CONTROLLING THE TORQUE OF THREE PHASE INDUCTION MOTOR WITH GENETIC ALGORITHM

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Abstract— The induction motor, known for its robustness, relatively low cost, reliability and efficiency, is the vital part in many research works. The advancement in power semiconductor devices, digital data processing and control has led to great improvements in torque response control of AC motors. Direct Torque control principle has been used for Induction Motor (IM) drives with fast dynamics. DTC has been widely recognized for its fast and robust torque and flux control.
Novel approach of the Genetic algorithm scheme for direct torque control (DTC) of an Induction Motor (IM) AC drive is the recent area of research. To improve the performance of conventional DTC, artificial intelligence like neural networks, fuzzy[1][2] are implemented. Though DTC has high dynamic performance, it has few undesirable contents like high ripple in torque, output current and deviations in switching frequency of the inverter. The Z-source converter employs a unique impedance network to couple the converter main circuit to the power source. This provided unique features that cannot be obtained in the traditional voltage-source or current-source converters where a inductor and capacitor are used, respectively.

Keywords— Direct Torque control, Flux Control, Genetic Algorithm, Z-Source Inverter, Speed , Torque independent Control, Optimization.

INTRODUCTION

Direct torque control was presented by Manfred Depenbrock 1984. Today DTC uses hexagon flux path only when full voltage is required at high speeds. Despite its simplicity, DTC is able to produce very fast torque and flux control. Stator flux and torque can be controlled directly and independently by properly selecting the inverter switching.
DTC provides very quick response with simple control structure and hence, so this method is gaining popularity in industries. The use of GA methods in the determination of the different controller parameters is practical due to their fast convergence and reasonable accuracy. Genetic algorithm is recently getting increasing emphasis in soft computing applications in the recent days. Genetic Algorithm methods have been widely used in control applications. The GA methods have been employed successfully to solve complex optimization problems. This methodology for AC drive systems is intended for an efficient control of the torque and flux without changing the motor parameters. The Z-source converter overcomes the conceptual and theoretical barriers and limitations of the traditional voltage-source converter and current-source converter and provides a novel power conversion concept. A genetic algorithm is one of a class of algorithms that searches a solution space for the optimal solution to a problem. The population evolves for many generations; when the algorithm finishes the best solution is returned. Genetic algorithms are specially useful for problems where it is extremely difficult or impossible to get an exact solution or for difficult problems where an exact solution may not be required.

DIRECT TORQUE CONTROL

There are many different ways to drive an induction motor. The differences in those methods are the motor's performance and the viability and cost in its real implementation. The most popular method, vector control was introduced more than 25 years ago in Germany by Hasse, Blaske and Leonhard. Under a constant rotor flux amplitude there is a linear relationship between the control parameters and output torque[10]. Transforming Induction motor equations into field coordinates makes the FOC method resemble the decoupled torque production[5]. Over the years, FOC drives have achieved a high degree of maturity in a wide range of applications. Their innovative studies depart from the idea of coordinate transformation and the analogy with DC motor control. The researchers proposed a technique that relies on a decoupling control which is the characteristic of vector control. After the innovation of the DTC method it has gained much momentum. The basic concept behind the DTC of induction motor drive, is to control the electromagnetic torque and flux linkage directly and independently by the use of six or eight voltage space vectors found in lookup tables[7]. As it can be seen from, if the load angle, δ, is increases then the torque error is also increases. To increase the load angle, δ, the flux of stator vector must rotate faster than rotor flux vector. In Fig .2. shows the Stator flux and rotor flux space vectors.

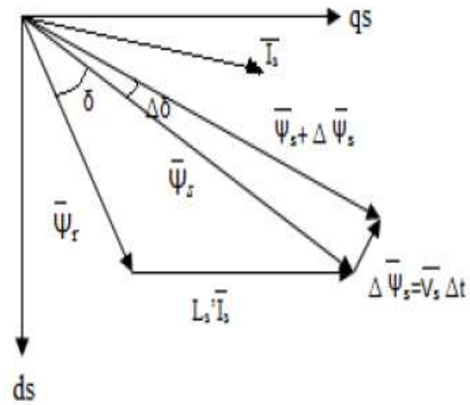

Fig. 1. Stator flux and rotor flux space vectors

$$\Delta T_e = \frac{3}{2}\frac{P}{2}\frac{Lm}{LrLs}\left|\Psi r\right|\left|\Psi s + \Delta\Psi\right|\sin\delta \qquad (1)$$

To achieve the above concept, accurate voltage vectors are applied to the terminal of motors. For counter-clockwise operation, if the actual torque is lesser than the reference value, then the voltage vectors that keep the stator flux vector, Ψ_S, rotating in the same direction are selected. When the load angle, δ, between Ψ_r and Ψ_S increases the actual torque increases as well[13].

GENETIC ALGORITHUM

In 1950, Alan Turing proposed a "learning machine" which would parallel the principles of evolution Computer simulation of evolution started as early as in 1954 with the work of Nils Aall Barricelli, who was using the computer at the Institute for Advanced Study in Princeton, New Jersey.Field of artificial intelligence, a Genetic Algorithm (GA) is a search that minimize the process of man-made selection. It is frequently used to generate useful solutions to optimization and search problems. It belong to the class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, similar as inheritance, mutation, selection, and crossover.

In a genetic algorithm, a population of candidate solutions. to an optimizing problem toward most accurate solutions. Each solution has a set of properties that can be mutated. The process usually begins from a population of randomly generated individuals of population, it is an iterative process, with the population in each iteration called a generation. In every generation, the fitness of solution in the population is evaluated; The fitness is usually the value of the objective function in the optimization problem being solved. The newly generated candidate solutions is then used in the next iteration of the algorithm.

The algorithm terminate when maximum number of generations has been produced, We consider how to determine the fitness of each individual. There is generally a differentiation between the ***fitness*** and ***evaluation*** functions. The evaluation function that returns an absolute measure of the individual. During each successive level of generation, a part of the existing population is selected to breed of a new level generation. Fitness based process is used in individual solution. Other methods rate only a random sample of the population, the olden processing methods are very time-consuming.

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Z-SOURCE INVERTER

The input voltage, frequency and output voltage , and power handling capacity based on the design of the specific device. The power is provided by the DC source. Inverter can't produce power by itself. The Z-source converter employs a unique impedance network to couple the converter main circuit to the power source, This unique features cannot be obtained in the traditional voltage-source where a capacitor and inductor are used, respectively[4]. The unique feature of the Z-source inverter is that the output ac voltage can be any value between zero and infinity. That is, the Z-source inverter is a buck–boost inverter that has a wide range of obtainable voltage. The traditional V- source inverters cannot provide such feature. Fig .3. shows Generalized Z-Source Inverter.

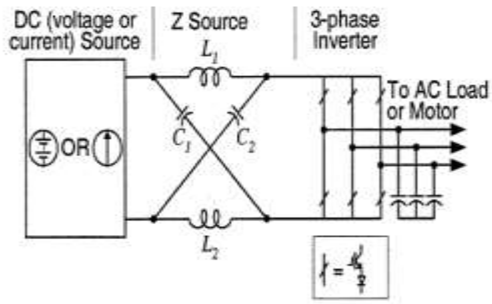

Fig . 2. Generalized Z-Source Inverter

The equivalent switching frequency viewed from the Z-source network is six times the switching frequency of the main inverter, which greatly reduces the required inductance of the Z-source network.

EXPERIMENT PRINCIPLE

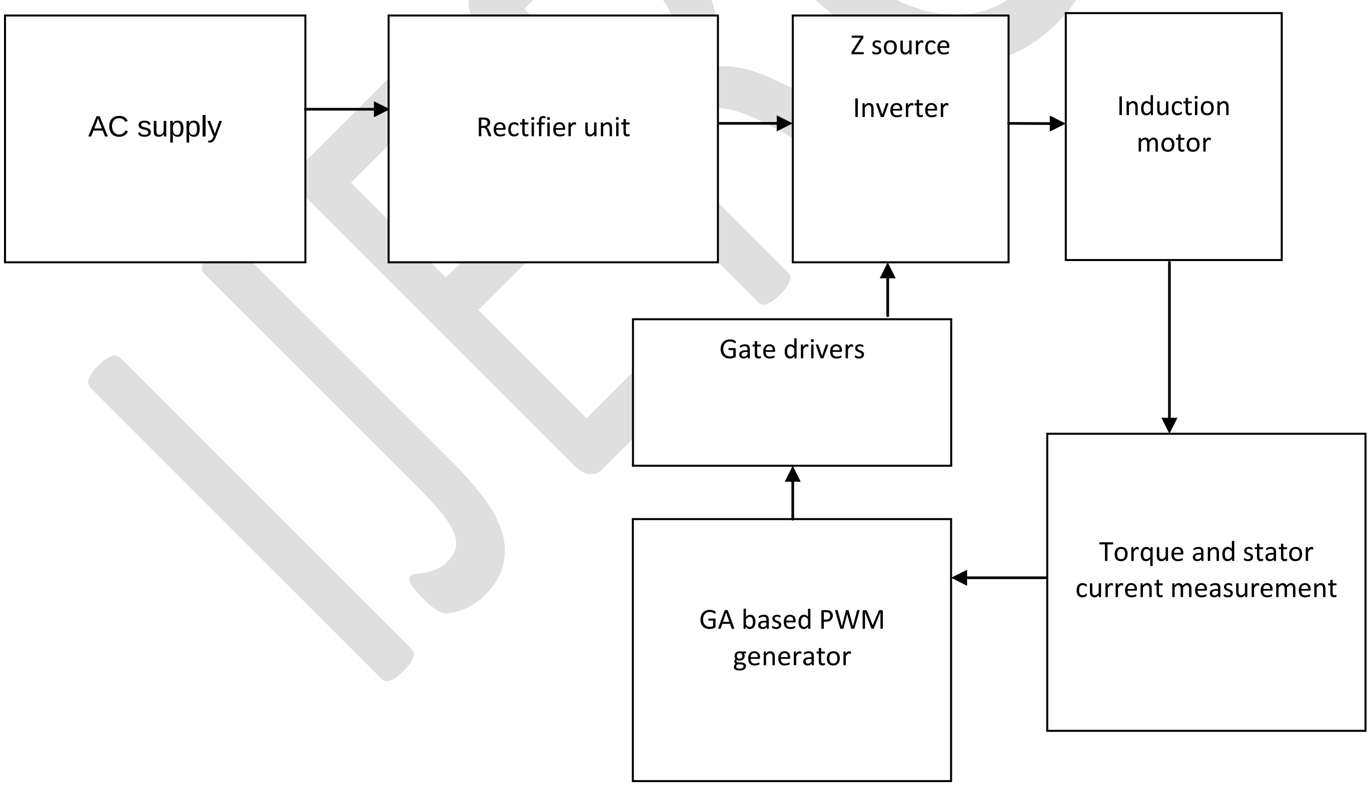

Fig .3 The Proposed Block Diagram

Here the AC Supply 440V 50 HZ Three Phase Supply is fed to the rectifier Unit for the conversion of AC to DC. After Converting to the Dc voltage is fed to the Z-Source Inverter and that AC Supply is again fed to the Induction Motor. From the Help of Ammeter and Tachometer the current and the Speed of the machine is measured. Fig .3. Shows Block Diagram of Proposed System. And that pulse is fed to GA Based PWM generator. And the pulse is fed to the gate driver that attached to the inverter. Due to closed loop the output is feedback to the input. It reduces the error in the output. As per the pulse from the inverter the Induction Motor will be rotate. In the simulation the torque can be directly measured. And the stator current can also be measured. Here the GA helps to identify the how the pulse to be generates. And that value will be fed to the inverter. And the Genetic Algorithm will calculate the various pulse that to be fed to the inverter[9][11].

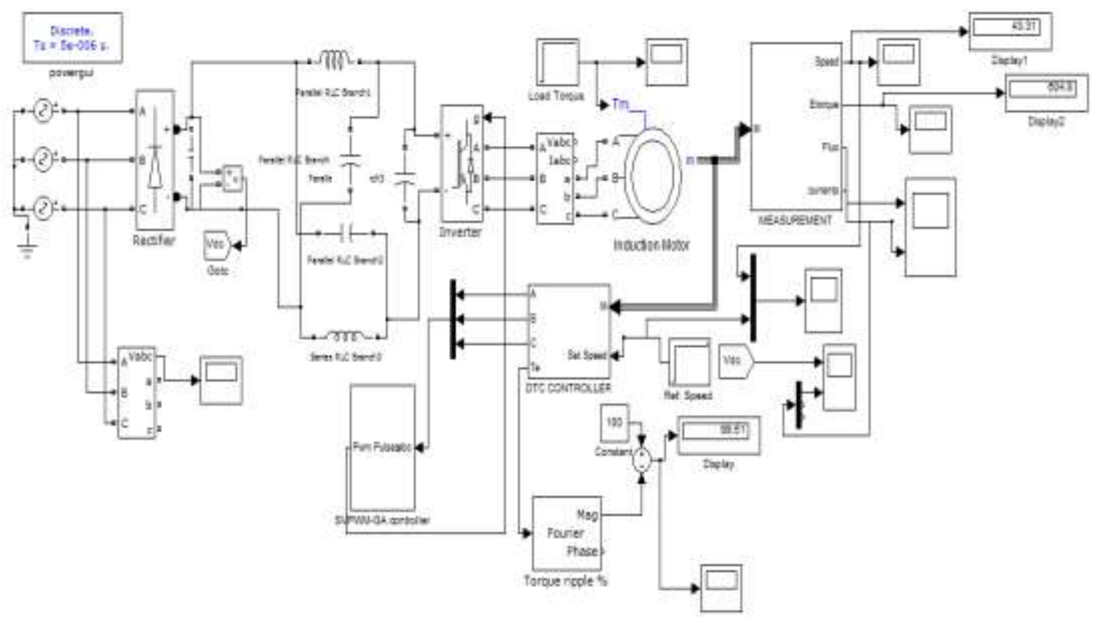

Fig . 4 Show the simulation Diagram of the DTC of Induction Motor with GA and Z-Source Inverter

The pulse to the inverter is obtained from SVPWM-GA Controller in the circuit. The output of the machine is given input to the measurement section, And the Scope is connected to see the simulation Result. The reference torque value is given to the Tm Section of the Induction Motor. The Simulation Diagram of the Proposed System is shown in the Fig. 4

The value of m i.e Stator Current Ia, Ib, Ic is given to the A-B-C to Alpha-Beta Conversion Section. , Park transformation Convertion is taking place in this section. Three Dimensional components is changing to 2D (Two Dimensional) Components (Alpha, Beta). Because in Park Transformation it is clearly mentioned that we can generate the signal on when the components are two in number. That's why we are going for Park transformation. From a-b-c Component to Alpha-Beta Conversion is take place block .The signal goes from the Parameter Estimation Section to the control section with the Set Speed Constant Value. And for applying to the inverter we again converting the Alpha-Beta Conversion to again 3 Components. The generated 3 components is given as the input to the SVPWM-GA Controller[3][6].

The signal form the DTC controller is given input to the SVPWM-GA Controller. From the input the three separate GA Controller is operated. For Each Phase Each GA Block will functioned. And the Error signal from the GA block is amplified With help of gain. From the error signal the signal is given input to software coding part. Where three voltage from the GA Controller and One reference DC Voltage. In this software coding section we provide the quadrant selection. When the quadrant selection is over the three switching pulse will be created. And that three signal is given as the input to the DISCRETE PWM GENERATOR[8]. Here the three pulses converted to six pulses and that pulse we fed to the gate of the inverter as the input.

From the DTC-Controller the Torque ripple percentage is measured and it is displayed using display. From the Output diagram Fig.5 Shows the percentage of ripple removed in the output torque. And Fig. 6 shows output actual torque. we can clearly note the set speed is achieved and torque is achieved with less amount of ripples.

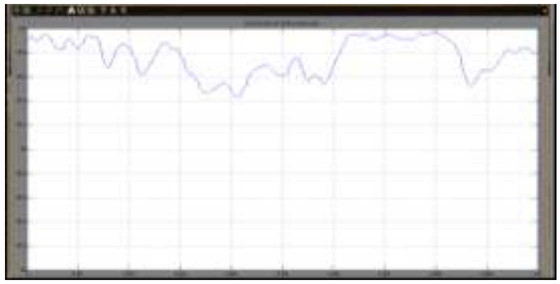

Fig .5. Percentage of ripple removed from the Output Torque

Fig .6 Actual Output torque.

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CONCLUSION

As concluding the project, the induction motor is the vital part in all the industry and its application is speechless. For the proper performance of the machine its controlling is important, especially its torque and speed. By controlling this both character then only the machine will give maximum efficiency. And project design is fewer ripples and required torque will obtain in the correct stage. Due to fewer ripples the machine centre of axis rotation will not deviate so that machine rotation speed will not change. Due to simultaneously and independent of speed and torque of the motor is very awesome when considering to the industry application. As the performance of the machine is increased the product and product quality will increase. So that as the industry production is increased, the total GDPA (GROSS DOMESTIC PRODUCT) will increase. And the workers strain and work load is decreased, as the production increase the salary and remuneration will increase.

Due to genetic algorithm is new artificial intelligence the performance of the existing will increase more so due to that the overall performance of the system is increased. This system is enhanced the torque response with the controller controlling it, this give good response to the user with who handling this system. I assure that Genetic Algorithm is giving the best situation pulse to the inverter at the right time. The system designed is having wide range of opportunities in commercial as well as residential.

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