ISSN (Online): 2456-5717

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

Performance Analysis of SRM Using Direct Torque Control

M.Vidhya [1], L.Senthilmurugan [2]
PG Scholar, Embedded System Technologies, RVS College of Engineering & Technology, Coimbatore, Tamilnadu, India. [1]
Assistant Professor, Electrical & Electronics Engineering, RVS College of Engineering & Technology, Coimbatore, Tamilnadu, India. [2]

Abstract— **Switched Reluctance Motor (SRM) is quiet attract the variable drives market by its unique characteristics such as constructional simplicity, built-up inexpensive, extensive speed variety, fault tolerance and high temperature capability. Even though it has several advantages, acoustic noise due to torque ripple is the chief reason to avoid this motor in the industrial applications. The Direct torsion management (DTC) technique will minimize the torque ripple by control torque inside nominative hysteresis band. The Direct torsion management of 4 parts 8/6 Switched Reluctance Motor fed through associate asymmetrical convertor. A four part asymmetrical convertor has total eighty one space voltage vectors. Therefore just like the typical DTC applied to ac motor, 8 space voltage vectors are sufficient to use DTC technique to SRM. The Direct torque management of SRM is simulated in MATLAB/ SIMULINK for constant torque load. The performance of the drive in the main in terms of torsion ripple is analyzed with new set of space vectors.**

Index Terms **– Speed control loop, Direct torque control, Direct torque control, Pulse width modulation, SRM drives, Torque ripple.**

I. INTRODUCTION

Switched Reluctance Motor (SRM) drives are more familiar in the variable drives market. It has been attracts by its unique characteristics such as simple arrangements, doubly salient, singly excited, speed ranges above 30,000 Revolution Per Minute (RPM), less maintenance, fault & high temperature tolerance. In SRM, though various combinations of stator pole (N_s) and rotor pole (N_r) numbers are used. The commonly used SRM motor N_s/N_r ratios are 4/2, 6/4, 8/6, 10/8 are used for 2 phase, 3 phase, 4 phase, 5 phase motor respectively [1], [2]. Its constructional view of basic 4/2 pole SRM is shown in the Fig. 1. Both the stator and rotor has salient poles but only stator has windings. The rotor has no permanent magnets and windings. The motor works on the principle of minimal reluctance. The rotor starts to rotate when the supply is given to the winding which is wound over the stator coil.

ISSN (Online): 2456-5717
International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

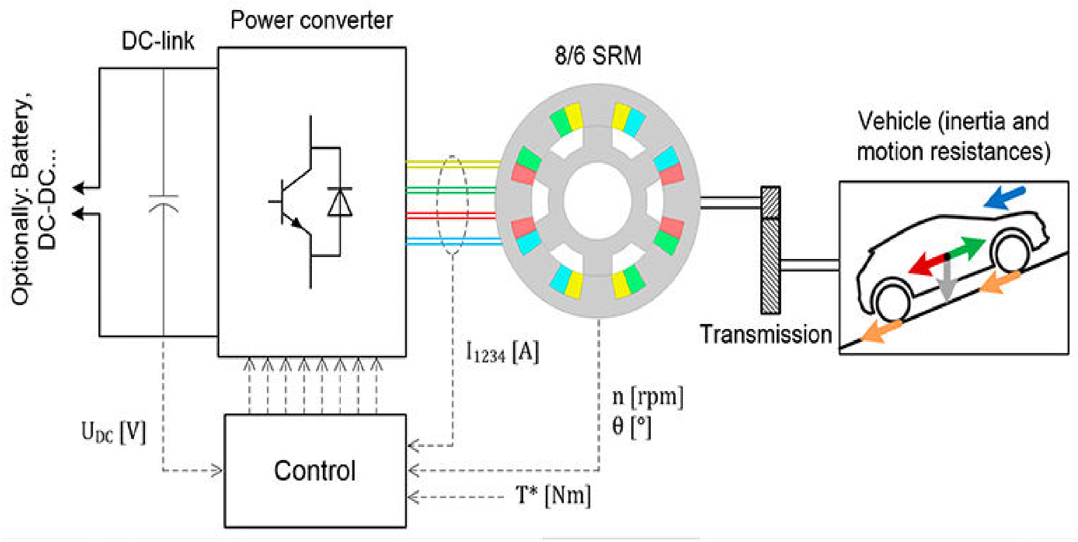

Fig.1 Constructional View of 8/6 SRM

A SRM has salient poles on each stator coil and rotor. Every stator coil pole has targeted winding. As SRM has straightforward, rugged construction, low producing value, fault tolerance capability and high potency the SRM drive is obtaining more and additional reorganization among the electrical drives. It even have some disadvantages that it needs an electronic management and shaft position sensing element and double salient structure causes noise and torque ripple. During this Figure 2 SRMs are usually designed so as to realize an honest utilization in terms of convertor rating.

In order to manage the torque, DTC theme needs torque feedback. One methodology of computing torque is by conducting the entire specifications of the SRM area unit needed. The look specifications of SRM aren't accessible or not disclosed by the manufacturer. Beneath such circumstances it's troublesome to reason torque as operate of current and position. Alternately, the torque is computed by Simplified torque Equation.

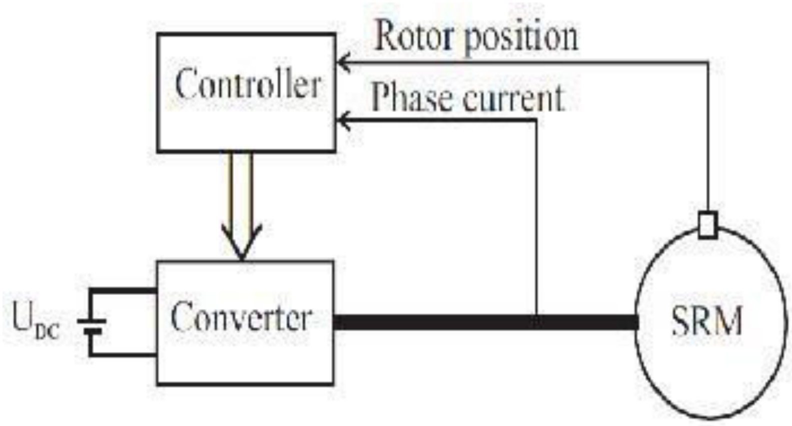

Fig.2 Switched reluctance motor drive systems.

This paper compares the performance of DTC based 4 phases 8/6 SRM in which torque is computed from Simplified Torque Equation.

ISSN (Online): 2456-5717

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

II. PRINCIPLE OF DTC

A. Block diagram of DTC

DTC's core is that the torque management loop, wherever a complicated adjective motor model applies advanced mathematical algorithms to predict motor standing. Primary controlled variables stator flux and motor torque are accurately calculable by the motor model exploitation inputs of motor part currents and DC bus voltage measurements, and the states of the ability change transistors within the drive. DTC seeks to manage motor flux and torque directly, rather than making an attempt to manage these variables indirectly like DC drives and vector-controlled AC drives do. Separate force associated speed management loops structure the total DTC system however work along in an integrated manner. The final diagram of DTC primarily based SRM drive system is shown in the Fig.3.

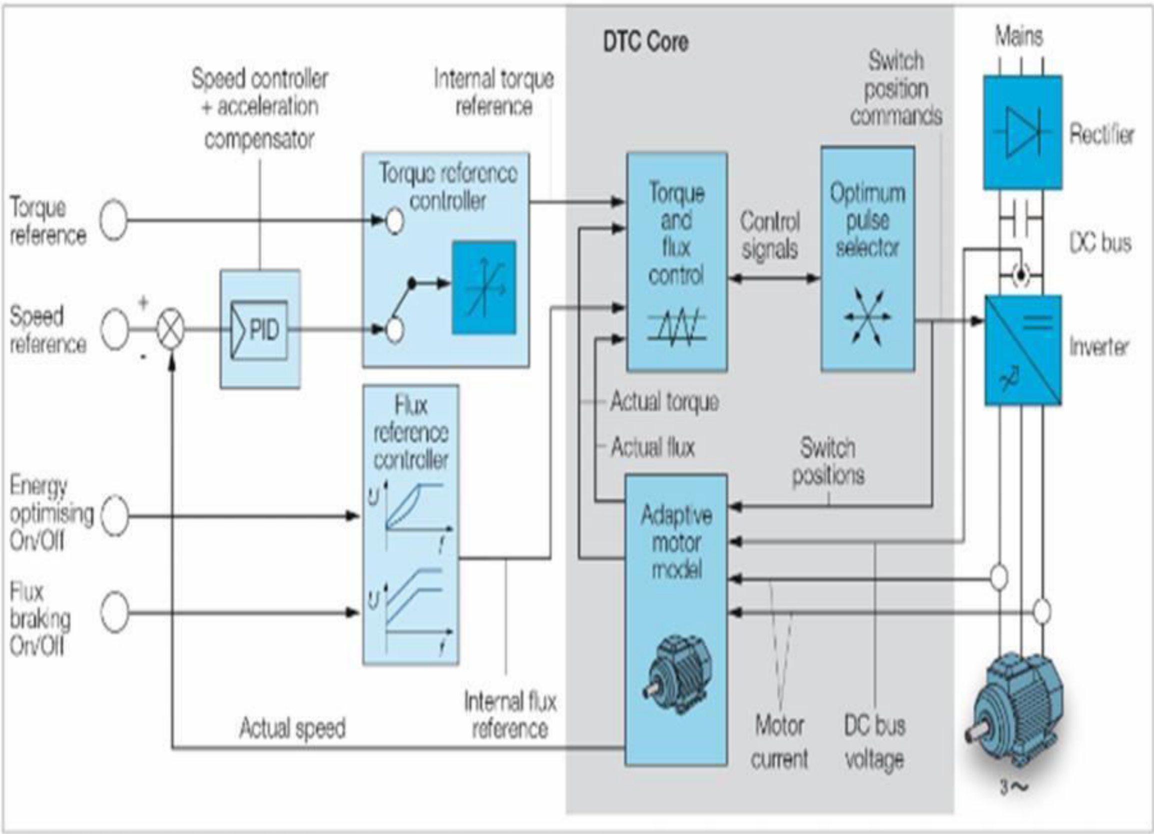

Fig.3 General Block Diagram of DTC based SRM motor

The motor model also calculates shaft speed. Temperature compensation helps to enhance calculation accuracy without an encoder.

B. Mathematical Model of SRM

The mathematical model of the SRM is inconsistency over an entire operative region. The parameters utilized in SRM are dynamical unendingly as a result of its extremely non-linear characteristics. The SRM motor is analysis with general mathematical equations [8].

The phase voltage can be written as

$$V = iR + \frac{d\lambda}{dt} \qquad (1)$$

where, V is the DC bus voltage , i is the phase current, R is the resistance in the phase winding, iR is the ohmic drop and λ is the flux linkage.

The inductance of the SRM is changing continuously w.r.to the position of the rotor. The inductance profile of SRM is shown in the Fig. 3.

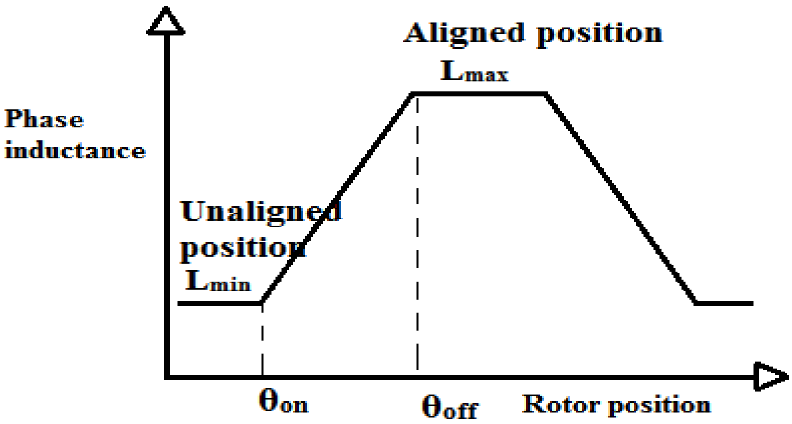

Fig.4 Inductance profile of SRM

The rate of change of magnetic energy can be obtained by multiply current, i in the above equation and it can be written as

$$Vi = i^2R + Li\frac{di}{dt} + i^2\omega\frac{dL}{d\theta} \qquad (2)$$

The magnetic energy stored can be written as

$$Wmag = \frac{1}{2}Li^2 \qquad (3)$$

$$\frac{dWmag}{dt} = \frac{d}{dt}\left(\frac{1}{2}Li^2\right) \qquad (4)$$

The instantaneous torque T is the ratio of mechanical output power (P_{mech}) to the rotor speed (ω) and is given as

$$T = \frac{1}{2}i^2\frac{dL}{d\theta} \qquad (5)$$

From the above equation,

T α square of the current & change in inductance,

T α 1 / change in the rotor speed.

III. SIMULATION & ANALYSIS

A. MATLAB Simulation

The simulation of the proposed error investigation system consists of ac source, uncontrolled rectifier, dc link filter, speed controller, gate triggering circuit, power converter, phase

ISSN (Online): 2456-5717

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

activation & position sensing block and SRM. The simulation circuit of SRM under healthy condition is shown in the fig. 5.

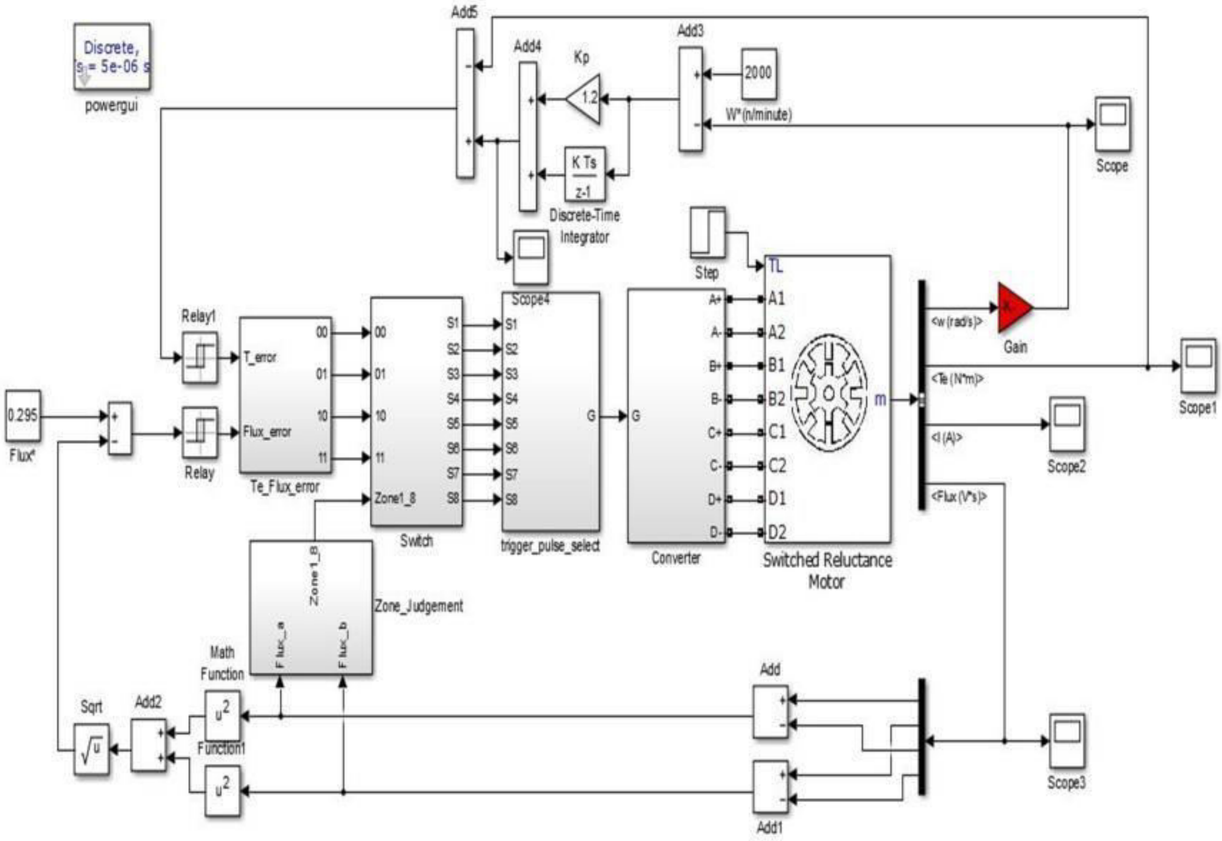

Fig.5 Simulation circuit of 8/6 SRM with DTC

The reference flux is set at 0.25 Wb and flux hysteresis band is set at 0.02 Wb. The reference torque is set at 8 Nm and the torque hysteresis band is set at 0.40 Nm.The DTC based SRM drive is analyzed for a Fan load of 8 Nm and at a reference speed of 800 rpm the simulation waveforms of the drive with DTC technique. The magnitude of the stator flux vector. The flux is maintained at the reference value of 0.25 Wb by following a hysteresis band of 0.020 Wb. The phase activation blocks consists of turn on and turn off angle. The calculation of turn on & turn off angle is given below.

- ✓ Turn on angle,α $= \frac{\pi}{N_r}$ (degree)
- ✓ Turn off angle,β = α + $\frac{2\pi}{q*N_r}$ (degree)
- ✓ Mod input angle = 2α (degree)

Where,

N_r = Number of rotor poles,

q = Number of phases.

Calculation:

i)For 3Φ, α $= \frac{\pi}{4} = 45^0$ & β $= 45^0 + \frac{2\pi}{3*4} = 75^0$

ii)For 5Φ, $\alpha=\frac{\pi}{8}=22.5^0$ & $\beta=22.5^0+\frac{2\pi}{5*8}=31.5^0$

TABLE - I PARAMETERS USED IN THE SIMULATIONS

Motor Specifications	Value
Number of stator poles	8
Number of rotor poles	6
Number of phases	3
Aligned Inductance(mH)	23.6
Unaligned Inductance(mH)	0.67
Input Voltage	230V
Maximum flux linkages(wb)	0.486

B. Results & Analysis:

The simulation result for the SRM using model predictive control is shown. The MATLAB / Simulink tool is used to simulate the results. The building blocks are designed in Simulink. This tool is used to analyze the speed, current and electromagnetic torque.

I. Current Characteristics

The area under the current-time discharge graph gives the charge held by the capacitor. The gradient of the charge-time graph gives the current flowing from the capacitor at that moment as shown in the Figure

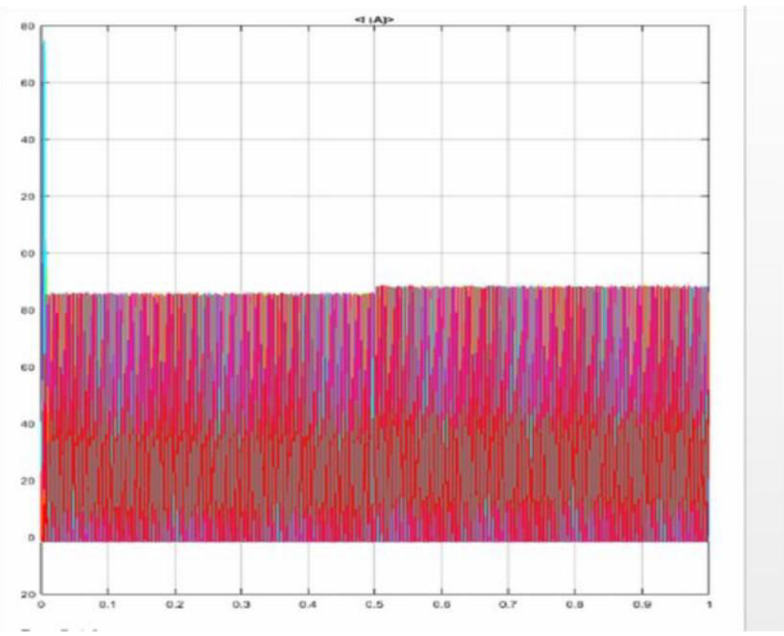

Fig.6 Current vs. Time

ISSN (Online): 2456-5717

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

II. Speed Characteristics

The principle is that the slope of the line on a speed-time graph reveals useful information about the acceleration of the object. If the acceleration is zero, then the slope is zero (i.e., a horizontal line). If the acceleration is positive, then the slope is positive (i.e., an upward sloping line). The figure shows the speed vs time graph as follows.

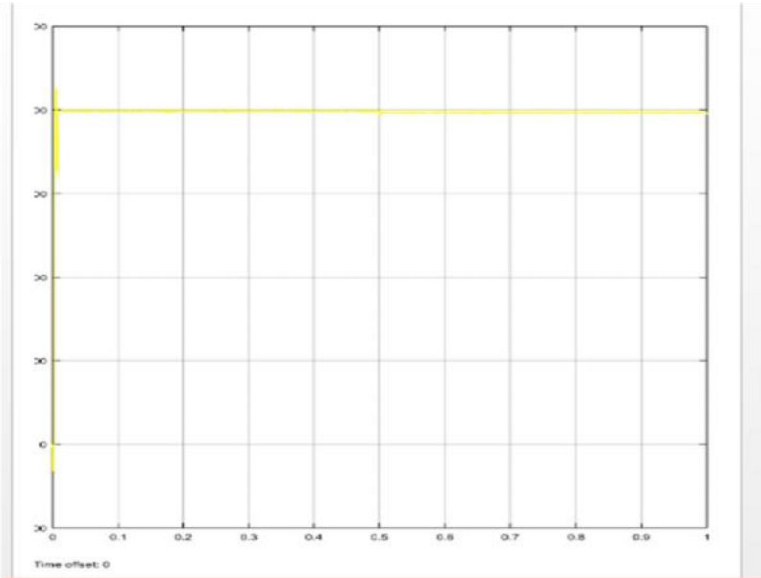

Fig.7 Speed vs. Time

III. Torque Characteristics

The area under the Torque-time discharge graph gives the charge held by the capacitor. The gradient of the charge-time graph gives the torque flowing from the capacitor at that moment as shown in the Figure.

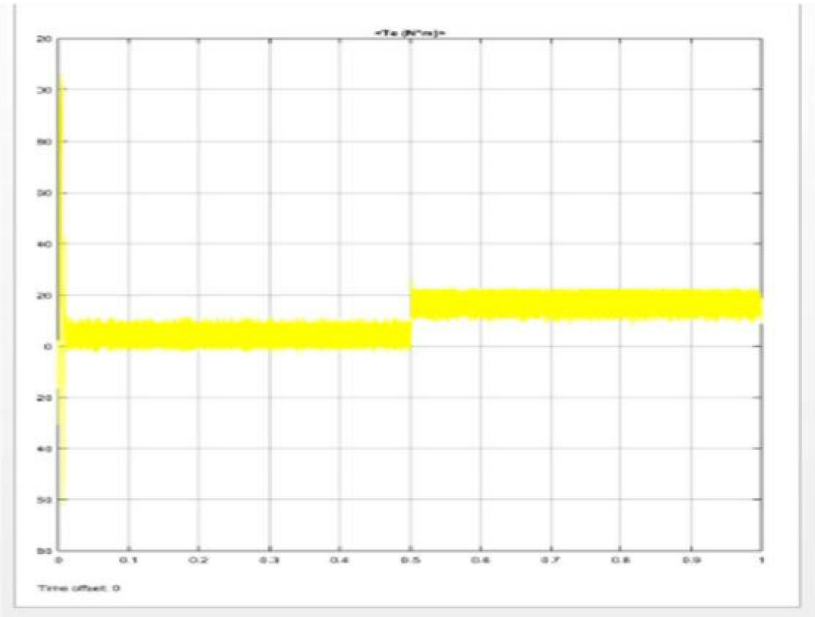

Fig.8 Torque vs. Time

ISSN (Online): 2456-5717

International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)
Vol.3, Issue.3, March 2017

IV. CONCLUSION

The proposed control of 4 phases 8/6 SRM is analyzed with Direct Torque Control technique. The torque is controlled directly through the control of magnitude of the flux linkage and the change in speed of the stator flux vector. The performance of direct torque controlled SRM drive is analyzed by selecting a suitable set of 8 Space voltage vectors for constant load torque. It is observed that torque is maintained within set hysteresis band of 10% of rated torque during acceleration and in the steady state. The torque ripple is 10% in the steady state. A further study can be made on the reduction of phase current variations by maintaining the torque and flux within their respective bands.

REFERENCES

[1] T. J. E. Miller, "Converter Volt-Ampere Requirements of The Switched Reluctance Motor Drives," in conf. Record IEEE-IAS Ann.Meeting, Oct.1984, pp.813-819.

[2] P. Jinupun and P. C. K. Luk, "Direct torque control for sensorless switched reluctance motor drives," in Proc. 7th Int. Conf. Power Electronics & Variable Speed Drives, 1998, pp. 329–334.

[3] D. Cheok and Y. Fukuda, "A new torque and flux control method for switched reluctance motor drives," IEEE Trans. Power Electronics, Vol. 17, No. 4, pp. 543–557, Jul. 2002.

[4] Guang Feng, Yan-Fei Liu, and Lipei Huang" A New Robust Algorithm to Improve the Dynamic Performance on the Speed Control of Induction Motor Drive "IEEE transactions on power electronics, Vol. 19, No. 6, November 2004.

[5] Y. X. Su, C. H. Zheng, and B. Y. Duan" Automatic Disturbances Rejection Controller for Precise Motion Control of Permanent Magnet Synchronous Motors "IEEE Transactions on industrial electronics, Vol. 52, No. 3, June 2005.

[6] H. Jeong, K. Y. Lee, J. D. Na, G. B. Cho and H. L. Baek , "Direct torque control for the 4-phase switched reluctance motor drives," in Proc. IEEE Int. Conf. Electrical Machines and Systems, ICEMS, September 2005, pp.524-528.

[7] H. J. Guo, "Considerations of direct torque control for switched reluctance motors," in Proc. IEEE Int. Symposium on Industrial Electronics, ISIE 2006, Jul. 2006, pp.2321–2325.

[8] R. Jeyabharath, P. Veena, and M. Rajaram, "A Novel DTC strategy of torque and flux control for switched reluctance motor drive," in Proc. IEEE Int. Conf. Power Electronics, Drives and Energy Systems, PEDES, December 2006, pp. 1–5.

[9] P. Cortes, J. Rodriguez, P. Antoniewicz, and M. Kazmierkowski, "Direct power control of an AFE using predictive control," IEEE Trans. Power Electron., Vol. 23, Nso. 5, pp. 2516– 2523, Sep. 2008.

[10] Guiying Song, Zhida Li, Zhenghan Zhao and Xiang Wang, "Direct torque control of switched reluctance motors," in Proc. IEEE Int. Conf.Electrical Machines and Systems, ICEMS 2008, Oct. 2008, pp. 3389-3392.

[11] P. Srinivas, P. V. N. Prasad, "Direct torque control of 4 phase 8/6 switched reluctance motor drive for constant torque load," World Journal of Modeling and Simulation (WJMS) , Vol. 8, No.3, pp 185-195, 2012

AUTHOR'S BIOGRAPHY

M.VIDHYA received her B.E (Electrical and Electronics Engineering) degree from Dr. Mahalingam College of Engineering and Technology, Pollachi , India in 2014 and currently pursuing her M.E (Electrical Drives and Embedded Control) degree in RVS College of Engineering and Technology. Her area of interest is Electrical machine, renewable energy and embedded systems.

L.Senthilmurugan received the B.E degree in EEE from Park College of Engineering, Coimbatore, India, in 2006, and the M.E degree in Embedded System Technologies from Anna University Coimbatore, India, in 2009. He is currently working as an Assistant Professor with Department of EEE. He is pursuing his PhD degree at Anna University Chennai, India. His current interest include embedded system, electric drives and control.