iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.66160

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Automatic Fault Detection and Isolation System in Distribution System

Prof.Pandurang M. Pujari[1], Prajakta Santosh Suryawanshi[2], Sanket Shantinath Khot[3], Prathmesh Rajendra Pharne[4]
Department of Electrical Engineering ADCET Ashta, Indiap

Abstract: Our project focuses on developing a cutting-edge, internet-based fault detection system for electrical distribution networks, aiming to address the critical need for rapid and accurate fault identification. Given the indispensable role of electricity in powering industries and daily life, particularly in urban areas, any disruption in the distribution system can have significant economic and operational repercussions. Our solution integrates advanced sensor technology with real-time data analysis and internet connectivity to swiftly detect and precisely locate faults within the distribution network. This innovative approach not only enhances the speed of fault detection but also minimizes downtime and expedites the restoration of power supply, thereby ensuring a more reliable and efficient electricity distribution system. By leveraging smart technology to streamline fault management, our project contributes to maintaining uninterrupted power flow and supporting economic stability and everyday convenience.
Keywords: Fault detection system, Electrical distribution networks, Internet-based, Real-time data analysis, Advanced sensor technology, Fault identification, Rapid detection, Accurate fault location, Downtime minimization, Power supply restoration.

I. INTRODUCTION

In power system, fault is defined as the defect in power system due to which current is distracted from the intended path. Then, the fault creates the abnormal in power system which reduces the insulation strength. A ground fault in a distribution network occurs when an energized conductor accidentally comes into contact with the ground or a grounded equipment frame. This can cause a significant increase in the flow of electricity, which can lead to dangerous situations such as shock, fire, and burns. The faults may occur for a temporary or permanent in power system and this can disturb the supply to users. Then, it is important to detect the faults occurred so that it will prevent from any damage of equipment and continue supply the energy to consumers. With the development of information technology, distribution automation system plays an increasingly important role in monitoring and control for distribution system. The advantages of distribution automation system in data collection, transmission and application should be given full play for SPG fault diagnosis, which is beneficial to improve maintenance efficiency and reduce work burden of operation staff. From the studies, by using IoT system, user can take immediate action to solve the fault problems in power system after getting notification. The single-phase ground faults account for more than 80% of the total number of ground faults in the overhead lines. Existing researches on fault location methods mainly focus on injection method ranging, ranging based on fault steady-state quantity and fault transient state quantity. The method of ranging based on fault steady-state quantity is basically ineffective in small-current grounding systems. The most common practice of utilities is to use overcurrent relays to detect faults in distribution systems which track the feeder current and indicate a fault if the current is higher than a predefined threshold [19].

In recent years one study for fault diagnosis is proposed for 6kv to 20kv line. this is performed for practical purpose. FLISR system will be used to enhance security and improve the distribution network [3]. As we all know, the earth fault in single phase transmission and distribution line is 70-80 percent. so we have to work in that field. In principle, faults in distribution network should be isolated in time, in order to reduce electric shock injury. This paper proposes a scheme of a novel scheme of single-line grounded-fault detection by sequential line tripping. Combined with dynamic weighted line selection method it can effectively improves the accuracy and efficiency of fault isolation in non-effective grounded system, this will give by author Jyh-Cherng [4].Like IOT system the Artificial Intelligence technique is used to detect the fault g to a short- circuit fault in distribution networks, the fault should be located and isolated before restoring the supply. A fast and accurate fault location method can help to improve the continuity of supply considerably. AI-based methods can be trained in off-line procedures to make fast online estimations of the fault location or faulted section. These methods need a considerable amount of training data which can be based on historical records or be generated in a simulation process. But this technique is less sensitive. implemented for rapid fault detection, faulted section isolation, and automatic network reconfiguration to restore service to non-faulted feeder sections, therefore minimizing the number of affected customers. this system will be very beneficial for underground distribution [12].

In principle, faults in distribution network should be isolated in time, in order to reduce electric shock injury. Further, re-closing function of protection and automatic devices are used to improve the power supply reliability. However, the fault characteristic of non- effective grounded system is not obvious which cannot be effectively identified. Studies on fault isolation methods by protection and automatic devices have been paid a lot of attention. Domestic and foreign experts put forward a variety of line selection methods, including steady-state signal line selection method and transient-signal line selection method.

II. RELATED WORK

The progression of automatic fault detection and isolation systems has moved from basic protection relays to AI-driven, IoT-enhanced smart grid systems that allow for real-time fault detection, location, and rapid isolation. Modern research is now focused on improving accuracy, speed, and the economic efficiency of fault management systems, along with enhancing their resilience to grid challenges.

1) *Traditional Fault Detection Methods*

Early fault detection in electrical distribution systems was largely based on overcurrent relays, fuses, and circuit breakers. These methods are still in use but tend to be reactive, leading to delays in fault identification and isolation. Research in this area focused on improving these traditional mechanisms by refining the coordination of protective devices and enhancing fault- clearing time. oDescribes early methods for fault detection and isolation, focusing on basic relay protections in distribution systems.

2) *Digital Protection Systems*

With the introduction of digital relays and microprocessor-based protection systems, fault detection improved significantly. These systems allow for more complex algorithms to detect faults based on various power system parameters, such as voltage, current, frequency, and impedance. oDiscusses advancements in protective relaying technologies and how digital systems have improved detection speed and accuracy in distribution networks.

3) *Smart Grid and Internet of Things (IoT) Integration*

Recent advancements leverage smart grid technology and IoT-based solutions to offer more advanced fault detection. Smart sensors and real-time data collection systems use communication networks to monitor the electrical grid and provide immediate feedback to central control systems. IoT- enabled sensors can detect changes in voltage and current in real time, improving fault localization accuracy. o Focuses on the integration of smart grid technology in fault detection and discusses the role of IoT sensors in creating more responsive distribution networks.

4) *Real-time Fault Location and Monitoring Techniques*

Several methods for real-time fault location have been developed, using traveling wave theory, impedance-based techniques, and wavelet transforms to pinpoint fault locations with great precision. These systems help reduce the response time required to isolate faults, thereby minimizing outages. oExplores real-time fault location using smart meter data and wavelet transforms to accurately identify and isolate faults.

5) *Fault Detection and Self-Healing Systems*

Self-healing networks, which are an extension of fault detection systems, use automatic control to isolate faults and restore power to unaffected areas. The self-healing process is achieved through the coordination of automated switches, remote terminal units (RTUs), and substation automation systems. oHighlights field experiences with self-healing networks and the benefits of distributed intelligence in fault isolation and recovery.

6) *Recent Commercial Solutions*

Many commercial solutions, such as General Electric's Grid IQ, Siemens’ Spectrum Power, and ABB’s MicroSCADA, offer integrated fault detection and isolation features. These platforms use a combination of SCADA systems, GIS technology, and automated fault detection to enhance operational efficiency in power distribution. oDescribes Siemens' fault detection and isolation system that integrates SCADA and GIS for real-time monitoring.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

III. PROPOSED SYSTEM

The proposed system for automatic fault detection and isolation (FDI) in electrical distribution networks aims to enhance fault detection accuracy, speed, and efficiency by leveraging real-time monitoring, smart sensors, and automated controls.

The system is designed to address the shortcomings of traditional methods by integrating Internet of Things (IoT), advanced data analytics, and machine learning (ML) for better fault management and grid reliability.

A. *System Architecture*

The proposed system comprises three major components:

1) *Smart Sensors and IoT Devices*

- Sensor Deployment: Smart sensors are strategically installed throughout the distribution network, including on feeders, transformers, substations, and transmission lines. These sensors continuously monitor electrical parameters such as current, voltage, and impedance.
- Data Collection: The IoT devices enable real-time data collection and communication across the network using wireless sensor networks (WSNs) or optical fiber communication. The gathered data is sent to the centralized monitoring system for processing.
- Real-time Alerts: These sensors detect abnormalities such as overcurrent, under-voltage, short circuits, or equipment failures, triggering immediate fault alerts

2) *Centralized Monitoring and Control Unit*

- Real-time Data Processing: Data from the sensors is transmitted to a centralized control unit that employs advanced data analytics to process the large volumes of real-time data.
- Cloud and Edge Computing: The system can incorporate both cloud computing and edge computing for faster processing and analysis of fault data. This ensures that critical fault data can be processed locally near the fault site (edge) for quicker response, while detailed analytics are handled centrally.
- Fault Visualization: The control unit visualizes the status of the entire distribution network, helping operators identify fault-prone zones, monitor fault occurrence, and track network performance metrics.

3) *Fault Detection and Isolation Algorithms*

- Machine Learning Algorithms: The system leverages ML algorithms trained on historical fault data to identify patterns and detect early signs of potential faults. These algorithms can predict faults based on deviations in voltage, current, and impedance.
- Fault Location Techniques: The system uses impedance- based fault location, traveling wave theory, and wavelet transform methods to precisely locate faults. This reduces the time needed to manually inspect the fault area.
- Self-Healing and Isolation: The system incorporates self- healing capabilities. Upon detecting a fault, automated switchgear (like reclosers and circuit breakers) is triggered to isolate the faulted section, ensuring that unaffected sections continue receiving power. The system can reroute electricity through alternative paths, minimizing outage times

.

B. *System Workflow*

1) Normal Monitoring: During normal operations, smart sensors continuously monitor key electrical parameters, such as voltage, current, and impedance.
2) Fault Detection: When a fault is detected (e.g., short circuit, overcurrent, or equipment failure), the system immediately sends real-time alerts to the central control unit.
3) Data Analysis: The fault data is processed using ML-based fault detection algorithms. The system cross-references the detected fault pattern with historical fault data to confirm the nature of the fault.
4) Fault Location: Once confirmed, the system utilizes impedance-based techniques or traveling waves to locate the fault precisely within the network.
5) Fault Isolation: Automated switching devices (reclosers or sectionalizers) isolate the faulted section, preventing the spread of the fault and ensuring that unaffected areas remain operational.

6) Restoration: After fault isolation, the system attempts to automatically restore power to the unaffected sections by rerouting electricity through alternative paths.
7) Maintenance Alerts: Maintenance crews are alerted about the exact fault location to expedite physical repairs.

C. Technological Components

1) IoT and Smart Sensors: Provide real-time data collection and communication across the network.
2) Wireless Sensor Networks (WSN): Enable reliable, real- time communication between sensors and the centralized control unit.
3) Advanced Machine Learning Algorithms: Used for both real-time fault detection and fault prediction based on historical data.
4) SCADA Integration: The system can integrate with existing Supervisory Control and Data Acquisition (SCADA) systems for monitoring and control.
5) Edge Computing: Enhances fault detection and response times by processing critical data closer to the fault location.
6) Automated Switchgear (Reclosers/Sectionalizers): Enable fast isolation of the faulted section.

➢System Design Method

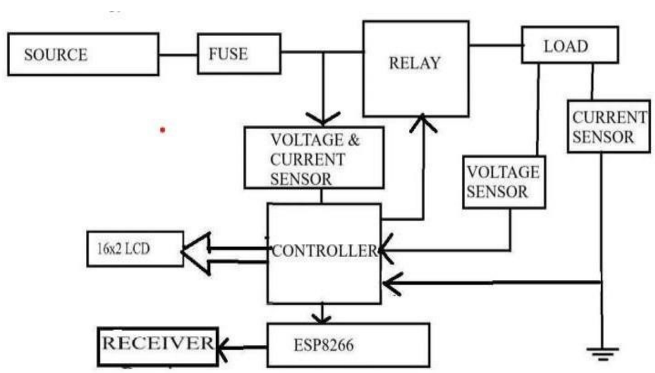


Fig 1. Block Diagram

Block Diagram:

Block diagram for the Automatic fault detection and isolation system in Distribution network is shown in figure. In this consist of five main blocks. for this block diagram controller, sensors, and relays are important.so firstly supply will be taken from the lines, the values of current and voltage are set manually. If the supply voltage and current will be less or more than that value then the controller will give signal to the relay. Relay will be taking action according to the signal. similarly, the earth voltage and current values are set. Same condition is used for the that side. but there is small difference that when earth fault occurs then the relay will not be get on until the fault is not resolved.so the customer is also safe from hazard. sensors used are ZNPT and pick up type sensor. relay is used for switching action. controller function is to control the whole system and monitor the fault condition. To make system advance IOT is used .by using IOT the message can be exchanged and data is used for further action.

IV. METHODOLOGY

The methodology for developing an Automatic Fault Detection and Isolation (FDI) System in a distribution system outlines the process of designing, implementing, and testing a smart, real-time solution. This methodology includes multiple stages that focus on integrating advanced technologies like IoT, machine learning, and automated controls to enhance fault management and isolation.

A. Problem Definition and System Requirements

➢Objective: To develop a system that can detect, locate, and isolate faults in a distribution network automatically with minimal human intervention, reducing downtime and improving reliability.

Requirements Analysis:

- Real-time monitoring of electrical parameters (voltage, current, impedance).
- Fast and accurate fault detection and location. oAutomated fault isolation to prevent cascading failures.
- Integration with existing systems like SCADA and substation automation. oSupport for IoT and ML-based predictive fault analysis.

B. System Design ➢Architectural Design:
- Develop a system architecture that includes smart sensors, a central control unit, communication protocols, and automated switches.
- Ensure scalability for small to large networks. oDivide the system into sensor layer, communication layer, control layer, and application layer for modular design and flexibility.

C. Development of Fault Detection Algorithms

1) Data Collection and Preprocessing:
- Collect historical fault data and real-time sensor data to develop and train the detection models.
- Clean and preprocess the data, normalizing it and removing any noise to enhance the accuracy of the algorithms.

2) Machine Learning Algorithm Development:
- Train supervised machine learning models (e.g., Random Forest, Support Vector Machines, Neural Networks) using historical fault data to classify types of faults. oUse unsupervised learning for anomaly detection in real- time data to detect abnormal conditions.
- Implement predictive analytics to forecast potential faults by learning from previous fault patterns and grid conditions.

3) Fault Location Techniques:
- Develop models for impedance-based fault location, which estimates fault distance by calculating impedance from the substation to the faulted point.
- Implement traveling wave analysis, where high-frequency components generated during a fault are used to determine fault location with high accuracy. oUse wavelet transforms to analyze transient signals from the fault, enabling precise identification of the faulted area.

D. Development of Automated Isolation Control
- Automated Switchgear: Install and program automated reclosers, sectionalizers, and circuit breakers that can isolate faults without human intervention.
- Self-Healing Logic: Develop self-healing algorithms that reroute power to unaffected areas after a fault is detected, minimizing outage duration.
- Coordination of Devices: Implement a coordination mechanism to ensure that the reclosers and sectionalizers operate in a predefined sequence, preventing over-tripping and ensuring accurate isolation.

E. Implementation and Deployment
- Pilot Deployment: After successful testing, deploy the system in a pilot area within a real distribution network for further validation under real-world conditions.
- Monitoring and Fine-Tuning: Continuously monitor the system's performance, gathering feedback from operators and making necessary adjustments to algorithms and control mechanisms.
- Scalability: Evaluate the scalability of the system to other areas of the distribution network. Ensure that the system can handle increasing loads and growing network sizes.

V. EXPERIMENTS AND RESULTS

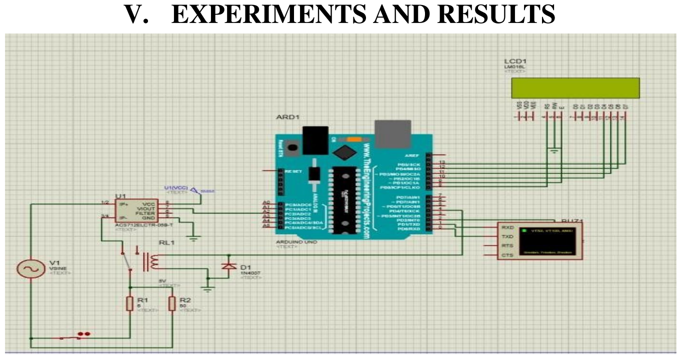


Fig 2. Simulated Circuit

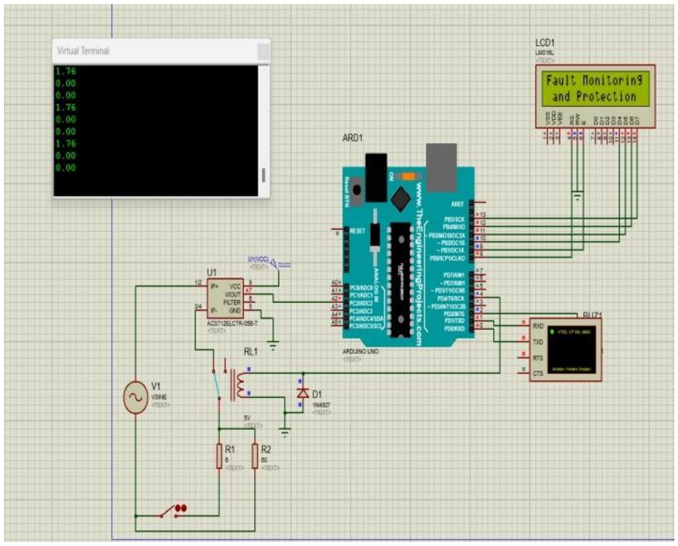


Fig 3. Simulation Result at Normal Condition

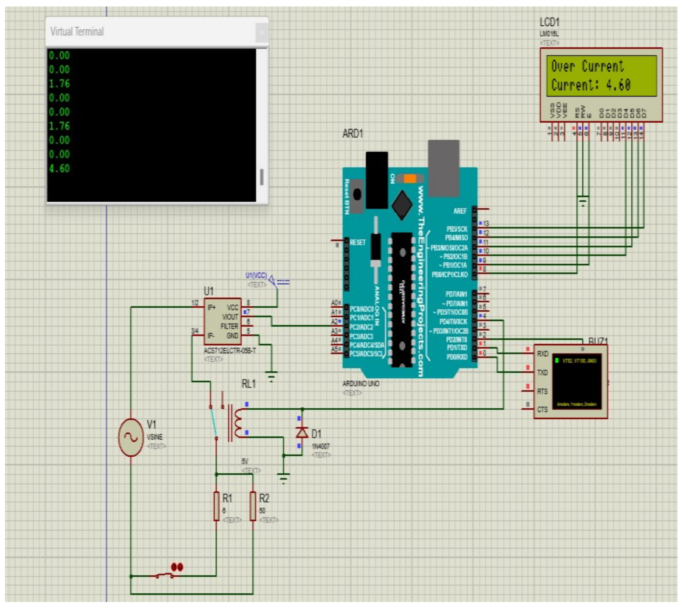


Fig 4. Simulation Result at Faulty Condition

Results: Values of current and voltage at normal and faulty conditions

VI. CONCLUSION

Continuous Monitoring: With the help of this system we can continuous monitor the voltage and current of system. Earthing system protection and isolation: If the voltage and current sensors detect any discrepancies between the values of voltage and current, the system will isolate. Isolation of distribution system when fault is occur at supply side: If the voltages of line is less than 190 V then circuit breaker will in off position. similarly if the voltage of line is greater than the 260 V then the circuit breaker will be in off position this will be happen in by the use of sensors like current, voltage sensors. The Automatic Fault Detection and Isolation (FDI) System represents a significant advancement in the management of electrical distribution networks. By integrating IoT technology, machine learning, and real-time data analysis, the proposed system offers enhanced capabilities for fault detection, location, and isolation, addressing the critical need for reliability in modern power grids. his system marks a step forward in ensuring a more reliable, efficient, and smart distribution network, improving both the quality of service and the resilience of power supply systems in an increasingly connected and energy-dependent world.

VII.FUTURE WORK

The Future of Automatic Fault Detection and Isolation in distribution systems lies in enhancing the intelligence, security, and scalability of these systems. Integrating emerging technologies such as machine learning, edge computing, smart grids, and cybersecurity will allow for faster, more accurate fault detection and system recovery. By continuing research and development in these areas, the next generation of FDI systems can provide smarter, more resilient, and more sustainable power distribution networks capable of meeting the challenges of an increasingly interconnected and energy-dependent world.

REFERENCES

[1] J. -C. Gu, Z. -J. Huang, J. -M. Wang, L. -C. Hsu and M. -T. Yang, "High Impedance Fault Detection in Overhead Distribution Feeders Using a DSP-Based Feeder Terminal Unit," in IEEE Transactions on Industry Applications, vol. 57, no. 1, pp. 179-186, Jan.-Feb. 2021, Doi: 10.1109/TIA.2020.3029760.

[2] B. Pham, C. Huff, P. E. Nick Vendittis, A. Smit, A. Stinskiy and S. Chanda, "Implementing Distributed Intelligence by Utilizing DNP3 Protocol for Distribution Automation Application," 2018 IEEE/PES Transmission and Distribution Conference and Exposition (T&D), Denver, CO, USA, 2018, pp. 1-7, Doi: 10.1109/TDC.2018.8440305.

[3] "IEEE Recommended Practice for Fault Diagnosis and Protection in Smart Distribution System," in IEEE Std 2748- 2023, vol., no., pp.1-76, 31May 2024, Doi: 10.1109/IEEESTD.2024.10542673. IEEESTD.2024. 10542673.

[4] X. Chen, Z. Shi, J. Yu and X. Ding, "A Novel Scheme of Single-Line-Grounded-Fault Detection and Its Practical Implementation for Non-Effective Grounded System," 2019 4th International Conference on Intelligent Green Building and Smart Grid (IGBSG), Hubei, China, 2019, pp. 521-525, Doi: 10.1109/IGBSG.2019.8886324.

[5] F. Mohammadi, G. -A. Nazri and M. Saif, "A Fast Fault Detection and Identification Approach in Power Distribution Systems," 2019 International Conference on Power Generation Systems and Renewable Energy Technologies (PGSRET), Istanbul, Turkey, 2019, pp. 1-4, Doi: 10.1109/PGSRET.2019.8882676.

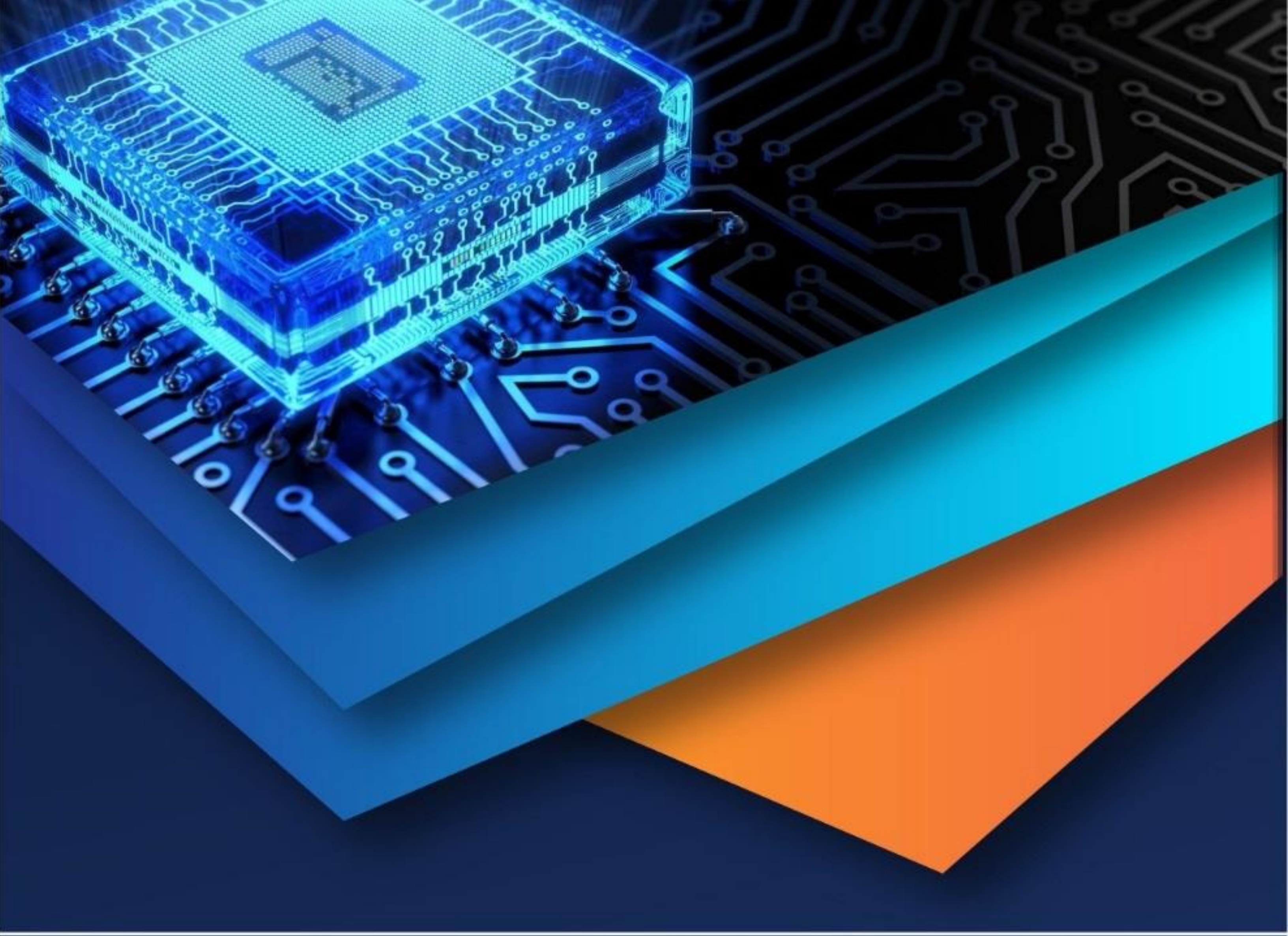
[6] B. Li, K. Liao, J. Yang and Z. He, "A Sensitive Fault Detection Method for AC-DC Hybrid Distribution Network Based on Intelligent Learning," 2022 IEEE/IAS Industrial and Commercial Power System Asia (I&CPS Asia), Shanghai, China, 2022, pp. 830-836, Doi: 10.1109/ICPSAsia55496.2022.9949842.

[7] H. Hamze, A. Fereidunian and H. Lesani, "Fault Detection and Location for Reinforcement of Smart Distribution Systems Restoration, Using Discrete Orthogonal Stockwell Transform and Regression ANN," 2022 12th Smart Grid Conference (SGC), Kerman, Iran, Islamic Republic of, 2022, pp. 1-8, Doi: 10.1109/SGC58052.2022.9998908 .

[8] H. Wang, J. Wang and Z. Guo, "Distribution network automation design and intelligent distributed FA positioning of failure," 2023 IEEE 3rd International Conference on Electronic Technology, Communication and Information (ICETCI), Changchun, China, 2023, pp. 652658, Doi:10.1109/ICETCI57876.2023.10176965.

[9] A. Wang and Y. Wang, "Distribution System Fault Detection through Feature Summarizing Matrix: A Case Study," 2020 IEEE Power & Energy Society General Meeting (PESGM), Montreal, QC, Canada, 2020, pp. 1-5, Doi:10.1109/PESGM41954.2020.9281780.

[10] H. Wu, "Grounding Fault Detection Method Of Intelligent Distribution Network Under Power Marketing Informatization," 2021 IEEE International Conference on Industrial Application of Artificial Intelligence (IAAI), Harbin, China, 2021, pp. 379- 384, Doi: 10.1109/IAAI54625.2021.9699896.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY