A NOVEL SCHEME FOR DIRECT TORQUE CONTROL ALGORITHM BASED INDUCTION MOTOR

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Abstract

In this paper a new approach to direct torque control of induction motor drive is presented. The Direct Torque Control technique both the stator flux and torque errors between references and estimated value are directly compared and appropriate voltage vector is produced by switching table. The switching frequency varies with mechanical speed .It is not constant in steady state. The disadvantages like high ripples in torque and possible problem during start as low speed operation and changes in torque command are overcome by using various approaches. Here in this project the deadbeat control and flux control has been done and is taken as controller named unified flux and torque controller. Thus this is more advantageous than other techniques like, stator voltage control, rotor resistance control field oriented control which are in existence. In the conventional method it has only fewer number of selectable voltage vector, it causes high ripples in the torque and flux and these ripples are removed.

IntexTerms -AC motor, Direct torque control (DTC)

1. Introduction

High dynamic performance of induction motor drives is indispensable in many applications of today's automatically controlled machine. Induction motor control has attracted much attention recently has been developed, enabling an AC motor to attain dynamic responses as rapid as far DC motor .The switching table based direct torque control is a very simple vector control method for voltage source fed induction motor .

However beside some attractive features such as fast dynamic response, low sensitivity to parameter changes, lack of internal current control loops and inherent motion – sensor less operation. There exist some problems associated with DTC namely difficult to start and low speed operation, high current and torque ripple, variable switching frequency and high noise level, violence of polarity consistency rules, as well as high sampling frequency needed for digital implementation of hysteresis controllers.

Three phase induction motor is widely used in many industries because of its simple and rugged construction and free of maintenance. However, to get a good performance, the corresponding controller needs more complex signal processing or computation than that of other motor, especially direct current motor. Fortunately this will be overcome by using digital signal processing having the capability to perform the associate signal computation easily and quickly such that the approach of the vector control can be realized.

2. Induction Motor Model

$$V_S = d\Psi/dt + R_S I_S \quad -(1)$$

$$0 = d\psi r/dt - j\,\omega\psi r + R_r I_r \quad -(2)$$

Three phase currents and voltages are transformed to two phase stationary d and q axis.

$$V_{qs} = V_{an} = \frac{2}{3} V_{ab} + \frac{1}{3} V_{bc} \quad -(3)$$

$$V_{ds} = \frac{1}{\sqrt{3}} (-V_{bc}) \quad -(4)$$

$$I_{qs} = I_{as} \quad -(5)$$

$$I_{ds} = \frac{1}{\sqrt{3}} (I_{cs} - I_{bs}) \quad -(6)$$

The rotor state equation for an induction motor referred to the stator in the synchronously rotating reference frame are

$$d\lambda_{dr} = \frac{R_r}{L_r} \lambda_{dr} + \omega_{sl} \lambda_{qr} + \frac{L_m R_r}{L_r} i_1 \quad -(7)$$

$$\lambda_{qr} = -\omega_{sl} \lambda_{dr} - \frac{R_r}{L_r} \lambda_{qr} + \frac{L_m R_r}{L_r} i_{qs} \quad -(8)$$

$$\lambda_{dr} = i_{dr} L_r + L_m i_{ds} \lambda_{qr} + i_{qr} L_r + i_{qs} L_m - (9)$$

If the two axis stator reference frame the current equation of an induction motor can be written as

$$\begin{bmatrix} i_{ds} \\ i_{qs} \\ i_{dr} \\ i_{qr} \end{bmatrix} = \int_{\tau=0}^{t} \left\{ \underbrace{\begin{bmatrix} L_s & 0 & L_m & 0 \\ 0 & L_s & 0 & L_m \\ L_m & 0 & L_r & 0 \\ 0 & L_m & 0 & L_r \end{bmatrix}^{-1}} \right.$$

$$\left. \times \left(\begin{bmatrix} V_{ds} \\ V_{qs} \\ V_{dr} \\ V_{qr} \end{bmatrix} - \begin{bmatrix} R_s & 0 & 0 & 0 \\ 0 & R_s & 0 & 0 \\ 0 & \frac{P}{2}\omega_0 L_m & R_r & \frac{P}{2}\omega_0 L_r \\ -\frac{P}{2}\omega_0 L_m & 0 & -\frac{P}{2}\omega_0 L_r & R_r \end{bmatrix} \begin{bmatrix} i_{ds} \\ i_{qs} \\ i_{dr} \\ i_{qr} \end{bmatrix} \right) \right\} d\tau$$

-(10)

The torque developed in the induction machine can be expressed as a cross product of stator flux and current as following

$T_e=3/2(p/2)\psi_s * I_s$ -(11)

that is, the magnitude of torque is

$$T_e = 3/2(p/2)L_M / L_r L_S \psi_r \psi_s \sin\gamma \quad \text{-(12)}$$

The voltage equation in machine variable form as follows

$V_{abcs}=r_s i_{abcs}+p\lambda_{abcs}$ - (13)

$V_{abcr}=r_r i_{abcr}+p\lambda_{abcr}$ - (14)

3. Conventional Method

In the conventional method there were several techniques like improving the torque and flux by using constant switching frequency technique, low frequency technique, etc. Though these techniques were implemented only few of the ripples from the induction motor is destroyed. In the conventional method the space vector modulation technique which has been used gives only a little performance variations.

The intelligent controllers like fuzzy logic controller, neural network are used but the expected ripple minimization is not obtained. And therefore to enhance the performance of the motor a new method has to be implemented and so the minimum distance vector method will be suitable to overcome the difficulties in the conventional method.

4. Proposed Technique

The proposed method is that in which the torque and flux ripples are improved by using the minimum distance vector method. Here the minimum distance between the voltage vectors is taken and that is used for reducing the ripples.

The Fig1.1.below depicts the block diagram of direct torque control of induction motor.

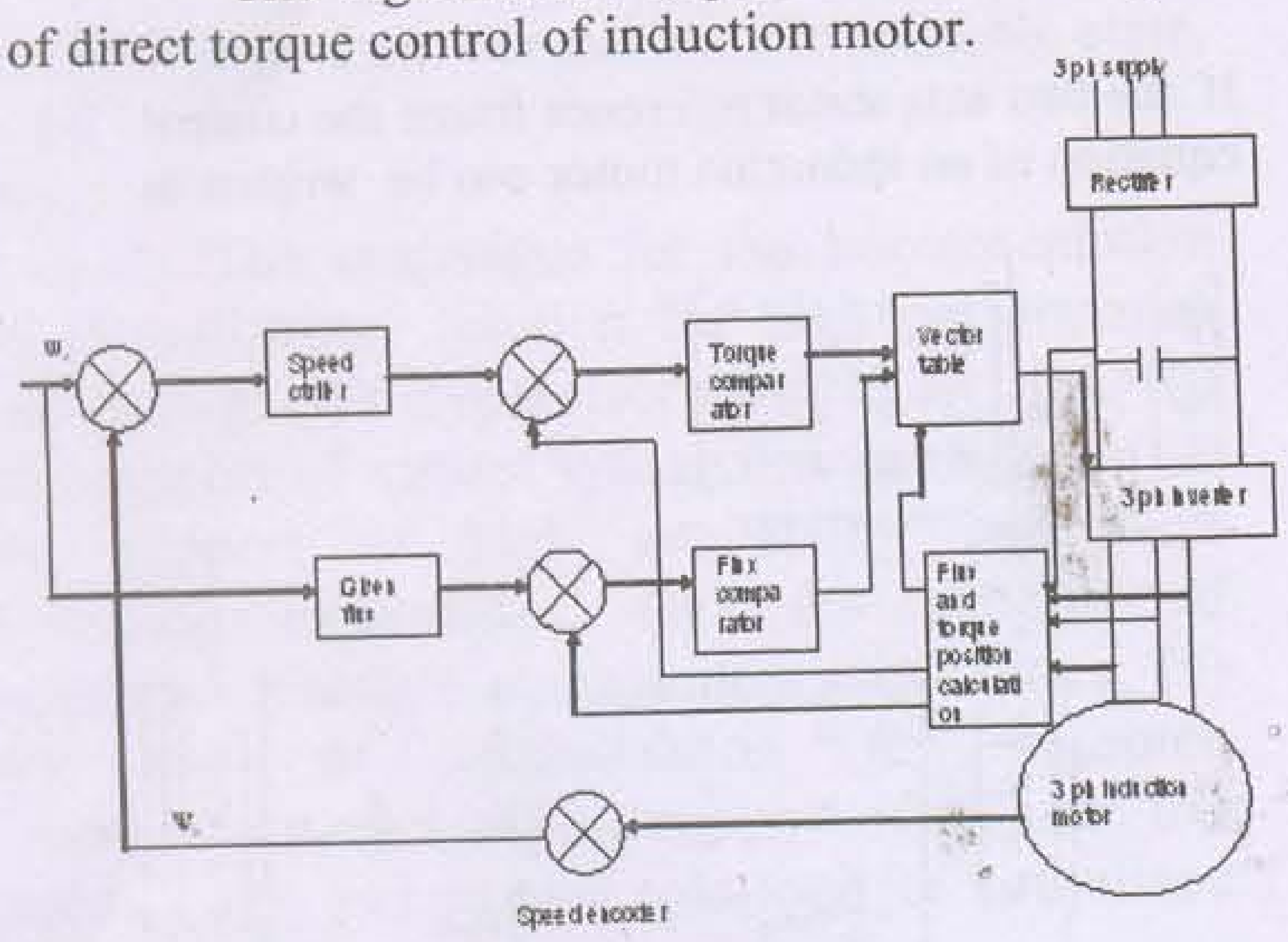

Fig. 1.1. Block Diagram of Speed Control of Induction Motor

Only by this setup the direct torque control of induction motor is obtained. Hence the speed of the induction motor is also controlled by controlling the ripples.

5. Simulation Block Diagram

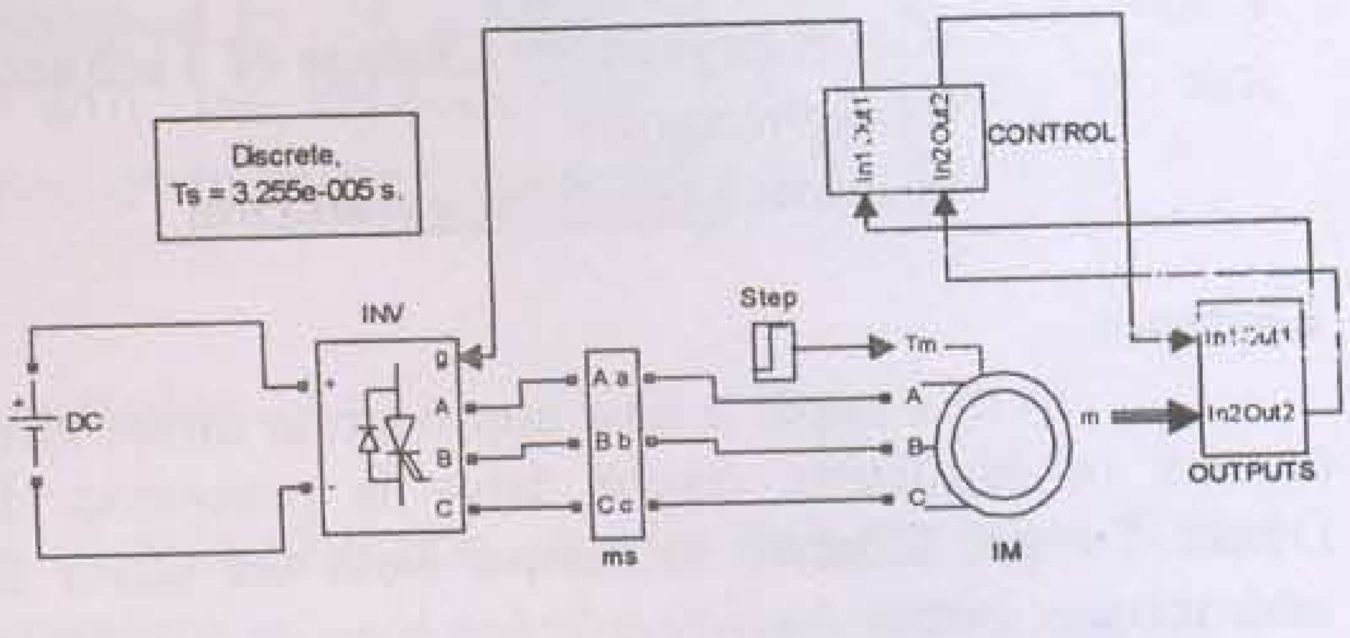

Fig.1.2.Simulation Block Diagram

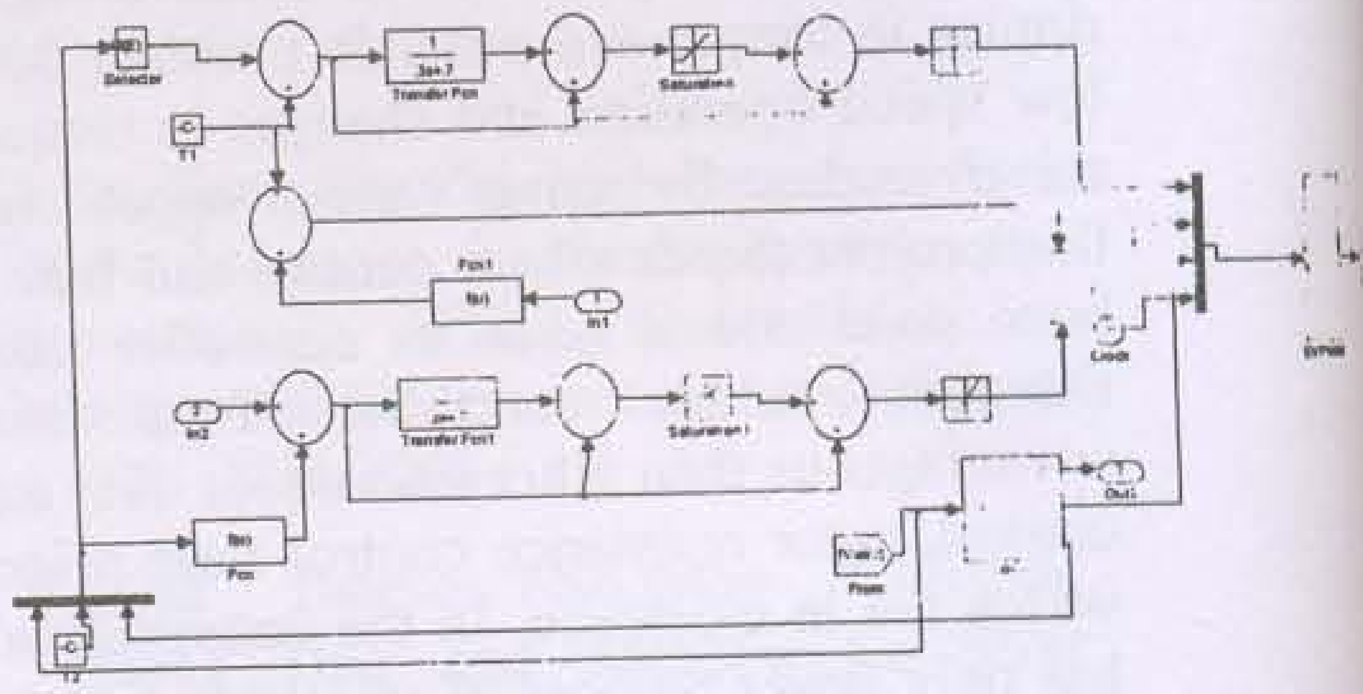

Fig.1.3.Simulation Sub System Control Unit

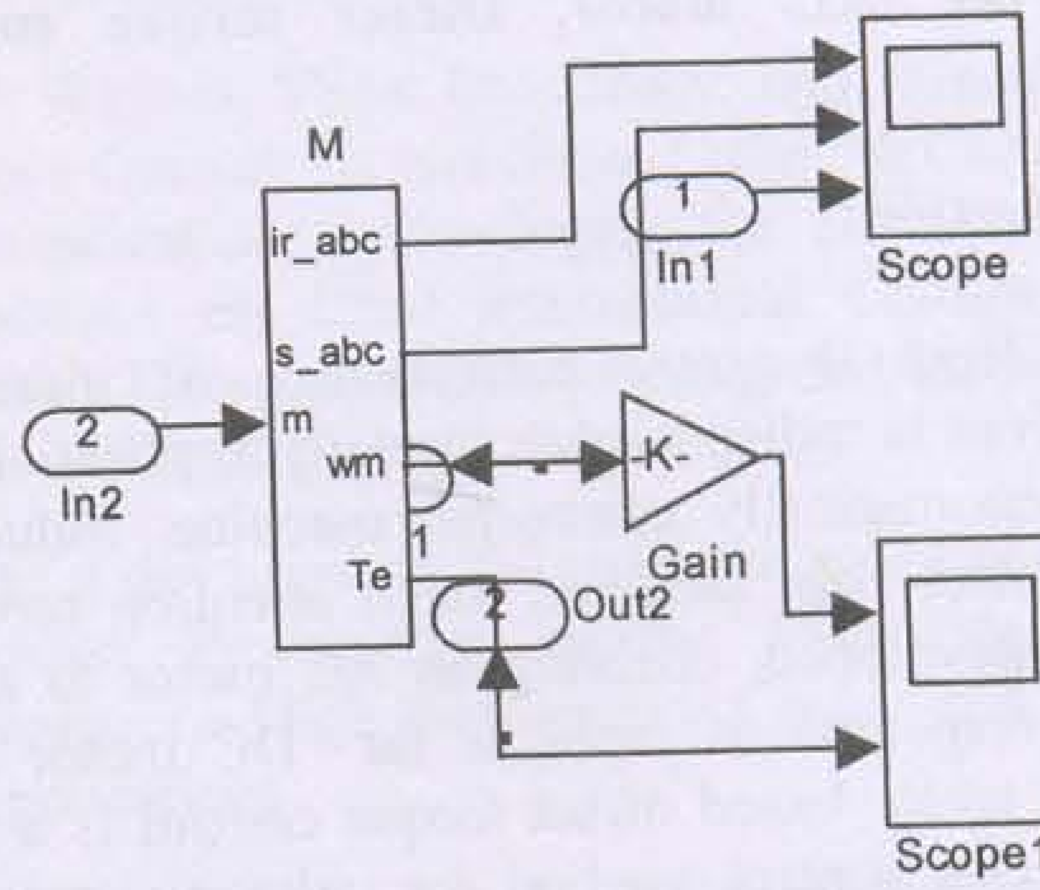

Fig.1.4.Simulation Sub System Output Unit

The above block diagram in the fig 1.2, fig1.3, fig 1.4 shows the simulation block diagram of direct torque control of induction motor for the proposed method.

Here the blocks are torque, flux current and voltage and so these are compared with the respective reference values based on that the output is obtained.

6. Simulation Results

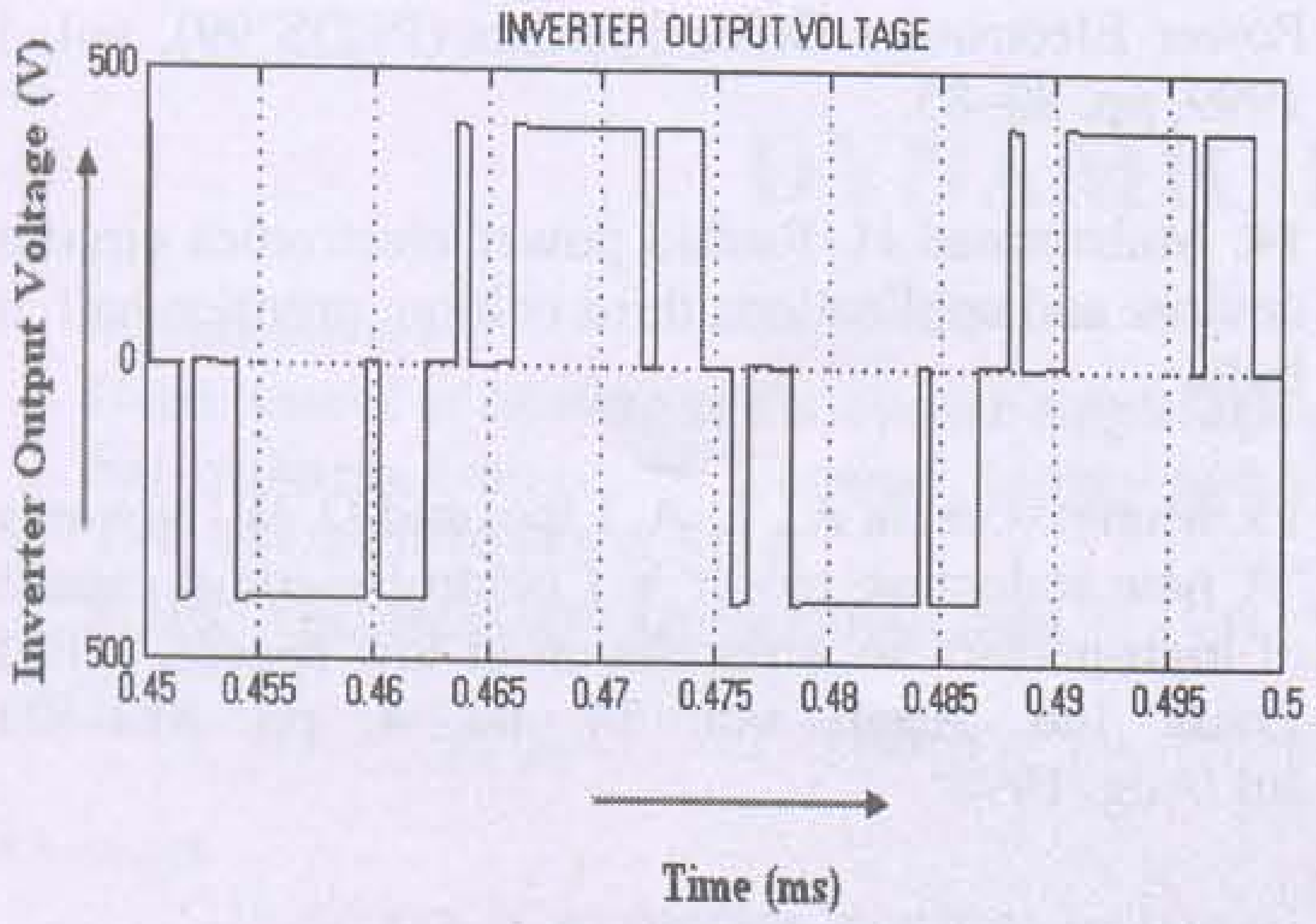

Fig.1.5 Inverter Voltage Vs Time

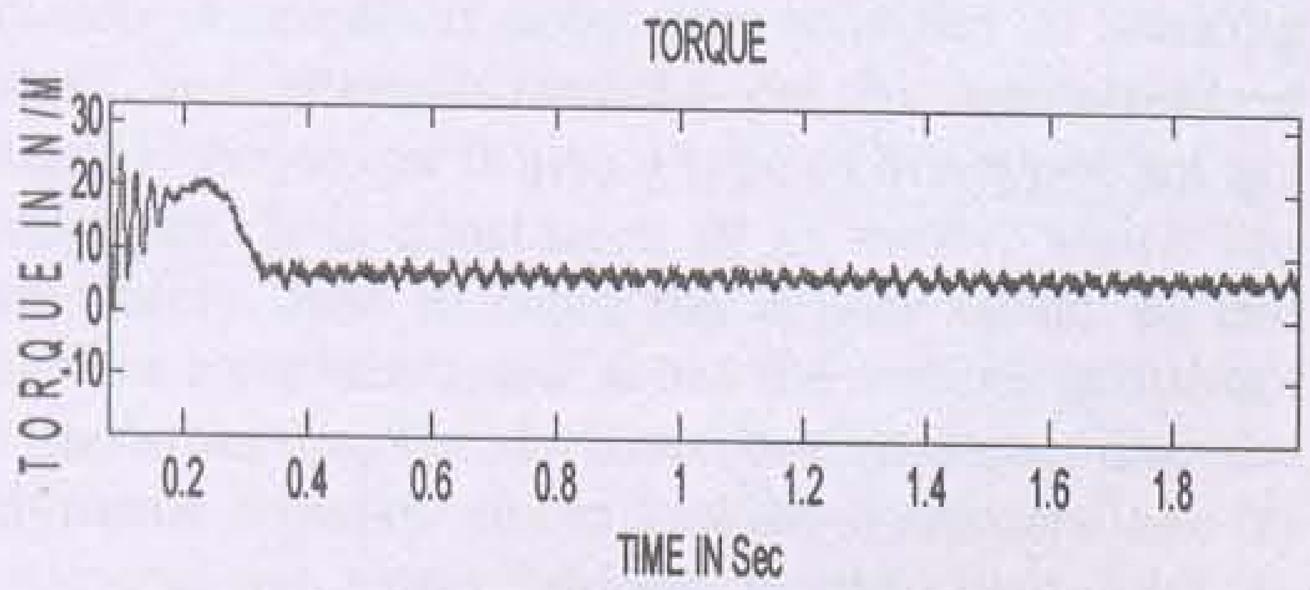

Fig.1.6 Torque Vs Time

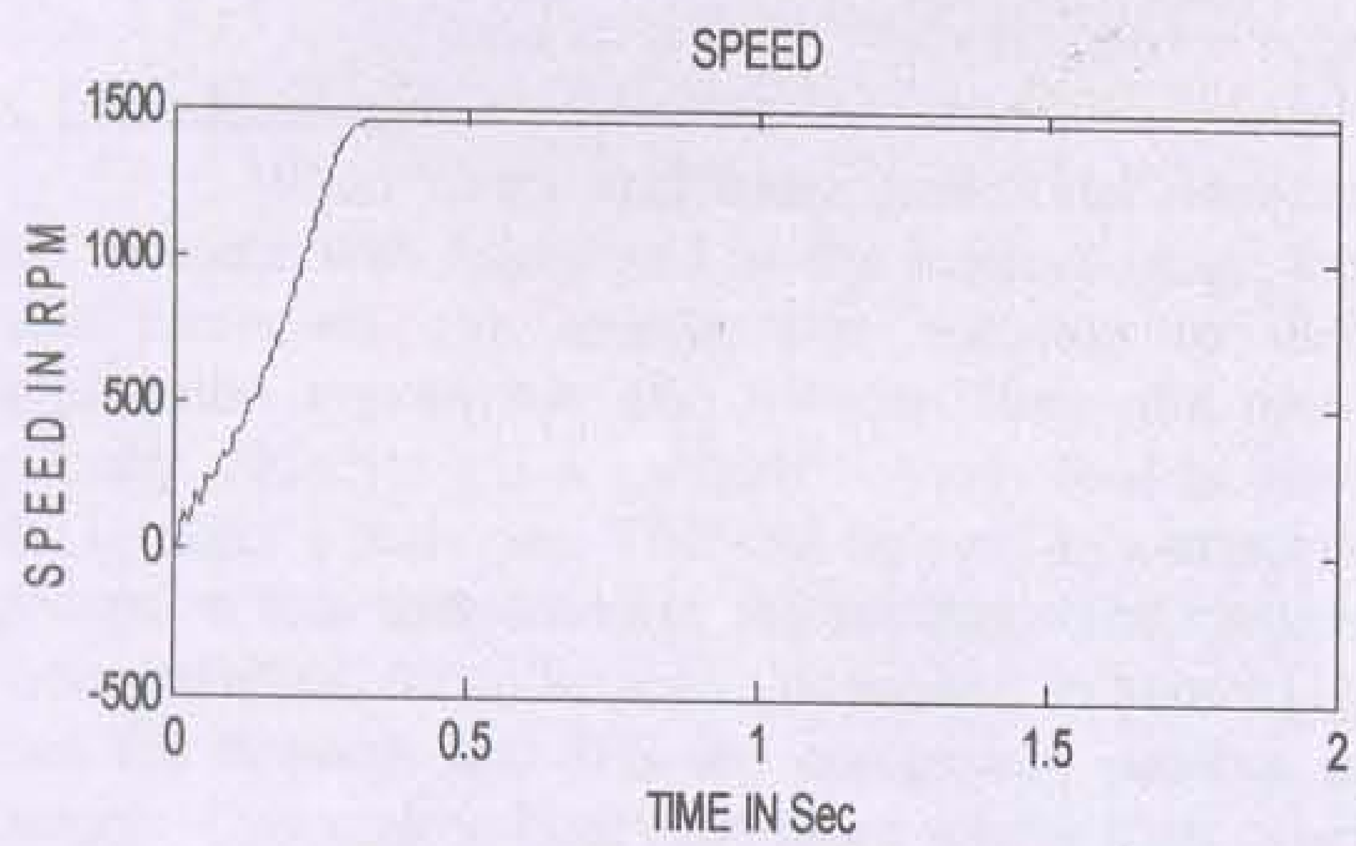

Fig.1.7 Speed Vs Time

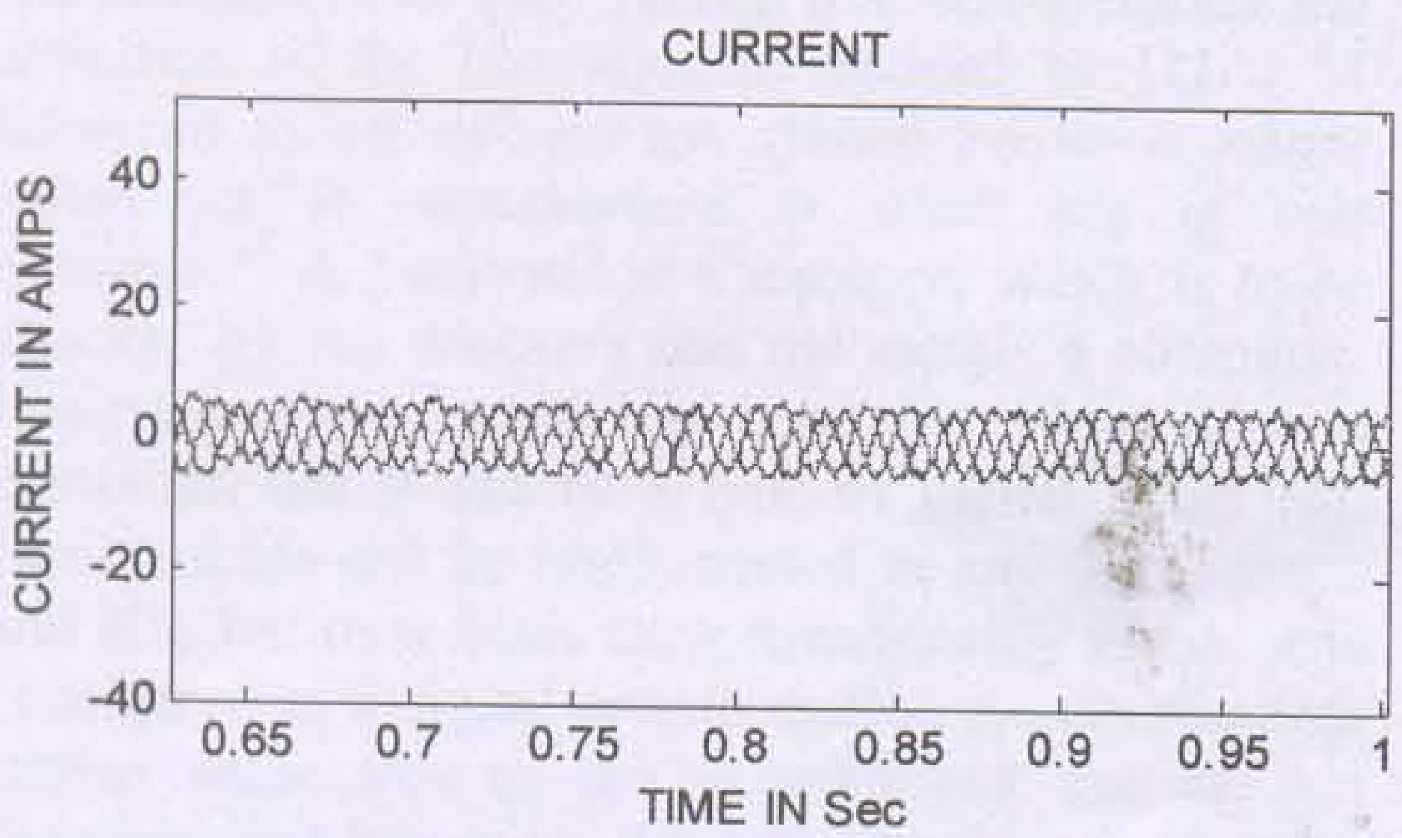

Fig.1.8 Current Vs Time

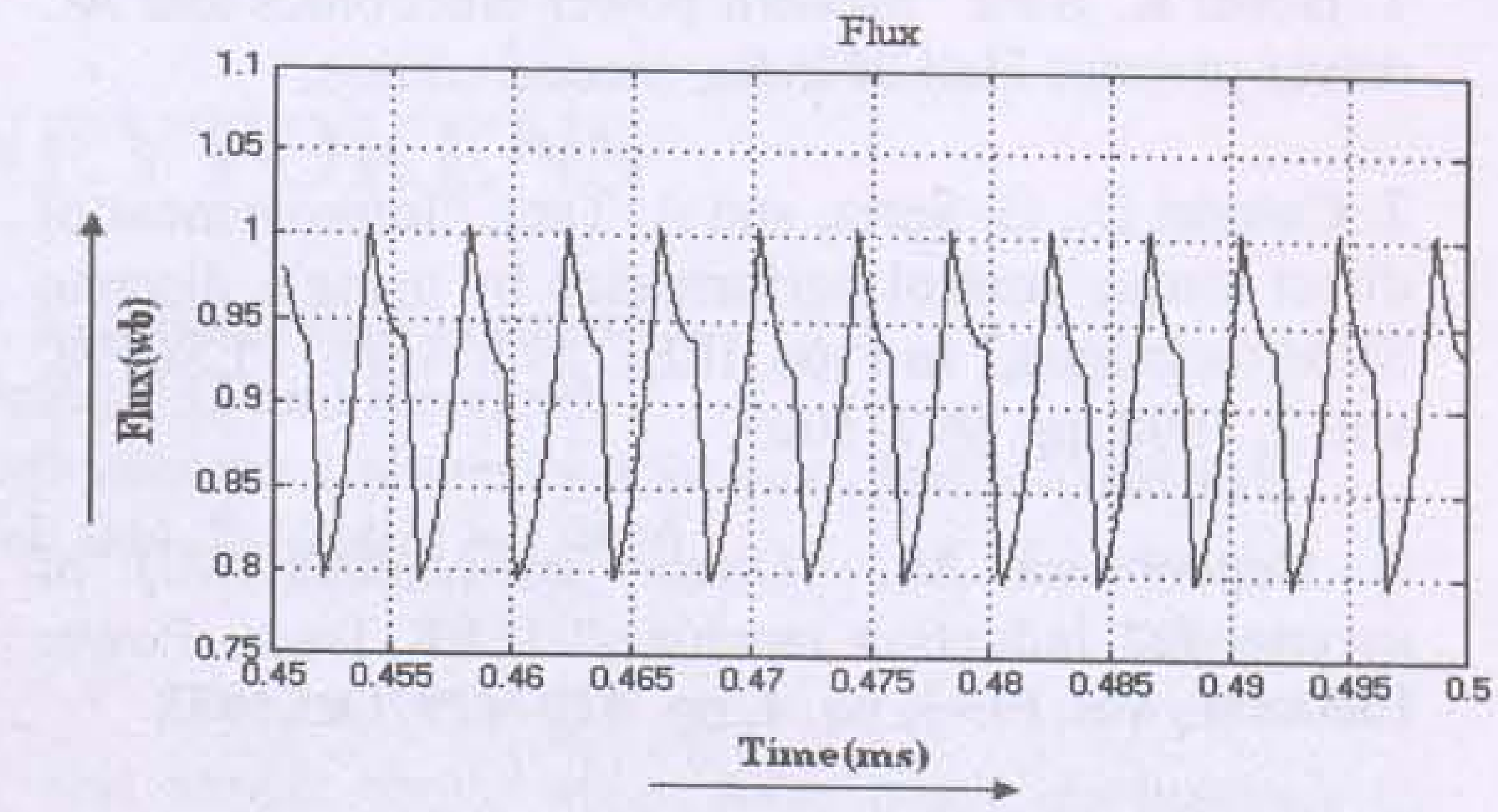

Fig.1.9 Flux Vs Time

The simulation result is obtained by doing the simulation in MATLAB/simulink. The minimum distance voltage vector is selected. The torque, flux, speed, current are taken and the output is also obtained for all these and the wave form clearly depicts the output for the proposed work shown in fig.1.5-1.9. The torque and flux ripples got reduced in this proposed technique and hence this is also an effective method for direct torque speed control of induction motor.

7. Conclusion

In this paper reduced flux and torque ripple content of induction motor. Here the deadbeat control and flux control has been done. This is more advantageous than other techniques like, stator voltage control, rotor resistance control field oriented control which are in existence.

In the conventional method it has only fewer number of selectable voltage vector, it causes high ripples in the torque and flux and these ripples are removed by the proposed work. Implementation of DTC algorithm with C++ and other languages and by using necessary software it can be interfaced with the system.

The PID controller for speed and hysteresis controller can be replaced by neuro-fuzzy controllers and also by DSP controller. There is also possibility of using FPGA control method for the DTC technique.

Motor Parameters

Voltage	230V
Frequency	50 Hz
Rotor type	Squirrel cage
Reference frame	Stationary
Stator Resistance	0.087 ohm
Rotor Resistance	0.228 ohm
Stator inductance	$0.08e^{-3}$
Rotor inductance	$0.08e^{-3}$
Mutual inductance	$34.7e^{-3}$

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