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SPEED CONTROL OF INDUCTION MOTOR USING CURRENT-FED SWITCHED COUPLED INDUCTOR INVERTER

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ABSTRACT : This paper presents a Current Fed Switched Coupled Inductor Inverter topology for boosting the low voltage from PV Cell / DC source to higher voltages and utilizing it for the speed control of Induction Motor . It is a Capacitor-less topology which reduces the system size. The proposed inverter uses the Shoot-through condition to achieve higher boosting operation . The speed of the motor is controlled by the fuzzy logic controller and the desired speed can be achieved.

Index Terms : Switched Coupled Inductor , Shoot through , Boost operation , motor drives , Fuzzy logic controller.

INTRODUCTION

The buck-boost operation of voltages has numerous applications.The conventional inverter such as VSI and CSI can either buck or boost the voltage levels.[1] ZSI can perform both the operations, but number of components are more. The ability of the Switched coupled inductor inverter [2]-[3] , which has high boosting ability of voltages due to the magnetic cores and magnetic couplings [4] as compared to other conventional inverter types such as voltage source inverters (VSI) , current source inverters (CSI) , impedance source inverters (ZSI) [5]. The boost of voltage is carried out by the interference of the shoot-through condition [6] , in which the switches of same legs are ON at a time. The technique implemented for the shoot-through condition was Space vector pulse width modulation(SVPWM) [7] , other type of techniques are pulse width modulation (PWM), Sinusoidal pulse width modulation (SPWM), etc. The increase in voltage has a variety of applications such as motor drives [8], micro-inverter circuits, generator or motors in hybrid electric vehicles etc. In this paper[9], speed control of Induction motor , and the design and modeling of the motor has been discussed. The speed can be controlled using the fuzzy logic controller [10] and the desired speed of the motor has been achieved.The harmonics are reduced and the electro-magnetic induction (EMI) immunity is superior in the case of current fed switched coupled inductor inverter(CF-SCII) [11].The proposed CF-SCII fed is capacitor less circuit which makes the system compact and reliable.

1. STRUCTURE OF THE PROPOSED SCHEME AND ITS DESCPITION

The range of duty cycle of converters can be extended by varying the trans ratio of the coupled inductor in the proposed structure. This circuit allows a variety range of voltages and current ratings especially for the switch and diodes used. So the ideaof using the coupled inductor in inverters has been implemented here. The current fed switched coupled inductor inverter topology is shown in fig. 2

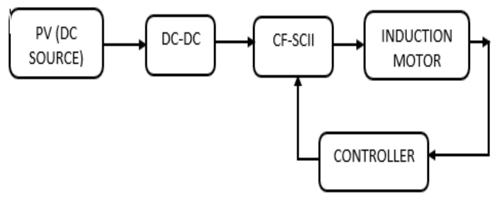


Fig. 1 System Configuration

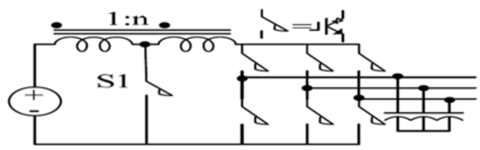
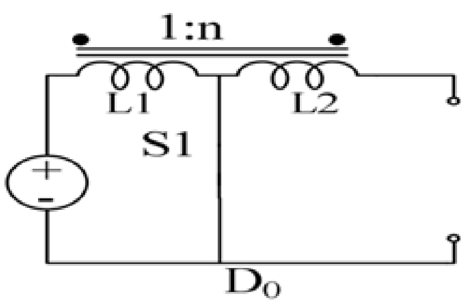


Fig.2 CF-SCII

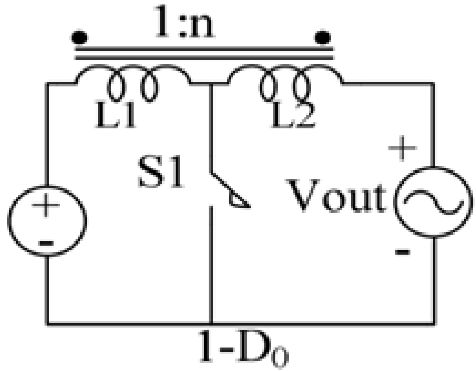
The diode or an active switch can be used as the front switch in the topologies of voltage fed and current fed circuits. Here , in current fed an active switch is preferred the most. The active switch is nothing but a single device without any diode connected in anti-parallel or in series. This system has less active switches when compared to the boost converter inverter systems.

2. CURRENT- FED SWITCHED -COUPLED - INDUCTOR INVERTER.

Take CF- SCII (fig.2) as analogous to current source inverter.CF-SCII has two operating states, namely shoot through and non- shoot through states conditions. Shoot through in the sense the both switches of the same leg in a phase will be turning on at a time. During the normal zero state, if shoot through is chosen then there will be no effect in the output current and voltages. The boosting of voltage is carried due to the shoot through condition because during this period the coupled-inductor gets charged, so the inverter is boosting the voltage. The two equivalent circuit states of the CF-SCII are shown in Fig.3. When the shoot through condition is active then the front active switch or the diode gets turned off and the coupled inductor 2 gets charged , where as in the case of non- shoot through case the diode or the active switch turned on automatically and the inductor 1 gets discharged. In the entire switching period or interval the energy in the coupled inductor is balanced and stable. That is the turns current product (N*I) equation is balanced and is a constant.



(a) Open zero state



(b) Active state

Fig.3 Two operation states of CF-SCII

In shoot through state condition the inductor 1 is having current as zero , but the inductor 2 is being charged by the short circuit . In non- shoot through condition the both inductors get charged by the potential difference of the source and the switch or diode. The inductor voltages in two states are :

For zero state:

$V_L = V_{L1} + V_{L2}$
$V_L = V_{L1} + nV_{L1}$
$V_L = (1+n)V_{L1}$
$V_{in} = V_L + V_{out}$
$V_m = V_{L1} = V_{in}*D_0$ ---(1)

For Active state:

$V_{in} = V_L + V_{out}$
$V_L = V_{in} – V_{out}$
$V_m = 1/(1+n)* V_m$
$V_m = 1/(1+n)*[V_{in} – V_{out}]$ ---(2)
$V_m *D_0 + V_m *D^1 = 0$
$V_{in} *D_0 + 1/(1+n)*[V_{in} – V_{out}]* D^1 = 0$
By solving
$V_{out} / V_{in} =(1+nD_0)/(1-D_0)$ ---(3)

The above expression is known as boost factor. Here, n is the trans ratio between the inductor 1 and 2 , D_0 is duty cycle in shoot through condition. Currents of the two inductors are discontinuous due to the different expressions at different circuit states in one switching cycle period. But the total flux is constant in the coupled inductors.

3. BLOCK DIAGRAM FOR FUZZY LOGIC CONTROLLER OF INDUCTION MOTOR SPEED CONTROL BY SVPWM TECHNIQUE

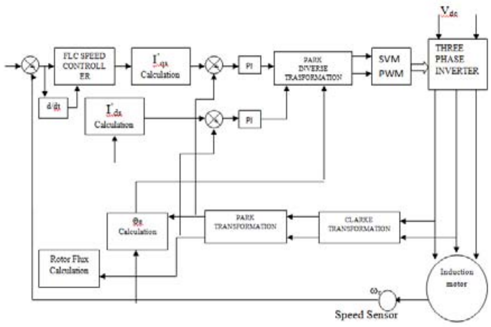


Fig.4 Block diagram for fuzzy logic controller of Induction motor speed control by SVPWM technique.

The suggested block diagram of fuzzy logic controller based induction motor drive The motor speed is observed and the observed actual speed ($\omega_r(n)$) and the reference speed ($\omega_r*(n)$) of motor are compared. The speed error $\Delta\omega_r(n)$ and change in speed error $\Delta e(n)$ are taken as the inputs to the fuzzy logic controller and the output of the FLC is the Electromagnetic torque (Te*) and the quadrature-axis stator current reference (i^*_{qs}) is executed from electromagnetic torque (Te*). SVPWM method which straightly utilizes the control variable given by the control system and distinguishes each exchanging vector as a point in complex space.

4. DESIGN OF FUZZY LOGIC-BASED SPEED CONTROLLER

If e is NB and ce is PS then output is ZE Where are the labels of linguistic variables of error (e), change of error (ce) and output respectively. e, ce and output represent degree of membership. To obtain the control decision, the max-min inference method is utilized. Control rules are given by

	Δe				
	NB	NS	ZE	PS	PB
NB	ZE	NS	NB	NB	NB
NS	PS	ZE	NS	NS	NB
ZE	PB	PS	ZE	NS	NB
PS	PB	PS	PS	ZE	NS
PB	PB	PB	PB	PS	ZE

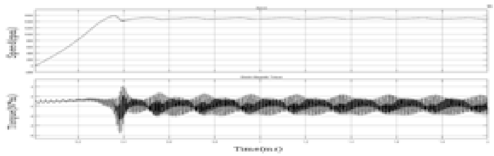


Fig. 6, it shows Output Speed and Electromagnetic Torque characteristics of IM without FLC by SVPWM. Torque: -0.05to0.15(N*m), Motor speeds: 1410 rpm, settling time is 3.0 ms

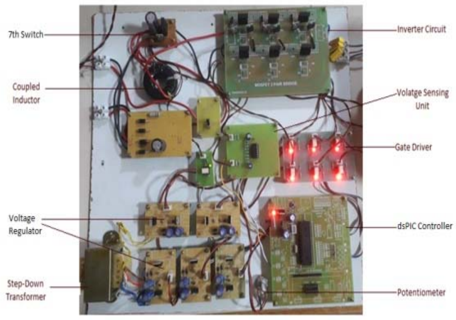


Fig. 8 Hardware Circuit

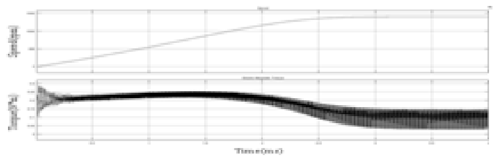


Fig. 7, it shows Output Speed and Electromagnetic Torque characteristics of IM using FLC by SVPWM.

5. CONCLUSION

The correct selection of trans-ratio n and extra switching state duty cycle, current-fed topology that can buck-boost voltage. Current-fed SCII has lower active switch current stress than current-fed Z/quasi-Z-source inverter at the same voltage gain, in buck motoring and regeneration mode with extra switch. Speed control of induction motor in open loop has more ripples but closed loop control reduces the ripples in speed by using fuzzy logic controller. The current-fed switched-coupled-inductor inverter is potential candidate for compact, high efficiency, low cost HEV/EV motor drive or engine starter.

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