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Direct Torque Control of IM Drive for Speed Regulator Using Adaptive Controller

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ABSTRACT
This paper presents a new improved method of direct torque control (DTC) of induction motor drive (IMD) for speed regulator (SR) by using an adaptive controller method .The method of controlling speed of induction motor based on DTC method by using adaptive controller. The Direct torque control of induction motor using adaptive controller method is one of the effective method strategies of controlling the torque and flux ripples. The inverter reference voltage signal is obtained based on input-output feedback signal controller. Designing of DTC-SVM system and one of the new Method for controlling speed of motor by adaptive controller is given. Adaptive controller techniques applied to achieve better performances of flux, torque control and speed controlling of induction motor. The simulation results with low torque, stator flux and speed control with the Adaptive controller technique in DTC using MATLAB/SIMULINK..

Index Terms: Adaptive stator flux observer, IMD, Space Vector Modulation (SVM), THD, DTC, Stator Flux Observer, Torque Ripples.

I. INTRODUCTION

Direct Torque Control (DTC), Pioneered In The 80's by takahashietal and depenbrock ,Is better performance induction Motor Drive Scheme That enables Independent Control Of The Torque And Flux. Compare To Other High Performance Drive Schemes Such As The Field Oriented Control (FOC), DTC Is Relatively Simpler To Implement And Only Requires The Stator Resistance Information While Maintaining Similar If Not Better Performance. DTC Also Offers The Fastest Motor Dynamic Response As It Changes The Inverter Switching States Directly To Control The Flux And Torque Without The Need Of A Modulator. Direct Torque Control (DTC) Abandons The Stator Current Control Philosophy, Characteristic Of Field oriented Control (FOC) And Achieves Torque And Flux Controlling By Modifying The Stator Voltage With Respective With The Torque And Flux Errors. So Error Can Essay To Find And Rectify. DTC Is characterized By Fast Dynamic Response, Simple Structure And Stronger Robustness In The Face Of Parameters Uncertainties And Perturbations. One Of The Disadvantages Of Direct Torque Control (DTC)Is better Torque Ripple. So Many Techniques Have Been Introduced To Reduce the Torque Ripple. One Of Them Is Duty Ratio Control Method.

In duty ratio Control, Selected Output Voltage Vectors Is Applied portion of sampling period, and then zero voltage vector is applied for rest of the period.

Direct torque control based on space vector modulation (DTC-SVM) preserve DTC transient merits, furthermore, produce improve quality steady-state performance in a wide speed range. At each cycle period, SVM method is used to obtain the reference voltage space vector to exactly compensate the flux and torque errors. The torque ripple of DTC-SVM in speed controlling is also better than previous method. In this paper, we are introducing a new method direct torque control (DTC) of induction motor drive (IMD) for speed regulator (SR) by using an adaptive controller method. SVM-DTC technique with PI controller for induction machine drives is developed. Further, controlling of speed adaptive controller the stator flux observer is designed for a speed sensor less DTC-SVM system and a speed-adaptive law is given. The observer gain matrix, which is obtained by solving linear matrix inequality, can improve the robustness of the adaptive observer gain. The simulation results with low torque, stator flux and speed control with the Adaptive controller technique in DTC using MATLAB/SIMULINK.

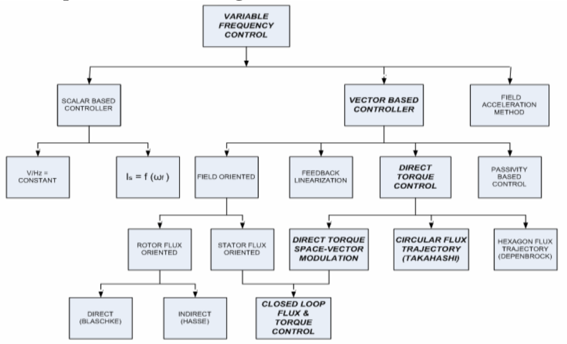


Figure1. classification of induction motor control methods

II. DIRECT TORQUE CONTROL AND INDUCTION MOTOR DYNAMICS

Fig.1 shows, The typical Direct Torque Control (DTC) method applied to a three phase induction motor. From the motor stator resistance R5, the inverter switching state and the sensed stator current, the stator flux phasor followed by the machine torque T, are estimated. The flux and torque estimator are compared with the reference values, and the differences are fed into hysteresis comparators. From Table 1 the appropriate inverter switching state are applied to the IM drive. The selection depended on the output obtained by an hysteresis comparators, dte and dfs, and the sector in which $\overline{\Psi}_s$ currently resides. The inverter switching state that produces the corresponding voltage vector is shown in the respective.

Since direct torque control selects the inverter switching state directly without the need of a modulator, it produces the fastest torque response compared to other high performance induction motor drive schemes. In fact, the torque response is at its natural limits. Torque response cannot be any faster. since the torque response is very faster than the mechanical dynamics. Therefore the dynamics of the DTC controller and the motor torque production stage are ignored. Moreover, the ignore dynamics can be treated as disturbances which the proposed adaptive controller is capable of counteracting. The torque-speed estimated by mechanical dynamics is adequately characterised by the equations

$$T_e - T_l = J\frac{d\omega_r}{d_t} + D\omega_r \qquad (1)$$

Te is the electromagnetic torque, TL is the load torque, J is the combined inertia of the motor and load, and D is damping constant that represents energy loss due to viscous friction

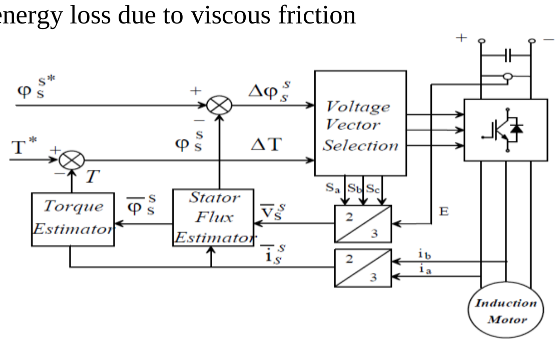


Figure2 Schematic circuit of the DTC method

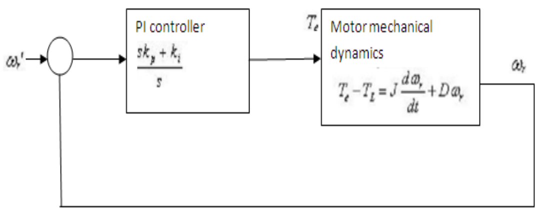


Figure.3 PI speed controlled direct torque controlled induction motor.

Figure 3 shows diagram of a typical PI speed controlled DTC induction motor with the simplified dynamics. Using PI controller, the kp and ki gains need to be tuned whenever motor parameter changes in order to maintain the desired response, for example when connected load and total system inertia change.

III. DIRECT TORQUE CONTROLLER-SPACE VECTOR MODULATION TECHNIQUE

The DTC-SVM METHOD is developed based on the Induction motor torque and the stator flux modules as the system outputs is shown in fig.4

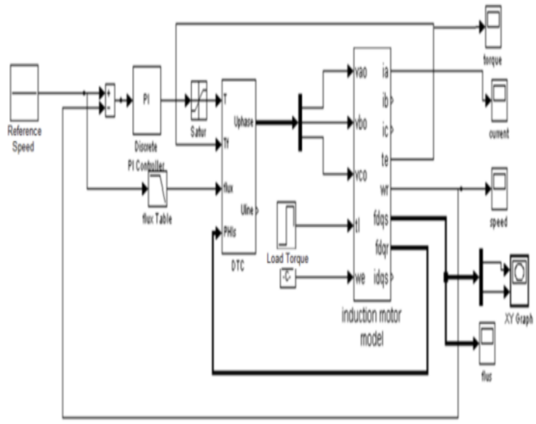


Figure.4 Block Diagram shows the DTC-SVM method

Flux error position	Torque error position	Sector I	Sector II	Sector III	Sector IV	Sector V	Sector VI
1	1	V2(110)	V3(010)	V4(011)	V5(001)	V6(101)	V1(100)
	0	V7(111)	V0(000)	V7(111)	V0(000)	V7(111)	V0(000)
	-1	V6(101)	V1(100)	V2(110)	V3(010)	V4(011)	V5(001)
0	1	V3(010)	V4(011)	V5(001)	V6(101)	V1(100)	V2(110)
	0	V0(000)	V7(111)	V0(000)	V7(111)	V0(000)	V7(111)
	-1	V5(001)	V6(101)	V1(100)	V2(110)	V3(010)	V4(011)

Table 1 Voltage Vector Selection

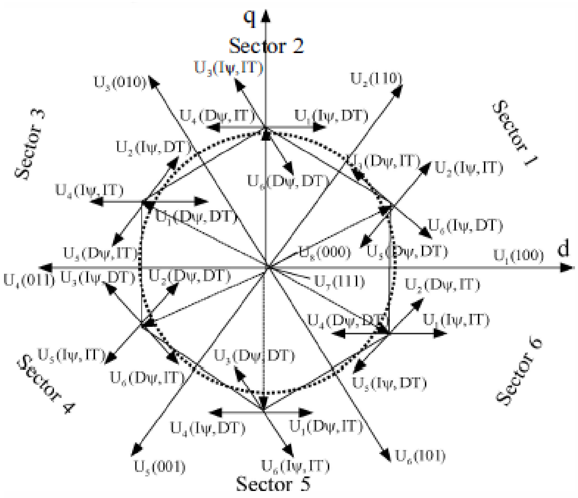


Figure 5.Control of Voltage space vector in six sectors of flux plane.

IV. DTC-SVM TECHNIQUE WITH PI CONTROLLER

PI control is one of the earlier control strategies. It is applied to the D-axis and Q-axis rotor flux of the Induction motor obtained from the IM model equation. This improvement can greatly reduce the torque ripple. The Block diagram of DTC-SVM with PI controller is shown in fig.6.

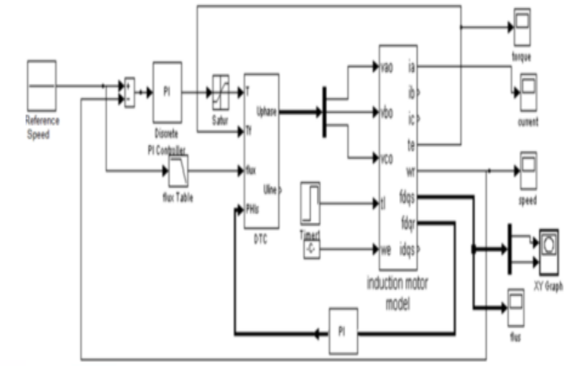


Figure.6. DTC-SVM with PI controller

V. DTC- ADAPTIVE CONTROLLER

Using the IM model of (1–4), the speed adaptive stator flux observer is introduced the uncertain parameters in matrix.

$$\dot{x} = Ax + Bu$$

$$i_{s=Cx}$$

$$B = \left[\frac{1}{\sigma L_s} II\right]^T ; C = [1 \quad 0] ; I = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} ; J = \begin{bmatrix}0 & 1\\1 & 0\end{bmatrix};$$

$$A = A_O \ + \Delta A_R + \omega_S A_W = \begin{bmatrix}\left(\frac{R_{so}}{\sigma L_S} + \frac{R_{r0}}{\sigma L_S}\right) I & \frac{R_{r0}}{\sigma L_r L_S} I\\ -R_{s0} I & 0\end{bmatrix} + \begin{bmatrix}\left(\frac{\Delta R_s}{\sigma L_S} + \frac{\Delta R_r}{\sigma L_S}\right) I & \frac{\Delta R_0}{\sigma L_r L_S} I\\ -R_0 I & 0\end{bmatrix} + \omega_S \begin{bmatrix}J & -\frac{1}{\sigma L_S} J\\ 0 & 0\end{bmatrix}$$

A aresplit in two parts; one corresponding to nominal or constant operation and the second unknown behavior.Rs and Rr are nominal value stator resistance and rotor resistance,the stator resistance and rotor resistance uncertainties, respectively.

The state observer, which estimates the state current and the stator flux together, is given by the following equation.

$$\frac{d\dot{x}}{dt} = [A_O + \Delta A_R + \omega_R A_s\,]\dot{x} + Bu + H(i_s - i_r)$$

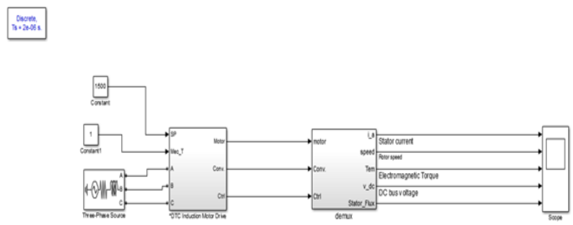
In order to derive the adaptive scheme, Lyapunov theorem is utilized. Now, let us define the following Lyapunov function:

$$V = e^T\, e \ + (\dot{\omega_r} - \omega_r)^{\,2} / \aleph$$

$$\frac{dv}{dt} = \ e^T\,[(A_0 + \ HC \ + \ \Delta A_R + \ \omega_r A_\omega)]^T + [(A_0 + \ HC \ + \ \Delta A_R + \ \omega_r A_\omega)]^T e + \ \Delta\omega_r(\dot{x}^T A_\omega^T e \ + \ e^T A_\omega \dot{x}\,)$$

VI. SIMULATIONS

To verify the DVC with adaptive controller, we are using PI controller and with adaptive stator flux observer simulations are performed in this section. The block diagram of the proposed system is shown in Fig. 4. The parameters of the induction motor used in simulation results shown below. The speed and torque response curves of conventional DTC and proposed DTC-adaptive controller.



The SIMULINK model of DTC of induction motor drive for speed regulator using conventional Adaptive controller scheme with torque and flux control for induction machine is shown in Figure 7 below. According to the control schematic, this technique uses only dc link voltage and current measurements to generate estimate of flux and torque response. The drive is operate under torque control and is very similar to a constant V/Hz drive in terms of power components and sensors used. Finally, this strategy supposes to be a good compromise between high performance field-oriented drives and low performance V/Hz drives.

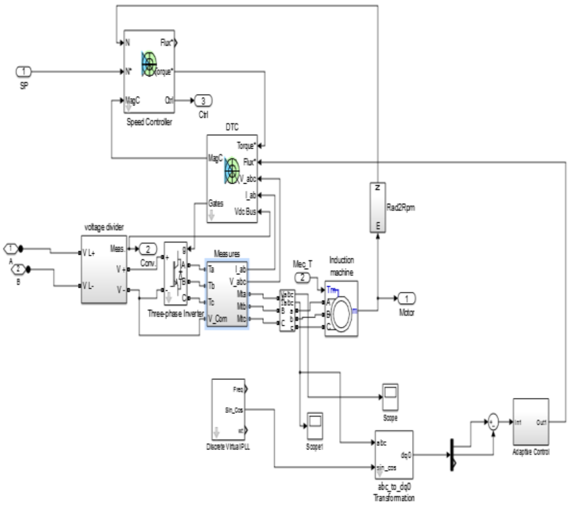
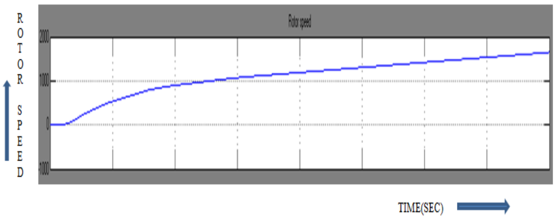
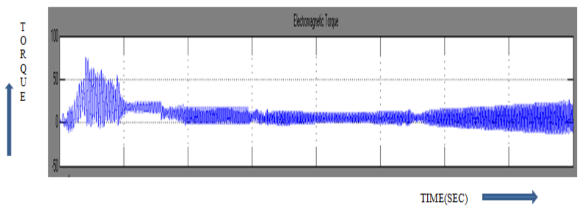


Figure 7 Simulink Diagram Of Adaptive Controller
Simulation Results Of Adaptive Controller

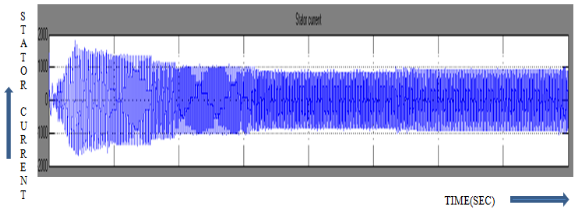


figure(a)) have X-Axis On Time(Sec) And Y-Axis On Rotor speed

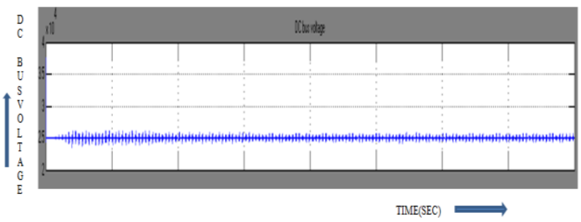


figure(b)have X-Axis On Time(Sec) And Y-Axis On Torque

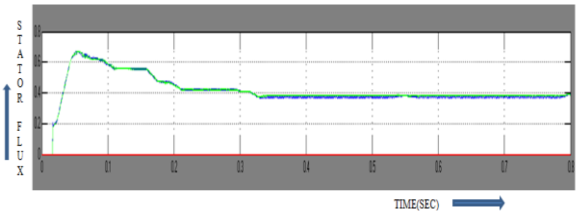
figure(c)have X-Axis On Time(Sec) And Y-Axis On



Stator Current



figure(d)have X-Axis On Time(Sec) And Y-Axis On DC Bus voltage



figure(e)have X-Axis On Time(Sec) And Y-Axis On Stator Flux

VII. CONCLUSION

This paper presented a new method of direct torque control (DTC) of induction motor drive (IMD) for speed regulator (SR) by using an adaptive controller technique. The method of controlling speed of induction motor based on DTC method by using adaptive controller. The Direct torque control of induction motor using adaptive controller method is one of the effective method strategies of controlling the torque and flux ripples is essay. Adaptive controller techniques achieving better performances of flux, torque control and speed controlling of induction motor compare to previous methods. The simulation results with low torque, stator flux and speed control with the Adaptive controller technique in DTC using MATLAB/SIMULINK.

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