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Performance Improvement in Three Phase Squirrel Cage Induction Motor by VFD Method

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Abstract: *The three-phase squirrel cage induction motor is widely used in industrial applications due to its rugged construction, reliability, and low maintenance requirements. However, its performance is greatly influenced by supply voltage, frequency variations, and load conditions. This project focuses on improving the overall performance of the induction motor by integrating a Variable Frequency Drive (VFD) system. A VFD allows precise control of input frequency and voltage, enabling smooth speed regulation, enhanced torque characteristics, reduced starting current, and improved operational efficiency.*

Keywords*:* VFD – Controls motor speed and voltage. Induction Motor – Main motor whose performance is improved, V/F Control – Keeps voltage and frequency balanced, Energy Efficiency – Saves power

I. INTRODUCTION

A three-phase squirrel cage induction motor is widely used in industries due to its simple construction and high reliability. However, its performance can vary with changes in load, voltage, and frequency. To overcome these variations, a Variable Frequency Drive (VFD) is used to control the motor's speed and voltage. By adjusting the supply frequency, the VFD provides smooth starting and better speed regulation. It also helps in improving efficiency and reducing energy consumption. The integration of a VFD minimizes mechanical stress on the motor. This enhances the overall lifespan and operational quality of the machine. The project focuses on studying how VFD control improves torque, current, and power characteristics. It also aims to analyze performance under different operating conditions. Overall, the VFD plays a major role in achieving better performance and energy savings in induction motor systems.

II. PROBLEM STATEMENT

Three-phase squirrel cage induction motors often operate at fixed speeds, leading to energy losses, reduced efficiency, overheating, and poor performance under varying load conditions. Traditional control methods cannot provide precise speed regulation or optimal torque control. To overcome these limitations, there is a need for an effective speed-control technique that enhances motor efficiency and overall performance. This project focuses on improving the performance of a three-phase squirrel cage induction motor by implementing a Variable Frequency Drive (VFD) method.

III. LITERATURE REVIEW

Three-phase squirrel cage induction motors (SCIMs) are widely used in industrial applications due to their robust design, low cost, and maintenance-free operation. However, conventional fixed-speed operation limits their efficiency, dynamic performance, and energy utilization under varying load conditions. To address these challenges, research has increasingly focused on advanced control techniques, with Variable Frequency Drives (VFDs) emerging as a prominent solution. VFDs adjust the supply frequency and voltage to the motor, enabling precise speed regulation, improved torque characteristics, and enhanced energy efficiency. Studies have shown that V/f control significantly improves.

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IV. METHODOLOGY

A three-phase squirrel cage induction motor (SCIM) was selected to study performance enhancement using a Variable Frequency Drive (VFD). Baseline parameters such as voltage, current, speed, torque, efficiency, and power factor were recorded. The motor was then connected to a VFD, which controlled its speed by varying supply frequency and voltage. Experiments were conducted under different load conditions, and performance parameters were measured using standard instruments. Data analysis compared motor performance before and after VFD implementation, highlighting improvements in efficiency, torque-speed characteristics, and power factor. VFD parameters were optimized to achieve maximum performance, demonstrating the benefits of VFD-based motor control in industrial applications.

V. WORKING

The three-phase squirrel cage induction motor is connected to a Variable Frequency Drive (VFD), which regulates the motor's speed by adjusting the supply voltage and frequency. When the VFD varies the input frequency, the motor speed changes proportionally, allowing precise control under different load conditions. Electrical and mechanical parameters such as current, voltage, torque, speed, and power are continuously monitored. By optimizing VFD settings, the motor operates efficiently with improved torque, reduced energy consumption, and better overall performance compared to direct-on-line operation.

WORKING PRINCIPLE

The three-phase squirrel cage induction motor operates on the principle of electromagnetic induction, where a rotating magnetic field in the stator induces current in the rotor, producing torque. When connected to a Variable Frequency Drive (VFD), the motor speed is controlled by varying the supply frequency and voltage. This allows precise speed and torque control, improves efficiency, and reduces energy consumption under varying load conditions**.**

VI. BLOCK DIAGRAM

COMPENTS USED:

AC SUPPLY
RECTIFIER
D C LINK FILTER
IGBT INVERTER
3 PHASE INDUCTION MOTOR

VII. COMPONENTS DESCRIPTION

AC SUPPLY

AC (Alternating Current) supply is a type of electricity that periodically reverses direction, unlike DC (Direct Current), which flows in only one direction. This constant reversal occurs at a specific frequency, typically 50 or 60 times per second (Hertz), and is ideal for long-distance power transmission due to the ability to change voltage easily using transformers. AC power is the standard for homes and industries, used in everything from household appliances to large electric motors.

RECTIFIER

A rectifier is an electrical device that converts alternating current (AC) into direct current (DC). This process is known as rectification, which is crucial because virtually all modern electronic devices, such as computers, phone chargers, and televisions, require the steady, unidirectional flow of DC power to operate.

DC LINK FILTER

DC link filters serve several key functions, including smoothing out voltage fluctuations (ripples) from power conversion processes to provide a stable voltage supply. They also store energy to buffer power demands, suppress voltage surges and transients from switching events or disturbances, and reduce electrical noise to meet EMI standards.

IGBT INVERTER

An IGBT (Insulated Gate Bipolar Transistor) inverter is a power converter that uses IGBTs as high-speed electronic switches to change a DC power source into an AC output. The high switching speed of the IGBTs reduces harmonic distortion in the output, resulting in a high-quality AC waveform that is suitable for sensitive electronic equipment.

3 PHASE INDUCTION MOTOR

A 3-phase induction motor uses a three-phase AC power supply to create a rotating magnetic field (RMF) in the stator, which then induces a current in the rotor, causing it to spin and produce mechanical power. This process, known as electromagnetic induction, converts electrical energy into mechanical energy without requiring extra components to start the motor, making it self-starting. The rotor always spins at a speed slightly slower than the RMF's synchronous speed, a condition known as slip, which is necessary for induction to occur.

VIII. ADVANTAGES

- Precise speed control of the three-phase squirrel cage induction motor is achieved using VFD-based V/f control, ensuring optimal performance under varying load conditions.
- Starting current is significantly reduced compared to direct-on-line starting, thereby minimizing electrical and thermal stress on the motor.
- Energy efficiency is improved by operating the motor at the required speed, resulting in reduced power consumption and lower losses.
- Smooth acceleration and deceleration provided by the VFD reduce mechanical stress and enhance the reliability of the motor-drive system.
- Improved torque control enables constant torque operation over a wide speed range, enhancing motor performance.
- Reduced thermal stress and improved operating conditions extend the lifespan of the motor and lower maintenance requirements.

IX. LIMITATIONS

1. Higher initial cost compared to conventional motor starters.
2. Introduction of harmonics affecting power quality.
3. Electromagnetic interference due to high-frequency switching.
4. Increased system complexity and need for skilled operation.
5. Additional cooling requirements for VFD components.
6. Performance depends on proper tuning of VFD parameters.

X. CONCLUSION

This project demonstrates that the application of a Variable Frequency Drive (VFD) significantly improves the performance of a three-phase squirrel cage induction motor. By maintaining an appropriate voltage-to-frequency (V/f) ratio, effective speed and torque control are achieved under varying load conditions. The use of VFD reduces starting current, minimizes electrical and mechanical stress, and enhances overall energy efficiency. Improved power factor, reduced losses, and smoother motor operation contribute to increased reliability and extended motor lifespan. Hence, VFD-based control is an efficient and flexible solution for modern industrial motor drive applications requiring energy savings and precise speed regulation.

XI. FUTURE SCOPE

The future scope of this work includes the implementation of advanced control strategies such as vector control and direct torque control to further enhance the dynamic performance of the three-phase squirrel cage induction motor. The integration of intelligent algorithms based on artificial intelligence and machine learning can enable adaptive speed and torque control under varying load conditions. Harmonic distortion introduced by the VFD can be minimized through the use of active or passive filtering techniques. Additionally, the adoption of sensorless control methods can reduce system cost and improve reliability. Integration of VFD-controlled induction motors with Industrial IoT platforms for real-time monitoring, fault diagnosis, and predictive maintenance also presents significant potential for improving efficiency and system reliability in future industrial applications.

REFERENCES

[1]. M. A. Al-Khawaldeh, J. A. Ghaeb, S. Z. Salah and M. S. Alrawajfeh, "High-performance speed control for three-phase induction motor based on reverse direction algorithm and artificial neural network," Int. J. Electr. Comput. Eng., vol. 14, no. 6, pp. 6237–6247, Dec. 2024.

[2]. Three-Phase Induction Motor Control and Monitoring Using VFD and ESP32 Based on Modbus RTU Protocol, American J. Electr. Comput. Eng., vol. 8, no. 2, pp. 71–80, Dec. 2024.

[3]. R. Borthakur and A. B. Kandali, "Design and simulation of a three-phase induction motor for speed control using constant V/f technique with sinusoidal PWM-based inverter," Int. J. Innov. Technol. Explor. Eng., vol. 14, no. 9, Aug. 2025.

[4]. Tri Safrizal, A. S. P. Tarigan and S. Annisah, "Analysis of the effect rotation speed control on three phase induction motor using VFD Powtech," Int. J. Econ. Technol. Soc. Sci., vol. 6, no. 1, pp. 55–68, May 2025.

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