An Improved PSO Based Selective Harmonic Elimination in Multilevel Inverter for Performance Enhancement of Induction Motor Introduction

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***Abstract* - Harmonics measurement of an industrial unit is done to asset the power quality aspects in a typical factory. Then with using a lumped steady state and thermal model we analyzed the influences of different harmonics on motor temperature rise. The real issues are the harmonics generated by the inverters which affects the induction machine performance. Several inverters like Voltage Series Inverters, PWM fed Inverters, Multilevel inverters etc. exist in literature. Among all these, multilevel inverters have been very popular of late due to its several advantages. But there is a challenge of optimal design of the inverter and optimal selection of pulse width of each level so as to get minimal Total Harmonic Distortion. This paper discusses various works done by researchers in this field over the course of time. For these reasons a novel multilevel inverter design based on an improved Particle Swarm Optimization is proposed in this thesis for obtaining the optimal width of the pulse of each level so as to get minimal Total Harmonic distortion. A Simulink model of the improved PSO modified multilevel inverter will be created and fed to an induction motor and the FFT analysis of the voltages and current will be done to evaluate the performance of the induction machine. The results will be compared to that of the existing techniques. All the simulations will be performed in MATLAB software.**

I. INTRODUCTION

With increasing the number of harmonics generating devices in power systems, the problem of their impact on the performance of system components like induction motors needs further consideration. Approximately, 60% of loads in all over the world are motor loads. More than 90% of these loads are consumed by three phase induction motors with a big utility factor between 0/7-0.9 in a day and most of them are used in industrial factories. Harmonics measurement of an industrial unit is done to asset the power quality aspects in a typical factory. Multilevel inverters are significantly different from the ordinary inverter where only two levels are generated. In lots of industrial applications, conventionally DC motors were the work horses for the adjustable Speed Drives (ASDs) because of their excellent speed and torque response. But, they have inherent disadvantage of commutator and mechanical brushes, which go through wear and tear with the passage of time. In most cases, AC motors are preferred to DC motors, particularly, an induction motor due to its low cost, low maintenance, lower weight, higher efficiency, improved ruggedness, higher efficiency, low cost and reliability all these features create the use of induction motors a mandatory in lots of areas of industrial applications. The improvement in Power electronics and semi-conductor technology has triggered the growth of high power and high speed semiconductor devices in order to get a smooth, continuous and step less variation in motor speed. Uses of solid state converters/inverters for changeable speed induction motor drive are common in electromechanical systems for a huge spectrum of industrial systems. Three phase induction motors are generally used in many industries and they have three phase stator and rotor windings. Balanced three phase ac voltages supplied by the stator windings, which produce induced voltages in the rotor windings due to transformer action. It is possible to manage the distribution of stator windings in order that there is an effect of many poles, producing some cycles of magneto motive force (mmf) around the air gap. This field establishes a spatially distributed sinusoidal flux density in the air gap. Particle swarm optimization has roots in two main component methodologies.

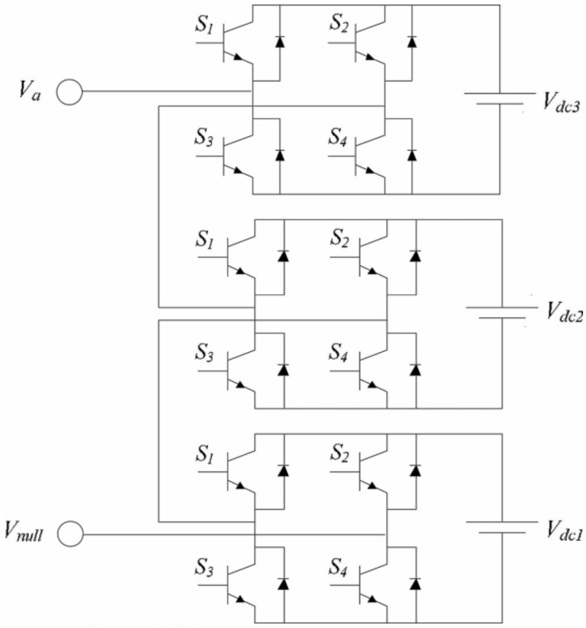

Fig. 1. Cascaded multilevel inverter with separate dc sources.

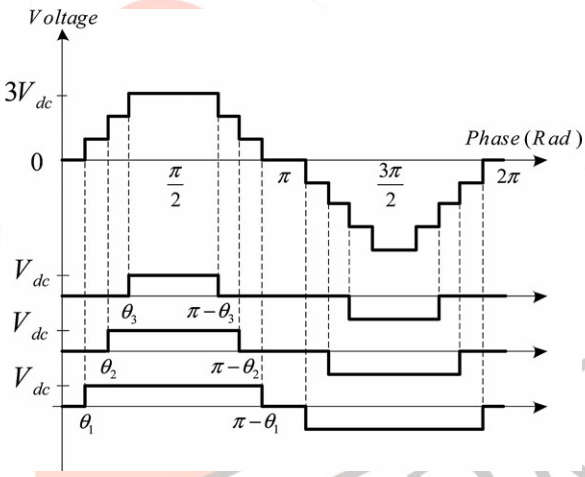

Fig. 2. The output voltage waveform of a 7-level inverter.

II. Related Work

Perhaps more obvious are its ties to artificial life (A-life) in general, and to bird flocking, fish schooling, and swarming theory in particular. It is also related, however, to evolutionary computation, and has ties to both genetic algorithms and evolutionary programming. Harmonics Problem in Induction Motors. The application of nonlinear loads as a result of power electronic development is rising very fast. Generally, the shape of network voltage can't be imagined sinusoidal and motor manufacturers should consider non-sinusoidal conditions in their designs.

The harmonics of network voltage effect on operation of all electrical equipment like relays, those are the guards of power system, electric motors and measurement equipment that are the wheels of industries In fact, all these equipments are designed to work in normal conditions, the power is non-sinusoidal in real networks that reduces the motor efficiency and their lifetime Temperature increase of machines is the most successful parameter that reduce the age of insulation and therefore the lifetime of the machine that depend on the condition of its insulation.

High temperature of the insulation decline its time exponentially according to the Arrhenius equation. Lots of parameters like different load cycling, working in hot weather, switching, harmonics and unbalances are main reasons in temperature rise of the motors. The motor losses are consistent mechanical and electrical losses. friction and windage are not affected by harmonics but Mechanical losses caused by friction and windage, but electrical losses that consist of Iron, Winding and stray load losses and they depend on order and magnitude of harmonics. Hystersis loss and eddy current loss takes place in the Iron vary with the square of the air-gap voltage.

The harmonic currents are comparative to the magnitude of voltage harmonics. Variants of Inverter for Harmonics Elimination. There are many variants of inverter which has been proposed over time for harmonic elimination so as to result in smoother operation of induction motor. A few of them are listed below. Voltage Source inverter PWM Inverters Multilevel H bridge inverters Selective Harmonic Elimination Method has been utilized in PWM inverters and multilevel inverters for elimination of lower order harmonics. In this thesis we propose an innovative approach of performance enhancement of multilevel inverters by using Particle Swarm Optimization Literature Review.

This Chapter discusses the various research works which has been done in this field till now. The various works which has been done in clustering techniques are discussed. The methodologies which we are trying to implement in this field i.e. PSO modified multilevel inverter fed induction motor is discussed. Induction motor Because of robustness, reliability, low price and maintenance free, induction motors (IMs) used in most of the industrial applications. The influence of these motors (in terms of energy consumption) in energy intensive industries is important in total input cost.

Adel Merabet, Mohand Ouhrouche and Rung-TienBui (June 2006) present a new modified control algorithm for speed and flux tracking of an induction motor. This algorithm called: Neural Networks Generalized Predictive Control (NNGPC) uses a mixture of Artificial Neural Networks (ANN and Generalized Predictive Control technique (GPC). This laterly used for systems characterized by a slow dynamic as in chemical process control. The NNGPC algorithm is based on the use of ANN as a nonlinear forecast model of the motor. This modeling technique is done by using the data from the system inputs/outputs information and it does not require the knowledge about machine parameters. The future values of the controlled variables needed by the optimization procedure which is outputs of the neural predictor . This is achieved by minimizing a cost function with the reference control model using the Newton-Raphson (NR) optimization algorithm. The reference control model is passed out from an open loop control strategy of the induction motor.

C. Thanga Raj, Member IACSIT, S. P. Srivastava, and Pramod Agarwal (April 2009) presents an analysis of the developments in the field of efficiency optimization of three-phase induction motor in the course of opt imal control and design techniques. Optimal control covers both the broad approaches namely, loss model control (LMC) and search control (SC). Optimal design covers the modifications of materials and construction in order to optimize efficiency of the motor.

The use of Artificial Intelligence (AI) techniques like artificial neural network (ANN), , expert systems fuzzy logic, expert systems and nature inspired algorithms (NIA), Experimental and simulation are the examples on efficiency optimization are illustrated.

S.C. Mukhopadhyay (September 2009) presents a hybrid thermal model for truthful estimation of thermal condition of cage-rotor induction motors in non-standard supply systems has been presented. The developed thermal model is a mixture of lumped and distributed thermal parameters which are obtained from motor dimensions and other physical constants. The thermal condition of the motor in non-standard supply systems such as unbalanced power supply and the distorted power supply can be estimated. The simulated and experimental results are obtainable.

Aravindh Kumar.B, Saranya G, Selvakumar R, Swetha Shree R, Saranya M,Sumesh.E.P. (June Proposed a novel approach to identify various faults happening in the induction motor is presented. Both vibration and motor current signature analysis are performed to sense the mechanical and electrical faults. Wavelet packet transform multiscale process is performed on the obtained signal to extract the features. The extracted features are given to a classifier to find out a fault has occurred or not. If a fault occurred then it identifies the fault location and isolates it.

K. Ranjith Kumar, D. Sakthibala and Dr.S.Palaniswami(June, 2010)proposed a new approach that minimizes the copper & iron losses and they also optimizes the efficiency of a variable speed Induction motor drive. This method is totally based on a simple motor field oriented control model which includes iron losses uses only in conventional IM parameters. In literature, Fuzzy logic and Genetic Algorithms are used for more efficiency optimization of induction motor drives. This paper proposes integration of Fuzzy model identification and PSO algorithm for loss decreases.

An enhancement of efficiency is obtained by changing the magnetizing current component with respect to the torque current component to obtain the minimum total copper and iron losses. The whole circuit is simulated using MATLAB 7.6. The presented method is compared to other soft computing techniques. The results obtained by Fuzzy PSO shows better results as compare to other approaches.

D. Ben Attous and Y. Bekakra December 2010) presented a comparison between a fuzzy logic controller and a conventional IP controller and it is used for speed control with a direct stator flux course control of a doubly fed induction motor. The effectiveness of the presented control strategy is evaluated in different operating conditions such as of reference speed and for the load torque step changes at nominal parameters and all this is in the presence of parameter variation. Simulation results explain that the fuzzy logic controller is stronger than a conventional IP controller against parameter variation and uncertainty, and is less susceptible to external load torque disturbance with a fast dynamic response.

K.Ramani and Dr.A.Krishnan SMIEEE (December 2009) proposed a hybrid multilevel inverter for A.C electrical drives. In latest days multilevel inverters has been become most popular for motor drive applications of industry Multilevel pulse width modulation inversion is an useful solution for increases the level number of the output wave form and in that way dramatically decrease the harmonics and total harmonic distortion. In conventional methods, the need of converters to supply the cells of reversible multilevel converters is increases the cost and losses of these inverters.

In this new topology we find out the output waveform consists of SV dc; S-number of stages and the allied number of level equal 2s+1 - 1. The output waveform has 15 levels. Also, the stage with higher DC link voltage frequency and thereby decreases the switching losses. Comparison of conventional results will be presented.

III. Problem Statement

The research problem which we are targeting here is the design of multilevel inverters and their optimal selection of pulse width in order to reduce the total harmonics distortion to a minimal value, thereby improving the performance of the induction machine.

IV. Proposed Methodology

The techniques of PSO and improved PSO for multilevel inverter tuning will be applied on the induction motor model and then their performance will be compared on the basis of FFT analysis, Total Harmonic Distortion, machine performance etc.
The approach of this thesis can be briefly summarised as follows:

1. To design a model of induction motor in MATLAB (SIMULINK) for analysing its performance.
2. To design a multilevel inverter of 7 levels and analyse its performance.
3. To design a model of multilevel inverter fed induction motor and monitors its performance in terms of motor parameters and FFT analysis of the line currents and voltages.
4. To implement an improved Particle Swarm Optimisation algorithm for finding optimal width of gate pulse in the design of multilevel inverters and utilise this algorithm in the multilevel inverter fed induction motor and compare its performance with other techniques.

V. Tools Used

All the simulations will be done utilizing the SIMULINK feature in MATLAB. While the PSO will be implemented as a function file in editor and will be called in the Simulink model using Embedded MATLAB feature of SIMULINK. The simulations will be carried out in MATLAB R 2012b in a Windows 8 based PC with 4 GB RAM, 2 GHz processor and 500 GB hard disk.

VI. Conclusion

It is proposed to study the performance of an induction machine using various types of inverter. A multilevel inverter is proposed to be designed with seven levels and the an improved Particle Swarm Optimisation is aimed to be implemented for deciding the pulse width of the various levels so as to obtain minimum Total Harmonic Distortion. The performances will be compared with those existing in literature and FFT analysis of the induction machine parameters will be done. Selective Harmonic Elimination method will be used for removing the lower order harmonics and the higher order harmonics will be removed using filters of lower size.

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