, and the active clamp circuit provides lossless operation. The open loop and closed simulation can be presented. The advantages of Boost converter are also obtained by adding Boost converter at the input side. This circuit is capable of performing D.C.to D.C. Conversion with high efficiency. The circuit using PI controller to maintain a constant with various value of input.

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