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# Direct Torque Control of Induction Motor Drives

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***Abstract*** *: The present work is to enhanced execution of Direct Torque Control (DTC) of enlistment engine drives . At the season of exchanging DTC drive gives the high torque swell. In DTC acceptance engine drive there are torque and motion swells in view of off base voltage vector choice by VSI states can't create the definite voltage esteem required to make zero both the torque electromagnetic blunder and the stator motion error.To beat this issue a Fuzzy Logic Controller is utilized. The fluffy rationale controller is accustomed to lessening the torque and transition swells and it enhance execution DTC particularly at low speed.*

***Keywords:*** *Direct Torque Control, Induction Motor, Fuzzy Logic, Torque Ripple Minimization, Fuzzy Logic Controller*

## I. Introduction

Increment in Induction Motor (IM) drives controlled with the vector control strategy is for the most part acknowledged in the business. In any case, this control method requires complex organize change, internal current control circle and exact framework parameters. Then again, the Direct Torque Control (DTC) strategy gives vigorous quick torque reaction without such facilitate change, PWM beat age and current controllers. Besides, DTC limits the utilization of engine parameters method experiences a noteworthy disservice of enduring state swell in torque and transition, since none of the inverter-exchanging vector can produce the precise stator voltage at appropriate moments just as in space. These torque and motion swells influence the exactness of speed estimation; result in high acoustic commotion and consonant misfortunes. There are numerous strategies to lessen this torque and transition swell: (a) the elective inverter topologies, staggered inverters and grid converters which increment the quantity of switches, and therefore cost and unpredictability; (b) the higher exchanging frequencies diminish the consonant substance of stator current and along these lines torque and motion swell. In any case, such higher changing frequencies lead to expanded exchanging misfortunes and weight on semiconductor switches of the inverter (c) yet, another strategy for lessening torque and transition swells is fluffy rationale controller gives consistent exchanging recurrence. Also this strategy requires complex control plans than traditional DTC and is machine parameter subordinate.

DTC roll throughout the most recent decade winds up one conceivable option in contrast to the outstanding Vector Control of Induction Machines. Its fundamental trademark is the great execution, getting results on a par with the traditional vector control yet with a few focal points dependent on its less difficult structure and control chart. DTC (Direct Torque Control) is portrayed, as concluded from the name, by straightforwardly controlled torque and motion and in a roundabout way controlled stator current and voltage. The DTC has a few points of interest in examination with the regular vector-controlled drives, as: Direct torque control and direct stator motion control, Indirect control of stator flows and voltages, Approximately sinusoidal stator motions and stator flows, High unique execution even at bolted rotor, Absences of co-ordinates change, Absences of mechanical transducers, Current controllers, PWM beat age, PI control of transition and torque and co-ordinate change are not required, Very straightforward control plan and low calculation time, Reduced parameters affectability, Very great powerful properties. Traditional DTC has additionally a few drawbacks: Possible issues amid beginning and low speed task, High necessities upon transition and torque estimation, Variable exchanging recurrence. These are impediments that we need to evacuate by utilizing fluffy rationale.

## II. Dtc Schematic

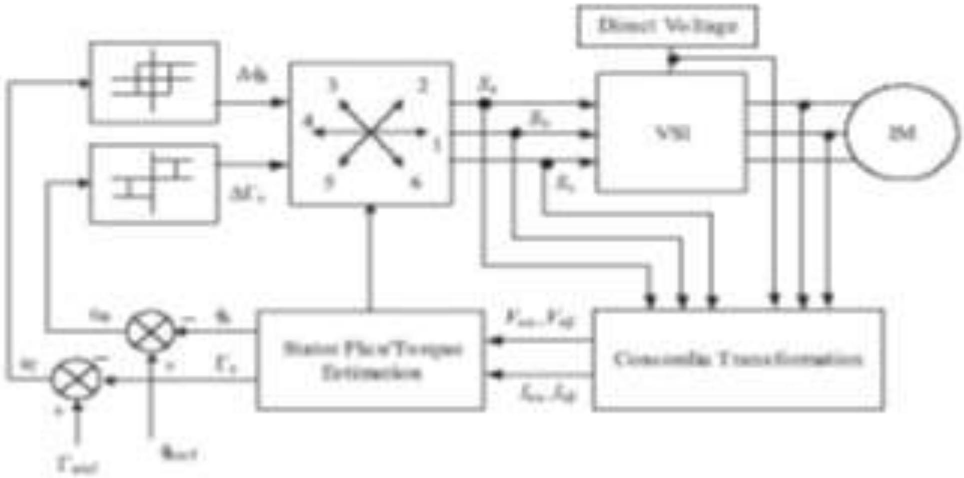



**Fig.1** Block diagram of DTC scheme

DTC conspire is given in Fig. 1, the and signals are conveyed to two hysteresis comparators. The relating digitized yield factors: change of attractive motion , of mechanical torque and the stator transition position division made a computerized word, which chooses the fitting voltage vector from the exchanging table. The choice table produces beats , to control the power switches in the inverter. Three-level torque and two dimension motion hysteresis controllers are utilized by the yields of the torque controller and the part data of , fitting voltage vectors for both the inverters are chosen from an exchanging table as it is appeared in fig.2

**Fig.2** Classical DTC switching table

| Flux | Torque | Sector Sϕ | | | | | |
|---|---|---|---|---|---|---|---|
| Δϕ | Δτ | Sϕ1 | Sϕ2 | Sϕ3 | Sϕ4 | Sϕ5 | Sϕ6 |
| 1 | 1 | V2 | V3 | V4 | V5 | V6 | V1 |
| 1 | 0 | V7 | V0 | V7 | V0 | V7 | V0 |
| 1 | -1 | V6 | V1 | V2 | V3 | V4 | V5 |
| -1 | 1 | V3 | V4 | V5 | V6 | V1 | V2 |
| -1 | 0 | V0 | V7 | V0 | V7 | V0 | V7 |
| -1 | -1 | V5 | V6 | V1 | V2 | V3 | V4 |

Figure.3.5shows the voltage vectors which are generally utilized in DTC conspire when the stator motion vector is lying segment I is appeared in fig 3.8. The determination of a voltage vector at each cycle period is made so as to keep up the torque and the stator transition inside the points of confinement of two hysteresis groups. This basic methodology enables a brisk torque reaction to be accomplished, yet the relentless state execution is portrayed by bothersome swell in current, transition and torque. This conduct is essentially because of the nonattendance of data about torque and rotor speed esteems in the voltage choice calculation

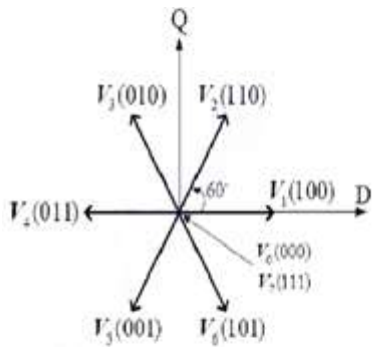



**Fig.3** Eight possible voltage space vectors

## III. Vector Transformations

Concordia transformation for voltages By using this transformation, two voltages $V_{sd}$ and $V_{sq}$ are obtained. The measured voltage U0 is necessary and the switching table also $S_a, S_b, S_c$.

$$V_{sd} = \sqrt{\frac{2}{3}}U_0\left(S_a - \frac{1}{2}(S_b + S_c)\right)$$

$$V_{sq} = \frac{1}{\sqrt{2}}U_0(S_b - S_c)$$

3.4.2 Concordia transformation for currents

This transformation is used to obtain currents $I_{sd}$ and $I_{sq}$ , after measures of $I_{sa}$, $I_{sb}$ and $I_{sc}$ of the stator.

$$I_{sd} = \sqrt{\frac{3}{2}}\, I_{sa}$$

$$I_{sq} = \frac{1}{\sqrt{2}}\,(I_{sb} - I_{sc})$$

3.4.3 Flux and torque estimations

DTC command is based on estimation in flux and in torque. In order to realize these estimators, we used results of Concordia transformations.

Because stator voltage is define by:

$$Vs = Rs * Is + (d\varphi s/dt)$$

We have $\varphi_s = \int Vs - Rs * Is$

That's why, we have two equations:

$$\Phi_{sd} = \int_0^t (V_{sd} - R_s I_{sd})\,dt$$

$$\Phi_{sq} = \int_0^t (V_{sq} - R_s I_{sq})\,dt$$

We can now estimate torque,

$$\tau_e = p[\Phi_{sd} I_{sq} - \Phi_{sq} I_{sd}]$$

Figure.3.5shows the voltage vectors which are ordinarily used in DTC scheme when the stator progress vector is lying part I is showed up in fig 3.8. The assurance of a voltage vector at each cycle period is made in order to keep up the torque and the stator progress inside the cutoff purposes of two hysteresis gatherings. This fundamental procedure empowers a fast torque response to be cultivated, anyway the steady state execution is depicted by terrible swell in current, movement and torque. This lead is generally a result of the nonappearance of information about torque and rotor speed regards in the voltage assurance figuring.

## IV. Dtc Controller

The best way to deal with power the required stator change is by strategies for picking the most sensible Voltage Source Inverter state. If the ohmic drops are disregarded for ease, by then the stator voltage rouses explicitly the stator movement according to the going with condition

$$\frac{d}{dt}\bar{\psi}_s = \bar{u}_s$$

Or

$$\overline{\Delta\psi}_s = \bar{u}_s \Delta t$$

Decoupled control of the stator movement modulus and torque is practiced by following up on the winding and digressive sections independently of the stator progress linkage space vector in its locus. These two sections are clearly comparing ( =0) to the fragments of a comparative voltage space vector
\in comparable ways.

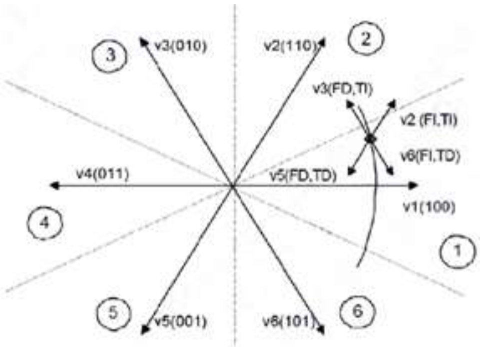



**Fig.4:** Stator flux vector locus

The hysteresis band must be set adequately tremendous to bind the inverter trading repeat underneath a particular measurement that is regularly managed by warm impediment of force contraptions. Since the hysteresis bunches are set to adjust to the most negative situation, the system execution is unquestionably degraded in a particular working reach, especially in a low speed district. In torque hysteresis controller, a sneaking past time to move from lower beyond what many would consider possible, and the other path around can be changed by working condition.

## V. Simulated Results For Dtc Model

Engine qualities :
The rating of enlistment engine is 5Hp, 415V, 50Hz, 1430 rpm star associated acceptance engine. For all reproduction, the engine qualities will be used as underneath:
Stator Resistance (ohm) = 1.405
Rotor Resistance (ohm) = 1.395
Stator Self Inductance (H) = 0.005839
Rotor Self Inductance (H) = 0.005839
Common Inductance(H) = 0.2037
No. of posts = 4
Snapshot of Inertia (kg.m^2) = 0.03
Burden torque (Nm) = 15
Examining time,(Ts) = 1 sec

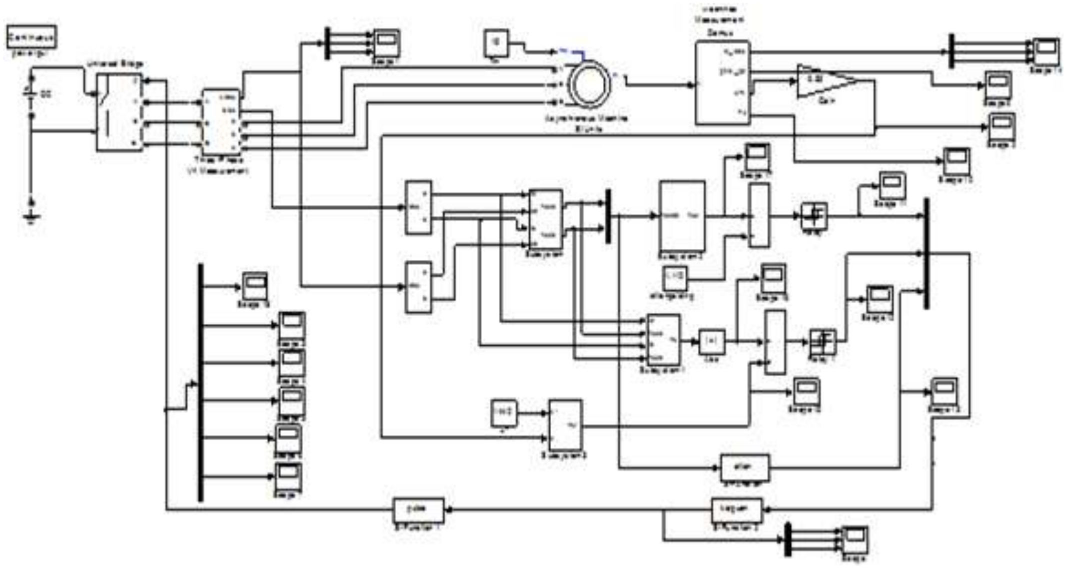


**Fig.5:** Direct Torque Control of Induction Schematic using SIMULINK/MATLAB**.**

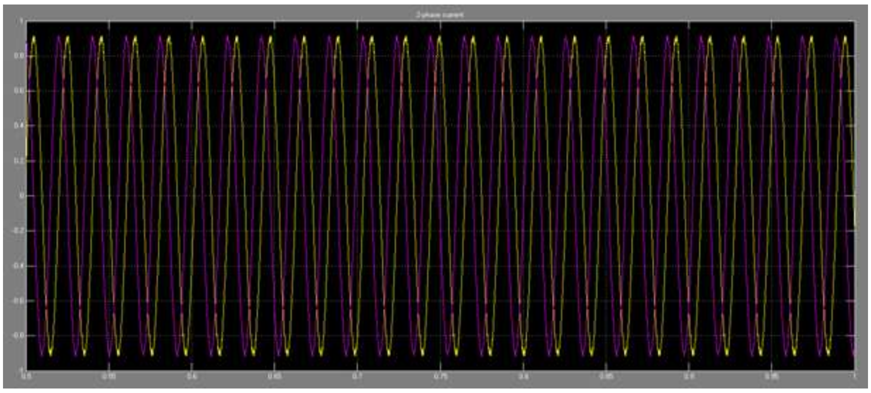


**Fig.6:** 2-phase current in DTC

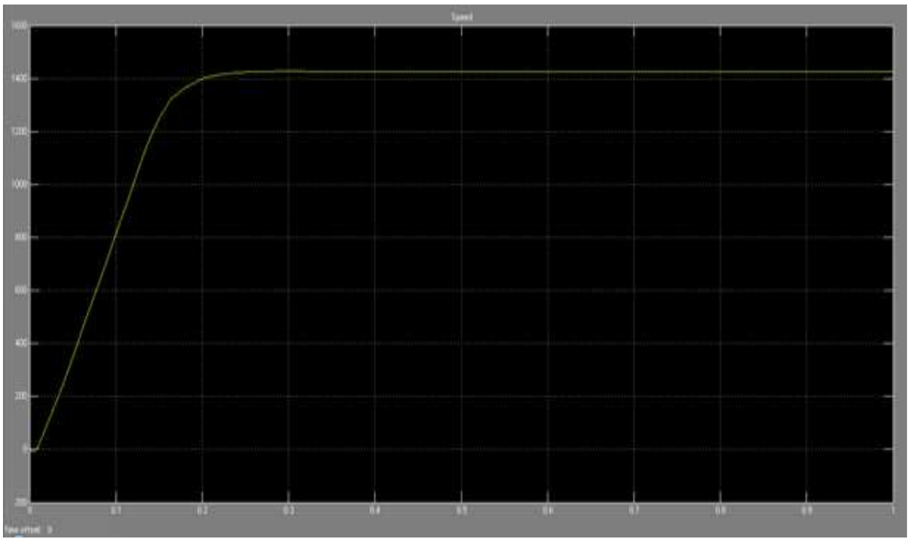


**Fig.7**: Speed in DTC

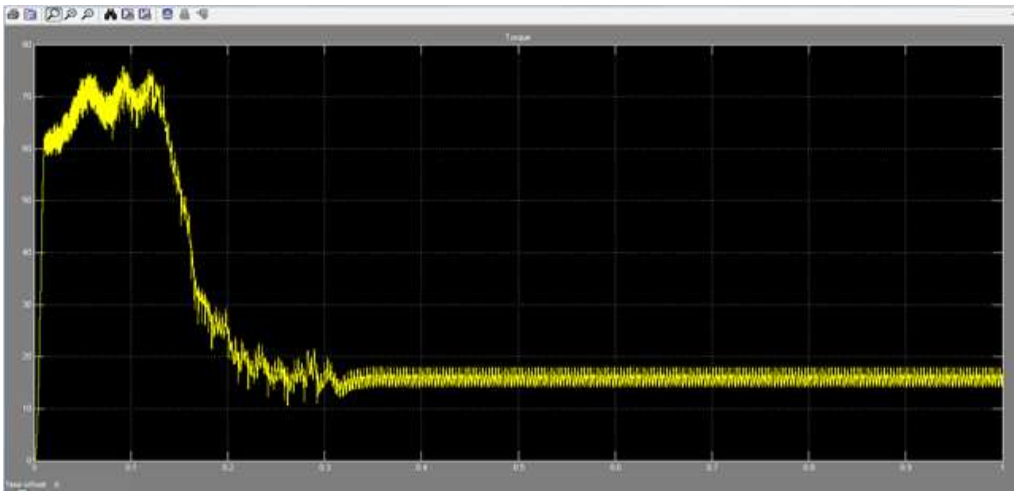
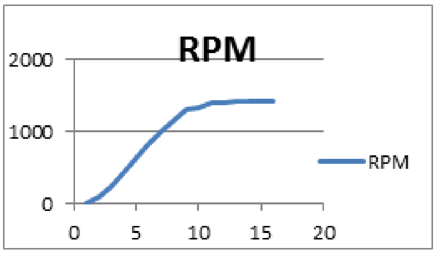
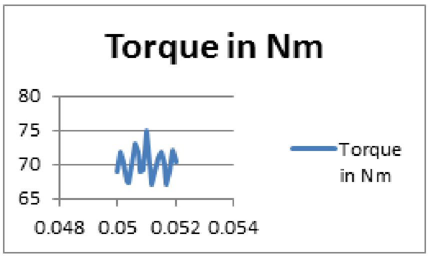


**Fig .8:** Torque in DTC

The multiplications of the DTC acknowledgment motor drive were finished using the Matlab/Simulink reenactment pack. From figure torque swell is on a very basic level diminished when DTC used. Furthermore DTC gives better execution at lock rotor just as at end. It is seen that the reliable state execution of the DTC

**Study Case:**




For DTC model:

## VI. Conclusion

For any IM drives, direct torque control is a champion among the best controllers proposed up until this point. It licenses decoupled control of motor stator progress and electromagnetic torque. From the examination it is exhibited that, this system of IM control is less demanding to realize than other vector control methods as it doesn't require beat width modulator and co-ordinate changes. Nevertheless, it presents undesired torque and current swell. DTC plot uses stationary d-q reference diagram with d-rotate agreed with the stator center point. Stator voltage space vector portrayed in this reference diagram control the torque and movement. The guideline surmisings from this work are:

1. In transient state, by choosing the quickest quickening voltage vector which produces most extreme slip recurrence, most noteworthy torque reaction can be acquired.
2. In relentless express, the torque can be kept up steady with little exchanging recurrence by the torque hysteresis comparator by choosing the quickening vector and the zero voltage vector on the other hand.
3. So as to get the ideal proficiency in enduring state and the most astounding torque reaction in transient state in the meantime, the transition level can be naturally balanced.
4. In the event that the exchanging recurrence is very low, the control circuit makes some float which can be remunerated effectively to limit the machine parameter variety. The estimation precision of stator transition is especially fundamental which for the most part relies upon stator obstruction on the grounds that a blunder in stator motion estimation will influence the conduct of both torque and motion control circles. The torque and current swell can be limited by fluffy rationale controller system

## References

[1]. B. K.Bose. 1997,. Power Electronics and Variable Frequency Drives. IEEE Press, New York.
[2]. Kazmierkowski, R.Krishnan, Blaabjerg, Control in Power Electronics, Selected Problems.
[3]. Takahashi Isao, Noguc hi Tos hihiko, „"A New Quick-Response and High-Efficiency Control Strategy of an Induction Motor"", IEEE Transactions on Industry Applications, Vol. IA-22 No-5, Sept/Oct 1986.
[4]. Thomas G.Habetler, Francesco Profumo, Michele Pastorelli and Leon M. Tolbert "Direct Torque Control of IM us ing Space Vector Modulation" IEEE Transactions on Industry Applications, Vol.28, No.5, Sept/Oct 1992.
[5]. E.Bassi, P. Benzi, S. Buja, "A Field Orientation Scheme for Current-Fed Induction Motor Drives Based on the Torque Angle Closed-Loop Control" IEEE Transactions on Industry Applications, Vol. 28, No. 5, Sept./ Oct. 1992.
[6]. James N. Nash, "Direct Torque Control, Induction Motor Vector Control Without an encoder" IEEE Trasaction on Industry applications,Vol.33,No.2,March/April 1997.
[7]. M. Depenbrock, „"D irect Self-Control (DSC) of Inverter-Fed Induction Machine"", IEEE Transactions on Power Electronics, Vol.3, No.4, Oct.1988.
[8]. Cristian Lascu, Boldea, Blaabjerg "A Modified Direct Torque Control for Induction Motor Sensorless Drive" IEEE transaction on Industry Applications, Vol.36, No.1, Jan/Feb 2000.
[9]. Anthony Purcell, P. Acarnley, "Enhanced Inverter Switching for Fast Response Direct Torque Control" IEEE Transactions on Power Electronics, Vol. 16, No. 3, may 2001.
[10]. M.Vasudevan, R.Arumugam "New Direct Torque Control Scheme of Induction Motor for Electric vehic le" Proceeding of control conference,5th Asian,Vol.2, 2004.
[11]. M.Vasudevan, R.Arumugam, S.Paramasivam" High performance adaptive Inte lligent DTC Schemes for induction motor drives" SJEE, Vol.2, No1,May 2005.
[12]. Sarat K. Sahoo, G. Tulsi Ram Das, Vedam Subrahmanyam "Implementation and Simulation of DTC scheme with the use of FPGA scheme" ARPN Journal of Engineering and Applied Sciences, Vol.3. No.2, April 2008.
[13]. Ehsan Hassankhan, Davood A. Khaburi,"DTC-SVM Scheme for Induction Motors Fed with a Three-level Inverter", World Academy of Science, Engineering and Technology 2008.
[14]. L. Bouras, M. Kadjoudj, "Vector control of induction motor based Space Vector Modulation" Electronics and Telecommunications, Vol.50, No.1, 2009.
[15]. Prof.K.B.Mohanty "A Direct Torque Controlled Induction Motor with Variable Hysteresis Band" 11th International Conference on Computer Modelling and Simulation, UK Sim 2009.
[16]. Zhifeng Zhang, Renyuan Tang, "Novel Direct Torque Control Based on Space Vector With Modulation Adaptive Stator Flux Observer for Induction Motors" IEEE Transactions on Magnetics, Vol. 46, No. 8, August 2010.
[17]. T.Nasser et al, "direct torque control of induction motor based on artificial neural networks With estimate and regulation speed using the MRAS and neural pi controller" Journal of Theoretical and Applied Information Technology" 2010.
[18]. S Allirani, V Jagannathan, "High Performance Direct Torque Control of Induction Motor Drives Using Space Vector Modulation" IJCSI, Vol. 7, Issue 6, November 2010.

[19]. K. Kaur, S. Duvvuri, S. Singh, "Simulation of Indirect Vector Controlled Induction Motor Drive" IEEE International Conference on Advanced Computing & Comm.Techno.2011.
[20]. Giovanna Oriti and Alexander L. Julian,"Three-Phase VSI with FPGA-Based Multisampled Space Vector modulation" IEEE transactions on industry applications, Vol. 47, No. 4, July/August 2011.
[21]. AuzaniJ idin, NikIdris, Mohamed Yatim, "Simple Dynamic Overmodulation Strategy For Fast Torque Control in DTC of Induction Machines With Constant-Switching-Frequency Controller"IEEE transactions on industry applications, Vol. 47, No. 5, Sept/Oct 2011.
[22]. A.Mishra, P.Choudhary, "Speed Control Of An Induction Motor By Using Indirect Vector Control Method" IJETAE,Volume 2, Issue 12, December 2012.