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Three Phase SEPIC Based Inverter Employing Reduced Amount of Switches for Renewable Applications

P.Revathy
PG Scholar
Department of Electronics & Communication Engineering
Christian College Of Engineering & Technology.
Dindigul Tamilnadu-624619 India

T.Parthasarathy
Assistant Professor
Department of Electronics & Communication Engineering
Christian College Of Engineering & Technology.
Dindigul Tamilnadu-624619 India

Abstract

The SEPIC based inverter with reduced amount of switches has been proposed as an innovative inverter design to reduced cost and complexity.The four switch three phase (FSTP) SEPIC based inverter have less switching losses of the DC-AC conversion system. FSTP inverter operates at half the DC input voltages, so the output line voltage cannot exceed this value. The proposes a design for the FSTP overcome this problems and produced pure sinusoidal without need of filter in output side. The proposed topology produce output line voltage which can be extended up to full value of the DC line voltage. The Fuzzy control is used with proposed topology to ensure the robustness of the system. Fuzzy logic allows, solving difficult simulated problems with many inputs and output variables. The parameters, component ratings, and the operation of the proposed SEPIC inverter is described in this paper. Experiment and simulation shows the effectiveness of the proposed inverter.
Keywords: Four switch three phase inverter (FSTP), Single Ended primary –Inductance converter(SEPIC), Fuzzy logic Controller, Mamdani Rule

I. INTRODUCTION

At first , the six switch three phase(SSTP) two level voltage.

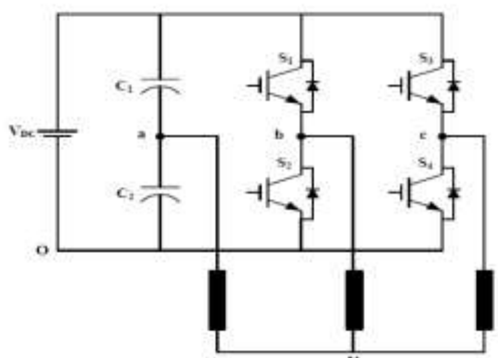

Fig. 1: Four Switch Three Phase Inverter.

source inverter(VSI) has found in the indutrial applications. Industrial applications have different forms such as renewable energy conversion, drive system and power filters Six switch three phase two level voltage source inverter is not good enough for the low power applications because of high cost of switches. To reduce the cost and complexity, the switch count are reduce for low power applications. Some industrial applications research have been directed to develop inverter with reduced amount of switches that can be achieve the goal. The research effort result showed that it is possible to implemented the four switch three phase inverter has output load connect to the two inverter leg and another one is directly from the DC source. FSTP SEPIC inverter circuit diagram is shown in Fig.1. Some FSTP control and applications are found in [1]-[5].

Some advantages have the FSTP inverters when compared to the SSTP, such as reduction in cost and increased reliability. Reduce in conduction and switching losses by 1/3 where one leg is omitted. FSTP inverter has to solve the open/short circuit fault of SSTP inverter [2] and [3]. The FSTP topology have non symmetrical due to third phase directly connected to the DC-link capacitor, which produced fluctuations in the voltage. To overcome this problem, in this paper FSTP based on SEPIC converter. SEPIC converter design methodology for finding the equivalent inductance and capacitance of the single ended primary inductor converter(SEPIC). The relation of the output voltage ripple (OVR) of the SEPIC converter are obtained in complete inductor supply mode continuous conduction mode in complete inductor supply mode and discontinuous conduction mode the dc/dc converter are widely used in different applications[6]. The main investigation focussed on the correlation exisiting among the size of coupling factor of CIS, the voltage conversion ratio and the amplitude of the peak to peak ripple current input and output ports of the CIS. Coupled magnetic devices are key component in power conversion [7].

Some modificationsof SEPIC converte has been done for renewable applications[8].SEPIC converter suffer from high conduction loss at the input bridge diode.To solve this problem a bridgeless SEPIC converter with the ripple free input current is used[10].SEPIC inverter improves the voltage utilization factor of the input DC supply and it have output voltage is pure sinusoidal wave ,therefore reducing the filter requirements.

II. FSTP SEPIC INVERTER CIRCUIT DIAGRAM AND OPERATION

The FSTP SEPIC inverter circuit diagram shown in Fig.2.SEPIC inverter consist of two SEPIC converter, the input DC source and the three phase output load. SEPIC inverter achieves DC- AC conversion in Fig.3. In SEPIC inverter, one phase is directly connected to the DC input source and the other two phases are connected to SEPIC converter. Each converter in the phase is shifted 120° and the DC-bias is exactly equal to the input DC voltages. Both SEPIC DC-DC converter produces a unipolar voltage, the differential DC voltage across load is zero and the voltage generated across the load is bipolar. The bi-directional SEPIC converter shown in Fig.4.

The bi-directional SEPIC converter includes DC input voltage Vdc, input inductor L1 ,two complementary bi-directional switches S1,S1', coupling capacitor C1, output inductor L2, and output capacitor C2, load resistance R0.

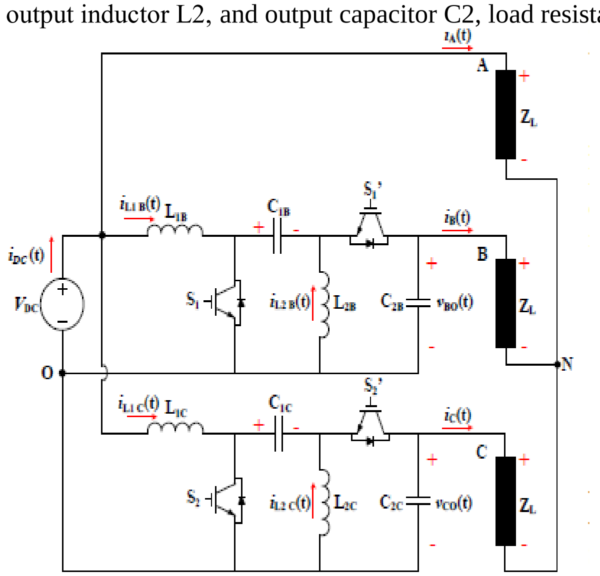

Fig. 2: FSTP SEPIC Inverter

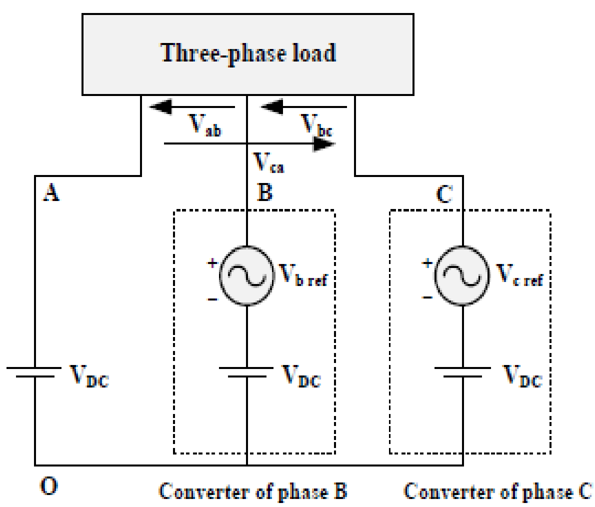

Fig. 3: DC – AC conversion

During ON state L1 and L2 are charging, its takes energy from input source and coupling capacitor C1 and during OFF state discharging through load and bi-directional switches S1',.The relation between the output and input voltages is as follows

$$V_o = \{D/(1-D)\} * V_{in} \qquad (1)$$

V_o – Output voltage, D – Duty cycle
V_{in} - Input voltage

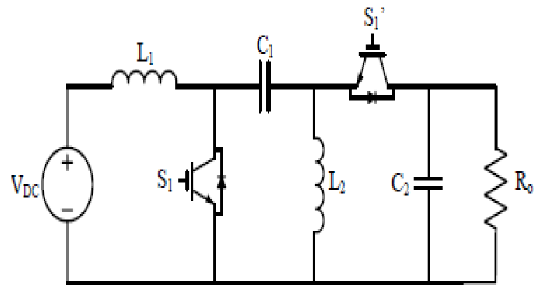

Fig. 4: Bi- directional SEPIC converter

The converter 1 is connected to phase B and converter 2 is connected to phase C. The reference voltages of both converters are shown in Fig. 5.

III. SELECTION OF PARAMETER AND COMPONENT OF SEPIC INVERTER

A.Input inductor Selection

The input inductance L1 is estimated as

$$L_1 = \{V_{DC}(1 - D_{max})\}/0.1 I_m f_{sw} \tag{6}$$

B.Output inductor selection

L2 could be selected according to the following equations

$$L_2 = \{V_{DC}(1 - D_{max})\}/0.3 I_m f_{sw} \tag{7}$$

C.Coupling capacitor selection

Based on the desired voltage ripples, the capacitance can be selected as follows

$$C_1 = (I_m D_{max})/\Delta v_0 f_{sw} \tag{8}$$

$$C_2 = (I_m D_{max})/\Delta v f_{sw} \tag{9}$$

$$D_{\max conv_1} = (V_{DC} + V_{mL-L})/(2V_{DC} + V_{mL-L}) \tag{10}$$

$$D_{\max conv_2} = (V_{DC} + (\frac{\sqrt{3}}{2})V_{mL-L})/(2V_{DC} + (\frac{\sqrt{3}}{2})V_{mL-L})$$

Table - 1
Parameters Of Fstp Sepic Inverter

INDUCTORS	$L_{1B} = 6.77mH$ L_{2B}=2.26mH
	L_{1C} =7mH L_{2C}=2.36mH
CAPACITORS	C_{1B}= 10.6μF , C_{2B}= 2.8μF
	C_{1c}=10.3μF , C_{2c}=2.8μF

IV. CONTROL STRATERGY

A Control is required to drive the FSTP SEPIC inverter, due to one phase is directly connected to the DC input voltage.

A. Fuzzy Logic

Fuzzy logic is a complex mathematical method that allows solving difficult simulated problems with many inputs and output variables. Fuzzy logic is able to give results in the form of recommendation for a specific interval of output state, so it is essential that this mathematical method is strictly distinguished from the more familiar logics, such as Boolean algebra.

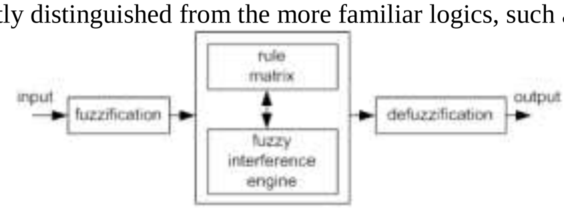

Fig. 6: Basic Fuzzy logic controller

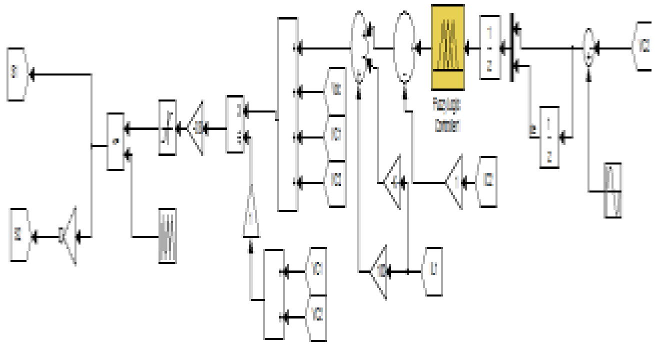
Fig. 7: Fuzzy controller

B. Mamdani Fuzzy Logic Controller

The database of a rule-based system may contain imprecisions which appear in the description of the rules given by the expert. Because such an inference cannot be made by the methods which use classical two valued logic or many valued logic, Zadeh in (Zadeh, 1975) and Mamdani in (Mamdani, 1977) suggested an inference rule called "compositional rule of inference". Using this inference rule, several methods for fuzzy reasoning were proposed. Zadeh (Zadeh, 1979) extends the traditional Modus Ponens rule in order to work with fuzzy sets, obtaining the Generalized Modus Ponens (GMP) rule. An important part of fuzzy reasoning is represented by Fuzzy Logic Control (FLC), derived from control theory based on mathematical models of the open-loop process to be controlled.

Table - 2
Mamdani Fuzzy Rule

e\de	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

C. Mamdani Membership Function

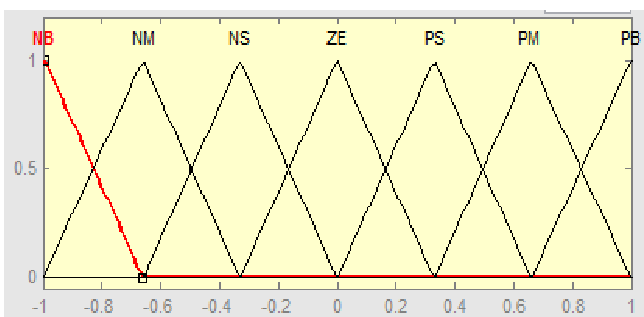

Fig. 8: Member ship function

In Fig. 8 Membership function for the fuzzy controller, it have 7*7 fuzzy rule basis, rules shown in table II.

V. SIMULATION

The proposed topology FSTP SEPIC inverter under the fuzzy control strategy has been investigated. The corresponding simulation output shown in Fig.9

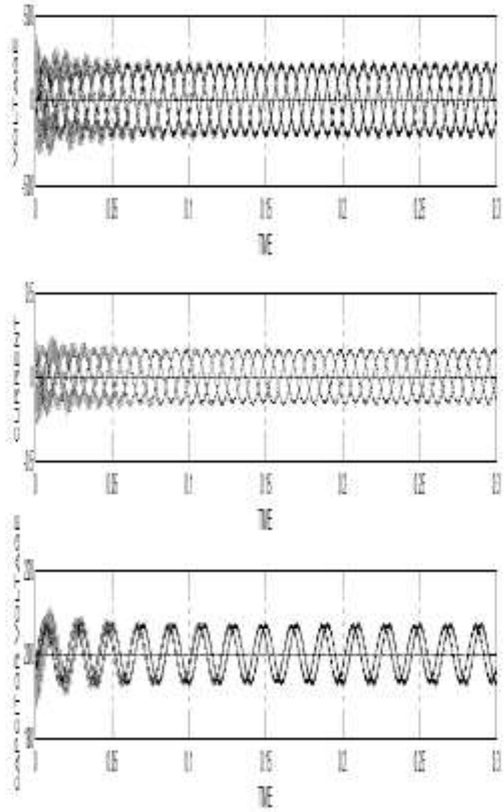

Fig. 9: Three phase Output Voltage and Current and Capacitor voltage

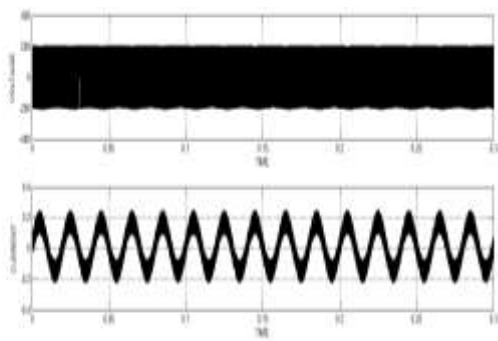

Fig. 10: Inductor across voltage and current

A small analysis made between sliding mode control and fuzzy control. Sliding mode method was difficult in solving the equations at the different operating region has found [11]. For different RL load values the method has compare. From the comparison table III the fuzzy control method is more effective than sliding mode control.

Table - 3
Comparison Table

Load Value (Watts)	Slidingmode control THD	Fuzzy logic control THD
800	5.93%	5.42%
900	5.81%	4.68%
1e3	5.12%	4.22%
1.1e3	5.81%	4.01%
1.5e3	5.28%	3.11%

VI. CONCLUSION

A DC-AC four switch three phase SEPIC -based inverter in this paper. The proposed inverter improves the utilization of the DC bus by a factor of two compared to the conventional four switch three phase voltage source inverter. The inverter does not suffer from the problem of voltage fluctuation across the DC link split capacitors as the third phase load current is directly drawn from the DC source without circulation in any passive component. The proposed system is implemented in the fuzzy logic controller. Simulation and experimental results verified the performance of the proposed inverter with the fuzzy control strategy.

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