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Renewable Power Application based Switched Boost Inverter

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ABSTRACT: Switched Boost Inverter (SBI) is a type of power converter. It converter the power from DC-AC with boosting in a single stage. This can be applied for micro grid and nano grid applicationusing renewable power sources , as this converter supplies the power for DC loads and AC loads in the same time. The operation of SBI is shoot through of inverter legs without damaging the converter operation. Control signals for SBI is given through the sinusoidal pulse width modulation (SPWM), also it has good EMI noise immunity. The proposed Switched boost inverter is explained theoretically & simulated using MTALAB / simulink model. This paper also represent the laboratory prototype of SBI , with its results**.**

KEYWORDS: Pulse Width Modulation, Switched Boost Inverter, Voltage Source Inverter

I. INTRODUCTION

The power or electrical energy requirement is increasing day by day, to fulfil this requirement apart from using non renewable energy sources the importance is given to the renewable energy sources like photo voltaic, fuel cells, wind etc.. But the output obtained from these sources is of low efficiency. Therefore before supply it to the loads, it requires boosting. This can be effectively achieved using switched boost inverter by pulse width modulation control.

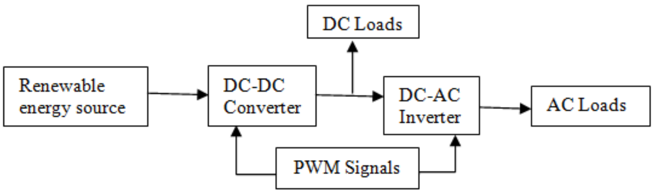

Fig.1. Block Diagram of SBI

The Fig.1 shows the basic Block Diagram of SBI which is suitable for micro and nano gird application. In a power generation system, the generated power is of variable DC voltage. Therefore power converters are used to obtain from DC- AC, The proposed SBI have flowing advantages

- A set of PWM signals controls the both converter and inverter switch simultaneously.
- It has a better EMI noise immunity and shoot through tolerance.
- No need of dead time compensation.
- Low device stress and high efficiency.
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II. LITERATURE SURVEY

The paper survey on SBI gives over all details to built a hardware prototype model of switched boost inverter as a single-stage power converter derived from Inverse Watkins Johnson topology. PWM control , shoot through state , EMI noise effect in power systems. Also the SBI is proposed as a power electronic interface in dc nanogrid. The structure and advantages of the proposed SBI-based nanogrid are discussed in detail. The *dq* synchronousreference-frame-based controller for SBI, which regulates DC and AC bus voltages of the nanogrid to their respective reference values under steady state as well as under dynamic load variation. The control system of SBI is implemented experimentally validated using a 0.5-kW laboratory prototype of the SBI supplying both DC and AC loads at same time

III. PROPOSED TOPOLOGY

The SBI is a power converter of single input dual output. Fig. 2 shows the proposed SBI circuit diagram. It is a buck-boost type DC-AC converter. The SBI is placed in between voltage source and voltage source Inverter Bridge. The main components are an electronic switch (S), inductor (L), high speed diode (D) , voltage source inverter bridge(VSI) and a capacitor (C), DC voltage source (Vg). A low pass filter (L_f and C_f) to filter the inverter bridge output.
The operation of SBI under steady state is explained as below
Mode 1:

During the positive half cycle, the time $D \cdot T_{s,}$ the Fig.3(a) shows the equivalent circuit diagram of SBI the switch (S) is ON as Vc > Vg the diodes Da & Db are reverse biased . $V_c = V_{sn1}$ Inverter is in shoot through state and it assumed to be shorted, capacitor charges the inductor through switch (S) therefore inductor current increases linearly. During this interval inductor current is equal to capacitor discharging current.

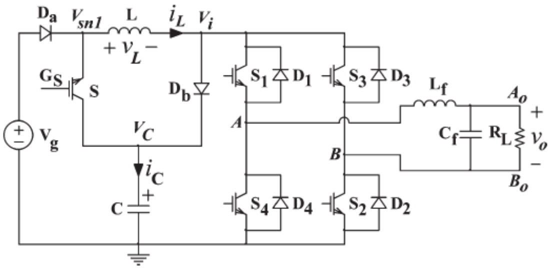
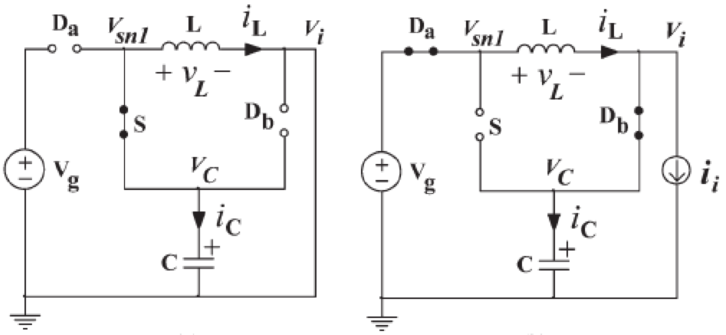


Fig.2. Circuit Diagram of SBI

Mode 2:
During the time (1-D) $\cdot T_s$ the negative of cycle equivalent circuit of SBI is as shown in Fig.3(b) the switch (S) is OFF . The inverter is in non shoot through state & is represented by current source I_i . The Da and Db diodes are forward biased $V_{sn1} = V_i$ (Inverter input voltage). Energy stored in inductor is discharges through the diodes therefore voltage source and inductor both are supplying power to the inverter. The capacitor charges through diode Da.



(a) (b)

Fig. 3(a) SBI Circuit diagram during positive half cycle D·Ts and 3(b) During negative half cycle the period (1-D·Ts)

Under steady state,

$$V_C . D + (V_g - V_c).(1 - D) = 0 => \frac{V_c}{V_g} = \frac{(1-D)}{(1-2D)} \qquad (1)$$

IV.PWM CONTROL FOR SBI

In this paper the proposed SBI is controlled by sine-triangle Pulse Width Modulation (SPWM) signals with unipolar voltage switching. Fig.4. shows the schematic circuit of PWM. $V_m(t)$ is a sinusoidal modulation signal of amplitude M.V_p, V_p is a magnitude of constant signal Vst and " M is a modulation index" f_s is a switching frequency of $V_{tri}(t)$ should be chosen much greater than the frequency f_o of sinusoidal signal $V_m(t)$, To maintain the $V_m(t)$ nearly constant in any switching cycle .

Sinusoidal, triangular and a constant is compared with each other as shown in Fig.4.from that will get the gate Signals G_{s1},G_{s2} ,Sa and Sb. these signals are further gone through the NAND operation, to generate the shoot through and non shoot through signals for SBI. The purpose of inserting the signals S_a and S_b is to obtain the shoot through interval DTs in the gate signals of the inverter bridge.

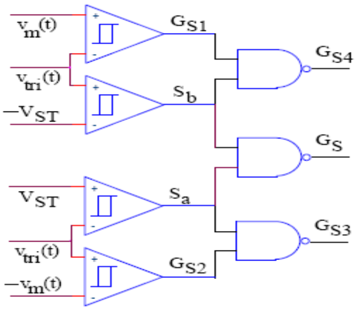


Fig.4. Schematic Control Circuit of PWM

This PWM control strategy says that "shoot-through state of SBI will have no effect on the harmonic spectrum of its output voltage Fig.10. shows the Harmonic Spectrum of VAB provided that the sum modulation index and duty should be less than unity [5] "

The logical expression used to obtain the required PWM control signals for switches is given as follows:

$$G_{S1} = G_{S4}+S_a \tag{2}$$
$$G_{S2} = G_{S3}+S_b \tag{3}$$
$$G_{S3} = G_{S2}+S_a \tag{4}$$
$$G_S = S_a+S_b \tag{5}$$
$$G_{S4} = G_{S1}+S_b \tag{6}$$
$$M+D \leq 1 \tag{7}$$

V. MODELING OF SBI USING MATLAB / SIMULINK MODEL

Modeling of PWM control signals

Simulink model of PWM control signal is as shown in fig.5 Also the parameter values used in PWM modeling is as shown in Table.1.The relationship between the shoot through duty ratio *D* and V_{ST} is (D should not be more than 0.5 because the conversion ratio Vg/Vc is very high at D=0.5)

$$D = 1- \frac{V_{ST}}{V_P} \tag{8}$$

Table.1. The parameter values used in PWM model

Parameter	Amplitude	Frequency
$V_m(t)$	0.5	50 Hz
V_{ST}	0.6	50Hz
$V_{tri}(t)$	1	10KHz

Shoot through width (Vsn1= Vc, Vi =0) must lesser than width of zero interval (VAB = 0).
Therefore,

$$DT_s < T_s - \max\frac{V_m(t)T_S}{V_p} \qquad (9)$$

$$D < 1 - M \qquad (10)$$

$$M = \max\frac{V_m(t)}{V_p} \qquad (11)$$

$$V_{ST} > M \cdot V_p \qquad (12)$$

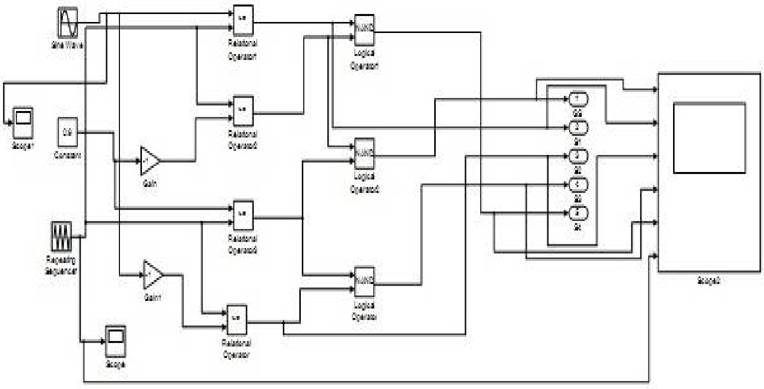


Fig.5. Model of PWM Control Signal

A generated PWM signal is as shown in Fig.6. are given to the respective gates of converter and inverter bridge.

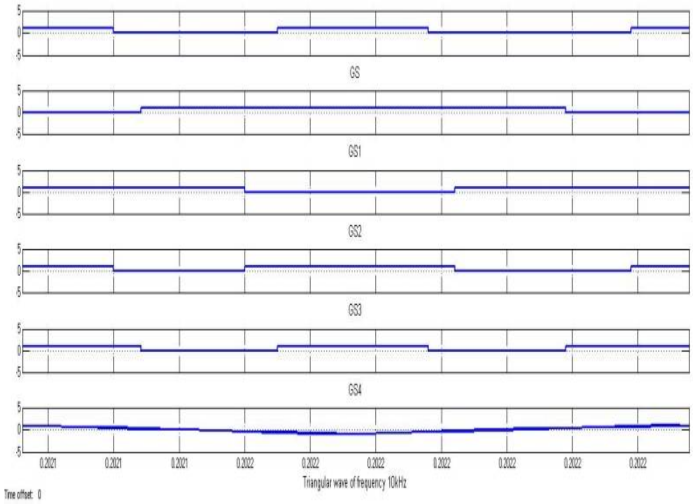


Fig.6.Generated PWM Signals.

Table 2: Parameters values used in simulation

Parameters	**Values**
Input voltage(Vg)	12V
Fundamental frequency(fo)	100µF
Switching frequency (fs)	10kHz
Shoot through duty ratio (D)	0.4
Inductor (L)	5.6mH
Modulation index(M)	0.5
Capacitor(C)	100µF
Lf	4.6Mh
Cf	100µF
R	100

Proposed SBI circuit is implemented using MATLAB/SIMULINK model by using parameter values as given in Table1, Fig.7. shows the simulation model of SBI.

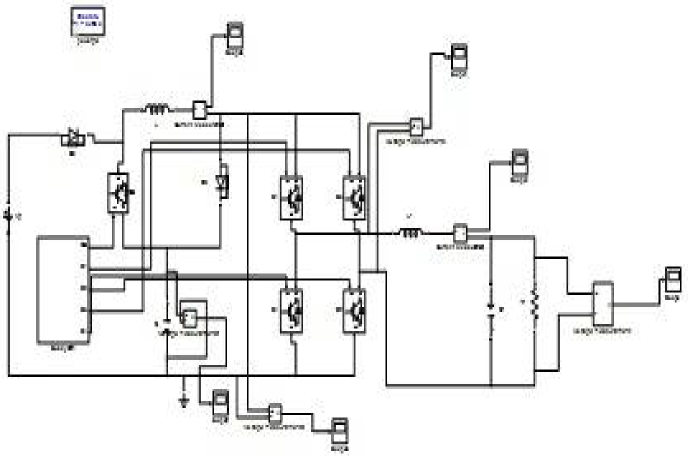


Fig.7.Simulation Model of Proposed SBI

Table.3 SBI output values

Parameters	MATLAB/Simulink	Experimental
Vg	12V	12V
Vo	20 V	18V

Table.3 shows the results obtained from proposed SBI model. Also Fig.8 shows the inverter output voltage V_{AB} and Fig.9 shows the AC output voltage Vo

Therefore from this power converter, boosting and conversion of DC –AC in a single stage is achieved effectively

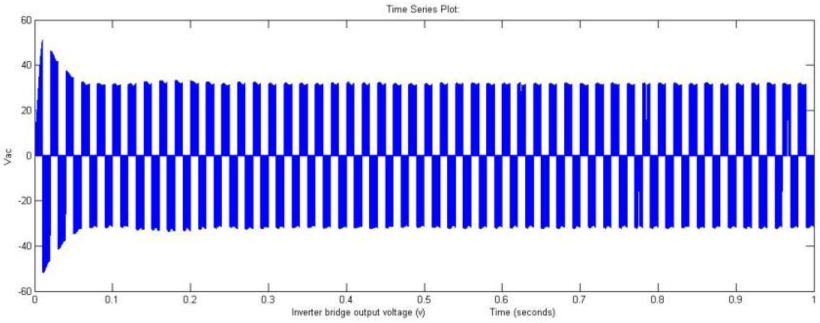


Fig.8.Inverter output voltage

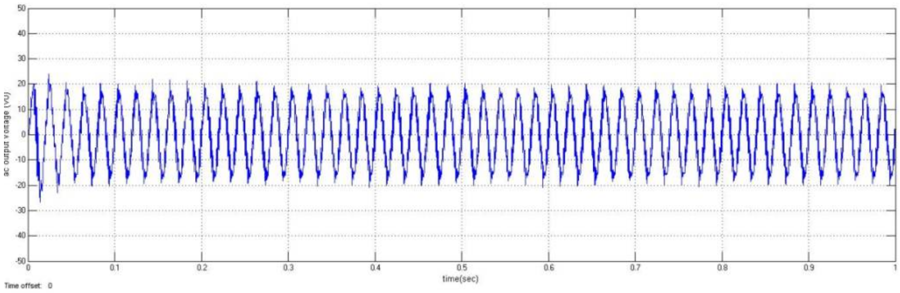


Fig.9.Output Voltage (Vo) of SBI

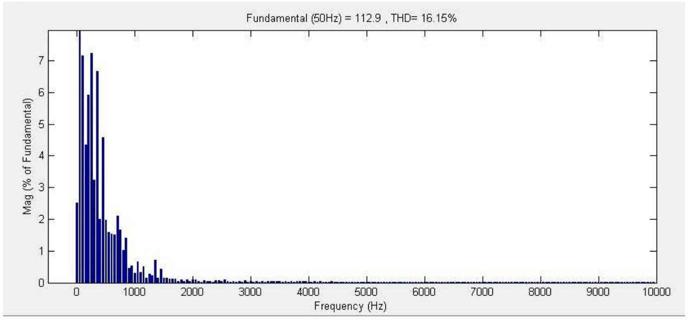


Fig.10. Harmonic Spectrum of V_{AB}

VI.EXPERIMENTAL SET UP AND RESULTS

Table.4. Components used in experiment

Components	Manufacturer
MOSFET	IRF540N
Diode	U1560
Pic controller	Pic6F877A
Gate driver	TLP250

Table.4. shows the list of components used in set up of laboratory prototype of SBI is as shown in fig 10. Here step down transformers supply power to the low side and high side MOSFET separately also used as input voltage source Vg by using bridge rectifier BR1005. Main SBI circuit and controller is isolated through gate driver TLP250. Piccontroller generate the low frequency pulses for inverter bridge, TL494 to generate the high frequency PWM signal for gate Gs. The results obtained from experimental set up is as shown in below Figs

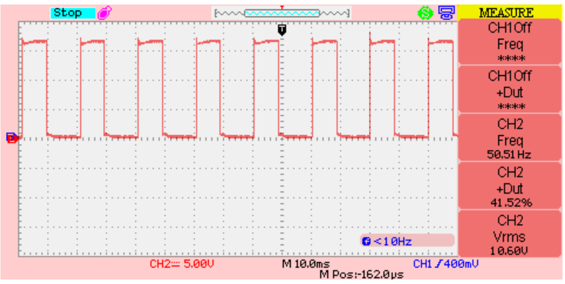


Fig 11 Gate signals for Inverter Bridge

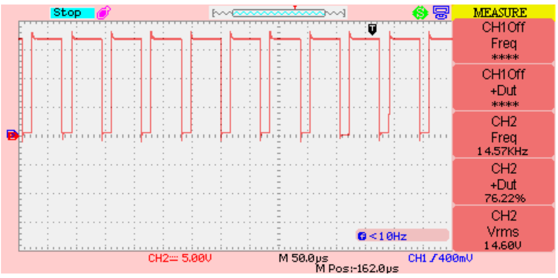


Fig 12 Gate signals of switch S

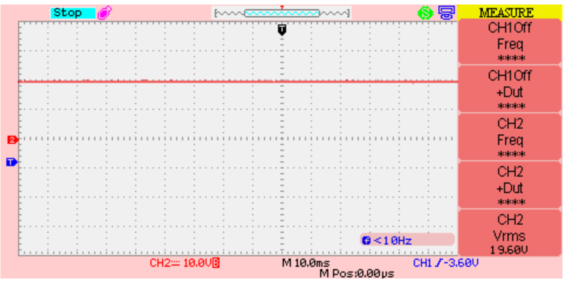


Fig13 SBI DC output voltage

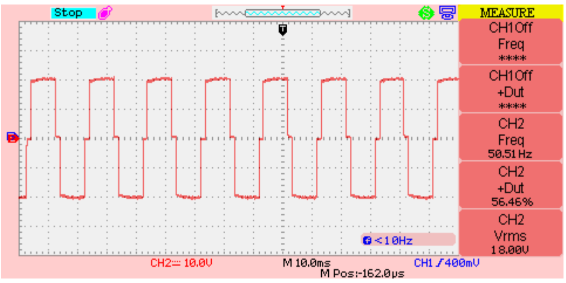


Fig 13 SBI output voltage V_{AB}

VII.CONCLUSION

This paper gives a theoretical analysis of SBI. The PWM control signals are generated using a MATLAB/SIMULINK. The generated PWM signals verified by applying these signal to a simulation model of SBI and we get the boosted and converted AC output voltage. The inverter Output voltage and its harmonic spectrum, proves that the "shoot-through state of SBI will have no effect on the harmonic spectrum of its output voltage provided that the sum modulation index and duty should be less than unity". Experimental results are verified by comparing SBI simulink model and laboratory prototype results. This can be implemented effectively in micro grid application by using renewable power sources.

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