International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878, Volume-8, Issue-1S4, June 2019

Direct Torque Control of Induction Motor Using SVM Techniques

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Abstract--- Direct Torque control (DTC) is a preferred approach for its fast torque reaction and smooth implementation in induction motor applications. But various switching frequency and current harmonics are the disadvantage of the method. There are many industrial packages already using DTC. in this have a look at novel switching desk is proposed to reduce modern-day harmonics based totally on torque-flux plane that can be implemented to present day motor drives with software program change, instead than a hardware advancement. They have a look at is illustrated with Simulink model and motor output images. The primary goal of this undertaking work is to manipulate method in order to obtain advanced dynamic response, rapid torque reaction and controller having low inverter switching frequency, low harmonic losses, and excessive efficiency. The DTC controller has all the above traits to be properly a controller. So the objective right here is to examine the most advanced IM manage method i.e. direct torque manipulate and look at its overall performance characteristics.

Keywords--- DTC, Induction Motor, SVPWM.

I. INTRODUCTION

Previously, DC Motors were utilized widely in zones where a variable-speed task was required, since their flux and torque could be controlled effectively by the field and armature current. However, DC motors have drawbacks, which are because of the presence of the commutator and the brushes. That is, they require periodic maintenance. They can't be utilized in hazardous or destructive situations and they have restricted commutator capacity under fast, high voltage operational conditions. These issues can be overcome by the use of alternating current motors, which can have basic and tough structure, high maintainability and economy. They are additionally strong and insusceptible to heavy overloading. Their little measurement contrasted and DC motors permits AC motors to be planned with generously higher output ratings for low weight and low rotating mass. Variable-speed AC drives have been used in the past to perform relatively undemanding roles in applications which preclude the use of DC motors, either because of the working environment or commutator limits. In light of the high cost of efficient, quick switching frequency static inverters, the lower cost of AC motors has additionally been an unequivocal economic factor in multi-motor systems.

Notwithstanding, because of the advancement in the field of power electronics, the proceeding with pattern is towards less expensive and progressively compelling power converters, and single motor AC drives contend positively on an absolutely economic basis with the DC drives Moreover they can't work in dirty and unstable situations (Bimal Bose 2002, Krishnan 2005). There are basically two types of instantaneous electromagnetic torque controlled drives (briefly, torque-controlled drives) used for high performance applications. They are vector and direct-torque-controlled drives. Vector-controlled drives were introduced more than 20 years ago in Gemany by Blaschke, Hasse, and Leonhard. They have achieved a high degree of maturity and have become increasingly popular in a wide range of applications. They have established a substantial and continually increasing worldwide market. Direct-torque-controlled drives were introduced in Japan by Takahashi and also in Germany by Depenbrock more than 10 years ago. In general, the direct torque control (DTC) of a synchronous motor involves the direct control of the flux linkages (e.g. stator flux linkages, stator transient flux linkages, etc.) and electromagnetic torque by applying optimum current or voltage switching vectors of the inverter which supplies the motor.

In the case of a current source inverter (CSI) fed motor, the optimum current switching vectors are selected, but in the case of a voltage source inverter (VSI) fed motor, the optimal voltage switching vectors are selected. Direct torque control DTC was first introduced by Takahashi in 1984 and by Dopenbrock in 1985 in Germany [3] [7] and today this control scheme is considered as the world's most exceptional AC Drives control innovation. This is a basic control method which does not require coordinate transformation, PI controllers, and Pulse width modulator and position encoders [20] [25].This system results in immediate and free control of motor torque and flux by choosing ideal inverter switching modes.

Manuscript received June 10, 2019.

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The electromagnetic torque and stator flux are determined from the essential motor inputs e.g. stator voltages and currents [16]. The ideal voltage vector determination for the inverter is made to limit the torque and flux errors within the hysteresis bands. The advantages of this control method are fast torque reaction in transient operation and improvement in the steady state efficiency. From the examination of the control strategies it is realized that torque control of IM can be accomplished by various procedures running from cheap Volts/Hz proportion technique to advanced sensor less vector control scheme. In any case, each strategy has its own burdens like losses, need of isolated current control loop, coordinate transformation (in this way expanding the multifaceted nature of the controller), torque and current ripple etc. So it is particularly important to structure a controller to acquire a perfect electric vehicle engine drive system which would have low torque ripple and minimum current distortion and high efficiency.

II. MOTOR DRIVE

The motor drive consists of Induction Motor, inverter, flux and torque estimator, flux controller, torque controller, vector selection table. The block diagram of the DTC based IM drive is shown in Figure 1.

Three Phase Induction Motor

Induction motor is a motor which works on AC supply and is having more advantages like simple, extremely rugged construction, low cost, less maintenance, higher efficiency with good power factor and starting is simple over conventional DC machines. It has two types namely single-phase and poly-phase AC machines. From the last three decades AC machines like induction motors are generally used and almost 60 to 70 % of industry applications. There is no separate source needed for induction motor to energize the field effect. The stator voltage produces rotating magnetic field that leads and interact with the rotor part to drive the rotor in asynchronous mode. Moreover in the recent years, the modifications of induction motor in terms of dimensions are not concentrated. In order to meet the requirement of industry, now-a-days power controlled devices based drives are emerged. In most of the industries these devices utilized in different drive system for the applications like cranes, trolley cars, blowers, pumps, tractions etc.

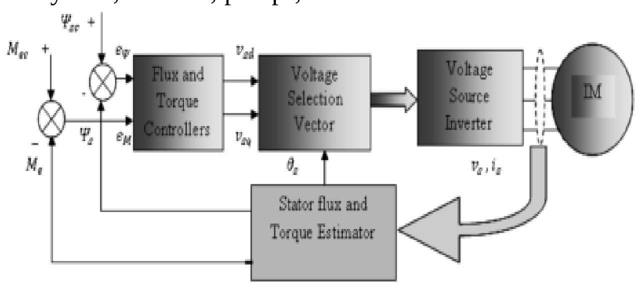

Figure 1: Block Diagram of DTC IM Drive

III. CLASSIFICATION OF INDUCTION MOTOR

It's broadly classified according to phase, single-phase and three phase induction motor based on power supply. Under the category of rotor construction again classified as cage wound rotor and slip-ring wound rotor motors. Three phase squirrel cage Induction motors are mainly installed many industrial applications, because it's easy to construct, control, maintain and operate.

Stator Flux and Torque Estimator

The estimator calculates the stator flux 'ψc', the electromagnetic torque 'Me'. The parameters are estimated by basic induction motor model equation. The inputs of the state estimator are the stator voltage 'vs', and the current 'is' space vectors. They are referred to a stationary reference frame. Flux and Torque Controller The flux 'e ψ' and torque 'em' errors are delivered to the hysteresis flux and torque controllers. The digitized output variables and the stator flux position sector 'γss(N)', selects the appropriate voltage vector from the switching table. Thus, the determination table generates pulses to control the power switches in the inverter.

Voltage Selection Vector

The stator voltage vectors are generated with respect to error signal and stator flux position sector. It generates six active vectors from V1 to V6 and two zero vectors V0 and V7 with no change in magnitude or maintain the current state. If voltage vector is in increasing mode the magnitude of voltage vectors can select V1, V2, V6. Contrarily, if the voltage vectors are in decreasing mode the magnitude of voltage vectors can select V3, V4, and V5. The motor is fed from a voltage source inverter and control is performed by voltage vector regulating the stator voltage of the motor. The flux and torque estimator and corresponding hysteresis controllers are used to generate gate signals for the inverter. The proper selection of the inverter devices and selection of the control technique will guarantee the efficiency of the drive. Voltage Source Inverter (VSI) is used to convert a DC voltage to AC voltage of variable, constant frequency, and magnitude. They are generally utilized in flexible speed drives and are described by a well-defined switched voltage waveform in the terminals. The inverter output frequencies can variable or constant depending on the application. Three phase inverter consists of six power switches and DC source connection as shown Figure 2 The inverter switches must be selected based on the requirements of operation, rating and the application.

Voltage Source Inverter Fed Induction Motor Drives

The type of waveforms that the electric drive system deals with is ac waveforms, so the main objective of power converters needed in adjustable speed drives (ASDs) should produce an ac output waveform from a dc power supply. The frequency, magnitude, and period of the sinusoidal ac yields ought to be controllable. As indicated by the kind of ac output waveform, the power converter topologies can be considered as voltage source inverters (VSIs) and current source inverters (CSIs). The voltage source inverters, where the ac output voltage waveform can be controlled independently, is the most widely used power converters in ASDs and many industrial applications because since they

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normally carry on as voltage sources as required in these applications. The output of the VSI is encouraged to the three phase induction motor which is at long last associated with the load of the drive system.

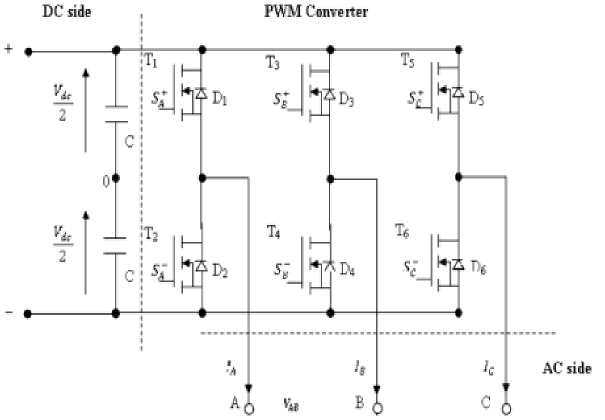

Figure 2: Three Phase Voltage Source Inverter

Dynamic Model of Induction Motor

The stator of induction motor consists of three phase balanced distributed windings with each phase isolated from other two windings by 120 degrees in space [1]. At the point when current flows through these windings, three phase rotating magnetic field is delivered. The dynamic conduct of the induction machine is considered in a flexible speed drive system utilizing a power electronics converter. This machine constitutes an element within a feedback loop. Investigation of the dynamic execution of the machine is complex because of coupling effect of the stator and rotor windings, additionally the coupling coefficient differs with rotor position. So a lot of differential conditions with time changing coefficients describe the machine model [1]. To determine the dynamic model of the machine, the following assumptions are made:

- No magnetic saturation, No saliency impacts i.e. machine inductance is autonomous of rotor position; Stator windings are so organized as to deliver sinusoidal mmf distributions.
- Effects of the stator slots might be ignored, No fringing of the magnetic circuit, Constant magnetic field intensity, radially directed over the air-gap; negligible eddy current and hysteresis impacts.

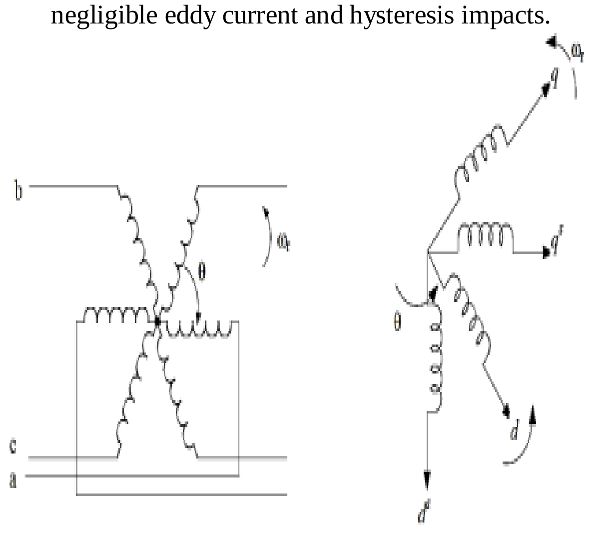

Figure 3: Dyamic Modelling of IM

A three phase balanced supply is given to the motor from the power converter. For dynamic modeling of the motor two axes theory is utilized [1]. As indicated by this theory the time differing parameters can be communicated in mutually perpendicular direct (d) and quadrature (q) pivot. In stationary reference frame the ds and qs axes are fixed on the stator, while these are rotating at a point as for the rotor in turning rotating fixed to the rotor or it might rotate at synchronous speed. In synchronously rotating reference frame with sinusoidal supply the machine factors show up as dc quantities in steady state condition.

Voltage Source Inverter

In VSIs the input voltage is kept up consistent and the amplitude of the output voltage is autonomous of the nature of the load. Be that as it may, the output current waveform just as magnitude depends on nature of load impedance. Three stage VSIs are increasingly regular for giving customizable recurrence capacity to mechanical applications when contrasted with single stage inverters.

The VSIs take dc supply from a battery or all the more often than not from a 3-ϕ connect rectifier. A fundamental three stage VSI is a six stage connect inverter, comprising of least six power hardware switches (for example IGBTs, Thyristors) and six feedback diodes. A stage can be characterized as the adjustment in firing starting with one switch then onto the next switch in proper sequence. For a six stage inverter each progression is of 60º interim for one cycle of 360º. That means the switches would be gated at regular intervals of 60º in proper sequence to get a three phase ac output voltage at the output terminal of VSI.

Fig.4 shows the power circuit diagram of three phases VSI using six IGBTs and six diodes connected anti parallel to the IGBTs. The capacitor associated in to the input terminals is to keep up the input dc voltage consistent and this also suppresses the harmonic sustained back to the dc source. Three phase load is star connected.

The six switches are separated into two groups; upper three switches as positive group (for example S1, S3, S5) and lower three as negative group of switches (for example S4, S6, S2). There are two gating patterns to the switches i.e. there are two conduction modes: 1. 180º conduction mode and 2. 120º conduction mode. In each example the gating signals are connected and evacuated at an interval of 60º of the output voltage waveform.

In 180º mode three switches are on at once, two from positive group and one from negative g group or the other way around, each switch conducts for 180º of a cycle. In 120º mode each switch lead for 120º in one cycle and two switches stay turned on at once, one from positive group and one from negative group.

Be that as it may, no two switches of a similar leg ought to be turned on at the same time in the two cases as this condition would short circuit the dc source. In 120º conduction mode the odds of short circuit of the dc link voltage source is avoided as each switch conduct for 120º in

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one cycle, so there is an interval of 60º in each cycle when no switch is in conduction mode and the output voltage right now interval is zero.

As a rule there is a 60º interval between turning off one switch and turning on of the complimentary switch in a similar leg.

This 60º interval is adequate for the active change to recover its forward blocking capacity. The standard three-stage VSI topology has eight valid switching states which are given in Table.4.1.

Of the eight switching states, two are zero voltage states (0 and 7) which produce zero ac line voltages and for this situation, the ac line flows freewheel through either the upper or lower segments.

The rest of the states (1 to 6 in Table.4.1) are dynamic states which produce non-zero ac output voltages. The inverter moves starting with one state then onto the next so as to create a given voltage waveform.

In this manner the subsequent ac output line voltages comprise of discrete estimations of voltages, for example, for the topology appeared in Fig.5.

In 180º method of conduction the waveform of ac phase output voltage stepped one having values and line voltage waveform is quasi-square wave type having discrete values. In 120º mode the phase voltage waveform is quasi-square type.

Direct Torque Control of Induction Motor

In recent years many researchers to find out different solutions for induction motor control having the reduction of the complexity of field oriented control and the features of precise and quick torque response. [3][7].

The Direct torque control (DTC) strategy has been perceived as the basic and practical solution for accomplish this requirements.

DTC is a standout amongst the most incredible and effective control methodologies of induction motor.

This system depends on decoupled control of torque and stator flux and today it is a standout amongst the most effectively inquired about control strategies where the point is to control viably the torque and flux.

Conventional DTC scheme is a closed loop control scheme, the essential components of the control structure being: the power supply circuit, a three stage voltage source inverter, the enlistment engine, the speed controller to create the torque direction and the DTC controller.

The DTC controller again comprises of torque and flux estimation block, two hysteresis controllers and sector selection block, the output of the DTC controller is the gating pulses for the inverter.

The DTC scheme does not require coordinate transformation as all the control methodology is completed in stationary frame of reference.

So this scheme does not suffer from parameter variations to the degree that other control methods do.

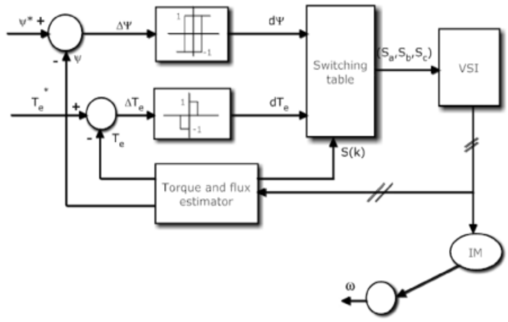

Figure 4: DTC Scheme of IM Drive

Also there is no feedback current control loop due to which the control actions not suffer from the delays inherent in the current controllers, no pulse width modulator, no PI controllers, and no rotor speed or position sensor. So, it is a sensor less control procedure which works the motor without requiring a shaft mounted mechanical sensor. Here on-line torque and flux estimators are utilized for cosing the loop. Here the torque and stator flux are controlled directly by utilizing hysteresis comparators. Fig.4 shows the basic block diagram of conventional DTC scheme [8] [10].

IV. PRINCIPLE OF DTC SCHEME

The essential standard of DTC is to directly choose stator voltage vectors as indicated by the torque and fux errors which are the contrasts between the references of torque and stator flux linkage and their actual values.

The governing equation for torque for this scheme is because of the cooperation of stator and rotor fields.

Torque and stator motion linkage are processed from estimated motor terminal quantities i.e. stator voltages and current. An ideal voltage vector for the exchanging of VSI is chosen among the six nonzero voltage vectors and two zero voltage vectors by the hysteresis control of stator motion and torque.

As we know from the previous chapter that a three-phase VSI has eight possible combinations of six switching devices which is shown in fig.6.

The six switches have a very much characterized state: ON or OFF in every arrangement. So all the possible configurations can be related to three bits (Sa, Sb, Sc), one for every inverter leg [17]. The bit is set to 1 if the top switch is shut and to 0 when the base switch is shut. So as to avoid short circuit of the supply, the condition of the upper switch is constantly inverse to that of the lower one.

V. SIMULATION MODELS, RESULTS AND DISCUSSIONS

The performance of the motor is first checked out for no load condition and then the load torque of 2Nm is applied and performance characteristics are drawn. The specification of the IM used is 1.5KW, 1440 rpm, 4 pole, 3-phase with parameters: Rs = 7.83 ohm, Rr= 7.55 ohm, Ls= Lr = 0.4751 H, Lm= 0.4535 H, J= 0.06 Kg.m2, B= 0.01 Nm.sec/rad. Results for no load condition, (TL = 0),

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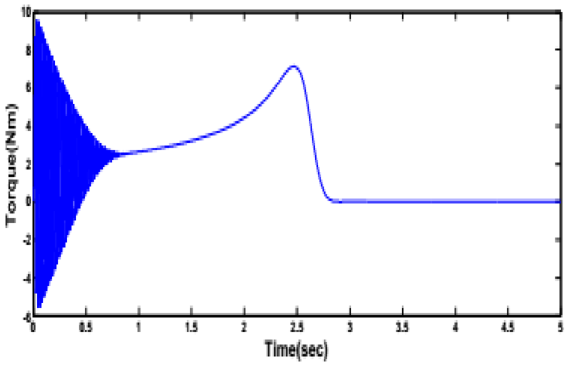

Figure 5: Electromagnetic Torque

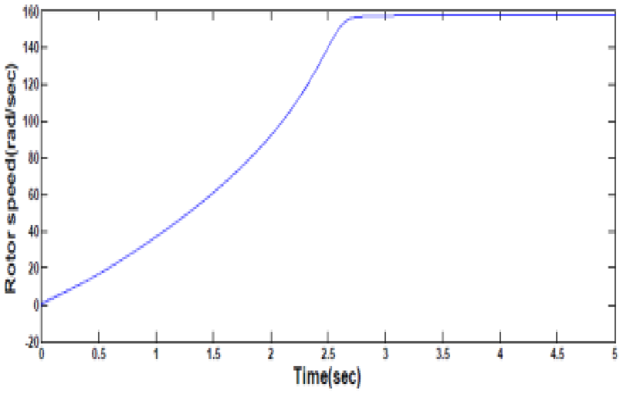

Figure 6: Rotor Speed

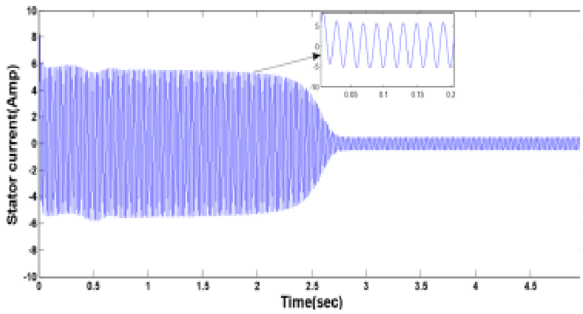

Figure 7: Stator Current

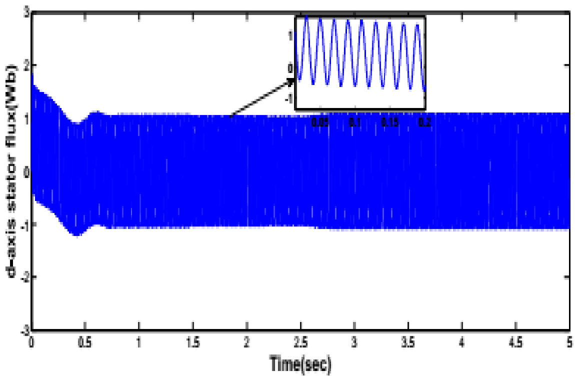

Figure 8: D Axis Staor Flux

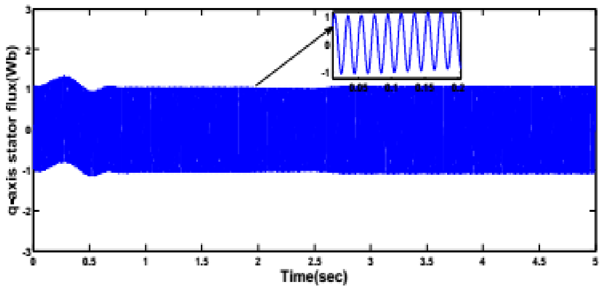

Figure 9: Q-Axis Stator Flux

For $T_L = 2$ Nm

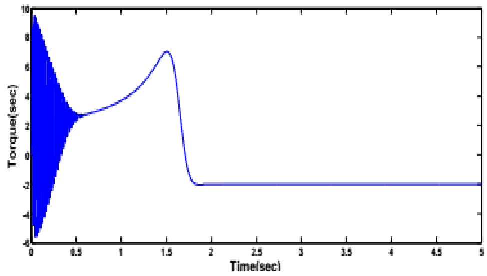

Figure 10: Torque

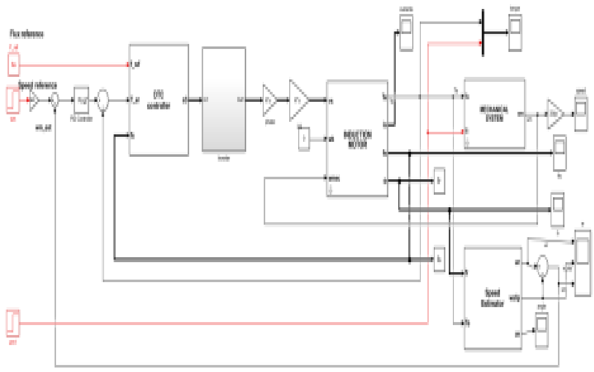

Figure 11: Simulation diagram of DTC

VI. RESULT AND DISCUSSION

The above figure gives the complete details of rotor speed of the machine. This shows the created DTC accomplished high powerful execution in speed response to changes popular torque. Nonetheless, there is some performance degradation with torque overshoot in the torque transient inferable from the hysteresis controllers utilized. Figure 8 and 9 show d and q axis stator currents.

Fig 5 and 6 show the motor electromagnetic torque and rotor speed. The torque has high initial value in the acceleration zone, increases due to load torque increment then decreases and remains constant in the deceleration zone. Fig.8 shows that at first flux increases in transient period and then it comes to steady state so that flux is maintained constant to control the torque. The q-axis stator flux varies with torque; it has high initial value in the acceleration zone then decreases and comes to steady state.

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VII. CONCLUSION

For any IM drives, Direct torque control is a standout amongst the best controllers proposed up until this point. It permits decoupled control of otor stator flux and electromagnetic torque. From the investigation it is demonstrated that, this methodology of IM control is more straightforward to execute than other vector control strategies as it doesn't require pulse width modulator and co-ordinate transformations. Be that as it may, it presents undesired torque and current ripple. DTC scheme utilizes stationary d-q reference outline with d-hub lined up with the stator axes. Stator voltage space vector characterized in this reference frame control the torque and flux. The main interfaces from this work are: In transient state, by choosing the fastest accelerating voltage vector which produces greatest slip frequency, most noteworthy torque reaction can be acquired. In steady state, the torque can be kept up consistent with little exchanging recurrence by the torque hysteresis comparator by choosing the quickening vector and the zero voltage vector then again. So as to get the ideal productivity in consistent state and the most noteworthy torque reaction in transient state in the meantime, the transition level can be naturally balanced.

On the off chance that the exchanging recurrence is very low, the control circuit makes some drift which can be compensated effectively to limit the machine parameter variety.

The estimation precision of stator flux is particularly fundamental which generally relies upon stator resistance because an error in stator flux estimation will influence the behavior of both torque and flux control loops. The torque and current ripple can be limited by utilizing space vector modulation technique.

FUTURE SCOPE OF WORK

In conventional DTC scheme, high torque ripple is produced because the selected voltage space vector is applied for the entire switching period irrespective of the magnitude of the torque error.

This torque ripple can be minimized in order to achieve a better drive performance, by varying the duty ratio of the selected voltage vector during each switching period, based on the magnitude of the torque error and position of the stator flux. This constitutes the basic of SVPWM technique. So the future work simulate DTC scheme dependent on SVPWM method and to have relative investigation of regular DTC scheme and DTC SVM scheme.

REFERENCES

1. S. Masoud Barakati,, Modeling and Controller Design of a Wind Energy Conversion System Including a Matrix Converter,2008.
2. S. Tao, “Power quality of grid-connected wind turbines with DFIG and their interaction with grid,” Ph.D. dissertation, Aalborg Univ., Aalborg, Denmark, 2004.
3. H. Wang, W. Wang and L. Bin, "Power quality analysis and system simulation on permanent magnet direct-drive wind turbine," International conference on Electrical Machines and Systems, ICEMS, Wuhan, China, 2008, pp. 866-869.
4. S.A. Papathanassiou and M.P. Papadopoulos, "Harmonic analysis in a power system with wind generation," IEEE Trans. Energy Convers, vol. 21, no. 4, pp. 2006–2016, 2006.
5. P. Tenca, A.A. Rockhill and T.A. Lipo,"Wind turbine current-source converter providing reactive power control and reduced harmonics," IEEE Trans. Energy Convers, vol. 43, no. 4, pp. 1050-1060, 2007.
6. N.S. Ting, Y. Yasa, I. Aksoy and Y. Sahin, "Comparison of SVPWM, SPWM and HCC control techniques in power control of PMSG used in wind turbine systems," Intl Conference on Electrical Machines & Power Electronics, ACEMP, Crystal Admiral, Turkey, 2015, pp. 69-74.
7. P. Ledesma, J. Usaola, and J. L. Rodr´ıguez, “Transient stability of a fixed speed wind farm,” Renewable Energy, vol. 28, no. 9, pp. 1341–1355, 2003.
8. Dr.A. Amudha, M. Siva Ramkumar , M., SivaramKrishnan “Perturb and Observe Based Photovoltaic Power Generation System For Off-Grid Using Sepic Converter” International Journal of Pure and Applied Mathematics , 114(7), pp. 619-628 , 2017 .
9. M. Siva Ramkumar, M. Sivaram Krishnan, Dr.A. Amudha “Resonant Power Converter Using GA For PV Applications” International Journal Of Electronics, Electrical And Computational System,6 (9) pp239-245 , 2017.
10. M. Siva Ramkumar, M. Sivaram Krishnan, Dr. A. Amudha “Impedance Source Inverter and Permanent Magnet Synchronous Generator For Variable Speed Wind Turbine ” International Journal of Computer & Mathematical Sciences (IJCMS) 6 (9) pp 98-105, 2017.
11. M. Siva Ramkumar “Unmanned Automated Railway Level Crossing System Using Zigbee” in International Journal of Electronics Engineering Research (IJEER) 9 (9) pp1361-1371, 2017.
12. M. Sivaram Krishnan M. Siva Ramkumar and A. Amudha “Frequency Deviation Control In Hybrid Renewable Energy System Using Fc-Uc “ in International Journal of Control Theory and Applications (IJCTA) 10 (2) pp 333-344, 2017.
13. M Siva Ram Kumar, Dr. AAmudha, R. Rajeev “Optimization For A Novel Single Switch Resonant Power Converter Using Ga To Improve Mppt Efficiency Of Pv Applications” in International Journal of Applied Engineering Research (IJAER) 11(9) pp 6485-6488, 2016. .
14. M. Sivaram Krishnan, M. Siva Ramkumar and M. Sownthara “Power Management Of Hybrid Renewable Energy System By Frequency Deviation Control” in ‘International Journal of Innovative Research in Science, Engineering and Technology’ on 3 (3) pp 763-769,2016.
15. R. Sudhakar and M. Siva Ramkumar “Boosting With SEPIC” in ‘International Journal of Engineering and Science’ 3 (4) pp 14-19,2014.
16. M. Sownthara and M. Siva Ramkumar “Wireless Communication Module To Replace Resolver Cable In Welding Robot” in International Journal of Advanced Information Science and Technology on 23(23) pp 230-235,2014.
17. M. Siva Ramkumar and M. Sivaram Krishnan “Hybrid Solar-Wind Energy System” in ‘International Journal of Advance Research in Computer Science and Management Studies’ 2(2), 2014.
18. M. Sivaram Krishnan and M. Siva Ramkumar “Power Management Of A Hybrid Solar-Wind Energy System” in ‘International Journal of Engineering Research & Technology’ 2 (1) pp1988-1992, 2014.
19. M. Sivaram Krishnan and M. Siva Ramkumar “Power Quality Analysis In Hybrid Energy Generation System” in ‘International Journal of Advance Research in Computer Science and Management Studies 2 (1) pp 188-193,2014.

20. S. Ananthanarayanan, Dr.A. Amudha, Dr.K. Balachander, M. Siva Ramkumar and D. Kavitha, "Design and Analysis of Power Quality Improvement in Distribution Side Using PCC Technique with Fuzzy Logic Control" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 844-852
21. T. Kalimuthu, M. Siva Ramkumar, Dr.A. Amudha, Dr.K. Balachander and M. Sivaram Krishnan "A High Gain Input-Parallel Output-Series DC/DC Converter with Dual Coupled-Inductors" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 818-824
22. C. Chinnusamy, Dr.G. Emayavaramban, Dr.A. Amudha, Dr.K. Balacahnder and M. Siva Ramkumar,"Transient Stability Improvement in Power System with SMES and Battery Energy Storage System" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 900-914
23. [K. Kaleeswari, Dr.K. Balachander, Dr.A. Amudha, M. Siva Ramkumar and D. Kavitha, "Analysis and Parallel Operation of Novel Bidirectional DC-DC Converter for DC Micro Grid" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 928-940
24. M. Jayaprakash, D. Kavitha, M. Siva Ramkumar, Dr.K. Balacahnder and M. Sivaram Krishnan, "Achieving Efficient and Secure Data Acquisition for Cloud-Supported Internet of Things in Grid Connected Solar, Wind and Battery Systems" Journal of Advanced Research in Dynamical and Control Systems, (12), pp 966-981
25. Gu Jialu, S. Ramkumar, G. Emayavaramban, M. Thilagaraj, V. Muneeswaran, M. Pallikonda Rajasekaran, Ahmed Faeq Hussein "Offline Analysis for Designing Electrooculograms Based Human Computer Interface Control for Paralyzed Patients" IEEE Access, 2018 , Vol.(6), pp: 79151 – 79161.
26. G.Emayavaramban, S.Ramkumar, A.Amudha, "Classification of Hand Gestures Using FFNN and TDNN Networks", International Journal of Pure and Applied Mathematics, Vol.118 (8), 27-32.
27. G Emayavaramban, A Amudha, "Identifying Hand Gestures Using SEMG for Human Machine Interaction", ARPN Journal of Engineering and Applied Sciences, Vol.11 (21), pp.12777-12785.
28. G Emayavaramban, A Amudha, "Recognition of sEMG for Prosthetic Control Using Static and Dynamic Neural Networks", International Journal of Control Theory and Applications, Vol. 9 (24), pp.205-215.
29. Xin Wan , Kezhong Zhang1, S. Ramkumar J. Deny, G. Emayavaramban , M. Siva Ramkumar And Ahmed Faeq Hussein ," A Review on Electroencephalogram Based Brain Computer Interface for Elderly Disabled" in IEEE Access, 2019 , Vol.(7), pp: 36380 – 36387.
30. Li Junwei, S. Ramkumar, G. Emayavaramban, D. Frankl n vinod, M. Thilagaraj, V. Muneeswaran, M. Pallikonda Rajasekaran, V. Venkataraman, Ahmed Faeq Hussein, IEEE Access, "Brain Computer Interface for Neurodegenerative Person Using Electroencephalogram", pp.2439 - 2452 Vol.(7), 2019.
31. Dr.A.Amudha, M.Siva Ramkumar, M.Sivaram Krishnan "DESIGN AND SIMULATION OF ZETA CONVERTER WITH ZVZCS SWITCHING TECHNIQUE" Journal of Engineering and Applied Sciences ,14(9) pp 2764-2774 (DOI: 10.3923/jeasci.2019.2764.2774
32. M. Sivaram Krishnan, S. Sri Ragavi, M. Siva RamKumar, D. Kavitha "Smart Asthma Prediction System using Internet of Things" Indian Journal of Public Health Research & Development, 10 (2) , pp 1103-1107 DOI:10.5958/0976-5506.2019.00445.5