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# Speed Control of Single Phase Induction Motor using Modified SEPIC Converter

Jithy Rachel Thomas[1], Ginu Ann George[2]

PG Student [Power Electronics], Dept. of EEE, SJCET Palai, Kerala, India[1]

Assistant Professor, Dept. of EEE, SJCET Palai, Kerala, India[2]

**ABSTRACT**: This paper proposed a modified SEPIC converter used for the speed control of single-phase induction motor. This is instead of boost topology, which is not suitable because it must have an output voltage higher than the maximum input voltage. SEPIC topology is advantageous because it allows the use of the ripple steering technique in order to reduce the switching frequency components of the input current without additional costs. The proposed converter presents a low input current ripple operating in discontinuous conduction mode. The switch voltage is lower than the output voltage. The lower switch voltage increases the converter reliability. Single-phase induction motors are widely used in home appliances and industrial control because of their low cost and rugged construction. Many industrial processes require variable speed drives for various applications. In this paper, single phase inverters have been modelled and their output is fed to the induction motor drives. A MATLAB simulation and hardware implementation was also developed to run and to control the speed of the induction motor.

**KEYWORDS:** Modified SEPIC Converter, Discontinuous Conduction Mode, Induction Motor.

## I.INTRODUCTION

For the PFC (power factor correction) converter, boost converter topology can be used when an output voltage lower than the maximum input voltage is required [1][2]. This method is simple and profitable because the design of rectifier in DCM allows the converter to operate as a voltage follower. In the absence of a current control loop the input current follows the input voltage profile. This solution is restrained for low-power applications due to conduction losses operating in DCM. In boost converter the input current ripple is very high. So in this boost converter an additional filter circuit is provided. The classical SEPIC converter is shown in Fig. 1 which is usually used as an HPF converter where output voltage must be lower than input ac voltage [3][4].

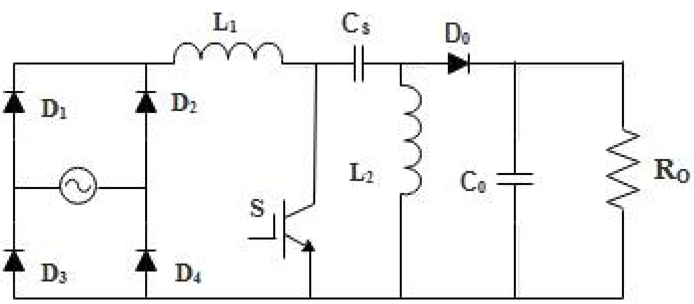


Fig. 1 Classical SEPIC converter

The converter operates as a voltage follower and using a lower value for the inductor $L_2$ and a higher value for inductor $L_1$. The third harmonic distortion is not presented since the inductor $L_2$ is demagnetized with the output voltage. A modified SEPIC dc-dc converter was proposed in [5]. However, dc-dc converter in CCM mode was analyzed. This converter was also used in [6] as a preregulator operating in CCM presenting some advantages when compared with the classical boost preregulator operating in CCM.

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The single-ended primary-inductance converter (SEPIC) is a DC/DC-converter topology that provides a positive regulated output voltage from an input voltage that varies from above to below the output voltage. This type of conversion is easy when the designer uses voltages from an unregulated input power supply such as a low-cost wall wart. Single phase induction motors are widely used in home appliances and Industrial control because of their low cost and strong in construction. Many industrial processes require variable speed drives for various applications. The use of a Variable Speed Drive for a speed control application usually offers an energy efficient and economic solution. In the next section of this paper, the different operation modes are analyzed. In section III, the design procedure is explained. In section IV the simulation results are presented.

## II.MODES OF OPERATION

The converter used is modified SEPIC converter operating in DCM. It has three modes of operation. In this, the theoretical analysis is done by considering the converter operation as dc-dc converter. The design procedure is developed for the converter with a diode bridge at input side. Also ac voltage is given as input voltage. Fig. 2 shows the modified SEPIC converter operating in DCM.

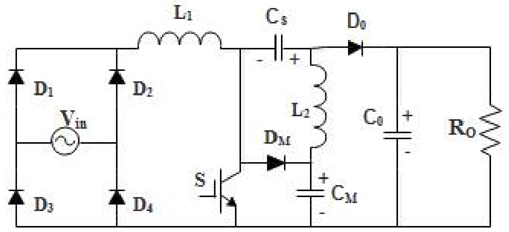


Fig. 2 Modified SEPIC converter

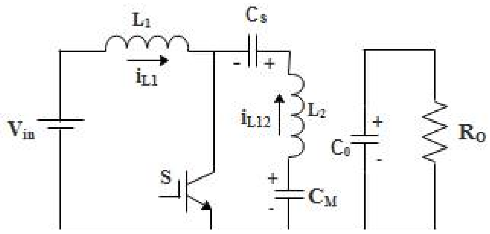


Fig. 3 First mode of operation

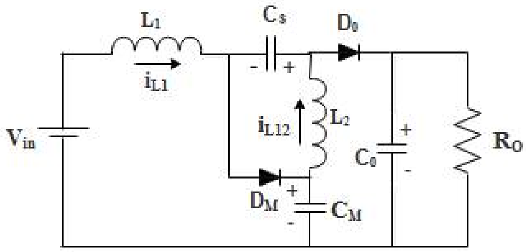


Fig. 4 Second mode of operation

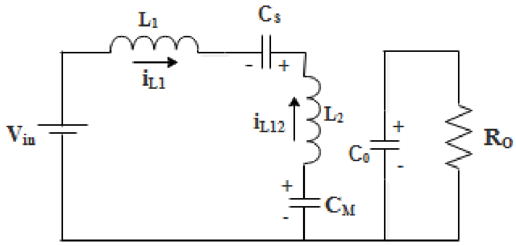


Fig. 5 Third mode of operation

1. First Mode of Operation: The first mode of operation is shown in Fig. 3. In this mode of operation switch S is in ON condition. In this stage the input inductor $L_1$ stores energy from input voltage. Inductor $L_2$ stores energy from $V_{CS}$-$V_{CM}$ ($V_{CM} > V_{CS}$). The diodes $D_O$ and $D_M$ are in reverse biased condition during this mode of operation.

2. Second Mode of Operation: The second mode of operation is shown in Fig. 4. During this mode of operation the power switch S is in OFF condition. In this mode the energy stored in the inductor is transferred to output. In this mode maximum switch voltage is equal to the $C_M$ capacitor voltage. The diodes $D_O$ and $D_M$ are in forward biased condition during this mode of operation.

3. Third Mode of Operation: This mode of operation is shown in Fig. 5. During this mode of operation, the switch S is in OFF condition and the diodes $D_O$ and $D_M$ are in reverse biased condition. The voltage applied across the inductors are zero. When the switch is turned ON this mode of operation is finished and returning to the first mode of operation.

The Fig. 6 shows the proposed converter fed induction motor. The proposed converter fed induction motor drive consists of modified SEPIC converter, single phase voltage source inverter, and a single phase capacitor start-run

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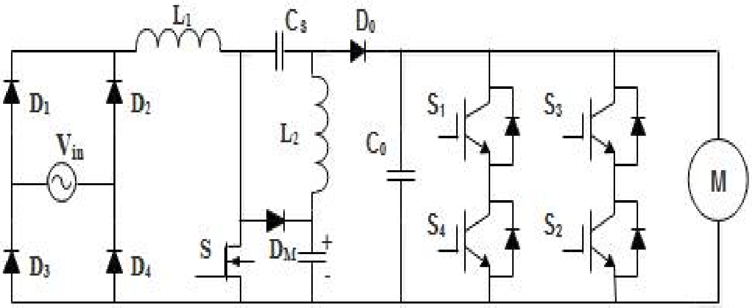


Fig. 6 Proposed converter fed induction motor

induction motor. The single phase inverter is used to convert AC to DC. Induction motors are the most widely used motors for appliances, industrial control, and automation hence, they are often called the workhorse of the motion industry. They are robust, reliable, and durable. When power is supplied to an induction motor, it runs at its rated speed. However, many applications need variable speed operations. These electronics not only control the motors speed, but can improve the motors dynamic and steady state characteristics. In addition, electronics can reduce the systems average power consumption and noise generation of the motor.

## III.ANALYSIS AND DESIGN

The converter is designed for an output power of 100 W and an output voltage of 400 V.

$$\text{Output current} = \frac{\text{Output power}}{\text{Output voltage}} = \frac{100}{400} = 0.25 \text{ A}$$

The static gain of the SEPIC converter is,

$$\frac{V_O}{V_i} = \frac{1+D}{1-D}$$

Assuming input current ripple to be 26% of input peak current.

Assume $\eta = 0.96$ then,

$$I_{inpk} = \frac{P_o}{\eta . V_{irms}} = \frac{100}{0.96 . 127} = 1.157 \text{ A}$$

Input current ripple,

$$\Delta i_L = 1.157 . \frac{26}{100} = 0.3 \text{ A}$$

$$L_1 = \frac{V_{pk} . D}{\Delta i_L . f} = \frac{180 \times 0.337}{0.3 \times 30 \times 1000} = 6.74 \text{ mH}$$

Where,

$$D \le \frac{V_o - V_i}{V_o + V_i} = \frac{400 - 180}{400 + 180} = 0.379$$

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Output dc load current is,

$$Io = \frac{V_{pk}\,.\,D^2}{2\pi L_{eq} f}\,.\,\mathrm{K_i}$$

$$L_{eq} = \frac{V_{pk}\,.\,D^2}{2\pi.\ f\left(P_o/V_o\right)}.\,K_i = \frac{180\times0.337^2}{2\pi\times30\times10^3\times\left(100/400\right)}\times1.159 = 500.28\ \mu\mathrm{H}$$

Inductor $L_2$ is given by,

$$L_2 = \frac{L_1\,.\,L_{eq}}{L_1 - L_{eq}} = \frac{6.8\times10^{-3}\times500.28\times10^{-6}}{6.8\times10^{-3}-500.28\times10^{-6}} = 540\ \mu\mathrm{H}$$

Considering converter resonance frequency $f_R$ = 5.5 kHz

The capacitors $C_S$ and $C_M$ are given by,

$$C_S = C_M = \frac{2}{(2\pi.\ f_R)^2.(\mathrm{L_1}+\mathrm{L_2})} = \frac{2}{\left(2\pi\times5.5\times10^3\right)^2.\left(6.8\times10^{-3}+0.54\times10^{-3}\right)} = 228.2\ \mathrm{nF}$$

## IV.SIMULATION RESULTS

The Fig. 7 shows the overall simulink model of the proposed converter fed induction motor drive. In this a universal bridge inverter is used to convert DC to AC. Also the motor speed control can be carried out by using single phase capacitance start-run induction motor. In this a manual switch is used to vary the torque of induction motor.

If the torque is varied speed has no change. It is always to be constant. Here the voltage is varied and frequency kept constant. By this method the speed control can be achieved. The control pulses to the inverter are generated by pulse width modulation technique. The gating signals are produced by comparing triangular wave as carrier signal and sine wave as the modulating signal. The fig. 8 shows the simulink model of the gate pulse generation of inverter.

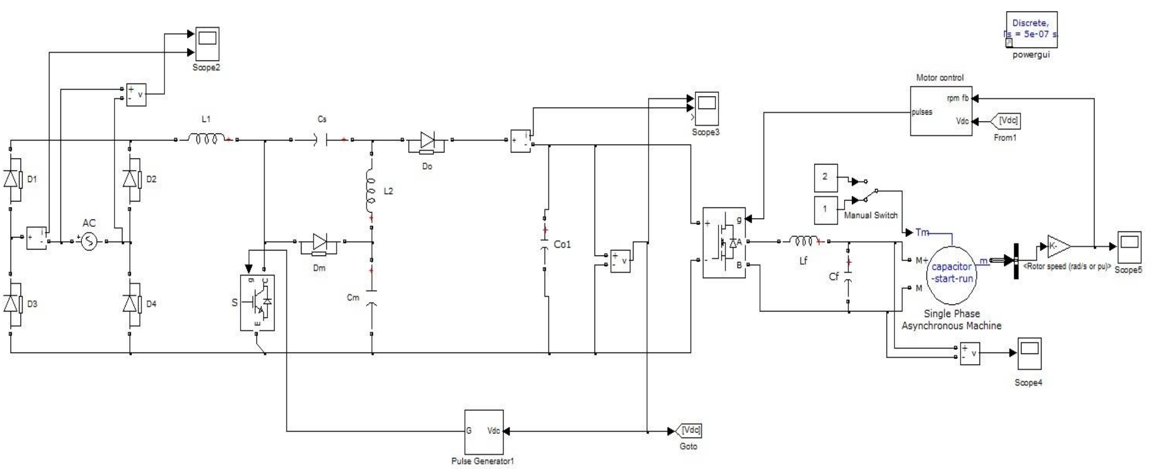


Fig. 7 Overall simulink model

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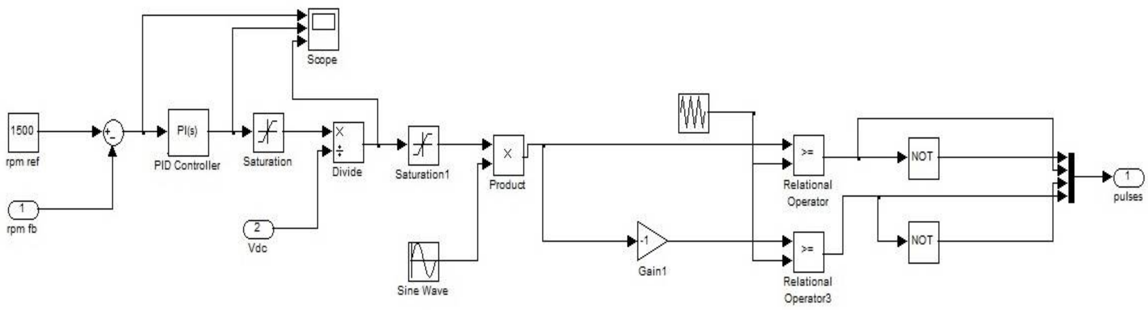


Fig. 8 Simulink model of gate pulse generation of inverter

The PI controller is used for the gate pulse generation of inverter. The Fig. 9 shows the input voltage waveform given to the converter. The output voltage and output current waveforms are shown in Fig. 10.

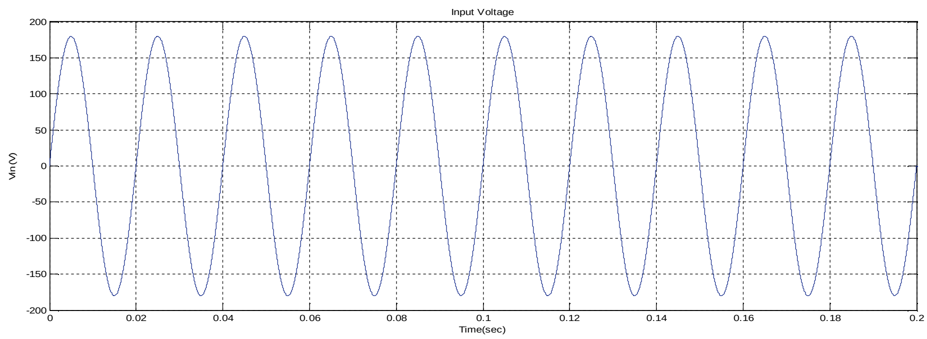


Fig. 9 Input voltage

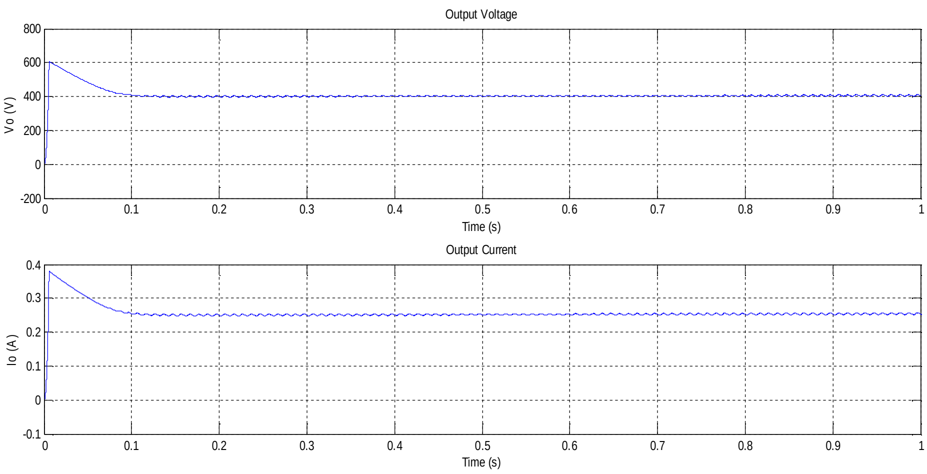


Fig. 10 Output voltage and output current

The Fig. 11 shows the rotor speed of induction motor at 1500 rpm and Fig. 12 shows the output voltage waveform of single phase inverter. This output of single phase inverter is given to run the single phase induction motor.

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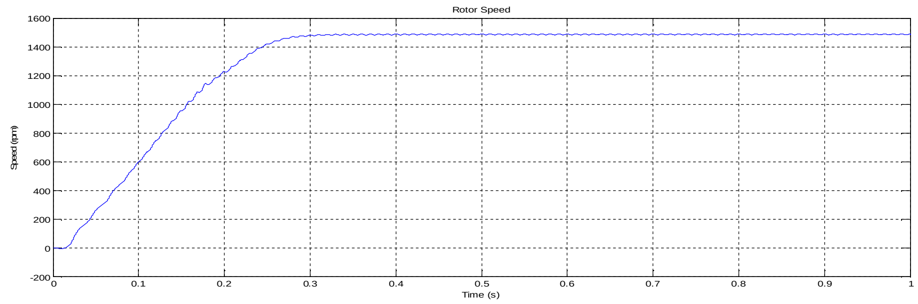


Fig. 11 Rotor speed at 1500 rpm

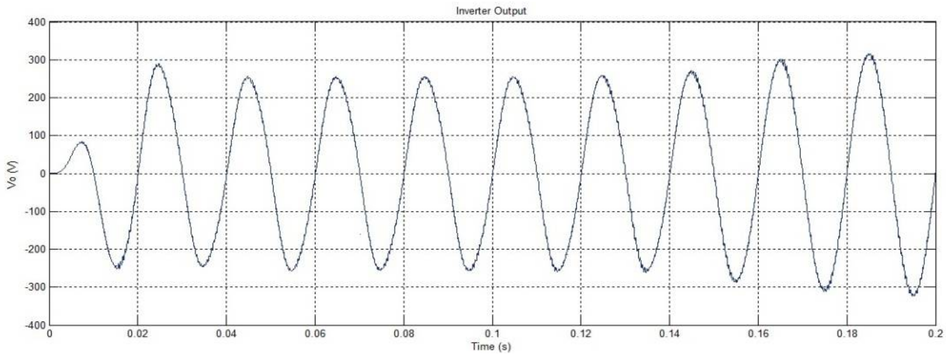


Fig. 12 Output voltage waveform of inverter

## V. CONCLUSION

The implementation of a modified SEPIC converter fed induction motor drive is presented. The SEPIC converter is operated in DCM mode. The proposed converter presents low input current ripple operating in DCM and the switch and diode voltages are lower than the output voltage. The single pulse width modulation signals are generated by the single phase inverter. An induction motor was run with the help of a single phase inverter. The MATLAB simulation for the converter fed induction motor drive can be done by using MATLAB R2013a software. From the simulation results we can clearly found that the speed control of induction motor can be achieved by varying the voltage at fixed frequency. From this we can clearly found that this motor drive gives better performance and efficiency. The speed control method adopted is very easiest and cheapest.

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