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Closed Loop PWM Control for Induction Motor Drive Using Dual Output Three Phase Inverter

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ABSTRACT: A novel dc link capacitors dual output six switch inverter topology is used for independently supplying two induction motor loads and also used to minimize the dc link voltage ripple and the value of dc link capacitors are reduced in this inverter. A three phase dc link capacitor dual output six switch pwm inverter is used to give a steady output voltage to the motor with low complexity, high reliability and high efficiency. The dc link capacitor dual output six switch inverter employs less number of switches so that the conduction loss is very less in this inverter. The speed-torque curve of an induction motor consists of stable range and an unstable range. To drive varying mechanical loads for long duty in both stable range and instable range the machine needs to be controlled. In closed loop system the efficiency is increased and transient is minimized by controlling the parameter of motors i.e., speed of the motor, the motor runs reliably even in unstable range. For the implementation of the proposed drive the MATLAB/SIMLINK environment has been used. The performance of the inverter is verified in terms of waveforms developed by the motor.

KEYWORDS*:* Dual output inverter, Induction motor drive, DC link source six switch inverter, pwm control.

I. INTRODUCTION

With the recent trends in power semiconductors and power electronics control methods, the cost of variable frequency inverter fed ac drives especially induction motor drive systems are reduced. These drives are being adopted for many applications in industries and also in many sensitive applications like robotic systems. In addition to cost reduction, the improvements in power inverter technology have significantly reduced the size and weight, improved waveform quality as well as providing a high degree of reliability. Reducing the number of active switches in power inverter is called as “Reduced Switch Count Inverters” [1-5] generally there are two types of reduced switch count inverters namely Single output inverter and Multi output inverter. The single output inverter is also called as B4 inverter [2]. B4 inverter is used as a practical alternative for B6 inverter or three phase inverter. B4 inverter consists of four switches and free wheeled diodes. The B4 inverter also consists of two split capacitors which have the capability of sending only sinusoidal input currents with unity power factor to the motor.

Multi output inverters are classified into five leg inverter [6] and nine switch inverter [7]. These inverters are used to supply and control two induction motor loads. Five leg inverters are used for low, medium and high range power applications. The five leg inverter consists of five legs and ten switches. Two phases of each induction motor is connected separately to four legs and the third phase of both the motors is connected to the fifth leg [6, 8].Nine switch inverter [9-13] consists of three legs and nine switches. It consists of higher, middle and lower switches. The higher switches are used to supply first motor, the lower switches are used to supply second motor. The middle switches are shared between both the motors. Based on the supply used the nine switch inverters are used in various applications. The nine switch inverter is used as an AC/AC converter[9-10] which has the advantages such as sinusoidal steady inputs and outputs, unity power factor and low cost due to less number of semiconductor switches. The performance of nine switch inverter can be improved by using space vector width modulation [11]. The current type nine switch inverter is used for high range power application where the input dc current is shared between two outputs. The output of this current type nine switch inverter is less than the output of single output inverter. To overcome this, the Z source nine switch current type inverter is used [12]. The bidirectional Z source inverter is used for hybrid electric vehicle

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applications [13].The dual output inverter [14] has only six switches and used for supplying two induction motors. The inverter has two legs and three voltage sources are placed in series for supplying the loads. The number of switches are reduced to 33% from the conventional multiple output inverters. The three voltage sources have different values which are decided in a manner to achieve balanced three phase ac outputs without dc components.

In this paper a novel dc link source six switch inverter is proposed for supplying two induction motors using six switches, a single voltage supply and series combinations of capacitors. The closed loop system is used to control the speed of the motor in unstable range. Speed control is done by phase control method here the speed error is reduced when compared to a set value. The modulation of carrier and reference signal is used to produce pulse width modulated output. The closed loop speed control method will provide steady speed even in the unstable range.

II. RELATED WORK

The dual output inverter [14] has only six switches and used for supplying two induction motors. The inverter has two legs and three voltage sources are placed in series for supplying the loads. The number of switches are reduced to 33% from the conventional multiple output inverters. The three voltage sources have different values which are decided in a manner to achieve balanced three phase ac outputs without dc components. Reducing switch count leads to reduction in necessary associated hardware, markedly gate drive and protection circuits, and cooling system, which in turn have a considerable impact on system volume, weight and cost. It can also result in reduction in total loss and increases the efficiency and the overall reliability of the system especially in applications with low and medium voltage and power ratings.

Two modes of operation are defined for the dual output inverter, VF mode of operation and CF mode of operation. Each mode employs two different strategies for eliminating DC component from output voltage; the first results in constant DC-link voltages and the second makes them vary according to upper and lower output modulation indices.

III. PRINCIPLE AND OPERATION OF SYSTEM

Fig. 1 illustrates the proposed dc link source six switch inverter. The inverter has two legs with three switches in each leg. It also consists of series combination of capacitors. The value of capacitors is selected in such a way that it produces an steady three phase ac outputs without any dc components.

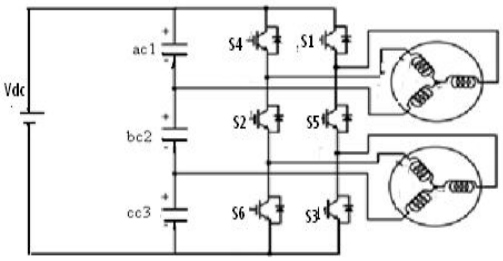

Fig. 1. Dc link source six switch dual output inverter.

The two phases of each induction motor is connected to each leg and the third phase is connected to the series capacitor combinations. There are two modes of operations, Variable frequency mode and Constant frequency mode. This paper presents the constant frequency mode where two motors have same frequency. The voltage amplitudes of the two outputs can be changed for controlling the speed of the motors. The dc link source six switch inverter has two modes of operation. In mode 1 the switches S1,S2 and S3 are turned ON and in mode 2 the switch S4,S5 and S6 are turned ON. Fig. 2(a) and Fig. 2(b) shows the modes of operation of dc link source six switch inverter. The conducting switches supplies current for the two phases of motor. The capacitor is used to supply current for the third phase. Fig 3 illustrates the closed loop system of dc link source six switch inverter.

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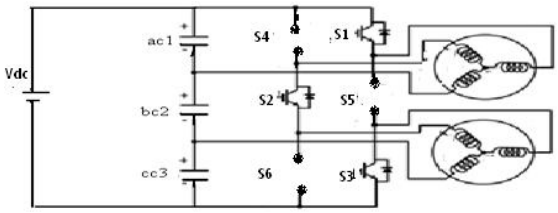

Fig. 2(a). Mode 1 operation of dc link source six switch inverter

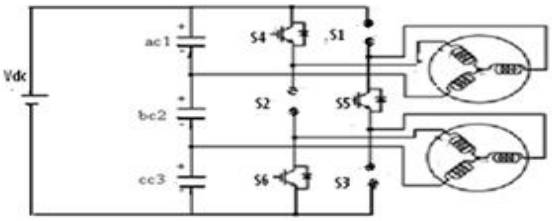

Fig. 2(b). Mode 2 operation of dc link source six switch inverter

The closed loop system consists of carrier signal and reference signal. The carrier signal is generated from the difference between running speed and set speed. The reference signal is generated from the supply voltage. Reference signal is an constant signal where, the carrier signal varies according to the speed changes in the motor. The reference signal and carrier signal is compared to generate the pwm signal. These signals are used to control the ON/OFF period of switch by which the inverter output is varied and the speed is controlled for any load changes.

Closed loop system is fully automatic control system. The control depends on the output of the motor. Based on the speed of the motor the control signal is varied. By doing closed loop system the result is more accurate and more reliable. The result is not disturbed in the presence of non linearities because it consists of feedback mechanism. The closed loop system clears the error between input and output signals and hence the system remains unaffected to any load variations. The complexity is reduced and the efficiency is increased.

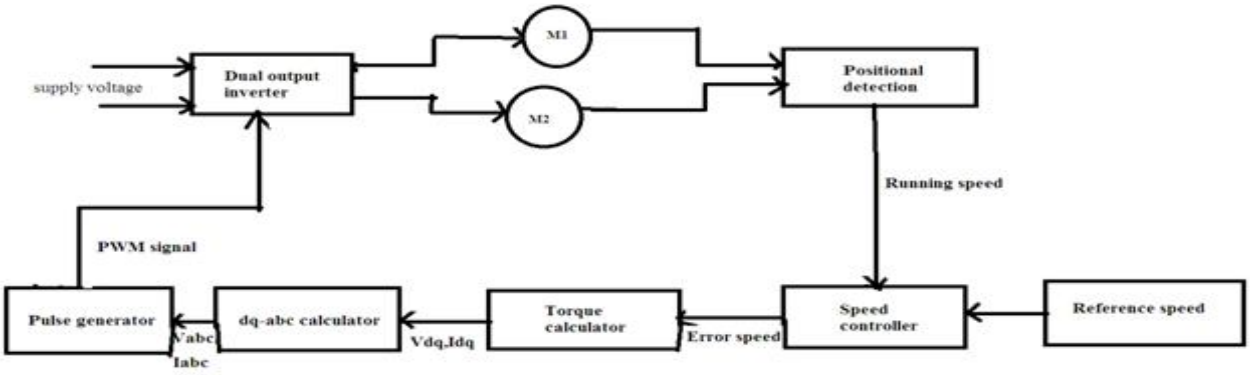

Fig.3. Closed loop system of dc link source six switch inverter

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IV. PWM PULSE GENERATION

The pulse width modulator (PWM) is used to generate the gate signals for the inverter. The ON/OFF time of the gate signal is controlled. When the gate signal is controlled the voltage applied to the motor will be pure sine wave shape. The pure sine wave shape is achieved by comparing the triangular wave with the sine wave shaped signal waveform.

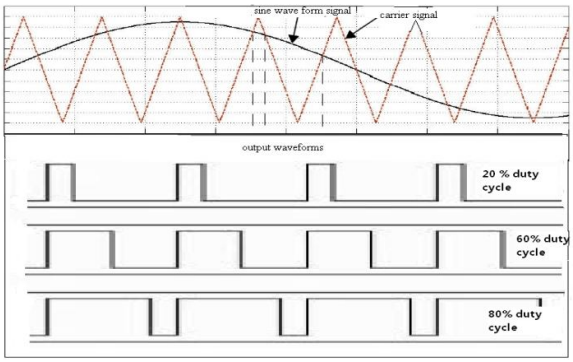

Fig. 4. PWM pulse generation

The speed of the induction motor is controlled by changing the frequency of the supply voltage of the motor. In an open loop system the speed changes as the load is changed.In fig.5, at no load condition and input voltage is V2; the operation point of motor is at point P with speed at N1. When the load torque is increased to T1,the operation point of motor shifts to Q and the speed is reduced to N2. To make the speed equal to N1 the voltage is increased from V2 to V3.Therefore, to increase the speed of the motor whenever the load is increased, the supply voltage of the motor must be increased. In an open loop system the speed cannot be increased because the input supply of the motor is constant and it cannot be varied.

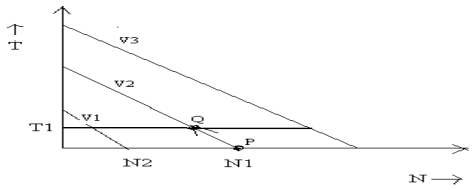

Fig. 5. Speed – torque characteristics

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TABLE 1

. SIMULATION PARAMETERS

PARAMETERS	VALUES
Switching frequency	6kH
f1	50Hz
f2	50Hz
ac1	2200µF
bc2	1100µF
cc3	2200µF
Input voltage	500 V

V. SIMULATION SETUP

The simulation circuit of open loop and closed loop systems are presented in this section. The MATLAB/ SIMLINK package is used for simulation and testing. A 5HP, 460V, 50Hz, 1750 rpm motor is used in this simulation. The capacitor values are listed in the table below. 500V dc supply is used as an input supply. The IGBT switches are used. The pulses are calculated for 60Hz motor and given for suitable switches. Fig. 6 shows the open loop simulation circuit for dc link source six switch dual output inverter. The output of the inverter is used to supply the two individual induction motor. The load torque used for simulation is 1 Nm.

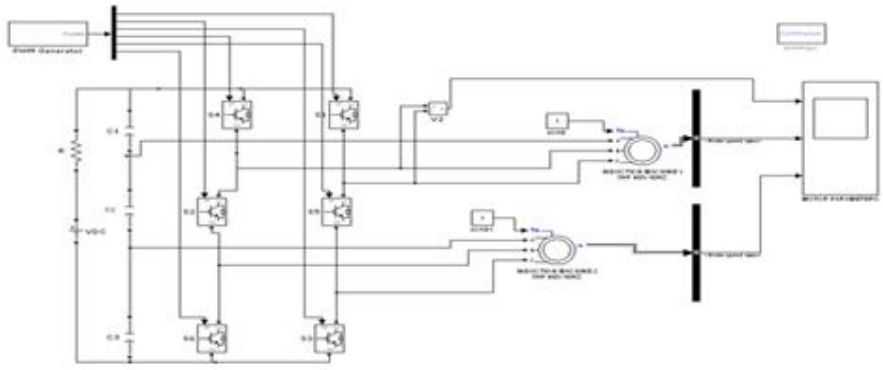

Fig. 6. Simulation circuit of dc link source six switch inverter

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Fig. 7 shows the closed loop circuit of dc link source six switch inverter. PI controller is used for closed loop controlling system. The reference speed is given as 500rpm. According to this reference speed the speed is controlled for all the load variations.

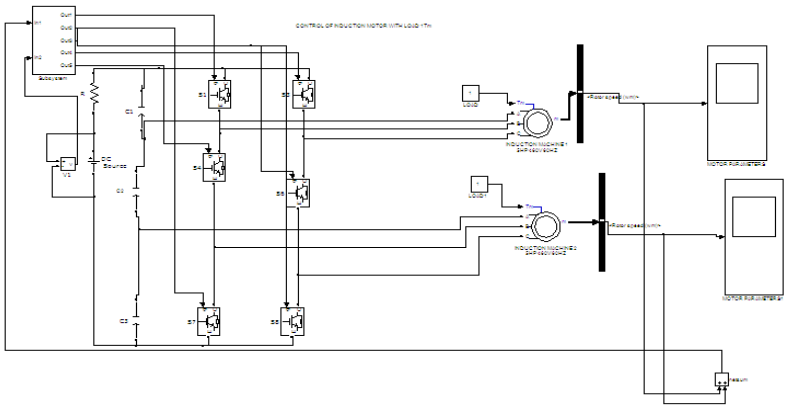

Fig.7. closed loop circuit of dc link source six switch inverter

VI. SIMULATION RESULT

The output phase voltage and the rotational speed of both the motors in open loop is given in Fig.8 . The Speed is decreased when the load torque is increased from 1 Nm. The rotational speed of both the motors in closed loop is shown in fig. 9. The motor will run in 500rpm for all the load variations.

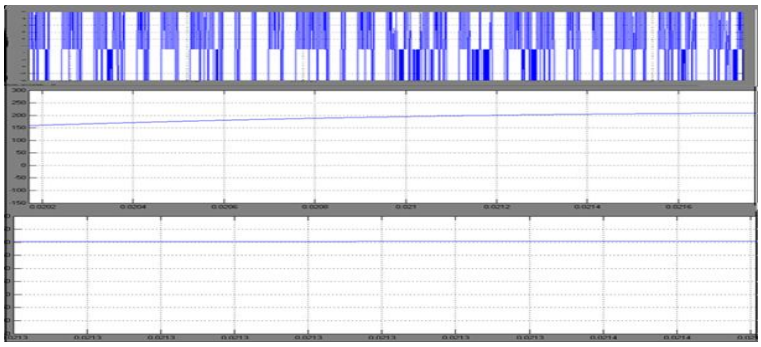

Fig. 8. Simulation output waveforms of open loop dc link source six switch inverter

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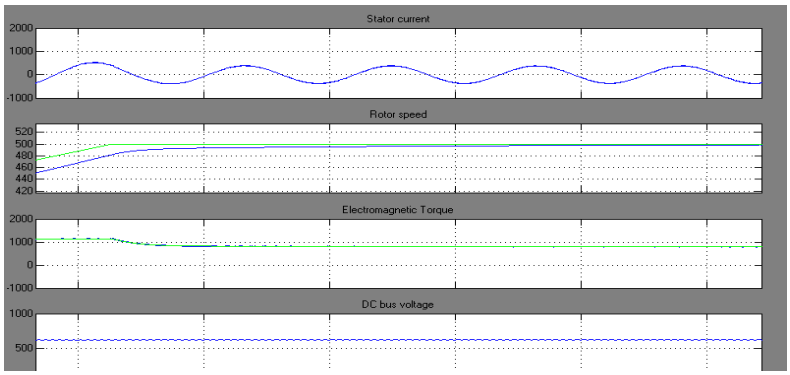

Fig. 9. Simulation output waveform of closed loop dc link source six switch inverter

VII. CONCLUSION

A novel reduced switch count multi output inverter named "dc link source six switch inverter": was proposed in this paper. The use of the proposed inverter in low and medium power application may reduce the cost of the system and improve its efficiency. The weight and size are reduced and the reliability is increased. The numbers of switches are reduced to 33%. The effective operation of the proposed inverter and its ability to supply two induction motor was demonstrated by simulation. By using closed loop control for dc link source dual output inverter, the speed is constant for all the load variations.

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BIOGRAPHY

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