International Journal of Interdisciplinary Innovative Research &Development (IJIIRD)
ISSN: 2456-236X
Vol. 05 Special Issue 01 | 2020

Direct Torque Control of Induction Motor Using Space Vector Modulation (SVM-DTC)

Santosh D. Jadhao[1], Prof. J. O. Chandle[2], Amol Game[3], Mukesh S. Bobade[4]

[1] M Tech Student, Department of Elecrical Engg , VJTI, Mumbai, Maharashtra, India
[2] Associate Proffesor, , Department of Elecrical Engg , VJTI, Mumbai, Maharashtra, India
[3] Asst. Proffesor, Department of Elecrical Engg, K.K. Wagh College of Engineering Nashik , Maharashtra, India
[4] Asst. Proffesor, Department of Elecrical Engg , P. R. Patil College of Engineering Amravati, , Maharashtra, India

ABSTRACT

This paper, direct torque control (DTC) of induction motor is studied based on space vector modulation (SVM) technique. DTC is a method for controlling machine with utilizing its torque and fluxes of motor to be controlled. The torque and current ripples are occurred in the normal DTC. Reason for unnecessary torque and current ripple is low number of voltage vectors applied to the induction motor controlled by the conventional DTC technique. SVMDTC is a technique which is used to reduce the ripple. SVM techniques has several advantages that are offering better DC bus utilization, lowers a torque ripple, lower total harmonic distortion(THD)in the AC motor current, lower switching loss, and easier to implement in the digital systems. Simulation results shows the comparision of conventional DTC over SVMDTC. Results with improved DTC is presented. Result shows that the torque, flux produced and stator current ripple are decreased with the improved DTC. Also power factor and efficiency got improved using Space vector modulation (SVM) technique.

Keyword : - DTC, Converter , Switching Table, Hysteresis Comparator , SVM technique.

1. INTRODUCTION

Induction motors are one of the electric machines are mostly used in industry. Its speed regulation in general can use the terminal voltage changes and frequency settings [1]. Induction motor a speed setting more difficult when using a DC motor, since the resulted of flux and torque has been related or not free. The factors that led to the induction motor control becomes more tough and complex [2]. Vector control separates flux and rotor, this its setting is as well as DC motor [3].

There are many IMs used in a number of industrial, commercial and domestic applications of variable speed drives. Since IMs requires well control performances: precise and quick torque and flux response, high starting torque at low speed, wide speed range, the drive control system is the most sensitive point of Induction motors [1]. DTC is method to control machine with utilizing torque and flux of motor to be controlled. The conventional DTC scheme consists of two comparators having different features, switching table, Voltage Source Inverter (VSI), flux and torque estimation block and IM.

Every control method has some advantages and disadvantages, This DTC method has too. Some of advantages are lower parameters dependency and making the system more robust , easier implements and the disadvantages are difficult to control flux and torque at minimum speed, current and torque distortion while the change of the sector in d-q plane, variable switching frequency and a high sampling frequency needed for digital implementation of the hysteresis controllers and high torque ripple. The torque ripple generates noise and vibrations, causes errors in sensorless motor drives, and associated current ripples are in turn responsible for the EMI. The reasons of the high current and torque ripple in DTC is the presence of hysteresis comparators together the limited number of available voltage vectors [2].

1.1 Control Method

DTC method has been first proposed for induction machines.DTC technique introduced by Takahashi and Noguchi [1] for low and medium power application and DTC technique introduced by Depenbrock [6] for high power application are popular in industry. DTC strategy is quite different from that of the field orientation control (FOC) or vector control, which does not need complicated coordination transformations and decoupling calculation [1]. The basic model of the conventional DTC induction motor scheme is shown in Figure 1. Two stator currents (iSA and iSB) and DC-bus voltage VDC are sampled. d-q components of stator voltage and current space vectors in the stationary reference frame and also magnitude of the stator flux and electric torque are calculated as shown below [3].

1.2 Formulation-2

The necessary formula for torque voltage and speed required is given below

$$V_{sd} = \frac{2}{3} V_{dc} (S_A - \frac{S_B + S_C}{2}) \quad (1)$$

$$V_{sq} = \frac{1}{\sqrt{3}} V_{dc} (S_A - S_C) \quad (2)$$

$$i_{sd} = i_{SA} \quad (3)$$

$$i_{sq} = \frac{i_{SA} + 2i_{SB}}{\sqrt{3}} \quad (4)$$

$$|\psi_s| = \sqrt{\psi^2_{sd} + \psi^2_{sq}} \quad (5)$$

$$T_e = \frac{3}{2} P(\psi_{sd} i_{sq} - \psi_{sq} i_{sd}) \quad (6)$$

$$\psi_{sd} = \int (V_{sd} - R_s i_{sd}) dt \quad (7)$$

$$\psi_{sq} = \int (V_{sq} - R_s i_{sq}) dt \quad (8)$$

2. BLOCK DIAGRAM

The magnitude of stator flux and electric torque calculated compared with their reference values in the hysteresis comparators shown in Figure 2 and then the outputs of the comparators are fed to a switching table to select an appropriate inverter voltage vector.

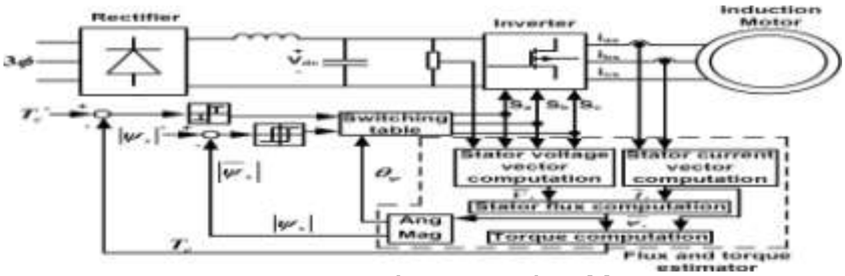


Figure 1. Basic DTC induction motor scheme [3].

2.1 Switching Table

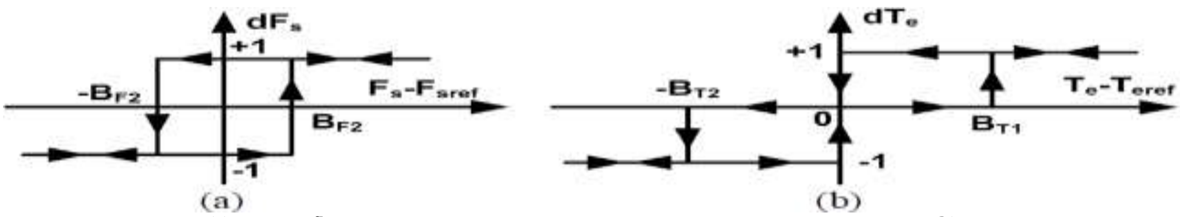
The switching table shown as Table I based on the position of the stator flux and the required changes in stator flux magnitude and torque related your research work.

Table -1 Switching Table

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)

2.2 Hysteresis Comparator and Vector Control

The selected voltage vector will be applied to the induction motor at the end of the sample time. In VSI, there are six equally spaced voltage vectors having the same amplitude and two zero voltage vectors. VSI voltage vectors are shown in Figure 3.



(a) Stator flux (b) Torque.

Figure 2. Hysteresis comparator

2.3 Vector Control

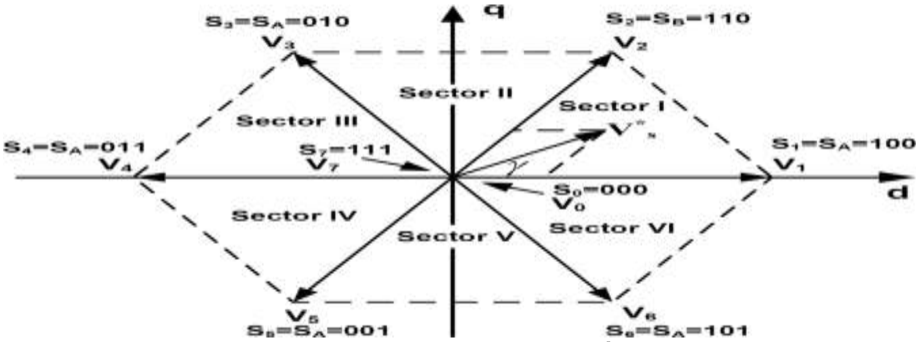


Figure 3. Sectorwise Vector Control

2.4 SVM Technique

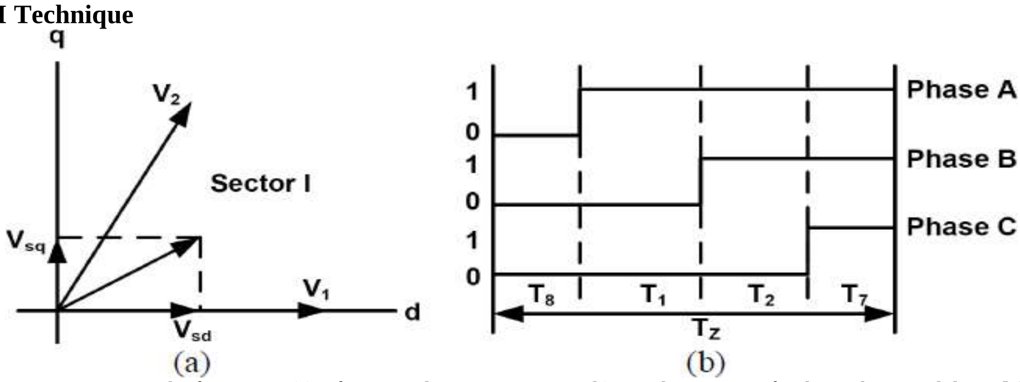


Figure 4. SVM in the first sector (a) reference voltage vector sector (b) switching pattern for three-phase modulation[3]

3. RESULTS

The simulation results of Convational DTC and with Space vector Modulation technique is obtained using MATLAB.

3.1 Results with Conventional DTC

Fig :1 (a) Speed response of Motor

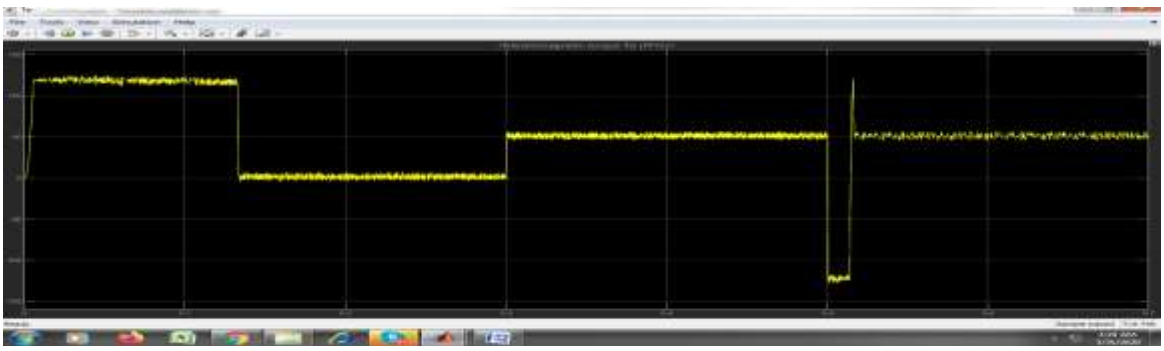


Fig :1 (b) Torque response of Motor

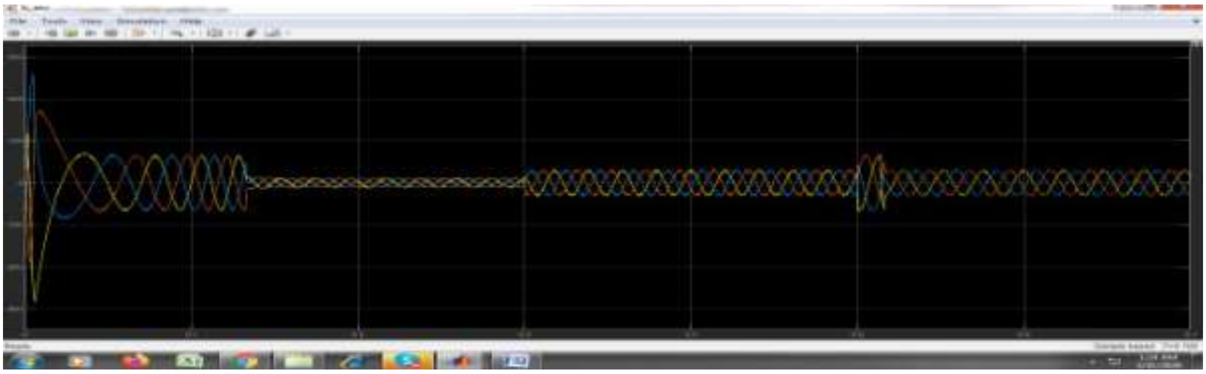


Fig :1 (c) Stator Current response of Motor

3.1 Results with DTC-SVM

The simulation results of DTC with Space vector Modulation technique is obtained using MATLAB.

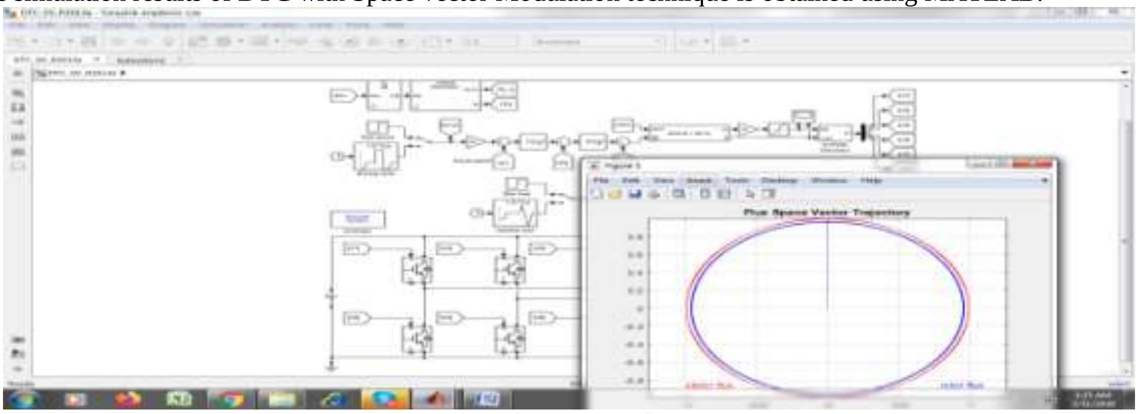


Fig :1 (a) flux response of Motor

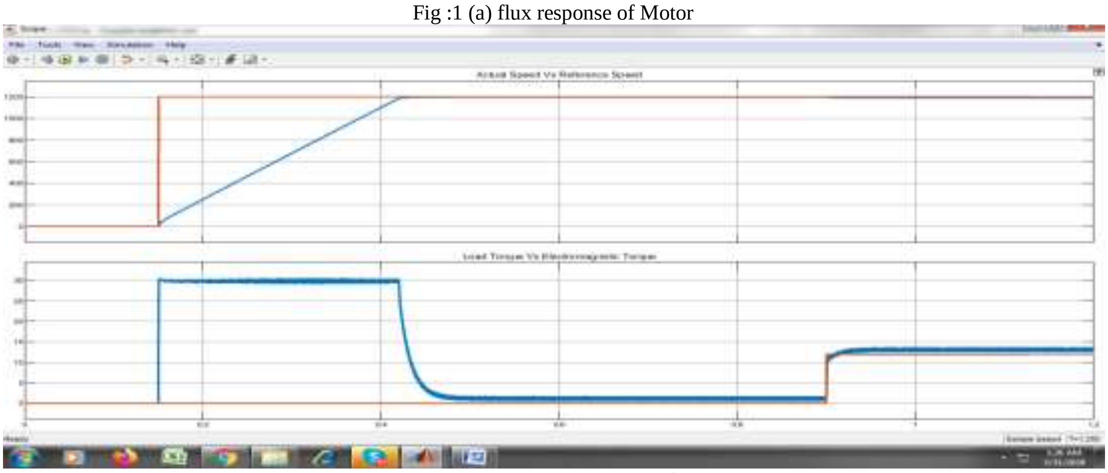


Fig :1 (b) Speed and load torque of motor

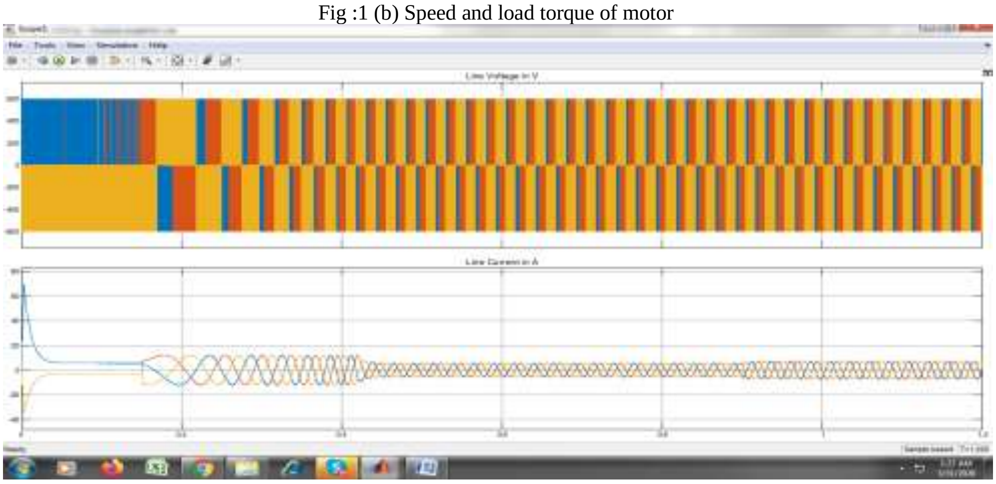


Fig :1 (c) Line voltage and line current of motor

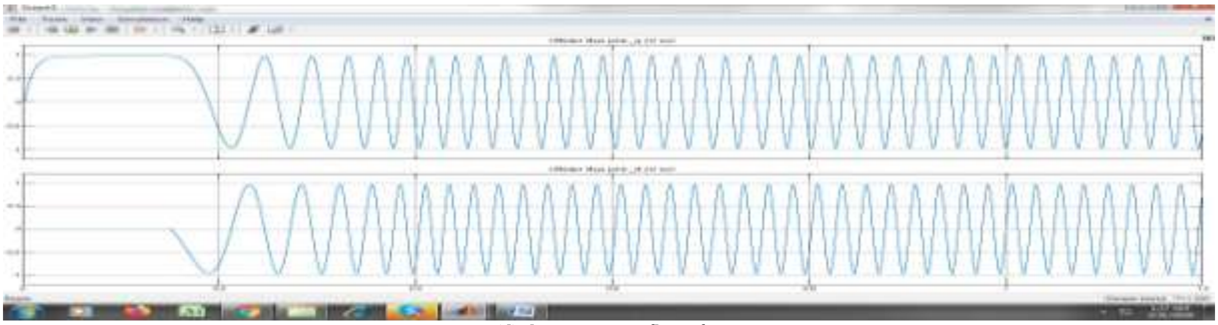


Fig :1 (d) d-q axix rotor flux of Motor

4. CONCLUSIONS

In Conventional DTC, as the torque ripple is maintained within hysteresis band, switching frequency changes with speed. Moreover, the torque ripple is important problem at low speed. So using constant switching frequency a desired torque ripple is achieved at less speed where it really matters. The torque ripple for this SVM- DTC is significantly improved and switching frequency is maintained constant. Numerical simulations have been carried out showing the advantages of the SVM-DTC method with respect to the conventional DTC.

5. ACKNOWLEDGEMENT

The author is specially acknowledge to Prof. J. O. Chandle , VJTI, Mumbai for valuable guidance in entire work and also to motivate at different levels of project.

6. REFERENCES

[1]. Takahashi, I. and Noguchi, T., 1986. A new quick-response and high-efficiency control strategy of an induction motor. IEEE Transactions on Industry applications, (5), pp.820-827.
[2] Tang, L. and Rahman, M.F., 2001, June. A new direct torque control strategy for flux and torque ripple reduction for induction motors drive by using space vector modulation. In 2001 IEEE 32nd Annual Power Electronics Specialists Conference (IEEE Cat. No. 01CH37230) (Vol. 3, pp. 1440-1445). IEEE.
[3] Ozkop, E. and Okumus, H.I., 2008, March. Direct torque control of induction motor using space vector modulation (SVM-DTC). In 2008 12th International Middle-East Power System Conference (pp. 368-372). IEEE.
[4] Purnata, H., Rameli, M. and Effendie, A.R., 2017, August. Speed control of three phase induction motor using method hysteresis space vector pulse width modulation. In 2017 International Seminar on Intelligent Technology and Its Applications (ISITIA) (pp. 199-204). IEEE.
[5] B.K.Bose. 1997. Power Electronics and Variable Frequency Drives. IEEE Press, New York.
[6] www.mathworks.com