Monitoring And Protection of Three-Phase Induction Motor in Case of Abnormal Conditions

A. M. Halmare[1], Tejas Meshram[2], Nikita Narnaware[3], Manish Patle[4]

[1]Assistant Professor, Department of Electrical Engineering, KDK College of Engineering, Nagpur, Maharashtra, India
[234]UG Students, Electrical Engineering, KDK College of Engineering, Nagpur, Maharashtra, India

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Abstract - *Three-phase induction motors are widely used in industrial applications due to their robustness, efficiency, and reliability. The primary aim of this paper is to monitor and protect the three-phase induction motor (IM) in case of faults like overheating, overcurrent, overvoltage, and single phasing. Protecting three-phase induction motors from these problems is essential since they can lower their efficiency. In the protection scheme, the current transformer (CT) and the Potential transformer (PT) are used to monitor the current and voltage of the induction motor on the LCD, respectively. The brain of the protection scheme Arduino Nano continuously checks the various parameters of an induction motor. The Arduino Nano has some pre-set values, and with the help of these pre-set values, Arduino Nano compares them with the parameter value. The relay receives the Arduino signal when a pre-set value exceeds, and the relay will trip the three-phase contactor and disconnect the three-phase supply of the induction motor.*

***Key Words*: induction motor, overvoltage, protection, overcurrent, single phasing.**

1.INTRODUCTION

Many motors are utilized for various tasks around us, from household appliances to machine tools in commercial buildings. In many sectors nowadays, electric motors are a vital source of power. These motors must have a wide range of functions and performances. Since IM motors are the most commonly used for automation, industrial control, and appliances, they are robust, dependable, and long-lasting. Three-phase induction motors typically experience overvoltage, overcurrent, overheating and single-phasing problems.

The three-phase induction motors begin to overheat when the supplied voltage is higher than the motor's rating. It is ideal for a three-phase induction motor to operate without these kinds of issues. Variations in the induction motor settings cause this issue to arise. It is essential to protect the three-phase induction motor from these potential problems while it operates continuously.

Three-phase induction motor's long lifespan is mostly dependent on its protection. Researches have created limited and costly protection for things like damaged rotor bars, thermal protection and stator winding protection. The induction motor primarily requires protection against input supply fluctuations. If supply voltage, current, and temperature are increased, then the Arduino Nano sends a signal to the relay that, in turn, actuates a three-phase contactor to safely disconnect the motor from its power source.

2.LITERATURE REVIEW

A. *Ivana Z. Giceva [1]*

Ivana Z. Giceva stated that three-phase IM does not start if one of its phases is disconnected, leaving the motor to operate in a physically two-phase regime. In certain situations, the motor would have trouble starting and we could hear buzzing. Maintaining such a routine has no practical or physical significance because the motor cannot start and may occasionally cause minor motor damage. When a motor is loaded with a rated or lower-than-rated load, it loses one of its phases for a variety of causes, such as a blown fuse, a damaged power supply line, a poor terminal connection, etc., leaving the motor to run on the remaining two phases. This is a very different regime. If protective measures are not immediately implemented, this so-called single phasing operation mode may result in a number of operational issues for IM, including the rapid deterioration of motor parameters and its burnout.

B. *Pragasen Pillay et.dal.[2]*

Pragasen Pillay et.dal. Examines the three-phase induction motor under the impact of under voltage and over voltage. In a complicated industrial system, the voltage at the motor terminals may be greater than the nominal value, and in a fully loaded industrial system, it may be significantly lower. NEMA and IEEE have varying definitions of voltage unbalance.

C. *Abalagan and Sudha M. [3]*

Abalagan and Sudha M. suggested a method to prevent single phasing in three-phase induction motors. This method uses a PIC16F877 microcontroller to sample the values of each phase, which a transformer then converts to low voltage ac. An ADC converter is used to transform the signals into digital values. When a malfunction arises, the controller opens the usually closed contactor and disconnects it from the power source after continually comparing the digital value with the reference value. A 2kW motor is protected against single phasing, under voltage, and overvoltage, and the motor is disconnected in the event that any of these conditions arise.

3. METHODOLOGY

3.1 Block Diagram and Working

The block diagram of the proposed motor protection system is shown in Fig.1. The system includes a step-down transformer, current transformer, relay, and contactor unit along with the Arduino Nano. Rectifier circuits are used to convert AC values of the CT and PT into DC. The information collected from the potential transformer and current transformer after converting into DC values is then digitally transmitted to the Arduino Nano after passing through the current and voltage measuring circuits.

The Arduino Nano features a built-in analog to digital (ADC) converter, eliminating the need for an external ADC unit. Typically, the Arduino Nano A/D converter (ADC) can process input signals below 5V. Therefore, sensors must be chosen in accordance with the specifications of the Arduino Nano design. Necessary comparisons are performed within the Arduino Nano based on the predefined limit values that have been input or programmed. If an abnormal condition arises, the Arduino Nano stops the motor by sending a control signal. Key motor parameters such as full load current in amperes and rated voltage in volts must be entered into the programming unit to automatically determine the appropriate motor protection curve. This system provides several protective functions.

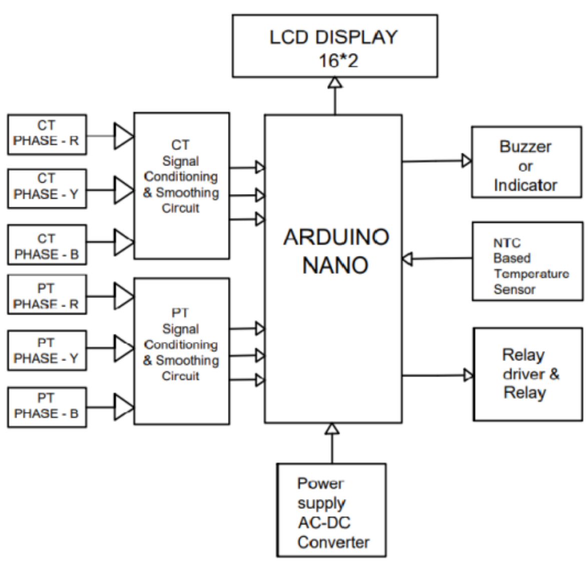

Fig.1. Block diagram of three phase induction motor protection unit

The system offers protection against single-phasing, over-voltage, overcurrent, and overheating conditions. The control of the system is managed by the Arduino Nano. This system operates with any motor design and maintains a high degree of accuracy.

The method is highly sensitive, quick, and capable of detecting faults during operation and prior to start up. Once the thresholds for maximum permissible over voltage are surpassed, the Arduino Nano produces a trip signal that shuts down the induction motor, thereby protecting the induction motor from severe over voltage situations. Similarly, other faults are monitored, ensuring the induction motor is protected against those issues.

4. SYSTEM HARDWARE

4.1 Current Transformer

A toroidal current transformer (CT) is a key component in electrical protection systems. Unlike conventional transformers, a toroidal CT does not have a primary winding. Instead, the conductor carrying the current to be measured passes through the center of the toroidal core, which is ring-shaped. The working principle is based on Faraday's Law of Electromagnetic Induction, where the alternating current flowing through the conductor induces a proportional current in the secondary winding wrapped around the core. These transformers are known for their high accuracy and reliability, making them ideal for precise current measurements in protection circuits, industrial automation, and other applications requiring careful monitoring of electrical parameters.

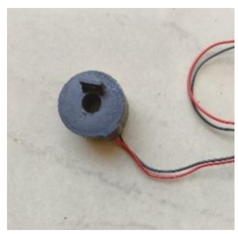

Fig.2 Current Transformer

4.2 Potential Transformer

A potential transformer (PT) is another form of instrument transformer designed to reduce high voltages to lower, safe, and measurable levels for monitoring and protection systems. Operating on the principle of electromagnetic induction, PTs provide accurate voltage measurements while minimizing errors. These transformers are integral to electrical systems that require precise voltage regulation for monitoring, protection, and control purposes. Potential transformers are typically used in high-voltage environments, where they ensure that voltage levels are brought down to manageable levels for both safety and measurement accuracy.

Fig.3 Potential Transformer

4.3 NTC Thermistor

An NTC (Negative Temperature Coefficient) thermistor is a type of resistor whose resistance decreases as the temperature increases. These thermistors are widely used in temperature-sensing applications, such as in motor protection systems, where even slight variations in temperature can be critical. NTC thermistors are small, energy-efficient, and capable of detecting rapid changes in temperature. With a wide operational range, often from -50°C to over 300°C, they are used in applications that demand precise temperature control and monitoring, ensuring the safety and proper operation of equipment like motors and other electronic systems.

Fig.4 NTC Thermistor

4.4 Arduino Nano

The Arduino Nano is a compact, versatile microcontroller based on the ATmega328P or ATmega168, designed for projects requiring small form factor and high performance. It is powered via a mini-B USB connection, with an operating voltage of 5V, but it can accept input voltages ranging from 5V to 20V. The Arduino Nano offers 8 analog input pins and a clock speed of 16 MHz, making it suitable for a wide variety of applications, from simple sensors to complex control systems. Due to its small size and ease of use, the Arduino Nano is popular in embedded systems, robotics, and DIY electronics.

Fig.5 Arduino Nano

4.5 LCD Display 16x2

A 16x2 LCD display is a commonly used display module in electronic projects, capable of showing 16 characters across 2 rows. With a standard operating voltage of 5V, these displays are essential for interfacing with microcontrollers like the Arduino, providing visual output for data, status information, and menus. The contrast of the display is adjustable using a potentiometer, typically 10K ohms, connected to the V0 pin. This feature allows for better readability in different lighting conditions, making the 16x2 LCD a popular choice in industrial automation and home appliances.

Fig.6 LCD Display16x2

4.6 Relay Module

A relay module is an electrically operated switch used to control high-voltage devices, such as motors, fans, and household appliances, from low-voltage control systems. The module operates at a 5V DC input, and it uses an electromechanical relay that can switch both AC and DC loads. With the ability to handle high switching voltages (up to 250V AC), relay modules are ideal for interfacing microcontrollers with high-power electrical circuits, providing an essential interface in automation and control systems.

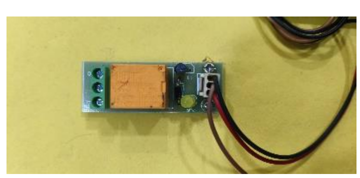

Fig.7 Relay Module

4.7 Contactor

A contactor is an electromechanical switch primarily used for controlling high-power electrical loads, particularly in three-phase motor circuits. It operates by using a magnetic coil to open or close electrical contacts, allowing or interrupting the flow of electricity to the connected load. Three-phase contactors are commonly used in industrial environments and commercial settings to switch motors and other high-power devices. These contactors are designed to handle the demands of large electrical systems, providing both protection and operational control of machinery and other electrical equipment.

Fig.8 Contactor

5. RESULT

Hardware system:

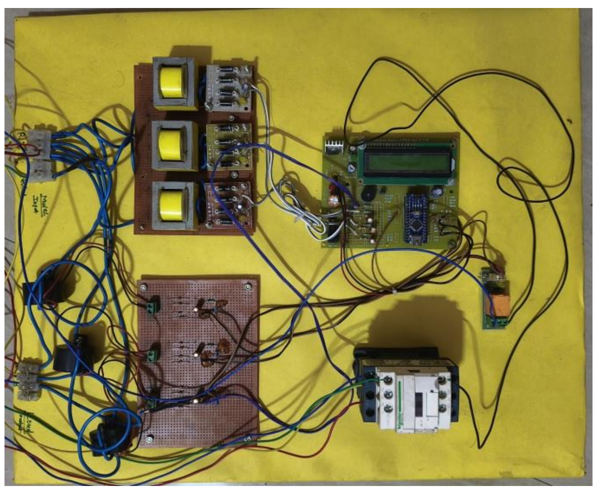

Fig.9. Three-phase induction motor protection system

Result on LCD:

- Over Voltage:
  If the supply voltage of the motor is more than 250V, then an over-voltage fault is detected and the motor stops running.

Fig.10. over voltage fault detection on LCD display

- Under voltage:
  If the supply voltage of the motor is less than 190V, then under voltage fault is detected and the motor stops running.

Fig.11. under voltage fault detection on LCD display

- Over Current:
  If the supply current of motor is more than 2.5Ampere, then an over-current fault is detected and the motor stops running.

Fig.12. Over current fault detection on LCD display

- Single Phasing:
  If one of the phases of the supply of motor is disconnected from the motor, then a single phasing fault is detected and the motor stops running.

Fig.13. Single phasing fault detection on LCD display

- Over temperature:
  If the temperature of the motor is increased than 65 degrees Celsius, then the over temperature fault is detected and the motor stops running.

Fig.14. Over temperature fault detection on LCD display

6. CONCLUSION

The implementation of this protection system for three-phase induction motors demonstrates an effective and affordable approach to mitigating the risks associated with electrical faults such as single phasing, overcurrent, overvoltage, and overheating. By integrating the use of CTs, PTs, and Arduino Nano with relay modules and contactors, the system ensures real-time protection and enhances the reliability of motor operations. Furthermore, its low-cost design makes it accessible to a wide range of applications, improving motor safety without significant investment in expensive industrial protection devices. The system can be further expanded or customized to address other motor protection needs, offering a scalable solution for various electrical control systems.

ACKNOWLEDGEMENT

We would like to express our deepest gratitude to all those who have contributed to the successful completion of this project. First and foremost, we are profoundly thankful to our respected guide, Prof. A. M. Halmare, for his exceptional guidance, continuous support, and inspiration throughout the entire project. His expertise and thoughtful advice have been pivotal in helping us navigate the challenges we encountered along the way. We would also like to extend our sincere appreciation to the faculty members who provided valuable insights and feedback, which significantly enhanced the quality of our work. Their contributions have played a key role in the development and refinement of this project. Without the guidance, resources, and moral support from all these individuals, the successful completion of this project would not have been possible. We truly appreciate each one's role in making this endeavour a success.

REFERENCES

[1] Ivana Z. Giceva, "Single Phasing of Three Phase Induction Motors under Various Load Conditions",*2018 23rd International Scientific-Professional conference on Information Technology (IT).*

[2] Pillay P., Hofmann P. And Manyage. "Derating of induction motors operating with the combination of unbalanced voltages and over or under voltages," *IEEE Transactions on Energy Conversion*, Vol.17, no.4, pp.485=491, Dec.2002.

[3] SudhaM. and AnbalganP., "A Novel Protecting Method for Induction Motor Against Fault to Voltage Unbalance and Single Phasing," *33rdAnnual Conference of the IEEE Industrial Electronics Society*,2007,pp.1144- 1148,5-8 Nov.2007,Taipei.

[4] Nagesh Bhakare, Laxman Ghanvat, "Detection of fault of three phase induction motor using Arduino uno R2 Microcontroller" International Journal of Trend in Research and Development, Volume 3(5), ISSN: 2394-9333

[5] R. Bayindir , "Fault Detection And Protection Of Induction Motor Using Sensors " Dept. of Electrical Educ., Gazi Univ.,Ankara IEEE Transactions on Energy conversion (Volume:23, Issue: 3) ,ISSN :0885-8969.

[6] D. Kumar, A. Basit, A. Saleem and E. G. Abbas, "PLC Based Monitoring & Protection of 3-Phase Induction Motors against Various Abnormal Conditions", *2019 2nd International Conference on Computing Mathematics and Engineering Technologies (iCoMET)*, pp. 1-6, 2019.

[7] Rupali Shivpuje,"Microcontroller based fault detection and protection system for induction motor",*2017 International Conference on Intelligent computing and control systems(ICICCS)* , Madurai, India, 15-16 June 2017.

[8] Ganapathy Subramanian,"Fault Detection and Protection of Induction Motors Using Sensors", *IEEE IFET College Of Engineering Villupuram III-BE Department.*