JOURNAL OF INNOVATION AND TECHNOLOGY
eISSN:2805-5179 Vol. 2025, No.05

Analysis Simulation of Overcurrent Protection System for 3 Phase Induction Motor Using an Arduino and ACS712 Current Sensor

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Abstract

This research explores a simple yet effective way to protect three-phase induction motors from overcurrent by using an Arduino Uno and an ACS712 current sensor. Overcurrent conditions can cause serious damage to motors, especially if left unnoticed. To address this, the study proposes a smart monitoring system that continuously reads current levels and responds based on their severity. The system categorizes the motor's status into three levels: normal, warning, and danger. Each level is indicated by an LED and corresponds to specific current ranges. The simulation was carried out using Proteus software, where the Arduino receives real-time current readings from the sensor. If the current crosses a set threshold (around 10% over the safe limit), the system automatically shuts down the power, helping prevent motor failure. Results from the simulation show that the system works as intended—it successfully detects overcurrent conditions and reacts appropriately. This proves that combining an Arduino with the ACS712 sensor is a practical, affordable, and easy-to-use solution for motor protection. The approach is especially useful for learning environments or small industries that need cost-effective safety systems.

Keywords

Three phase Induction Motor; Overcurrent; Arduino; ACS712 Sensor; Proteus Simulation; Real-Time Monitoring.

Introduction

Overloading of a 3-phase induction motor occurs when the motor is forced to work beyond its rated power. This can be caused by several factors, including excessive mechanical load, increased friction, and mechanical resistance. Meanwhile, overcurrent is a condition in which the electrical current flowing through the motor exceeds its rated value. The main cause of overcurrent in 3-phase induction motors is the relationship between overload and overcurrent. When the motor is working under overload, the torque required to turn the load increases. To generate more torque,

Submission: 18 February 2025; **Acceptance:** 10 March 2025; **Available online:** April 2025

the motor will draw more current. If this condition persists, the motor may overheat, which may cause damage to the motor winding insulation (Aulia et al., 2021) (Tiyono, 2013).

One of the possible control systems for measuring electricity consumption was developed, namely an Arduino-based control system using sensors current ACS712 (suteja & surya antara, 2021). ACS712 is an integrated circuit (IC) that acts as a current sensor replacing a transformer's relatively large current in terms of magnitude. This sensor has the ability to monitor electricity consumption and can provide analog values, so that electricity usage can be controlled and regulated (Satya et al., 2020). The same as ACS712, another hall effect sensor uses a magnetic field around the current and then converts to a linear voltage with the current changes. Censorship ACS712 can detect currents from -5 amps to 5 amps. This sensor requires a microcontroller acting as a data processor. The boards of this Arduino Uno were chosen (Ratnawati & Sunardi, 2020), Arduino is a tool for digital electronics having input-output and control using programs that can be written and erased in a special way.

Currently, there are many protection systems designed to handle current more about induction motors. For example, the research titled " Three-Phase Induction Motor Protection Systems Against Various Disturbances Using Microcontroller” (Darmawansyah et al., 2020). This study discusses testing methods for designing protection systems. Next is, the project Protection system using the Simulink method (Dwi Artika Putra et al., 2021), discusses testing protection systems against the influences of unbalanced voltage. The project by (Juwono, 2022), in their 2022 research discusses protection systems using methods of experiments, namely through simulation as a visualization of the protection system three-phase induction motor operating semi-automatically, especially the efficiency and losses of the motor.

However, their work stopped at current detection and did not implement a complete protection system that responds automatically to overcurrent conditions. This current study stands out by offering a practical, low-budget solution that integrates monitoring and protection in a single system. Using the Arduino Uno and ACS712 sensor, the proposed setup can detect current flow in real time and respond to dangerous levels by triggering a shutdown—protecting the motor from possible damage. What makes this approach different is the way it defines and visualizes motor operating conditions into three levels: normal, warning, and danger. Each state is clearly represented with visual indicators (LEDs), and when current exceeds a 10% tolerance threshold, the system will take action automatically.

Moreover, by simulating the system using Proteus software, the design can be tested and understood without needing physical hardware-making it especially useful for education, training, or early-stage prototyping. In summary, this research contributes a practical, educational-friendly, and cost-effective alternative for overcurrent protection in three-phase induction motors. It bridges the gap between theoretical design and real-world application, especially for students, educators, and small industries looking for reliable motor protection without the high cost.

Methodology

a. Materials

The method used is approaching method simulation of the overcurrent protection circuit usage for a three-phase induction motor. ACS712 current sensor based on Arduino Uno and using Proteus software. The induction motor control is operated using the ACS712 sensor as a control system to detect the current value. It will be the input for the microcontroller. The data will be obtained from the Arduino microcontroller, which acts as the entire processing and control unit input and output. The output of the Arduino in this system will be displayed using a Liquid Crystal Display (LCD). This system is designed with the ability to set the level warning. Fig. 1 shows a block diagram of the design and simulation system.

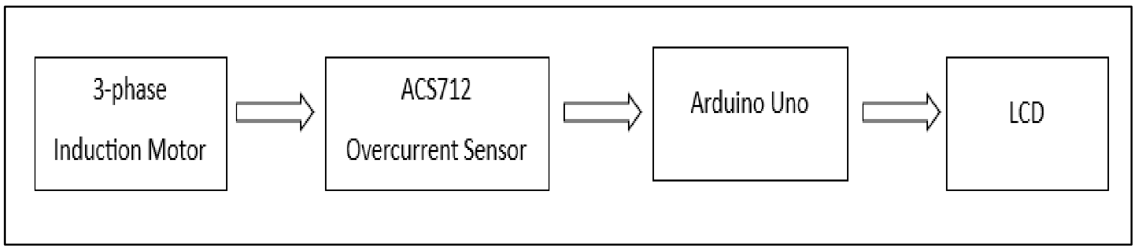

Fig. 1 System Block Diagram

b. Method

To support the simulation of the overcurrent protection system, an Arduino Uno board was programmed to read analog input from the ACS712 current sensor. The sensor provides voltage output proportional to the current flowing through the motor circuit. This analog value is then processed by the Arduino using basic current conversion formulas.

The system logic is implemented in three stages; Normal Condition: When the current is within a safe range (e.g., 2–4 A), the green LED (LED1) is turned on; Warning Condition: If the current approaches the maximum tolerance (e.g., 6–9 A), the yellow LED (LED2) is activated as a caution signal; Danger Condition: When the current exceeds the defined safety threshold (e.g., above 10 A), the red LED (LED3) is turned on, and the system sends a command to disable the power source, simulating a motor shutdown. The Arduino sketch (program) is uploaded to the board and simulated in Proteus by linking with a virtual ACS712 sensor and other components like LEDs and LCD. When the danger condition is active, the sensor will send a command to the Arduino Uno to turn off the sources.

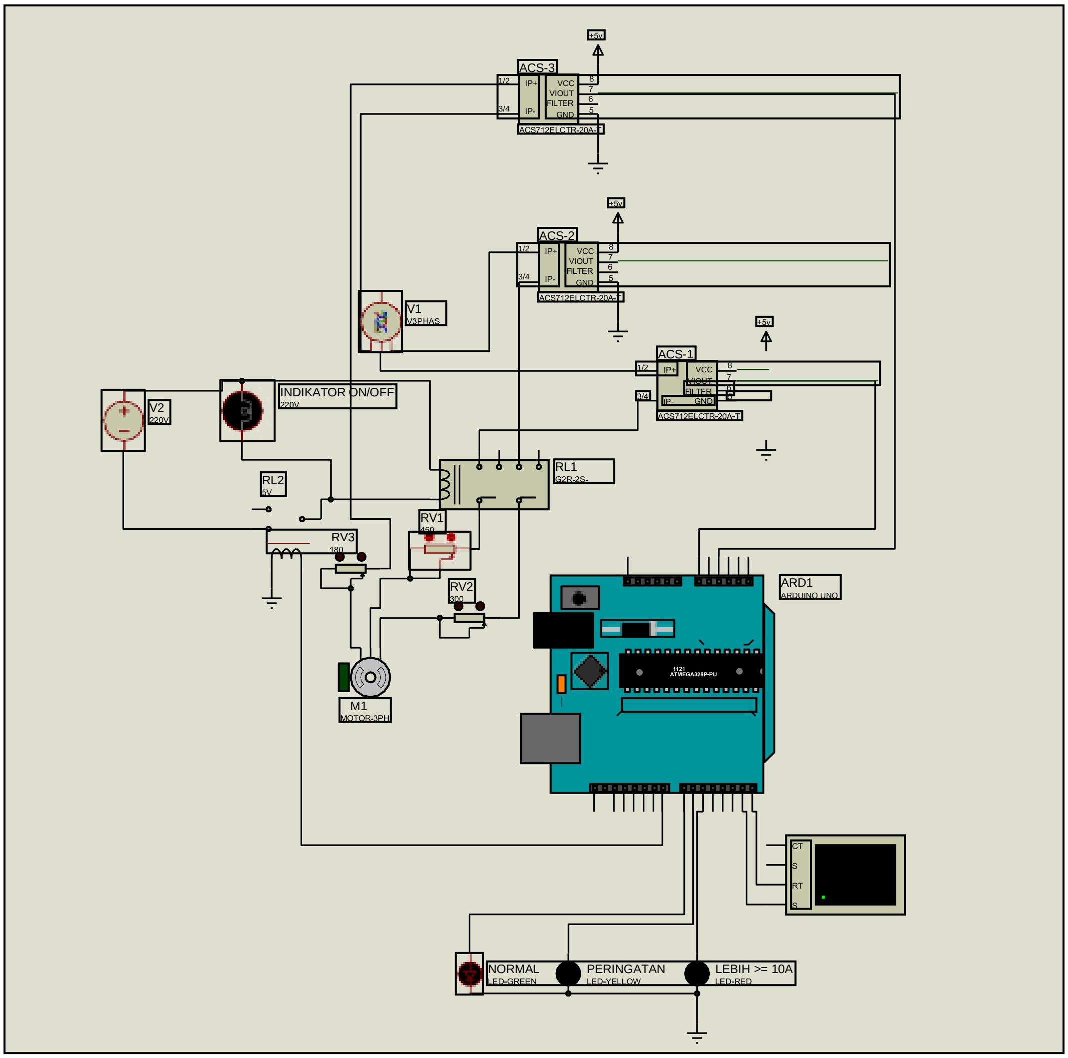

Fig. 2 Simulation series with proteus software

Result And Discussion

This section discusses the simulation outcomes of the overcurrent protection system for a three-phase induction motor using an Arduino Uno and ACS712 current sensor. The system was tested under three different conditions—normal, warning, and danger—based on the current values detected by the sensor. Each condition activated different system responses, as shown through LED indicators and automatic control behavior.

(i). Normal Condition

In normal operating conditions, the measured output current ranged from 2.23 A to 4.11 A, which is well within the safe operational range of the motor. Under this condition, LED 1 (green) lights up to indicate that the system is functioning normally. The sensor reads the

current, and the Arduino confirms that it is below the threshold value (set at approximately 5 A). The LCD displays the real-time current value, ensuring continuous monitoring.
These readings reflect expected behavior during typical load conditions. No shutdown or warnings are triggered. This confirms that the sensor and microcontroller integration is working properly in identifying low-risk current levels.

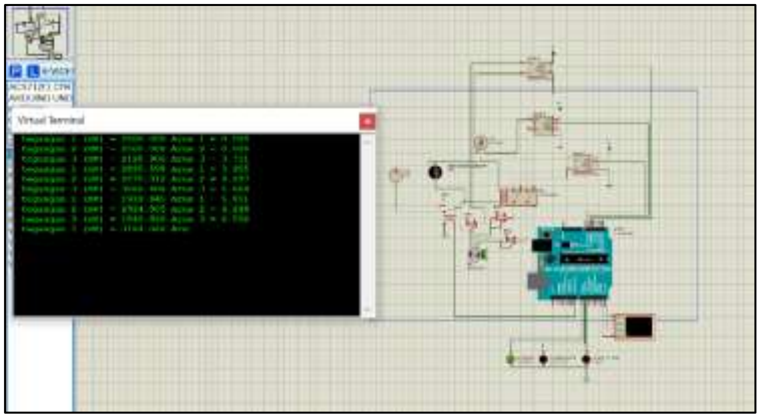

Fig. 3 Current reading results under normal conditions

(ii). Warning Condition

The warning condition is triggered when the current values are between 6.10 A and 9.82 A. Although these values are still below the system's critical threshold of 10 A, they indicate that the motor is approaching an overload state. In this condition, LED 2 (yellow) is activated, signaling caution to the user. However, the system does not shut down, allowing continued operation with heightened awareness. This condition simulates a scenario where the motor might be subjected to increasing mechanical loads or partial phase imbalance. The warning alert is essential for preventive maintenance, allowing operators to take corrective action before reaching a dangerous threshold.

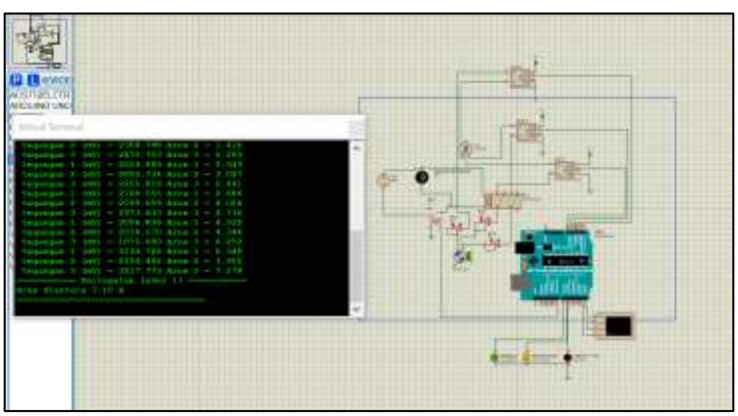

Fig. 4 Current reading results during warning conditions

(iii). Danger Condition

When the output current exceeds 10.00 A, the system enters the danger condition. The measured values ranged from 10.00 A to 10.84 A, exceeding the tolerance limit set by the system. Upon detection, the ACS712 sensor immediately signals the microcontroller, which responds by activating LED 3 (red) and simulating a shutdown of the power supply. This automatic response is a critical feature of the system, effectively protecting the motor from possible overheating or winding damage. In the simulation, the current drops to 0 A after shutdown, indicating that the control logic successfully cut off the power source. This confirms the system's ability to act in real-time to prevent motor failure.

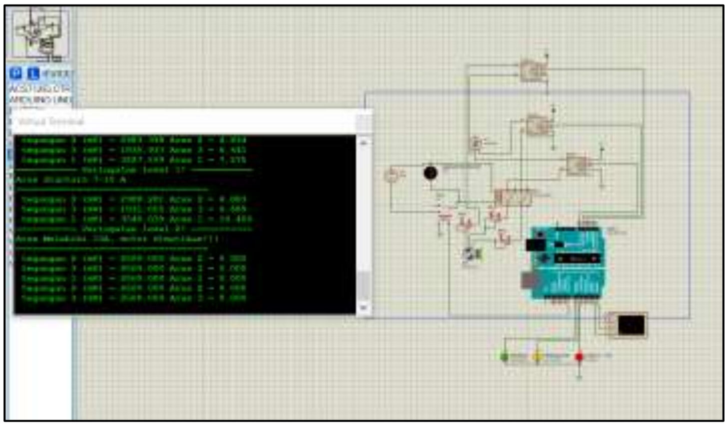

Fig. 5 Current readings in hazardous conditions

Table 1. Measurement Results In Simulation

Condition	Current Range (A)	System Respones	LED Indicator
Normal	2.33 – 4.11	System operates normally	Green
Warning	6.10 – 9.82	Warning signal activated	Yellow
Danger	10.00 – 10.84	Poower cutoff initiated	Red

The simulation results demonstrate that the integration of the ACS712 sensor and Arduino Uno provides an effective and low-cost solution for real-time overcurrent monitoring and protection. This system is not only responsive but also replicable, making it ideal for applications in small-scale industries and educational laboratories.

Conclusion

This study successfully demonstrated the design and simulation of an overcurrent protection system for a three-phase induction motor using the ACS712 current sensor and Arduino Uno microcontroller. Through simulation in Proteus, the system was able to detect and respond to different current conditions—normal, warning, and danger—with appropriate system behavior. In normal conditions, the system allowed continuous motor operation, indicating safe current levels. During warning conditions, the system issued a visual alert without disrupting the operation, allowing time for preventive action. When dangerous current levels were detected, the system automatically initiated a shutdown to prevent motor damage, thereby fulfilling its protection objective.

The use of the ACS712 sensor and Arduino Uno provides a low-cost, easily replicable, and educational-friendly solution, particularly suitable for technical training environments or small-scale industrial applications. The simulation approach via Proteus also enables testing and validation without requiring physical hardware, adding further value to this research. In future development, the system can be enhanced by integrating real-time data logging, wireless monitoring, and implementing the prototype in a physical hardware environment for field testing.

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