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ARTICLE

PV BASED BOOST - SEPIC CASCADED INVERTER FED INDUCTION MOTOR SYSTEM WITH LOW CURRENT RIPPLE

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ABSTRACT

Induction motor IM is a low cost motor with high ruggedness required in paper and textile mills. This paper deals with comparison of performances of Boost-Boost inverter fed IM drive system with boost SEPIC inverter fed IM drive system. The output of PV system is boosted using boost SEPIC converter. The output of SEPIC is converted to seven level output using an inverter. Boost - SEPIC converter is proposed to reduce the ripple in the input current. Boost-SEPIC cascaded inverter is proposed in the present work.

KEY WORDS
Solar Power,:SEPIC;Open loop control; THD;MLI; Boost Converter

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INTRODUCTION

THE electric vehicles (EV) and Hybrid Electric Vehicles (HEV) currently seem to constitute an increasingly effective alternative to the conventional vehicles, allowing to the vehicle manufacturers to be able to fulfill the requirements required by the users of vehicles (dynamic performances and fuel consumption) and the environmental constraints (reduction of the pollutant emissions). The electric propulsion system is the heart of EV [1]. It consists of the motor drive, transmission device, and wheels. In fact, the motor drive, comprising the electric motor, the power converter, and the electronic controller, is the core of the EV propulsion system. The motor drive is configured to respond to a torque demand set by the driver.

The induction motor seems to be a very interesting solution for EV's propulsion. Field Oriented Control (FOC) [2] and Direct Torque Control (DTC) [3-4] have emerged asthe standard industrial solutions to achieve high dynamic performance. However some drawbacks of both methods have motivated important research efforts in the last decades. Particularly for DTC, the high torque ripple and the variable switching frequency introduced by the hysteresis comparators have been extensively addressed [5-6]. In addition, several contributions that combine DTC principles together with PWM and SVM have been reported to correct these problems. This approach is based on the load angle control, from which a voltage reference vector is computed which is finally modulated by the inverter [7]. Although one major feature of classic DTC is the absence of modulators and linear controllers, this approach has shown significant improvements and achieves similar dynamic performance.

On the other hand, the power converter technology is continuously developing, and cascaded multilevel inverters have become a very attractive solution for EV applications, due to its modular structure, higher voltage capability, reduced common mode voltages, near sinusoidal outputs, and smaller or even no output filter [8]. In general, cascaded multilevel inverter may be classified in two groups. The first one refers to the amplitude of isolated DC sources devoted to supply each H-bridge cell. If the amplitude of all sources is equal, then the inverter is called symmetrical, otherwise, if at least one of the sources present different amplitude, then it will be called asymmetrical. The second classification label the multilevel inverter whether hybrid or not. If the converter is implemented with different technologies of semiconductor devices (IGBTs, SCRs, GTOs, IGCTs), different nature of DC sources (fuel cells, batteries and super capacitors) and/or if it presents a hybrid modulation strategy, then it is classified as hybrid [9-10]. This structure greatly simplifies the converter complexity.

The proposed control algorithm eliminates the need of additional isolated DC sources. The control strategy regulates the DC link voltages of capacitors connected to the smallest voltages of a two cells 7-level cascaded H-bridge inverter. The obtained results validate the voltage control strategy and confirm the high dynamic performance of the proposed method, presenting very low torque ripple. Two viable Schemes for induction motor torque control is given by Casadei [11]. Control of a hybrid asymmetric multilevel inverter for competitive medium-voltage industrial drives is given by Veestra [12]. A cascade MLI using a single fuel cell DC source is given by Du [13]. A cascade MLI H-bridge inverter utilizing capacitor voltages sources is given by Corzine [14]. Cascaded H-bridge multilevel inverters- A re-examination is given by Liao[15].The above literature does not deal with Boost-SEPIC seven level inverter fed induction motor drive. This work proposes cascaded Boost-SEPIC converter.

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MATERIALS AND METHODS

MULTILEVEL INVERTER TOPOLOGY

The block diagram of the existing system is illustrated in [Fig. 1]. The inverter is composed by the series connection of power cells, each one containing an H-bridge inverter and an isolated dc-source. In the particular case of asymmetric inverters these sources are not equal (V1> V2). The asymmetry of the input voltages can

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reduce, or when properly designed, eliminate redundant output levels, maximizing the number of different levels generated by the inverter.

Therefore this topology can achieve the same output voltage quality with less number of semiconductors, space, costs and internal fault probability than the symmetric fed topology.
A particular cell i can generate three voltage levels (+Vi,0,−Vi). The total inverter output voltage for a particular phase j is then defined *by*

$$v_{iN} \sum_{j=1}^{m} v_{ij} = \sum_{j=1}^{m} v_j = (s_{j1} - s_{j2}), \qquad i \in \{a, b, c\}$$

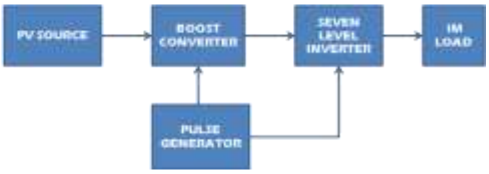

Fig.1: Block diagram of existing system

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Where v_{iN} is the total output voltage of phase i (respectively, the neutral of the inverter N), is the output voltage of cell of phase, and the switching state associated to cell. Note how the output voltage of one cell is defined by one of the four binary combinations of the switching state, with “1” and “0” representing the “On” and “Off” states of the corresponding switch, respectively.

The inverter generates different voltage levels (e.g. an inverter with m = 4 cells can generate (2m+1 – 1 = 31) different voltage levels). When using three-phase systems, the number of different voltage vectors is given by 3nl(nl −1) + 1, where nl is the number of levels. For example, for the m = 4 case with 31 levels there are 2791 different voltage vectors. Table I summarizes the output levels for an asymmetric 7-level inverter using only m=2 cells per phase (only phase is given). An example of the voltage waveform generation for an asymmetric seven-level inverter is illustrated in [Fig. 2].

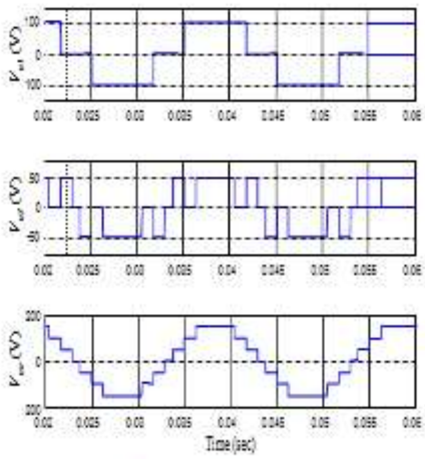

Fig. 2. Asymmetric multilevel inverter with 7-levels output voltage synthesis.

Table I. 7-LEVEL ASYMEMETRIC CASCADED INVERTER SWITCHING STATES

n1	cell 1			cell 2			total
	S_{11}	S_{11}	V_{a1}	S_{21}	S_{22}	V_{a2}	V_{aN}
1	1	0	$3V_{dc}$	0	0	0	$3V_{dc}$

2	1	0	$3V_{dc}$	0	1	$-V_{dc}$	$2V_{dc}$
3	0	0	0	1	0	$-V_{dc}$	V_{dc}
4	0	0	0	0	0	0	0
5	0	0	0	0	1	$-V_{dc}$	$-V_{dc}$
6	0	0	$-3V_{dc}$	1	0	V_{dc}	$-2V_{dc}$
7	0	1	$-3V_{dc}$	0	0	0	$-3V_{dc}$

SYSTEM DESCRIPTION

The block diagram of proposed system is shown in [Fig. 3]. Boost converter is replaced by Boost-SEPIC converter to increase the control range and reduce input current ripple.

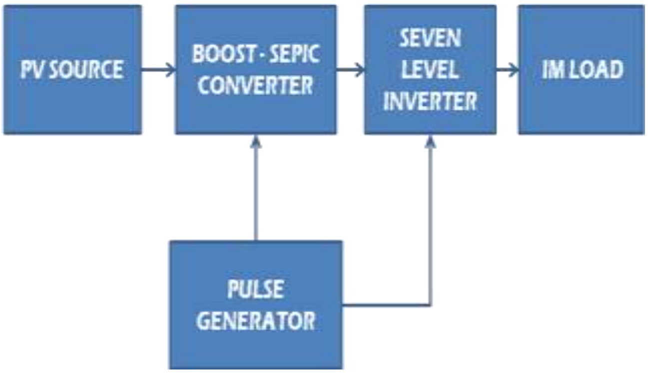

Fig.3: Block diagram of proposed system

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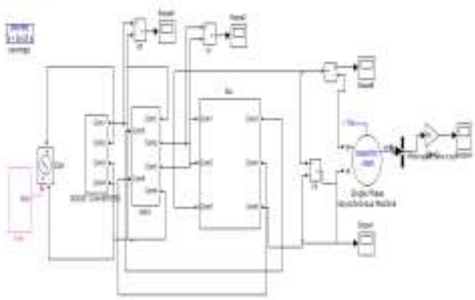
RESULTS

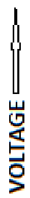
SIMULATION RESULTS

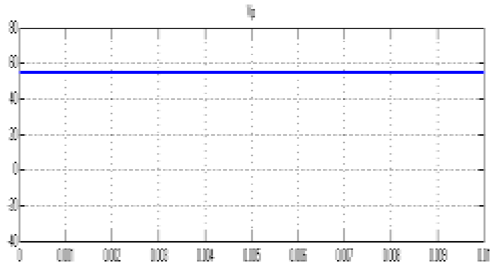
Boost-SEPIC cascaded multi level inverter system is shown in [Fig.4.1]. The output of PV is stepped up in two stages using Boost and SEPIC converters. A single phase induction motor is used as the load. Output voltage of solar system is shown in [Fig.4.2].Boost converter circuit and its input current ripple are shown in [Figs.4.3&Fig.4.4]respectively. The output voltage of the Boost converter is shown in [Fig.4.5].

SEPIC converter and its input current ripple are shown in [Figs.4.6 and 4.7] respectively. The peak to peak ripple is 5A. The output voltage of SEPIC converter is shown in Fig.4.8 and its value is 100V.Switching pulses for M1 and M3 of MLI are shown in [Fig. 4.9]. The output voltage of MLI is shown in Fig.4.10. The peak value is 200V. The speed response is shown in [Fig. 4.11]. The speed settles at 1400RPM. The frequency spectrum for the output is shown in [Fig. 4.12]. The THD is 16.72%.

The comparison of Boost – Boost and Boost - SEPIC systems are given in Table 1. The comparison is done in terms of current ripple, output power and THD.



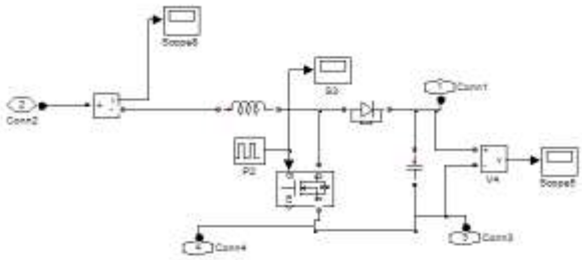


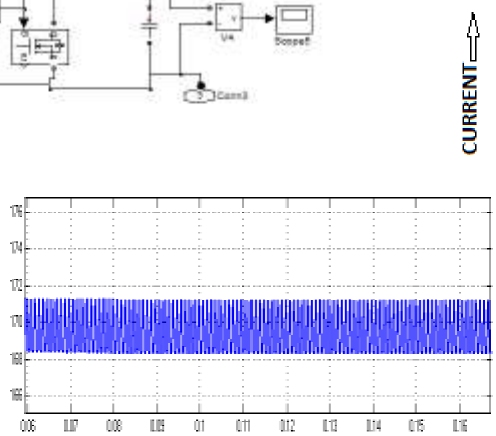


TIME

Fig. 4.1: Boost with SEPIC converter based MLI

Fig. 4.2: Solar output voltage

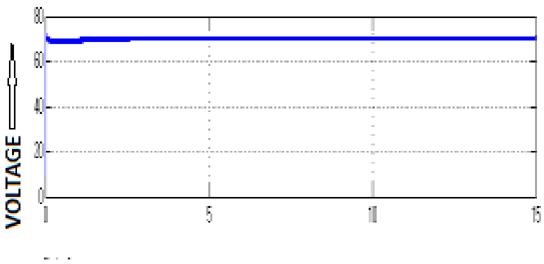




TIME

Fig. 4.3: Boost Converter Circuit converter

Fig.4. 4: Output current ripple of Boost



TIME

Fig.4.5: Output voltage of Boost Converter

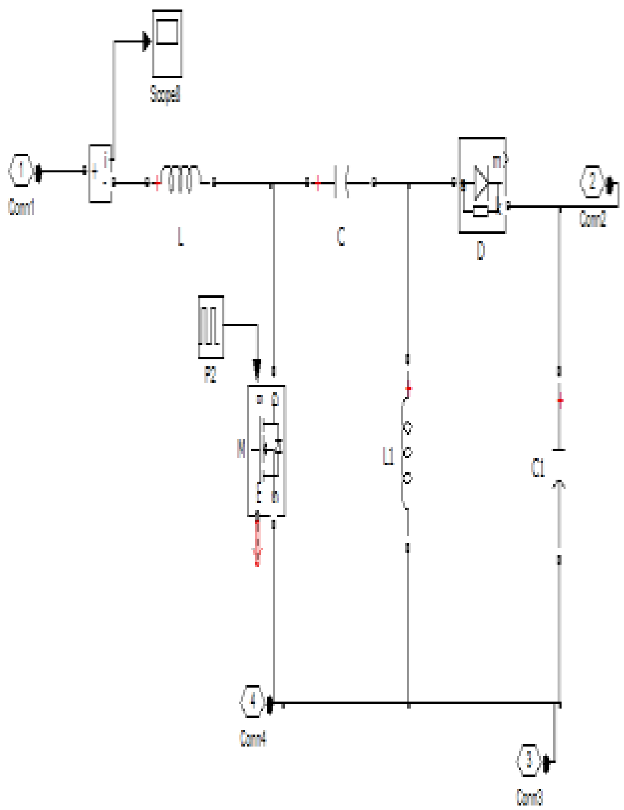


Fig. 4.6 :SEPIC converter circuit

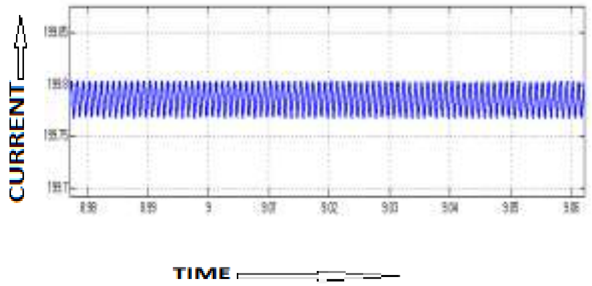


Fig. 4.7 : Input current ripple of SEPIC

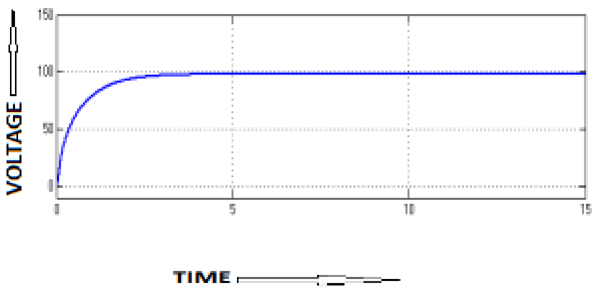


Fig. **4.8:** Output voltage of SEPIC converter

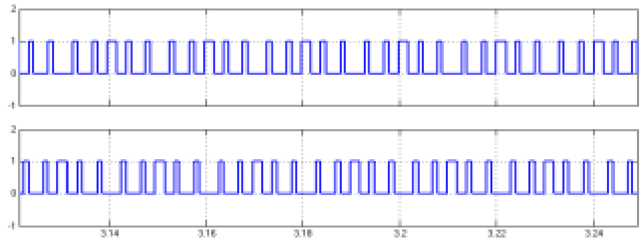


Fig. 4.9 : Switching pulse for M1 & M3 of MLI

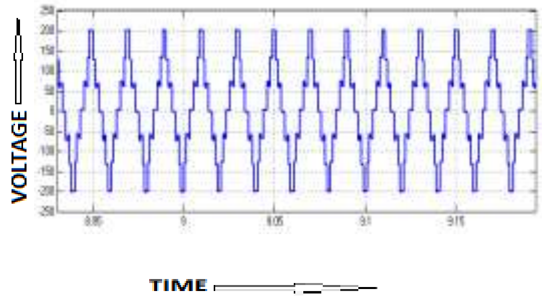


Fig.4.10 : Output voltage

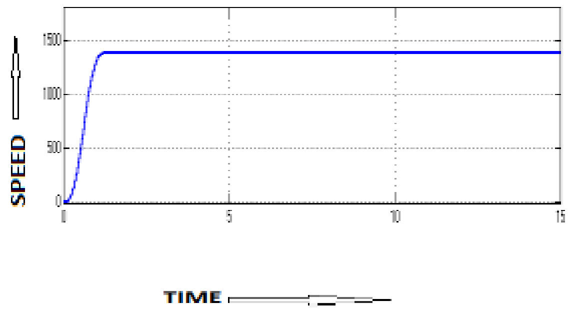


Fig.4.11: Motor Speed

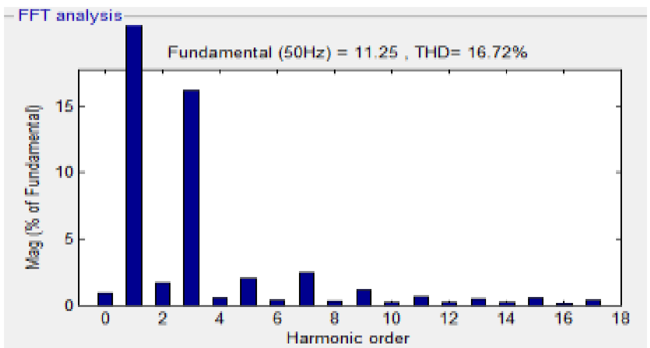


Fig. 4.12: Frequency Spectrum

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Table 1: Comparison of Current ripple & Output Power

converter	Input current ripple	Power (Po)	THD
Boost	3.5A	3125W	24.16%
SEPIC	0.04A	3320W	16.72%

RESULTS

The snap shot for complete hardware system is shown in [Fig.4.25]. The hardware is realized with 230/15V,230/5V transformer,PIC 16F84, IR2110, IRF840 and MCT2E. The output voltage of solar system is shown in fig.4.26. The output voltage of boost converter and SEPIC converter are shown in [Fig. 4.27] and [Fig. 4.28] respectively. Switching pulses for M1 and M3 is shown in [Fig. 4.29]. Switching pulses for M5 and M7 is shown in fig.4.30.The output voltage of seven level inverter is shown in [Fig. 4.31]. The results given in [Figs. 4.10 and Fig. 4.31] indicates that the experimental results are similar to the simulation results.

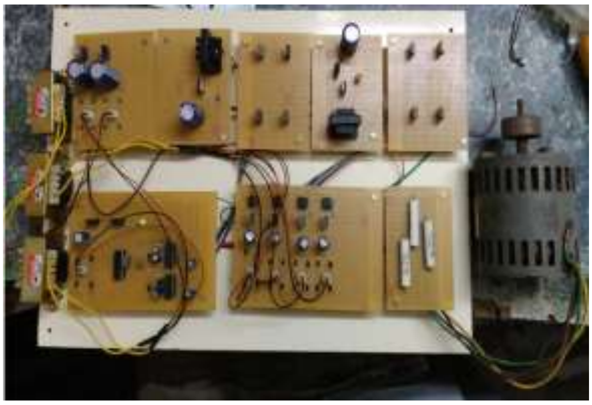

Fig. 4.25: Hardware snap shot

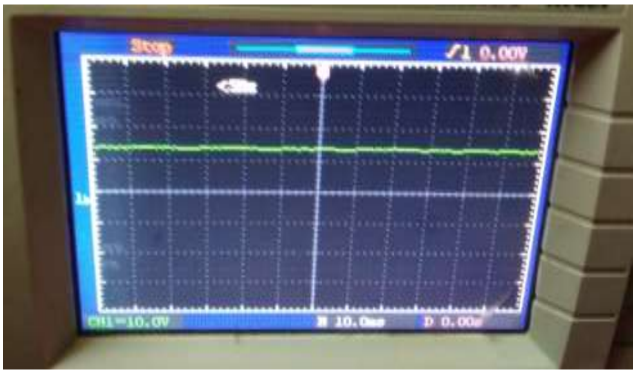

Fig.4.26: Input voltage

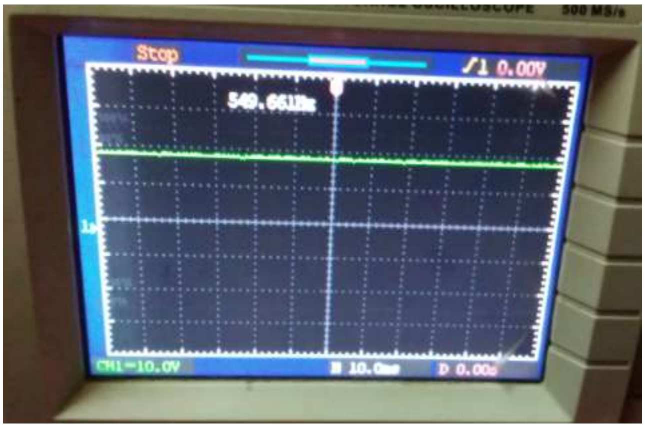

Fig.4.27: Output voltage of boost converter

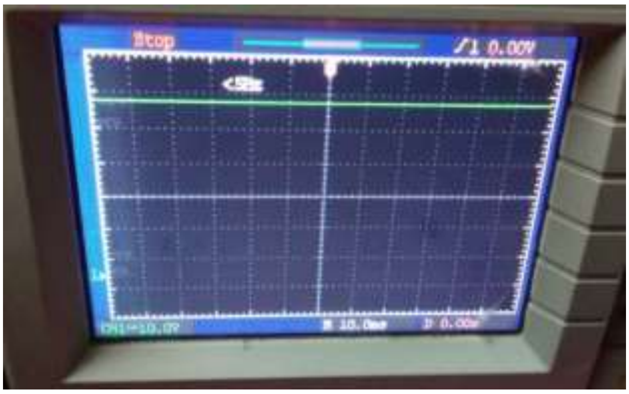

Fig.4.28: Output voltage of sepic converter

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Fig.4.29: Switching pulse for M1,M3

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Fig.4.30: Switching pulse for M5, M7

CONCLUSION

PV based Boost – Boost and Boost- SEPIC cascaded inverter fed induction motor drive systems are designed, modelled and simulated using Matlab and the results are presented. The comparison indicates that the output power is higher & THD is lower with Boost-SEPIC cascaded inverter system.

The disadvantage of the proposed system is that the number of stages are increased. This paper deals with investigations on open loop system. The closed loop system will be investigated in future.

CONFLICT OF INTEREST

There is no conflict of interest.

ACKNOWLEDGEMENTS

None

FINANCIAL DISCLOSURE

None.

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