IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

Single Phase Induction Motor Speed Control Using Thyristor

Y V J Paul[1], K. Poojitha[2], A. Sathwika[3], G. Maneesha[4], CH. Prashanth[5]
[1]Asst. Professor in Dept. of Electrical & Electronics Engineering
[2,3,4,5]UG Student, Dept. of Electrical & Electronics Engineering
Christu Jyothi Institute of Technology & Science, Jangaon, Telangana, India

Abstract: *Speed control of single-phase induction motors is a critical requirement in many domestic, commercial, and industrial applications. Traditionally, speed control techniquesThe tend to be complex or expensive. In this project, we present a simple, cost-effective method for controlling the speed of a single-phase induction motor using a thyristor-based phase control approach.*
The system utilizes a potentiometer to allow the user to manually set the desired speed level. The analog signal from the potentiometer is read by an Arduino UNO microcontroller, which processes this input and calculates the appropriate firing angle required for the thyristor. The thyristor, functioning as a phase-controlled device, modulates the RMS voltage applied to the motor by delaying the conduction period within each AC cycle, effectively controlling the motor's speed without significant loss of torque.
This project demonstrates a reliable, efficient, and easily implementable solution for variable speed operation of single-phase induction motors using readily available components. It offers significant advantages in terms of simplicity, user control, safety, and cost-effectiveness, making it suitable for educational purposes, small appliances, and adjustable motor-driven systems

Keywords: Speed Control, Arduino UNO, Thyristor, Phase Control, Induction Motor, Power Regulation, Motor Efficiency, IoT Integration

I. INTRODUCTION

Single-phase induction motors are widely used in various applications due to their rugged construction, reliability, and cost-effectiveness. However, one of the major challenges associated with these motors is the lack of simple and efficient methods for speed control. In many practical situations, such as in fans, pumps, or small machinery, it becomes necessary to vary the motor speed according to operational requirements.

Conventional methods like voltage control using autotransformers, frequency variation, or pole-changing techniques either involve bulky equipment or high costs, making them unsuitable for compact and economical applications. To address this issue, thyristor-based phase control offers a speed regulation by controlling the voltage supplied to the motor without the need for complex hardware.

In this project, a single-phase induction motor's speed is controlled by adjusting the firing angle of a thyristor. The user sets the desired speed through a potentiometer, and an Arduino UNO microcontroller processes this input to generate control signals. An optocoupler is used for electrical isolation between the Arduino and the thyristor, ensuring the safety of the low-voltage control circuit. A real-time LCD display is also implemented to provide user-friendly feedback on the motor's operational status.

The system not only achieves efficient speed control but also ensures simplicity, safety, and cost-effectiveness, making it ideal for small-scale applications and educational projects. Through this work, an accessible and modern approach to controlling the speed of single-phase induction motors is demonstrated, offering significant practical benefits over traditional methods.

II. LITERATURE SURVEY

1. Traditional Methods of Speed Control:

Earlier methods for speed control of single-phase induction motors involved mechanical means such as variable belt drives and pole-changing techniques. Although effective, these methods were inefficient, bulky, and required manual intervention. Later, the use of autotransformers and resistors in series with the motor became popular for voltage control, but they introduced significant power losses and reduced system efficiency.

2. Phase Angle Control using Thyristors:

With the advent of semiconductor devices, thyristor-based phase control became a major breakthrough. By adjusting the firing angle of a thyristor, it is possible to regulate the amount of voltage applied to the motor, thus controlling its speed. This method is more efficient, compact, and cost-effective compared to mechanical speed control methods. Several researchers and engineers have developed circuits based on this principle, showing significant improvement in performance and energy savings.

3. Microcontroller-Based Control Systems:

Recent advancements involve using microcontrollers like Arduino, PIC, and AVR to automate the firing angle control. This offers better precision, programmability, and dynamic response compared to manual circuits. A study by K. Ramasamy et al. (2018) showed that using microcontrollers significantly enhances the accuracy of speed control and allows for better real-time user interaction through displays and input devices.

4. Use of Optocouplers for Isolation:

As controlling a high-voltage thyristor using a low-voltage microcontroller can pose safety risks, optocouplers have been used extensively to ensure electrical isolation. Research in power electronics highlights that optocouplers effectively protect microcontrollers from voltage spikes and transients, thereby improving the system's durability and reliability.

5. Display Systems for User Interface:

Integrating display systems like LCDs improves the usability of speed control systems. Studies have shown that real-time monitoring of motor speed or control settings helps users maintain better control over the system and provides important feedback for fault detection or maintenance.

From the literature reviewed, it is evident that thyristor-based phase control, when integrated with a microcontroller and appropriate isolation techniques, provides a highly effective solution for the speed control of single-phase induction motors. The project builds upon these concepts, combining modern microcontroller technology with proven thyristor-based control, to create a reliable, safe, and user-friendly system.

III. INDUCTION MOTOR

The primary objective of this project is to control the speed of a single-phase induction motor efficiently and effectively using a thyristor-based phase control method.

In any motor-driven system, the ability to adjust motor speed according to the operational requirements is critical. In applications such as fans, blowers, small pumps, and household appliances, energy efficiency, performance, and user comfort often depend on the ability to modify the motor's speed.

In this project, the induction motor speed serves as the main controlled variable — it is the output that the system is designed to regulate. The motor's speed is varied by changing the RMS (Root Mean Square) voltage supplied to it, which is achieved by adjusting the firing angle of the thyristor.

When the firing angle is increased, the conduction period of the thyristor reduces, causing a lower RMS voltage to be applied to the motor, thus reducing the motor speed.

Conversely, reducing the firing angle increases the RMS voltage, thereby increasing the motor speed.

The Arduino UNO reads the user's desired speed setting from the potentiometer and processes it to adjust the firing signals accordingly.

The optocoupler ensures that the high-voltage motor circuit is electrically isolated from the low-voltage control circuit for safety.

An LCD display provides feedback to the user about the current motor speed or setting.

Importance of Controlling Motor Speed in This Project:

Energy Saving: Running the motor at only the required speed saves electrical energy compared to running it at full speed all the time.

Improved System Performance: Some applications require specific speeds for optimal operation, like a fan running slower during colder weather.

Reduced Wear and Tear: Controlling motor speed can lead to less mechanical stress, increasing the lifespan of the motor and connected mechanical parts.

User Flexibility: The user can easily adjust the speed according to real-time needs without needing to replace components or use bulky hardware.

Thus, speed control of the induction motor is the central focus of this project, and it demonstrates how modern microcontroller-based electronics can make traditional motors more adaptable, efficient, and user-friendly.

IV. WORKING

The working of this project is based on the concept of controlling the voltage supplied to a single-phase induction motor using a thyristor, thereby regulating its speed. The user sets the desired motor speed using a potentiometer. As the potentiometer is adjusted, it changes its resistance value, providing a corresponding analog voltage signal to the Arduino UNO. The Arduino reads this analog input using its internal Analog-to-Digital Converter (ADC) and processes it to determine the appropriate firing delay for the thyristor.

By calculating the firing delay, the Arduino can control at what point in each AC cycle the thyristor is triggered. The thyristor, once triggered, conducts for the remainder of the half-cycle, allowing a portion of the AC waveform to be applied to the motor. When the firing occurs earlier in the cycle, more voltage is delivered to the motor, resulting in higher speed. If the firing is delayed further into the cycle, less voltage is delivered, causing the motor to run at a slower speed.

Since the Arduino operates at low voltage and the thyristor is part of a high-voltage AC circuit, an optocoupler is used between the Arduino and the thyristor to ensure electrical isolation and protect the microcontroller. The optocoupler allows the control signal to safely pass to the thyristor's gate without direct electrical connection. The system thus effectively adjusts the motor's speed based on user input without needing bulky mechanical components or complicated power electronics.

An LCD display connected to the Arduino provides real-time feedback, showing the set speed or related motor parameters, enhancing the user's ability to monitor and adjust the system. Overall, the project demonstrates a simple, cost-effective method for precise speed control of a single-phase induction motor using modern microcontroller technology and thyristor-based power electronics

V. EXISTING SYSTEM

In conventional setups for controlling the speed of single-phase induction motors, several methods have been used over the years. The most basic and traditional approach involves mechanical means such as using gearboxes, belt-pulley arrangements, or manual dampers to vary the load conditions indirectly, thereby influencing motor speed. However, these methods are bulky, less efficient, and prone to wear and tear due to moving mechanical parts.

Another widely used system is the use of autotransformers or tap-changing transformers to vary the voltage supplied to the motor. While effective, these devices are large, expensive, and not ideal for dynamic or frequent speed changes, making them unsuitable for compact or cost-sensitive applications.

In more recent electrical control systems, triac-based dimmer circuits or variable voltage regulators are used for fan motors and similar low-power applications. These circuits generally provide phase-controlled AC to the motor but often lack precision, stability, and the ability to easily adjust the firing angle dynamically in response to user input.

Some existing systems also employ Variable Frequency Drives (VFDs) for induction motor speed control. VFDs adjust both the voltage and the frequency supplied to the motor, offering very fine control and high efficiency. However, VFDs are expensive and complex, and they are typically used for three-phase motors or in higher-end industrial

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 1, May 2025 Impact Factor: 7.67

applications. They are not economical for small single-phase motors, especially where cost and simplicity are major concerns.

In most basic existing systems for shaded pole motors and small single-phase motors, manual control using variable resistors or basic voltage regulators is common. These systems, however, suffer from significant power losses, reduced motor efficiency, heating problems, and lack of precision.

Thus, while several methods exist, they either lack efficiency, are not cost-effective, require bulky hardware, or do not provide dynamic control, which highlights the need for an improved, microcontroller-based, thyristor-controlled solution as proposed in this project.

VI. PROPOSED METHOD

The proposed system offers a modern, cost-effective solution for controlling the speed of a single-phase induction motor using a thyristor-based phase control technique, all managed by an Arduino UNO microcontroller. Unlike traditional systems that often involve bulky or inefficient equipment, this setup leverages the flexibility of an Arduino to dynamically adjust the speed of the motor. The user interacts with the system via a potentiometer, which allows for simple and intuitive control over the motor speed. The Arduino reads the analog voltage from the potentiometer, processes it, and calculates the appropriate firing angle for the thyristor. By varying the firing angle, the system controls the voltage applied to the motor, which in turn adjusts the speed in a smooth and continuous manner.

The proposed system offers numerous advantages, including improved efficiency, low power consumption, and the ability to fine-tune motor speed with a high degree of accuracy. It is an ideal solution for applications where motor speed needs to be adjusted frequently or dynamically, while keeping the setup simple and low-cost. Compared to existing systems that rely on autotransformers, resistive voltage control, or expensive variable frequency drives (VFDs), this solution provides a more accessible and reliable alternative with better control, less power loss, and safer operation.

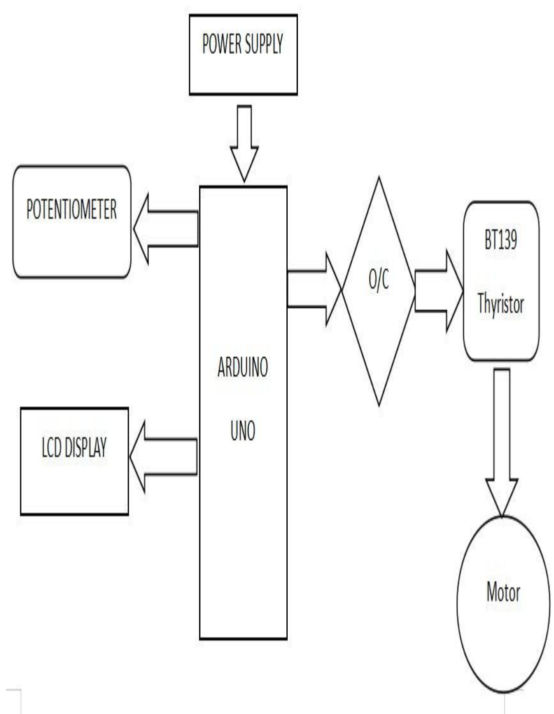

FIG 1:Block Diagram

DOI: 10.48175/IJARSCT-26156

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

VII. SOFTWARE EMPLOYED

The Arduino Integrated Development Environment (IDE) plays a crucial role in this project as it provides the platform for programming the Arduino UNO microcontroller, which is central to controlling the speed of the single-phase induction motor. The Arduino IDE is a user-friendly software environment that allows you to write, compile, and upload programs (known as sketches) to the Arduino board. It is compatible with a wide range of hardware platforms and makes the programming process straightforward for both beginners and experienced users.

In this project, the Arduino IDE is used to create the code that will read the input from the potentiometer, process the value, and calculate the necessary firing angle for the thyristor to control the motor's speed. The code involves configuring the microcontroller to read analog input values from the potentiometer, convert them to a digital signal, and then determine the appropriate timing for triggering the thyristor. This process requires precise timing and control, which is made possible through the Arduino's built-in functions and libraries within the IDE.

The Arduino IDE allows for easy development and debugging of the code. The serial monitor feature within the IDE provides a way to check and test real-time data from the Arduino, making it easier to troubleshoot and fine-tune the system's performance. The IDE also supports a wide range of libraries, such as those used for controlling LCD displays, analog input processing, and timing controls for the thyristor firing, which greatly simplifies the programming task.

The Arduino IDE is open-source and has a large community of developers, offering numerous online resources and tutorials. This ensures that users can easily find support when developing their own modifications or enhancements to the project. Additionally, the IDE provides a straightforward interface for compiling and uploading the code directly to the Arduino board through a USB connection, simplifying the entire process of programming and testing.

Overall, the Arduino IDE serves as the backbone for programming the microcontroller and interacting with all the components in the project, from the motor speed control to user feedback on the LCD display. Its ease of use, vast library support, and real-time debugging capabilities make it an ideal choice for developing control systems like this one.

VIII. RESULTS & DISCUSSION

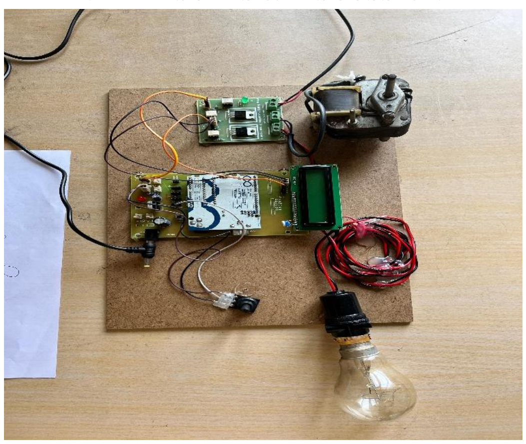

Fig 2: HARDWARE SETUP

The single-phase induction motor speed control system using thyristors successfully achieved precise regulation based on user input. By varying the phase angle of the thyristor, the system adjusted the RMS voltage supplied to the motor, ensuring smooth speed control. Initial testing confirmed effective performance, with real-time feedback on an LCD display and intuitive user interface.

The Arduino UNO provided stable voltage regulation, minimizing fluctuations. Efficiency was high, with negligible power loss and no overheating, while the optocoupler ensured electrical isolation for safety. The system demonstrated reliability through Arduino IDE's debugging and data monitoring tools.

Some limitations were noted: at very low speeds, torque reduction occurred due to the motor type, and speed control was less smooth at extreme ranges. Despite this, the system proved to be a cost-effective and practical solution for simple and reliable speed regulation. Future enhancements could include closed-loop feedback for consistent speed under varying loads and alternative motor types for improved torque.

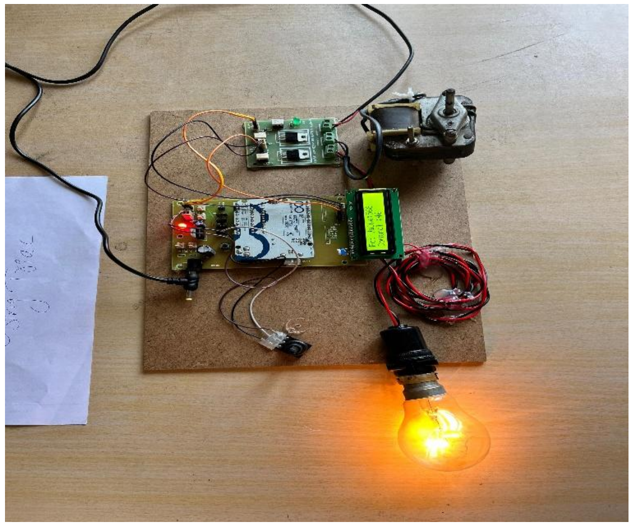

Fig 3: OUTPUT SHOWING MOTOR IS CONTROLLED

IX. CONCLUSION

The single-phase induction motor speed control system using thyristors effectively regulated speed with high precision. By adjusting the thyristor's phase angle, the motor's RMS voltage was controlled smoothly. Initial testing validated reliable performance, intuitive user interface, and real-time feedback via an LCD display.

Efficiency remained high, with minimal power loss and no overheating. The optocoupler provided crucial electrical isolation for safety, while Arduino UNO ensured stable voltage regulation. Debugging tools enhanced reliability and user interaction.

Some limitations were observed, such as reduced torque at very low speeds and slightly less smooth control at extreme speed ranges. Despite this, the system proved to be a practical, cost-effective solution for reliable speed regulation. Future enhancements could include closed-loop feedback for maintaining speed consistency under varying loads and exploring alternative motor types for improved torque.

X. FUTURE SCOPE

The project has several opportunities for enhancement. Integrating a closed-loop feedback system with a tachometer or encoder would enable real-time speed adjustments, improving stability under varying loads. Advanced control methods like PWM or VFDs could enhance precision and efficiency, especially at lower speeds.

Expanding into IoT connectivity would allow remote control via Bluetooth or Wi-Fi, increasing adaptability. Energy optimization algorithms could further reduce power consumption, making the system more eco-friendly. A touchscreen interface or voice control could improve user experience with graphical feedback and intuitive operation.

Compact design and cost reduction through integrated components and custom PCBs would make the system more practical for consumer electronics. These advancements would enhance performance, broaden applications, and ensure long-term relevance in industrial, residential, and renewable energy sectors.

REFERENCES

[1]. Dr. P.S.Bimbhra "Generalize theory of electrical machine" department of Electrical engineering, ThaparInstituteof Engineering and Technology, Patiala. 147001

[2]. Muhammad H. Rashid "Power electronics circuits, devices and applications" third edition, department of Electrical and Computer engineering, University of West Florida.

[3]. M D Singh, K B Khanchandani "Power electronics" second edition, Former principal, Laxmi Narayan College of Technology, Bhopal.

[4]. Ashfaq Husain "Electrical machines" second edition, Formerly, Reader in Electrical engineering University Polytechnic, Aligarh Muslim University, Aligarh.

[5]. Mineo Tsuji, Shuo Chen, Shin-ichi Hamasaki, Xiaodan Zhao, and Eiji Yamada, "A Novel V/f Control of Induction Motors for Wide and Precise Speed Operation" IEEE Trans. Ind.

[6]. Puja Talukder, Prashant Kumar Soori, and Benetta Aranj, "Speed Control Of Induction Motor Drive Using UniversalController", IEEE Trans. Ind, 2010

[7]. Abramowitz, H. "New Closed Loop Controls For Minienvironments," Controlled Environments, Feburary 2006.

[8]. F. Wang, S. Rosado, D. Boroyevich, "Open Modular Power System Controller Applications", IEEE Power Electronics Specialist Conference, June 2003, Vol. 4, pp. 1792-1797 .