Automated Protection and Control System inInduction Motor

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Abstract: Induction motors are used considerably domestically and industrially because of their ruggedness, low cost, ease of operation. On the other hand, they operate efficiently but demand high- position control and protection systems for dependable performance and safe operation. The principles and perpetration of control and protection systems for induction motors are bandied with respect to speed control, necklace control, fault discovery and forbearance, tackle- in- the- circle simulation (HILS), etc. Different control strategies like scalar and vector control ways are bandied, emphasizing the use of these styles in controlling the motor like a good performance at different cargo conditions. It's also studied the objectification of protection systems(overcurrent protection, thermal protection and phase- failure discovery) to avoid motor failures and increase its functional life.

It also explores the ultramodern technologies like microcontrollers grounded monitoring for the motor control and protection progress as well. With the help of these technologies, real- time monitoringand prophetic conservation can be fulfilled along with remote fault diagnostics making them a great improvement in effectiveness. In the end it concludes with some imperative directions and unborn trends making inductive motor intelligence systems an investment strategy in itself.

This review paper begins by furnishing a foundational understanding of the induction motor, exploring its abecedarian principles, literal development, and crucial characteristics. latterly, it delves into a comprehensive disquisition of motor speed control ways grounded on optimization algorithms. Through a relative analysis, the strengths, limitations, and implicit operations of optimization- grounded control styles are illustrated, aiming to enhance the performance and effectiveness of induction motors across different artificial and marketable settings. First, this exploration aims to deliver a deep sapience into the crucial features of machine control and protection in induction motors for better artificial robotization results.

Keywords: Induction Motor, Automation, Protection, Control, Microcontroller, Fault Detection, Real Time Control.

INTRODUCTION

The induction motor stands as a foundation of ultramodern artificial processes, furnishing the driving force behind in numerous operations, from manufacturing to transportation. Its robustness, simplicity, and effectiveness have solidified its position as the idler of the electromechanical world. Since its commencement over a century agene , the induction motor has experienced multitudinous advancements, evolving to meet the demands of decreasingly sophisticated systems and technologies.

This introductory section aims to give a foundational understanding of the induction motor, exploring its abecedarian principles, literal development, and crucial characteristics. We claw into the operating principles that bolster its functionality, expounding the interplay of glamorous fields and electromotive forces that drive its operation. also, we trace the elaboration of the induction motor, from its early onsets to the present day, pressing vital inventions and mileposts that have shaped its line. likewise, this preface sets the stage for a comprehensive disquisition of motor speed control ways grounded on optimization algorithms.

By establishing a establishment understanding of the induction motor, we lay the root for assaying the colourful strategies employed to regulate its speed effectively. Through this relative analysis. we aim to interpret the strengths, limitations, and implicit operations of optimization-grounded control styles in enhancing the performance and effectiveness of induction motors across different artificial and marketable settings. In the realm of electromechanical systems, the capability to precisely regulate motor speed stands as a pivotal factor impacting effectiveness, performance, and overall system functionality.

From artificial ministry and robotics to automotive propulsion and renewable energy systems, precise control over motor speed is essential for optimizing processes, conserving energy, and icing safe operation. This preface serves as a gateway to the disquisition of motor speed control ways, with afocus on the operation of optimization algorithms. We embark on a trip through the principles, methodologies, and advancements in motor speed control, aiming to give a comprehensive understanding of the underpinning mechanisms and the different array of approaches employed to achieve asked speed biographies are considered.

LITERATURE SURVEY

1. "Journal, I. (2020): This review explores the evolution of traction motor technology and its impact on mechanical health monitoring and fault diagnosis. It highlights motor current signature analysis as a technique for identifying harmonic signals in line current. Various faults affecting induction motors, such as rotor, stator, bearings, vibration, and air gap eccentricity, are examined alongside diagnosis techniques. The review emphasizes AI's role in advancing fault detection and provides a comprehensive overview of traction motor faults and diagnostic schemes, aiming to guide future exploration and innovation.
2. "Bonet-Jara, J., et al. (2021): This study evaluates the effectiveness of recently developed approaches for choosing weighting factors in finite control set pulse width modulation (PWM) techniques. It categorizes methods into offline and online categories based on how weighting factors are computed, focusing on the evaluation of online methods for their ability to adjust factors automatically. The study scrutinizes four newly devised methods and the conventional method, delineating their merits and limitations to aid practitioners in selecting optimal approaches.
3. "Jannati, M., et al. (2017): This paper discusses speed control of induction motors using variable frequency drives (VFDs). It provides a basic understanding of VFD concepts and operation, highlighting the need for variable speed operation in response to varying load requirements. The document explores methods for changing motor speed, emphasizing VFD-based techniques.
4. "Ouanjli, N. El, et al. (2019): This study investigates methods for estimating sensorless speed in induction motors, focusing on their applicability for diagnosis purposes. It offers a comprehensive analysis of commercial diagnostic devices and real-world examples to elucidate prevailing challenges and guide future research efforts.
5. "Hannan, M. A., et al. (2018): This paper addresses the efficiency and control of single-phase induction motors (SPIMs) in residential and commercial electricity consumption. It emphasizes the need for efficient control strategies to optimize SPIM operation, providing a thorough examination of variable speed control techniques tailored for SPIM drives.
6. "Subasri, R., et al. (2020) : This review focuses on enhancing the performance of conventionaldirect torque control (DTC) for induction machines. It evaluates modern techniques targeting torque and flux control, assessing their effectiveness in managing algorithm complexity, minimizing losses, and improving control performance.
7. "Talla, J., et al. (2018) : This study critically assesses control and optimization strategies for induction motor (IM) drives. It provides a comprehensive analysis of scalar and vector control techniques, including speed and V/f control, direct and indirect field-oriented control, and various optimization techniques, aiming to guide future research in advancing IM drive technology.
8. "Sobhi, S. et al. (2023): This paper addresses the need for condition monitoring systems tailoredto small electric motors in industrial settings. It presents an ongoing project aimed at developinga machine-learning-based solution for faultdetection in multiple small electric motors, utilizing both shallow and deep learning approaches.
9. "Gudiño-Ochoa, A. et al. (2023): This study investigates the interaction of AC drives with induction motors in interharmonic generation. It analyzes the impact of different AC drives on interharmonic generation and employs time-frequency spectral analysis to understand harmonic generation, offering insights into the interaction between drives and motor characteristics.
10. Vijayakumari K V et. al. 2015, This paper is based on the “Three phase motors protection” from various faults. This paper emphasis on various difficulties such as phase reversal in singleand three phase systems, drop out of line, damage due to overload, failure of single phase therewill be usually recommended to perform in

complex environmental conditions. This includes in built cut-off frequency having several facilities together with timer in off condition and a starter which is automatic. This main circuit of this controller comprises of a circuit with power supply, a latch and a counter which is used for phase sequence, timer of a motor with on and off conditions.

PROBLEM IDENTIFICATION

Induction motor can be seen as the heart of any industry or organization. On the other hand, like any other machine, they must become inoperative at some point due to heavy duty cycle, inadequategrounding conditions, installation and design aspects, and so on. Industrial automation is developing quite rapidly, with growing requirements for reliability and efficiency, and therefore, the area of induction motor parameters fault diagnosis is becoming more and more relevant.

In the absence of divine faults the potentialize revenue loss and even cause reliability and safety doubts. Certain situations such as under voltage supply, overheating, three phase supply single phasing and phase reversal situations are what the three-phase induction machine constantly endures. In the event where the Induction motor is supplied with a voltage higher than it is rated value the Induction motor tends to start burning out quickly.

Motor Damage and Current Overload Protection:

Starting and fault conditions are notorious for causing overcurrent duration on the induction motors. In such situations, the lack of a robust protection solution can cause hot burning, insulation damage and even total motor breakdown. It is important to have Overcurrent protection measure to limitthese situations, so that the device can perform within the designed range of electrical characteristics.

Motor Speed Automatic Control Problems:

There are situations where it is required to change the speed of the motor in case when it's usingas pump, fan, conveyor actions. However, it is hard to achieve with changing the voltage of supply.

Voltage Fluctuations and It's Effect on Motor Protection:

Motors may operate under off conditions if there are sudden dips in the supply voltage which can, in turn, result in poor operation, overheating of the motor or damage to windings. Such variances to the electrical supply must be regulated within the specified limits so that unanticipated operational downtime and costs associated with maintenance do not necessarily arise.

Phase Imbalance or Loss:

Induction motors tend to also suffer from issues caused by the loss of one phase or when thereis a phase imbalance. If the protection system is not designed to react to such faults in a short period, the motor can expect overheating, impaired efficiency, or damage to the winding insulation permanently.

COMPONENTS (TOOLS)

Arduino uno (Microcontroller):

Operating based on temperature, speed, and current inputs to monitor the operation of motorand control it.

Fig.1. Micro Controller

Motor Protection Relay:

Overload Relay:

This prevents the motor from accidentally drawing too much current which could lead tooverheating and possibly damaging it.

Fig.2. Overload Relay

Phase Failure / Phase Sequence Relay:
Provides the motor with required phase sequence while preventing phase loss.
Under-voltage/Over-voltage Relay:

That can identify voltage fluctuations which could impact the functioning of the motor ordamage them.

Current and Voltage Sensors:

Current sensor:

It helps to track overloads in the motor circuit or faults in it by measuring the current.

Fig.3. Current Sensor

Voltage Sensor:

Tracks motor supply voltage and sends over-voltage or under-voltage alerts.

Fig.4. Voltage Sensor

Temperature Sensors:

Provides Overheat Protection RTD (Resistance Temperature Detector) or Thermocouple – toobserve the temperature of the motor.

Fig.5. Temperature Sensor

Speed and Position Sensors:

Ultrasonic sensor

Senses motor shaft speed and is an important input to control systems, protecting against abnormal speeds.

Circuit Protection Devices:

Fuses/MCB (miniature circuit breaker):

It protects the motor circuit from short circuits and overloading conditions.

Fig.6. MCB

Surge Protection Devices:

They also help to protect it from voltage spikes/surges that can potentially be harmful or damaging to its windings.

The Control Panel / Motor Starter Panel:

It contains all the controlling and protection equipment, relays & contactors for motor safety, indicators & control buttons.

Power Electronics Components:

Transistor:

Used in soft starters for controlling the voltage and current supplied to the motor.

Fig.7.Transistor

Diodes and Rectifiers:

For converting AC to DC in the motor drive system.

Fig.8. Diode

Arduino exe software:

For programming of Micro controller(Arduino uno)

Alarm System:

Provides visual or audible warnings when a fault is detected, such as overload, over- temperature, or phase failure.

CONCLUSION AND FUTURE SCOPE

Conclusion:

After working on this protection system, we can easily conclude that the numerical relay offers various features such as self-checking for faults, adaptive capacity, self-monitoring easy programmability improves communication low burden and multiple function. Numerical relays differ from other relay because the aloe us to identify and minimize faults occurring in motors.

This protection system is crucial for industrial application ensuring that motors are adequately safeguarded. Three phase devices are commonly used in industries and tend to be more expensive, making their protection essential. The method described above provides an effective solution to preventthree phase appliances from being damages by fault like undervoltage, overvoltage and overheating.

The discussion include the advantages and disadvantage of induction motor, emphasizing their robustness, reliability and simplicity, while also addressing their limitation in speed control and starting current surges. Various starting method for induction motors have been examined, including direct online starting stator resistance reactance starting auto transformer starter, star delta starter and rotor resistance control each with its own set of benefits and consideration. Overall induction motors are essential; components in a wide range of electromechanical system and ongoing research and innovation in motor speed control techniques are expected to further enhance their performance and efficiency in the future.

FUTURE SCOPE

- The future of induction motor control and protection will emphasize greater automation andintelligence.
- Integration with smart grid technologies will improve energy management capabilities.
- Continuous innovation will lead to enhancements in efficiency, reliability and sustainability
- Wireless technologies are evolving, allowing for more flexible and scalable control and protection systems. Induction motors can be controlled and protected remotely, without the need for physical wiring or complex infrastructure.
- As industries evolve and new standards emerge, future control and protection systems will needto be developed in line with updated regulations regarding safety, energy efficiency, and environmental impact.
- As the demand for compact and affordable control systems increases, future developments could focus on miniaturizing protection and control components while maintaining high reliability and performance. This would be particularly beneficial in small-scale or residential applications.
- With the growing adoption of electric vehicles (EVs) and automation in industrial settings, there is an increasing demand for advanced motor control systems that can be used in these applications. Induction motors in EVs, for example, require sophisticated control systems to optimize torque, efficiency, and regenerative braking.

REFERENCE

[1] Jacobina, C. B., de Rossiter Correa, M. B., da Silva, E. C., & Lima, A. M. N. (1999). Induction motor drive system for low-power applications. IEEE Transactions on Industry Applications, 35(1), 52-61.

[2] Glowacz, A., & Glowacz, Z. (2017). Diagnosis of the three-phase induction motor using thermal imaging. Infrared physics & technology, 81, 7-16.

[3] Lewis, C. (2002, July). The advanced induction motor. In IEEE Power Engineering Society Summer Meeting, (Vol. 1, pp. 250-253). IEEE.

[4] Mamdouh, M., Abido, M. A., &Hamouz, Z. (2018). Weighting Factor Selection Techniques for Predictive Torque Control of Induction Motor Drives: A Comparison Study. Arabian Journal for Science and Engineering, 43(2), 433– 445. https://doi.org/10.1007/s13369-017- 2842-2

[5] Journal, I. (n.d.). A REVIEW PAPER ON VARIABLE FREQUENCY DRIVE.

[6] Bonet-Jara, J., Quijano-Lopez, A., Morinigo-Sotelo, D., & Pons-Llinares, J. (2021).

Sensorlessspeed estimation for the diagnosis of induction motors via mcsa. Review and commercial devices analysis†. Sensors, 21(15), 1–35. https://doi.org/10.3390/s21155037

[7] Jannati, M., Anbaran, S. A., Asgari, S. H., Goh, W. Y., Monadi, A., Aziz, M. J. A., & Idris, N. R. N. (2017). A reviewon Variable Speed Control techniques for efficient control of Single- Phase Induction Motors: Evolution, classification, comparison. Renewable and Sustainable Energy Reviews, 75(April), 1306–1319. https://doi.org/10.1016/j.rser.2016.11.115

[8] Ouanjli, N. El, Derouich, A., Ghzizal, A. El, Motahhir, S., Chebabhi, A., Mourabit, Y. El, &Taoussi, M. (2019). Modern improvement techniques of direct torque control for induction motor drives-A review. Protection and Control of Modern Power Systems, 4(1). https://doi.org/10.1186/s41601-019-0125-5

[9] Hannan, M. A., Ali, J. A., Mohamed, A., & Hussain, A. (2018). Optimization techniques to enhance the performance of induction motor drives: A review. Renewable and Sustainable Energy Reviews, 81(September 2016), 1611–1626.https://doi.org/10.1016/j.rser.2017.05.240

[10] Subasri, R., Meenakumari, R., Panchal, H., Suresh, M., Priya, V., Ashokkumar, R., &Sadasivuni, K. K. (2020). Comparison of BPN, RBFN and wavelet neural network in induction motor modelling for speed estimation.

[11] International Journal of Ambient Energy, 0(0), 1–6. https://doi.org/10.1080/01430750.2020.1817779

[12] Talla, J., Leu, V. Q., Smidl, V., & Peroutka, Z. (2018). Adaptive speed control of induction motor drive with inaccurate model. IEEE Transactions on Industrial Electronics, 65(11), 8532–8542. https://doi.org/10.1109/TIE.2018.2811362

[13] Sobhi, S.; Reshadi, M.; Zarft, N.; Terheide, A.; Dick, S. Condition Monitoring and Fault Detection in Small InductionMotors Using Machine Learning Algorithms. *Information* 2023, *14*, 329. https://doi.org/10.3390/info14060329

[14] Gudiño-Ochoa, A.; Jalomo-Cuevas, J.; Molinar-Solís, J.E.; Ochoa-Ornelas, R. Analysis of Interharmonics Generationin Induction Motors Driven by Variable Frequency Drives and AC Choppers. *Energies* 2023, *16*, 5538. https://doi.org/10.3390/en16145538

[15] Chang, Y., Yan, H., Huang, W., Quan, R., & Zhang, Y. (2023). A novel starting method with reactive power compensation for induction motors. *IET Power Electronics*, *16*(3), 402-412.

[16] Priya V. Kale, Amit M. Kale, Nikhil R. Kamdi, Prof. Ankita A. Yeotikar, "Protection of induction motor using classical method", International Research Journal of Engineering and Technology, Volume: 04 Issue: 01 | Jan - 2017.