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Research Article

An Advance Dtc-Svm Scheme For Speed Control Of Vsi Fed Induction Motor Using Fuzzy Logic Controller

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ABSTRACT

This paper presents an advanced Direct Torque Control-Space Vector Modulation (DTC-SVM) scheme enhanced with a Fuzzy Logic Controller (FLC) for precise speed control of Voltage Source Inverter (VSI) fed Induction Motors (IM). The proposed system combines the benefits of DTC's rapid torque response and SVM's improved voltage waveform quality, optimizing the performance of induction motors in various applications. In the conventional DTC-SVM approach, a fixed switching frequency is used, which can result in higher losses and harmonics. To address this limitation, our method employs FLC to adaptively adjust the switching frequency and voltage vectors based on real-time motor operating conditions. This adaptive control strategy enhances the motor's efficiency and minimizes harmonic distortions, leading to improved overall system performance. The effectiveness of the proposed scheme is evaluated through extensive simulations and experimental tests under varying load conditions. The results demonstrate superior speed control precision, reduced torque and flux ripples, and enhanced dynamic response compared to traditional DTC-SVM methods. Furthermore, the adaptive switching frequency ensures energy efficiency, reducing power losses and enabling smoother operation of the induction motor. In summary, the integration of Fuzzy Logic Control into the DTC-SVM scheme offers a robust and versatile solution for speed control of VSI-fed induction motors. This advanced control strategy can significantly benefit various industrial applications where precise speed control and energy efficiency are paramount.

Key words: Grid, Inverter, Rectifier, Filter, Direct Torque Controller, PI Controller, Fuzzy Logic Controller, Space Vector PWM.

1. Introduction.

The main forces behind the most recent improvements in electric motor control systems are the development of semiconductor power components and the rise in there is a high demand for motors with high speeds and torques. In addition to being able to meet the aforementioned requirements, these more recent components also have high switching frequencies even at extreme large voltages and currents. It is now possible to design machines that are more dependable and powerful thanks to developments pertaining to micro informatics (quick and potent microcontrollers) [1-3]. High efficiency, greatest accuracy, and affordability are requirements for industrial variable speed drive applications. Dynamic adapters are now commonly used thanks to the development of controlled power semiconductors like MOSFETs, IGBTs, and GTOs that can switch between the on (conduction) and off (blocking) states [4]. Because high power applications call for electronic components able to withstand high reverse voltage and intense currents, using a conventional two-level inverter is inappropriate [5–6]. Between 1986 and 1988, TAKAHASHI and DEPENBROCK developed direct torque control (DTC) for asynchronous machines [6–9]. This method of control establishes vector control from semiconductor switching states and takes into account the connection between the inverter and machine as a whole. Speed, a quick response to dynamic torque, and a low reliance on machine parameters are its main benefits.

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2. Induction Machine

The induction motor is a crucial component of the modern world because it provides a very efficient way to transform electrical energy into mechanical energy. Due to its dependability, toughness, and affordability, it is utilized in a variety of applications. A motor is referred to as an induction motor if an electrical energy into mechanical energy by means of electromagnetic induction. It is an AC electric motor. It was created by Nikola Tesla in the late 19th century and is still widely used today for a variety of purposes.The basic components of an induction motor include a stator, which is a stationary component containing a series of copper windings arranged in a specific pattern, and a rotor, which is a rotating component that is usually made of copper or aluminium.The application of an AC voltage to the stator windings causes currents to flow through the rotor, creating a rotating magnetic field. The magnetic field created by these currents interacts with the stator field to rotate the rotor. Because of their high reliability, dependability, and efficiency, induction motors are appropriate for a variety of applications. They are used in a variety of devices, such as fans, pumps, compressors, and industrial machinery, as well as in transportation systems, such as trains and electric vehicles.

3. Fuzzy Logic Controller

FLC is a type of fuzzy logic-based control system used to handle ambiguous or imprecise data. It falls under the category of expert systems and can be used to manage a range of devices, including robotics, consumer electronics, and business operations.

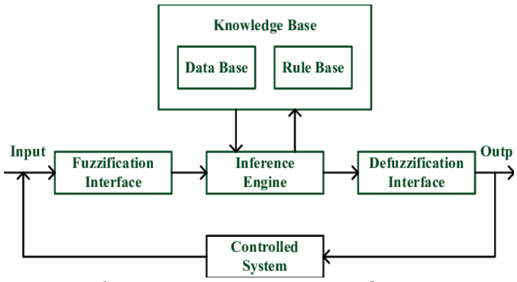


Figure 1. Structure of FLC

The system's dynamic behaviour can be accurately simulated using SIMULINK, and the simulation's results can be tracked as it goes along. In order to increase simulation speed and accuracy, SIMULINK provides both fixed-step and variable-step solvers for ordinary differential equations (ODEs). These solvers are complemented by a graphical debugger and model profiler. When enhancing the simulation's performance, these tools help to keep the simulation's accuracy high.

4. Simulation Circuit

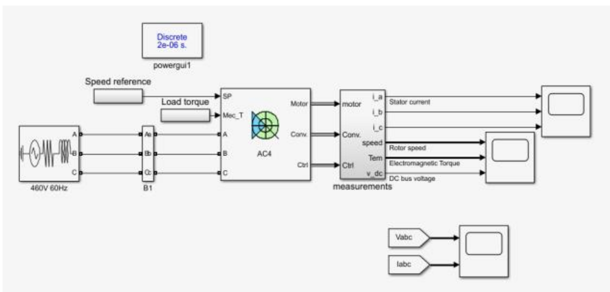


Figure 2: Simulink Model of the Proposed System

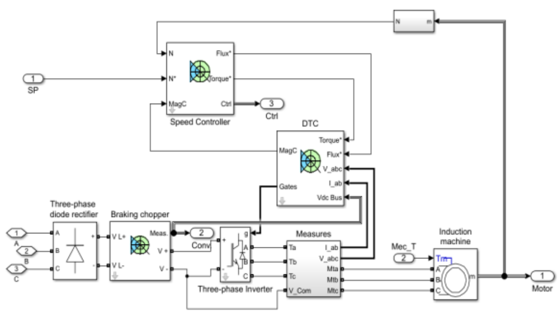


Figure 3: speed vector PWM-DTC induction motor drive during torque regulation

5. Simulation Result

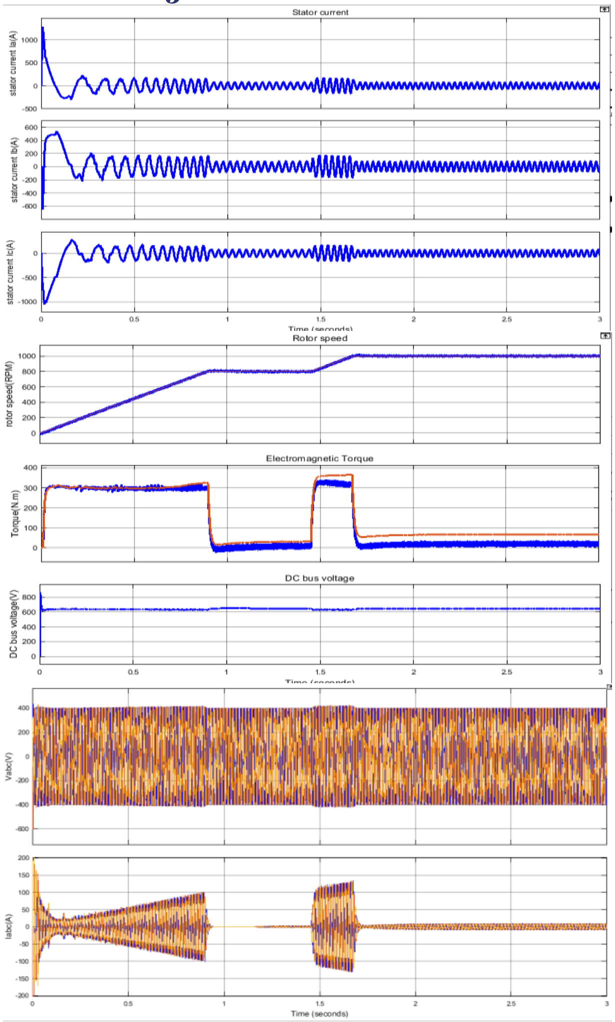
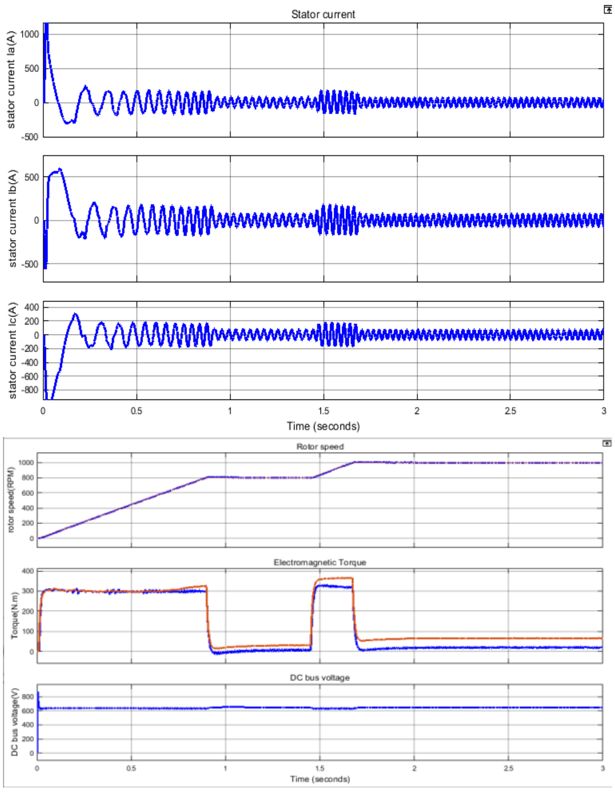


Figure 4: Performance of Proposed system using PI Controller



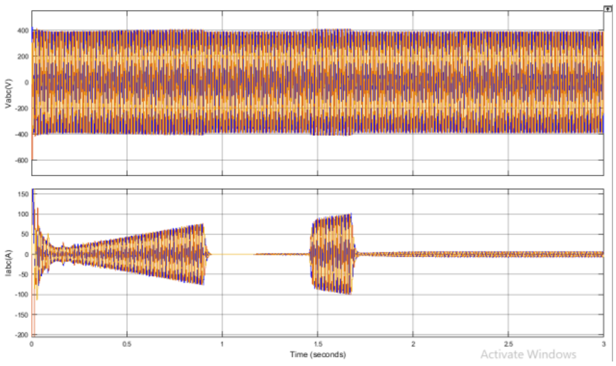


Figure 5: Performance of proposed system using FLC

6. Fuzzy Based Simulation Result

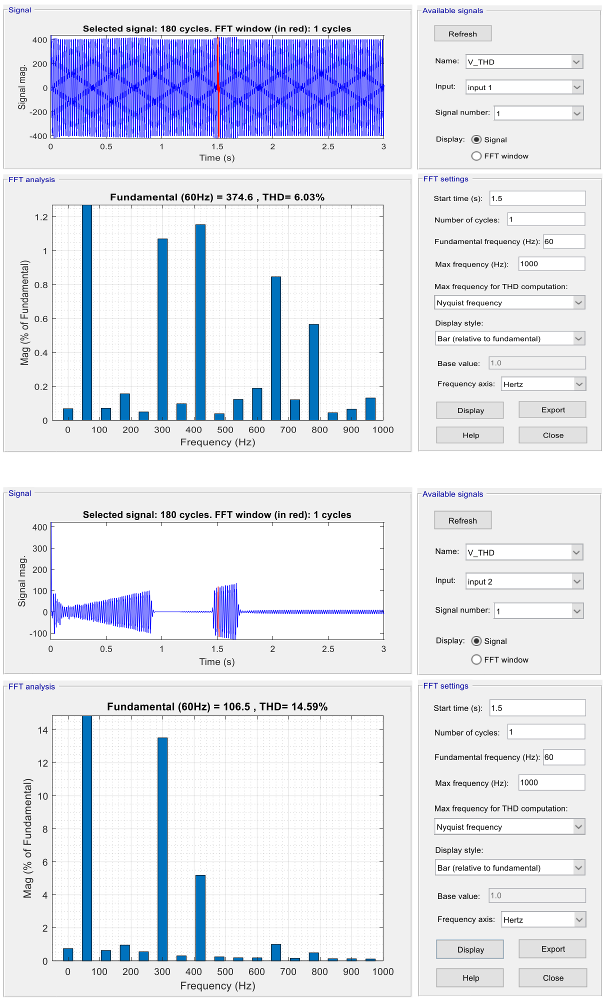
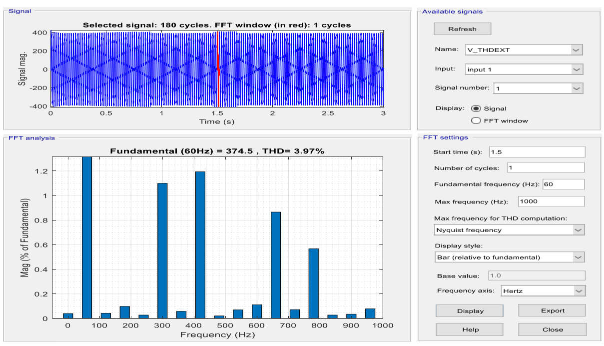


Figure 6: THD of Current and Voltage



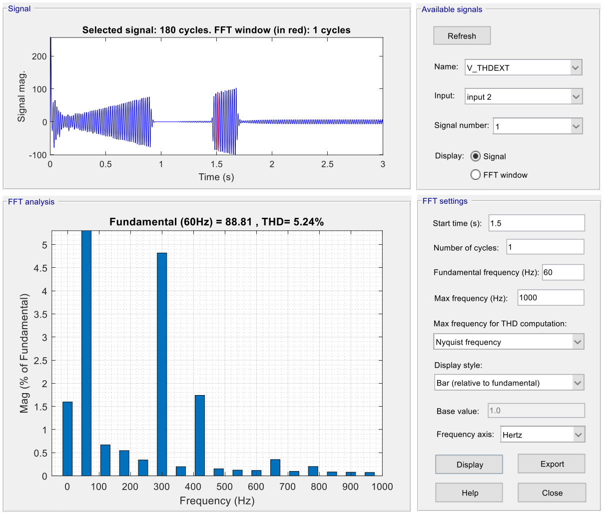


Figure 7: THD of Current and Voltage

7. Comparison

PARAMETER	% THD obtained Using PI Controller	% THD obtained Using FLC Controller
GRID VOLTAGE	6.03%	3.97%
GRID CURRENT	14.59%	5.24%

8. Conclusion

In this research project, an Advanced DTC - SVM scheme, complemented by a Ts FLC, was developed and applied to a 3-phase induction motor. The primary goal was to improve the motor's performance traits, such as torque response, speed control, and overall efficiency. The proposed advanced control strategy effectively addressed the drawbacks of conventional DTC methods, notably reducing torque ripple and minimizing current harmonics. By combining DTC with SVM, the motor drive achieved smoother torque control and improved speed regulation, resulting in better dynamic performance. The integration of the Ts Fuzzy Controller provided an intelligent and adaptive approach to enhance the control system's robustness against parameter variations, load disturbances, and uncertainties.

The FLC effectively adjusted the switching vectors in real-time, optimizing motor performance under different operating conditions. To assess the system's performance, numerous simulation tests were run, and the results showed remarkably improved motor response and efficiency. The Advanced DTC-SVM scheme, utilizing the Ts FLC, outperformed conventional control methods and showed great potential for outstanding performance industrial motor applications, where exact torque and speed control are crucial. The findings of this study highlight the significance of advanced control techniques and Fuzzy Logic in enhancing the act of induction motor drives in modern industrial systems.

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