Abstract: Direct Torque Control is a control technique used in AC drive systems to obtain high performance torque control. The conventional DTC drive contains a pair of hysteresis comparators, a flux and torque estimator and a voltage vector selection table. The torque and flux are controlled simultaneously by applying suitable voltage vectors, and by limiting these quantities within their hysteresis bands, decoupled control of torque and flux can be achieved. However, as with other hysteresis-based systems, DTC drives utilizing hysteresis comparators suffer from high torque ripple and variable switching frequency.

The most common solution to this problem is to use the space vectors of multilevel inverter, which depends on the reference torque and flux. The reference voltage vector is then realized using a voltage vector modulator. Several variations of DTC-SVM with multilevel inverter have been proposed and discussed in the literature. The work of this project is to study, evaluate and compare the various techniques of DTC-SVM with parallel inverter applied to the induction machines through simulations. The simulations were carried out using MATLAB/SIMULINK simulation package. Evaluation was made based on the drive performance, which includes dynamic torque and flux responses, feasibility and the complexity of the systems. It is better technology for electric vehicles.

Key words: Multilevel inverter, DTC-SVM, converter, electric vehicles, reliability, SVPWM, 3 level H-Bridge inverter.

1. INTRODUCTION

Multilevel inverters have been developed to overcome harmonics in output, and improve the shape of output to reach sinusoidal waveform. By using PWM inverters have been developed to overcome shortcomings in solid-state switching device ratings.

In this paper we give detail model of multilevel inverter applications in ac drives and give DTC-SVM of induction motor with three level H-Bridge inverter and their results are compare with classical model or DTC-SVM of induction motor with simple inverter.

2. MULTILEVEL INVERTER FOR DTC-SVM OF INDUCTION MOTOR

Induction motor torque control has traditionally been achieved using Field Oriented Control (FOC). This involves the transformation of stator currents into asynchronously rotating d-q reference frame that is typically aligned to the rotor flux. In this reference frame, the torque and flux producing components of the stator current are decoupled. A PI controller is then used to regulate the output voltage to achieve the desired stator current and therefore torque. This PI controller limits the transient response of the torque controller.

Direct Torque Control (DTC) uses an induction motor model to achieve a desired output torque. By using only current and voltage measurements, it is possible to estimate the instantaneous stator flux and output torque. An induction motor model is then used to predict the voltage required to drive the flux and torque to demanded values within a fixed time period. This calculated voltage is then synthesized using space vector modulation (SVM).

The stator flux vector, and the torque produced by the motor, $T_{em}$, can be estimated using the previously applied voltage vector, measured stator current, and stator resistance.

As shown in Fig 1, the voltage required to drive the error in the torque and flux to zero is calculated directly. The calculated voltage is then synthesized using Space Vector Modulation. If the inverter is not capable of generating the required voltage then the voltage vector which will drive the torque and flux towards the demand value is chosen and held for the complete cycle.

![Fig1. DTC-SVM of IM drive with 3level inverter.](image)
3. SIMULATION RESULTS

Fig. 6.a diagram of general DTC and fig 6.b diagram of DTC-SVM with three level H-Bridge inverter using SIMULINK/MATLAB

Fig. 7 (a) and (b) show the simulation results for load
stator currents for general and DTC-SVM with three level H-Bridge inverter respectively for a reference speed of 1440 rpm. As shown, reduces steady-state ripple in stator current.

Fig. 7 Simulation results for stator current of (a) general DTC (b) DTC-SVM with three level H-Bridge inverter for 1440 rpm

Fig. 8 (a) and (b) show the stator flux response for general and DTC-SVM with three level H-Bridge inverter respectively for a reference speed of 1440 rpm. The classical DTC uses a constant flux command of 0.742 Wb, whereas SVM method uses an optimized value, which is 0.989 Wb. The SVM method reduces the flux ripple to a considerable lower mount.

Fig. 9 (a) and (b) show the 3-phase stator current for general and DTC-SVM with three level H-Bridge inverter respectively for a reference speed of 1440 rpm. An on load torque applied at 2 second. The enlarged view of Fig. 9 (a) and (b) at a torque load condition is presented. The proposed method (DTC-SVM with three level inverter) is able to reduce ripples in 3-phase stator current as well.

Fig. 10 (a) and (b) Show the speed for general and DTC-SVM with three level H-Bridge inverter respectively for a reference speed of 1440 rpm. It is observed that, the transient and steady state ripples are less in DTC-SVM.
Fig. 10 Simulation results for Speed of (a) general DTC (b) DTC-SVM with three level H-Bridge inverter for 1440 rpm.

Fig. 11 (a) and (b) Show the 3-phase output voltages for general and DTC-SVM with three level H-Bridge inverter respectively for a reference speed of 1440 rpm. It is observed that, in on load condition the output voltage ripples are reduced in DTC-SVM.

Fig. 12 (a) and (b) show stator flux trajectory for general and DTC-SVM with three level H-Bridge inverter respectively for a reference speed of 1440 rpm. The smoother flux trajectory for the proposed one confirms the ripple reduction in torque, flux, stator current and speed response.

Fig. 12 (c) and (d) show electric torque response for general and DTC-SVM with three level H-Bridge inverter respectively a reference speed of 1440 rpm. A step change in load torque from 20 N-m to 5 N-m is applied at 1.5 second. In addition to the inherent disadvantages of general DTC, the constant reference...
flux causes higher ripple at lower torque level. The proposed (DTC-SVM with three level H-Bridge) method causes lower ripple at lower torque level. In addition to the torque ripple minimization (~1/12th), this method is also able to eliminate the torque under-shoot and over-shoots.

Fig (c)

Fig (d) Simulation results for torque response of (a) & (c) general DTC, (b) & (d) DTC-SVM with 3 level H-Bridge inverter for 1440 rpm.

3- Level H-Bridge inverter

Fig 14.1: phase voltage of 3 level inverter (mi=1; mf=21; Ar=1). THD is 49.46%

Fig 14.2: line voltage of 3 level inverter (mi=1; mf=21; Ar=1).

4 CONCLUSION

This technology is better for multilevel inverter from construction and life time point of view, and also low THD values.

This paper has proposed a DTC-SVM control method with a three-level inverter for induction motor. It operates the three-level inverter effectively as a two-level inverter. This allows for a significant reduction in the rating requirements of the clamping diodes, which would result in a lower cost implementation of this topology. The paper also extends the parallel topology to the use of a charge pump circuit as a method to obtain the required independently referenced gate drive power supplies. This charge pump circuit eliminates the need for individual power transformers for each of the gate drive supplies which significantly reduces the cost and size of these required supplies. With these proposed methods, a low power motor drive was constructed using inexpensive high-volume low-voltage power MOSFETs and other low cost discrete components. Thus the paper demonstrates the possibility of basing a low power motor drive around inexpensive power MOSFET switches that previously could not be used due to voltage limitations. While the proposed converter was constructed using discrete power devices, it should be noted that the two-level control principle and four-level charge pump make this topology attractive for integration into a single device package much like a standard six-pack arrangement. With the lower voltage rating requirement of the main switches, and the familiar and standard two-level control principles, this topology could become even more economical than a standard two-level inverter depending on what future device dies are developed and manufactured. This is important since
the trend of integration into standard packages and automated manufacturing focus attention on performance and total cost while making the actual topology inside the package of lesser importance.

REFERENCES


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