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# Simulation Modeling on High Performance FLC based Induction Drive

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***Absract*: This paper proposes fuzzy based current control in the field weakening region of induction motor. In this project it proposes an expert controller before current regulators to process current command and thus avoiding unreasonable fast tuning in the high-speed flux weakening region so as to keep current command followed by actual current. The proposed topology consist of a single phase ac input source,three phase IGBT inverters ,fuzzy inference mechanism and a capacitor filter is used. Thus proposed fuzzy inference controller is to handle the current commands before current regulator and this is based on the consideration of the bandwidth decreasing and for the critical voltage limitation.At the load one induction motor is connected , here current control of motor is done with the help of a fuzzy controller.Simulation and experimental results are provided to verify the stability of current control**.

***Keywords: Simulation modelling FLC, Field weakening IGBT Inveretr,***

## I. INTRODUCTION

In the fast running world the main problem is the current global energy crisis. So the focus is on efficiency and delivering high performance, while consuming less power for the electronic components. As a result of this crisis, various agencies around the world have or are looking to increase their efficiency standards for numerous products in their respective specifications. In general among the motors, the induction motors (IM) are widely accepted in the recent days so that this has been used as the efficient most promising candidate for electric propulsion of hybrid electric vehicles (HEVs) and electric vehicles ,due to their reliability, ruggedness, low maintenance, low cost, and the ability to operate in fast mode for the extended high speed[1]-[7]. Recently proved that in ,most of the research on the current control in the flux weakening operation region is below 2 to 3 times of the base speed. The most worse is that current regulators are too unstable, and they even result in damage to insulation gate bipolar transistors (IGBTs) and drive equipment in some cases[10]-[11]. In the view of temperature variable, magnetic hysteresis and some other reasons, parameters are mainly variable. Mostly the existing research focuses on flux weakening strategy optimization and current regulators design. In induction motor, the stator winding is fed from 3-phase supply. The electromagnetic induction is the mechanism in the rotor winding. Generally the flux weakening strategy are of two types. They are robust and model based. The model based method uses motor parameters and dc bus voltage to calculate current references.The ideal optimal current trajectory which consists of the maximum torque per current trajectory at a specified contains an inductive output filter, to reducing the conduction losses and the ripple voltage of the converter. Here a higher switching frequency implies smaller and lighter inductor, capacitors, as well as filter components of the converter. The soft switching techniques used here will helps to avoid EMI and switching losses during high frequency speed is determined under the voltage and current limitation due to the motor and inverter capacity. In the proposed flux weakening scheme realises the smooth transition between control modes and winding resistance is accounted for the speed range. Although the model based control guarantees the stability and fast transient response, they are extremely sensitive to the motor parameters and operating conditions.In the flux weakening region, the current distribution (*ids* and *iqs*) is absolutely important to the torque capability . There two major flux weakening optimal strategies is to achieve maximum torque capability[1]-[3]. First, *ids* and *iqs*are calculated by the IM parameters Secondly, *ids* and *iqs*are selected by utilizing voltage regulators and the flux regulator .

The current regulators forming the inner loop of the IFOC system are able to regulate the ac current over a wide frequency range with high bandwidth and zero steady-state error by proportional-integral (PI) regulators. Anyways, there will be cross coupling between *ids* and *iqs* that is proportional to the frequency of the fundamental excitation. As a result of this , the performance of the current regulator has been shown to degrade as the excitation frequency increase. To eliminate the cross-coupling influence, the complex vector synchronous frame the PI current regulator was introduced [8]-[9]. A similar solution was proposed in using an internal model control formulation and by using the complex vector current control approach generalized with a transfer function matrix In the existing system approach the bandwidth of the current regulators is decreased and voltage is critically limited in the high speed flux weakening region. In voltage model the direct and quadrature axis of rotating synchronous coordination are computed to obtain mainly the synchronic angular speed, direct axis stator flux magnitude and quadrature axis stator flux magnitude.

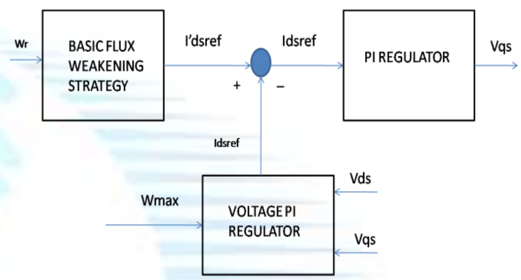


Fig.1 Flux Weakening Strategy.

This is critically limited as a result the differential term cannot be ignored. Thus the proposed fuzzy inference controller to handle the current commands before current regulator, it is based on the consideration of the bandwidth decreasing and the critical voltage limitation

## II. FLUX WEAKENING STRATEGY

In the flux weakening strategy analysis is in order to produce the maximum current q axis component is proportional to current. .The basic strategy is that iqs is inversely propotional to speed.. The fig 1 shows the advanced flux weakening strategy..The fig.1 shows the advanced flux weakening strategy in which magnetizing current is inversely proportional to speed [7]. This approach need to add just one regulator.

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III. BLOCK DIAGRAM DESCRIPTION

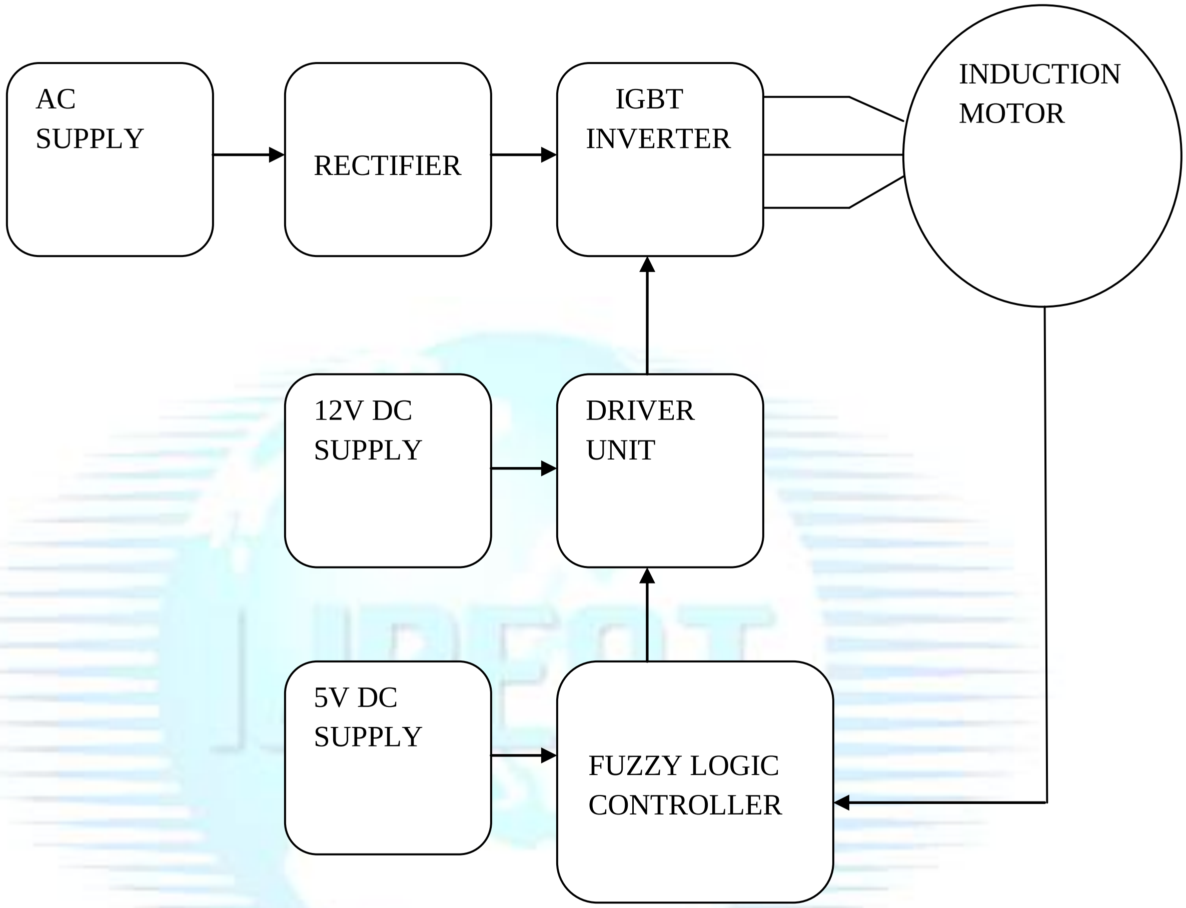


Fig. 2. Block diagram for proposed fuzzy controlled induction motor.

In the fig.2 the induction motor is controlled by the three phase inverter .The block diagram consist of input supply, driver unit and a fuzzy based PIC controller. Three-phase inverters are used for variable-frequency drive applications and for high power applications such as HVDC power transmission. A basic three-phase inverter consists of three single-phase inverter switches each connected to one of the three load terminals. For the most basic control scheme, the operation of the three switches. . A dc supply is given to the driver unit and to the control algorithm. The ac output is given to the induction motor after rectification. In the power supply unit, rectification is normally achieved using a solid state diode. Diode has the property that will let the electron flow easily in one direction at proper biasing condition.The ac voltage coming after resonant inverter is the input to this bridge rectifier. Here the rectifier is in uncontrolled manner with diode switches. It is very cheap and simple. This rectifier converts ac to dc output and fed to capacitor filter to reduce the ripples in the output voltage. The induction motor may be considered to be a transformer with a rotating secondary winding.

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IV. CIRCUIT DIAGRAM DESCRIPTION

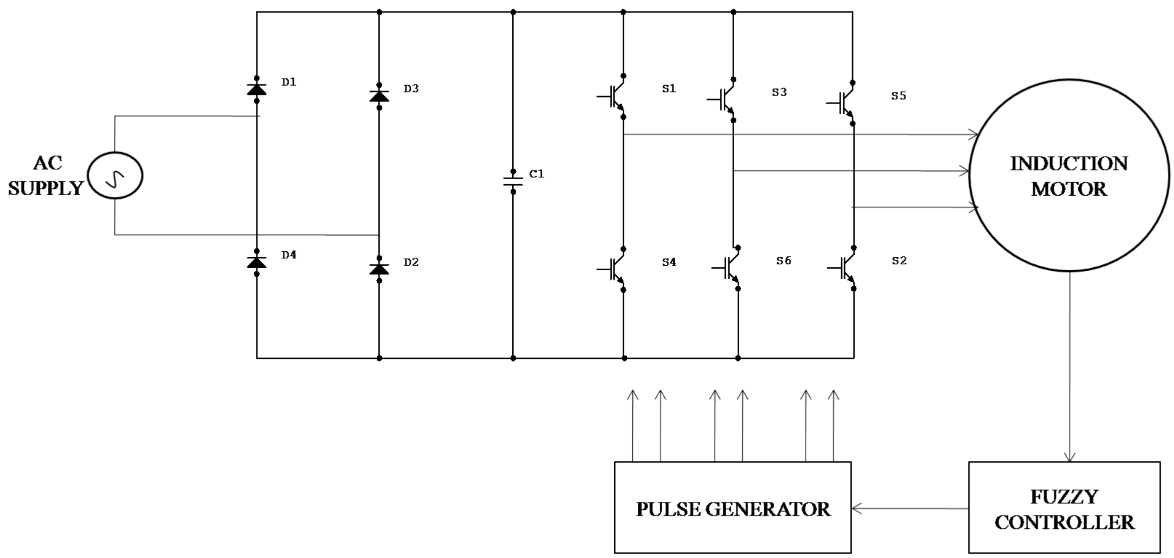


Fig.3. Circuit diagram for proposed fuzzy controlled induction motor drive

Here Fig 2 shows the proposed circuit diagram of the ac to dc converter using fuzzy controller for an induction motor is shown above. Here the driver circuit is the key part, output from inverter is effectively utilized for driving a induction motor, and motor controlling is done with the help of a fuzzy controller. In the circuit consists of an ac supply at the input , this given to the rectifier for conversion between the rectifier and three phase inverter. . Here the induction motor is connected at the ouput side..thus the proposed system includes appropriately sized power supply unit, rectifier and voltage source inverter to energize the Induction motor. along with this auxiliary power supply unit also considered to energize the control equipments. The rectification is normally achieved using a solid state diode. Diode has the property that will let the electron flow easily in one direction at proper biasing condition. As AC is applied to the diode, electrons only flow when the anode and cathode is negative. Reversing the polarity of voltage will not permit electron flow. As we know any invention of latest technology cannot be activated without the source power. So in this fast moving world we deliberately need proper power source which will be apt for a particular requirement. All the electronic components starting from diode to Intel IC's work with DC supply ranging from +5v to +12v. We are utilizing the same cheapest and commonly available energy source 230V-50Hz and stepping down transformer, rectifier, filter and voltage regulator. Filter circuits which are usually capacitors acting as a surge arrester always follow the rectifier unit. The capacitor is also as a decoupling capacitor

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or a bypassing capacitor, is used not only to 'short' the ripple with frequency .[1]-[5].

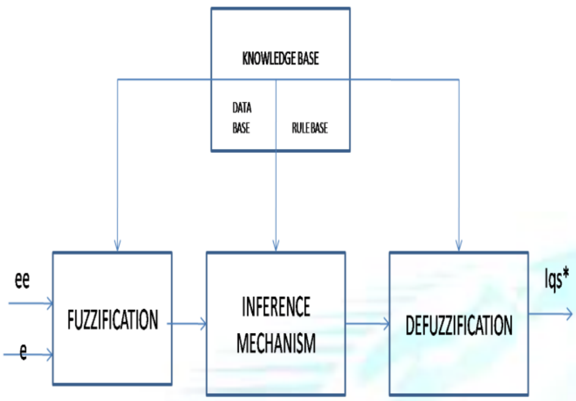


Fig.4 Fuzzy Logic Controller Block

## V. PRICIPLE OF OPERATION

The operation of the induction motor in this paper is by implementing the new expert controller so as to improve the performance .This is done using the fuzzy controller. The fuzzy control is explained in detail.

### FUZZY LOGIC CONTROLLER : INTRODUCTION

In the recent years the fuzzy logic has become popular in many applications of electrical drives and control, where classical PI controllers were used. Several design techniques exist to tune the classical PI controller parameters, but they can be time consuming and moreover fixed controller settings cannot usually provide good dynamic performance over the whole operating speed range of the drive. Varying load conditions, changes of mechanical parameters and process non linearity and inaccuracy in the process modeling can cause degradation of the performance. Fuzzy control technique does not need accurate system modeling. It employs the strategy adopted by human operator to control complex process and gives superior performance than the conventional PI control. The fuzzy algorithm is based on the human intuition and experience and can be regarded as a set of heuristic decision rules. It is possible to obtain very good performance in the presence of varying load conditions and changes of mechanical parameters and inaccuracy in the process modeling .Comparing the traditional current control in IFOC, an expert controller is added to preprocess current commands before the current regulators. The expert controller based on the fuzzy inference consists of the following components. They are knowledge database, the fuzzy inference mechanism and the characteristics recognition. The feature recognition records the waveform features of idsfed, iqsfed, vds, and vqs. When a period of the tuning ends, it calculates mainly the properties of the current control, such as the rise time, the ratio of attenuation and the oscillation period. The characteristic recognition provides references for the fuzzy inference mechanism . Fuzzy logic (FL) is one of the main artificial intelligent techniques. Fuzzy logic apart from Boolean logic, deals with problems that have fuzziness or vagueness. The classical set theory is based on Boolean logic, where the particular object or variable is either a member of a given set (logic 1), or it is not (logic 0). On the other hand, in fuzzy set theory is based on the fuzzy logic, where in a particular object has a degree of membership in a given set that may be anywhere in the range of 0 (completely not in the set) to 1 (completely in the set). For this reason, FL is often defined as multi-valued logic, compared to bi-valued Boolean logic by B.K. Bose, in 1986. The self-tuning mechanism consists of a performance model, an evaluation block and a fuzzy logic control (FLC) block. This reference model defines the desired dynamic performance of the motor drive. It is selected based on the maximum performance of the drive and to avoid the excessive control action. For the IFOC of the induction motor, the reference model can be approximated by a second order system. Mainly the second order model is obtained from the procedure used in and the constants a and b are adjusted to meet the specific requirements of the induction motor.

The actual speed of the motor ωr is compared with the output from reference model ω'r , to generate the speed signal e'r , which is the difference between ωr and ω'r . The error signal is given as an input to the evaluation block. The evaluation block is designed in such a way that, if the error signal is within + 1 rad/sec, the self-tuning mechanism will not operate perfectly . If the error e'r exceeds the specific range of ±1 rad/sec, the evaluation block generates the tuning error e ω which is given as an the input to the fuzzy logic control (FLC) block. The first input is error 'e' and second is the change in error 'ce' at the sampling time 'ts,. The two input variables are calculated e(ts) and ce(ts) at every sampling time as e(ts) = ωr*(ts) – ωr(ts) ce(ts) = e(ts) - e(ts-1) Where 'ce' denotes the change of error 'e', ωr*(ts) is the reference rotor speed , ωr(ts) is the actual speed, e(ts-1)is the value of error at previous sampling time. The output variable is the change in torque ΔT which is integrated to get the reference torque as shown in the equation T*(ts) = T*(ts-1) + ΔT .

The fuzzy logic controller has four functional blocks. They are the Fuzzification, Interference mechanism, knowledge the fuzzy inference.base and Defuzzification. The stability of a current control depends on the bandwidth of current regulators and the voltage that can be utilized in the mechanism.. As previously mentioned , the bandwidth of current regulators is decreased and voltage is critically limited in high-speed flux weakening region. The differential items are always ignored by considering the stable condition. However, it is unreasonable when a motor is in dynamic process because the differential items take an important part in the valid voltage. Particularly, when a motor is in high-speed flux weakening region, the valid voltage except CEMF is mostly critically limited[1]-[3]. As a result of this, the differential items cannot be ignored any more. For improving the current control stability in high-speed flux weakening region, a fuzzy inference expert controller is proposed to handle current commands before current regulators. This is based on the consideration of the bandwidth decreasing and the critical voltage limitation. The controller performes mainly has two purposes. Firstly, it can avoid unreasonable fast tuning of current concerning the bandwidth of regulators. Secondly, it can limit the current margin concerning the .valid voltage. Comparing with the traditional current control in IFOC, an expert controller is added to preprocess current commands before the current regulators. The expert controller based on the fuzzy inference consists of the following parts , knowledge database, the fuzzy inference mechanism and the characteristics recognition. The feature recognition records the waveform features of *i*dsfed, *i*qsfed, *vds*, and *vqs*. When a period of the tuning ends,it calculates the properties of the current control, the rise time, the ratio of attenuation and oscillation period. These are the main properties of fuzzy inference. .

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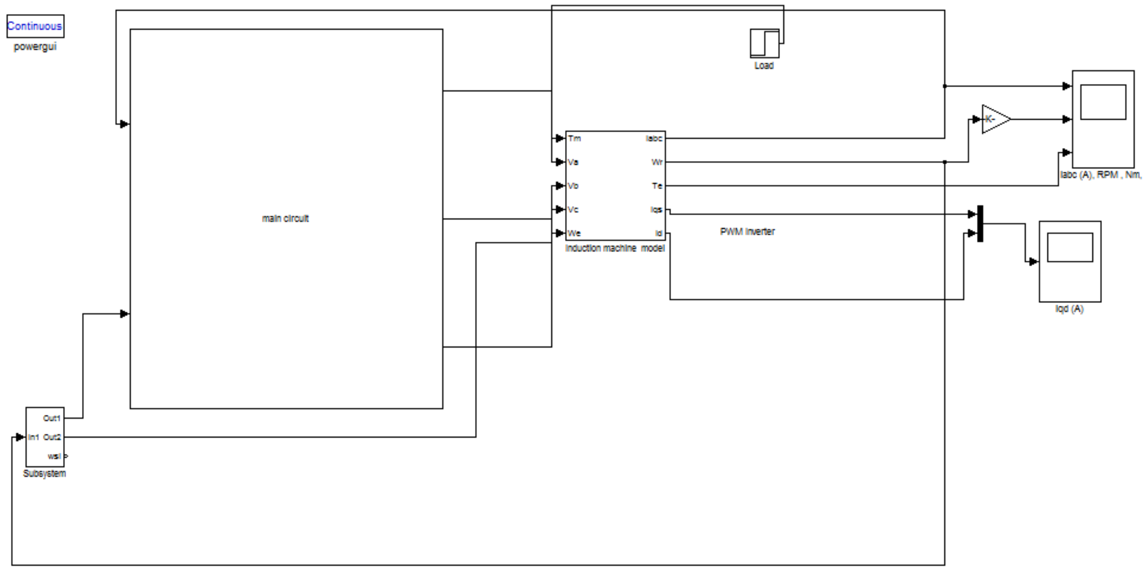


Fig..5 Main Simulation Circuit.

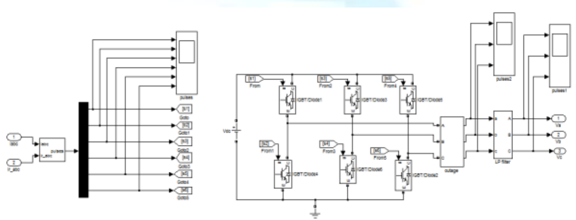

Fig..6 Simulation of Three phase inverter circuit.

## VI. EXPERIMENTAL RESULTS

The proposed circuit is developed and analyzed with MATLAB software. for analysis of the current controlling for the field weakening operation and output voltage is fed to induction motor. Here for the analysis we use a 230 V 50 Hzac supply in the input side. This is then given to the rectifier side. In the simulation results Fig.8 shows the converter output voltage.The motor speed range is between 600 and 700 rpm . The motor current and the torque ranges are shown in the simulation output results.

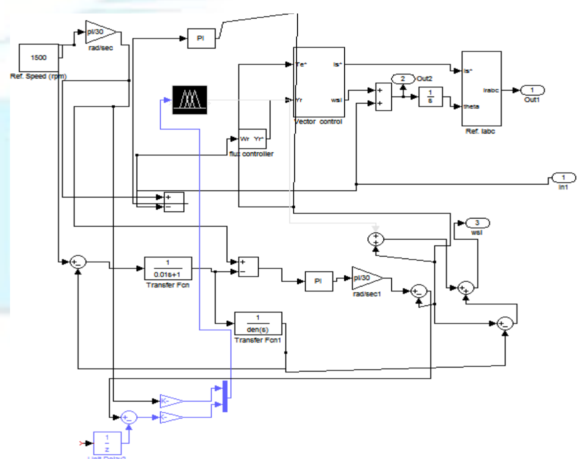


Fig.7 Sub System Circuit

MATLAB simulation circuit diagram, resultant waveforms for converter output voltage, current and motor speed is given below. The fuzzy controller block is used for better performance in the drive. This is shown in the sub system circuit. Similarly Fig.6 shows the simulation of the three phase inverter circuit. The output results are from fig.8 to fig.11.

**Resultant Waveforms** :

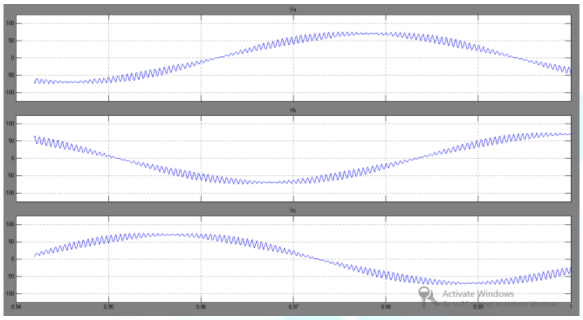

Fig 8 .Inverter Output voltage

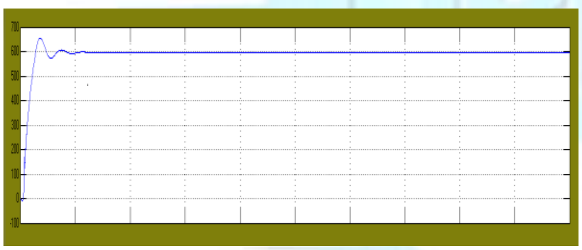

Fig. 9 Motor speed waveform

The simulation resultant waveform of motor speed waveform is shown in fig.9 .

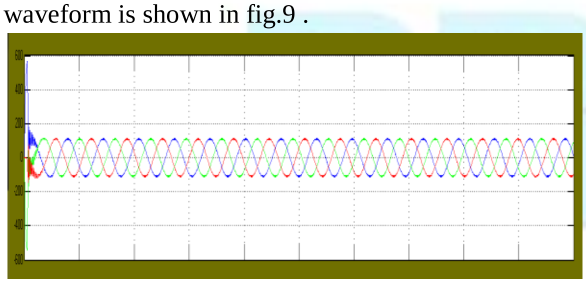

Fig.10 Motor current waveform

The motor current and the current waveforms are shown in the fig. 10 and fig.11 respectively.

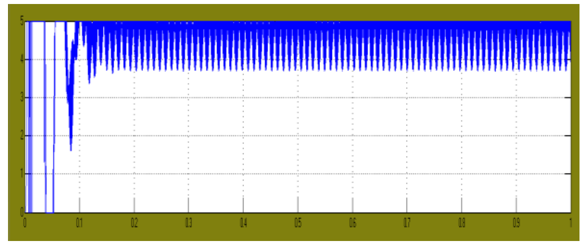

Fig.11 Motor torque waveform

## VII. CONCLUSION

In this new proposed paper a simplified flux weakening strategy for engineering application is introduced. This strategy can improve the current control performance significantly even in too high flux level. This paper thus investigates the influence of the rapid current regulation in the high-speed flux weakening region. The main concept has been proved in this project , that an expert controller based on the fuzzy inference has been proposed to self-tune the current commands.This is done in order to avoid the unreasonable variation of current commands. The extensive simulation have been performed and the results verify that the performance of current control has been improved. Thus it is proved that the scheme proposed is very much effective.

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