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Symmetrical and Unsymmetrical Fault Detection and Circuit Breaker in Power System Using Pi

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Abstract: The reliable operation of a power system largely depends on the fast and accurate detection of faults and the timely restoration of supply. Faults in power systems are broadly classified as symmetrical and unsymmetrical faults, both of which can cause severe damage to equipment, voltage instability and interruption of power supply if not properly handled.

This project presents the design and implementation of a symmetrical and unsymmetrical fault detection system with an automatic reclosing circuit breaker to improve system reliability and continuity of service. The proposed system continuously monitors line parameters such as voltage and current to identify abnormal conditions during fault occurrences. Upon detection of a fault the protection circuit isolates the faulty section by tripping the contactor with relay.

An automatic reclosing mechanism is implemented to restore power after a predefined time delay, assuming the fault is temporary in nature. This reduces the outage duration, improves system stability and minimizes manual intervention. Simultaneously global system for mobile communication (GSM) communicates with the controller and sends the message of the fault and occurrence of the system. Simultaneously MQTT dash (android application) is connected to the system server through the cloud and personnel can monitor the active and real time data, therefore also can control through the dash application changing its mode to auto or manual mode of operation. Secondly through the SMS command (0 or 1) we can charge and trip the system therefore where charge is denoted as 1 and trip is denoted as 0. The developed system is suitable for application in transmission and distribution networks where fast fault clearance and frequent supply restoration are critical.

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I. INTRODUCTION

A reliable and continuous supply of electrical power system is essential for todays society. Power systems are to be designed to transmit and to distribute electricity from generating stations to consumers with high reliability efficiency and stability. However, faults occurring in the transmission and distribution lines can be disturb the normal operation of the system and lead to power interruptions and as well disturbance , equipment failure and at some case even equipment damage. Therefore, the detection and protection of faults are very important aspects of power system operation. In electrical power systems, faults are mainly classified into symmetrical faults and unsymmetrical faults. A symmetrical fault occurs when all the three phases of the system are gets short-circuited simultaneously and resulting in balanced fault current in all phases but the symmetrical faults occur less as compared to other where this type of fault current can severely affect the stability to other of the power system. On the other hand unsymmetrical faults involve only one or two phases of the system and are more common in practical power networks. Examples of unsymmetrical faults include single line-to-ground faults, line-to-line faults and double line-to-ground faults.

Faults in power systems may be caused by several factors such as insulation failure, lightning strikes, equipment malfunction, tree branches touching transmission lines or environmental conditions such as storms and heavy rain. If these faults are not detected and cleared quickly, they may cause serious damage to electrical equipment and may also result in prolonged power outages. To minimize these effects, protection systems are used to detect faults and isolate the faulty section from the healthy part of the network. One effective technique used in power system protection is auto-reclosing. Many faults in overhead transmission lines are temporary in nature. The auto-reclosing circuit automatically reconnects the power line after a short delay once the fault disappears. This helps restore the power supply quickly without manual intervention and improves the reliability of the power system. In addition to fault detection and automatic restoration, modern power systems also require efficient

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monitoring and communication systems. GSM (Global System for Mobile Communication) technology can be used to send fault alerts and system information to operators through SMS messages and calls and as well via a android application . This allows operators to monitor the system remotely and respond quickly to abnormal conditions. This research focuses on the design and implementation of a system for detecting symmetrical and unsymmetrical faults in a power system with an auto-reclosing circuit and real time monitoring. The proposed system aims to improve the reliability, safety and efficiency of power system protection by providing fast fault detection, automatic restoration and real-time communication to the system Operation.

II. LITERATURE REVIEW

Our investigation reveals that the vast research there are many and end numbers of studies on fault detection and protection that methods in power systems to enhance the safety and reduce interruptions. However at traditional power systems, protection and safety were mainly done using electromechanical relays and breakers. Where these devices were used to detect the abnormal current conditions such as short circuit, overcurrent and line fault. Although these systems were reliable, they had some limitations such as delay of response time and there were no real time monitoring . hence with the development of modern technology and microcontroller-based protection systems were introduced. These systems are far more better than traditional method where it can monitor electrical parameters such as voltage and current continuously and help in detecting different types of faults more precise and accurate in real time based. These method are widely used in identifying the symmetrical faults and unsymmetrical faults in power system. Many of researcher have focused in the use of auto-reclosing circuit at transmission and distribution lines. Many faults in power systems are temporary which fault is caused by lightning or touching the line by trees branches. Where Auto-reclosing logic operates automatically to reconnect the supply after a short delay when the fault disappears. This system helps to reduce the power interruption and improves the the transmission power system. In recent years, communication technologies such as GSM and real time monitoring have been used for monitoring and controlling power systems. GSM modules can send SMS and call alerts to operators when a fault occurs. This allows quick response and helps in monitoring the system from remote locations. Therefore, combining fault detection techniques, auto-reclosing circuits, and GSM communication and android application based can improve the protection, reliability and monitoring of modern power systems. Although earlier researcher has made a system similar to this but not as that accurate, precise and real time monitoring based. hence we are using an advance microcontroller raspberry pi 4 for analysing and processing our every data, essential for a balanced and efficient system for this type of problem.

III. METHODOLOGY

The proposed system is designed to detect symmetrical and unsymmetrical faults in a power system and restore the power supply automatically using an auto-reclosing circuit. The system also sends fault information to the operator through a GSM module for remote monitoring. In this system, the power line is continuously monitored using voltage and current sensing module. These sensors measure the electrical parameters of the system and send the data to the control unit. The control unit analyses the values of voltage and current to identify abnormal conditions in the power line. When a fault such as line-to-line fault, line-to-ground fault or three-phase fault occurs, the system detects the abnormal condition immediately. Once the fault is detected, the protection circuit operates and sends the signal to relay and opens the contactor to disconnect the faulty section from the power supply. This helps prevent damage to electrical equipment and maintains the safety of the system. After a short delay, the auto-reclosing circuit attempts to restore the power supply automatically. If the fault was temporary, the system reconnects the power line and normal operation continues. However, if the fault still exist the contactor opens the circuit and need to manual charge through the remote or SMS command after the permanent fault clears.

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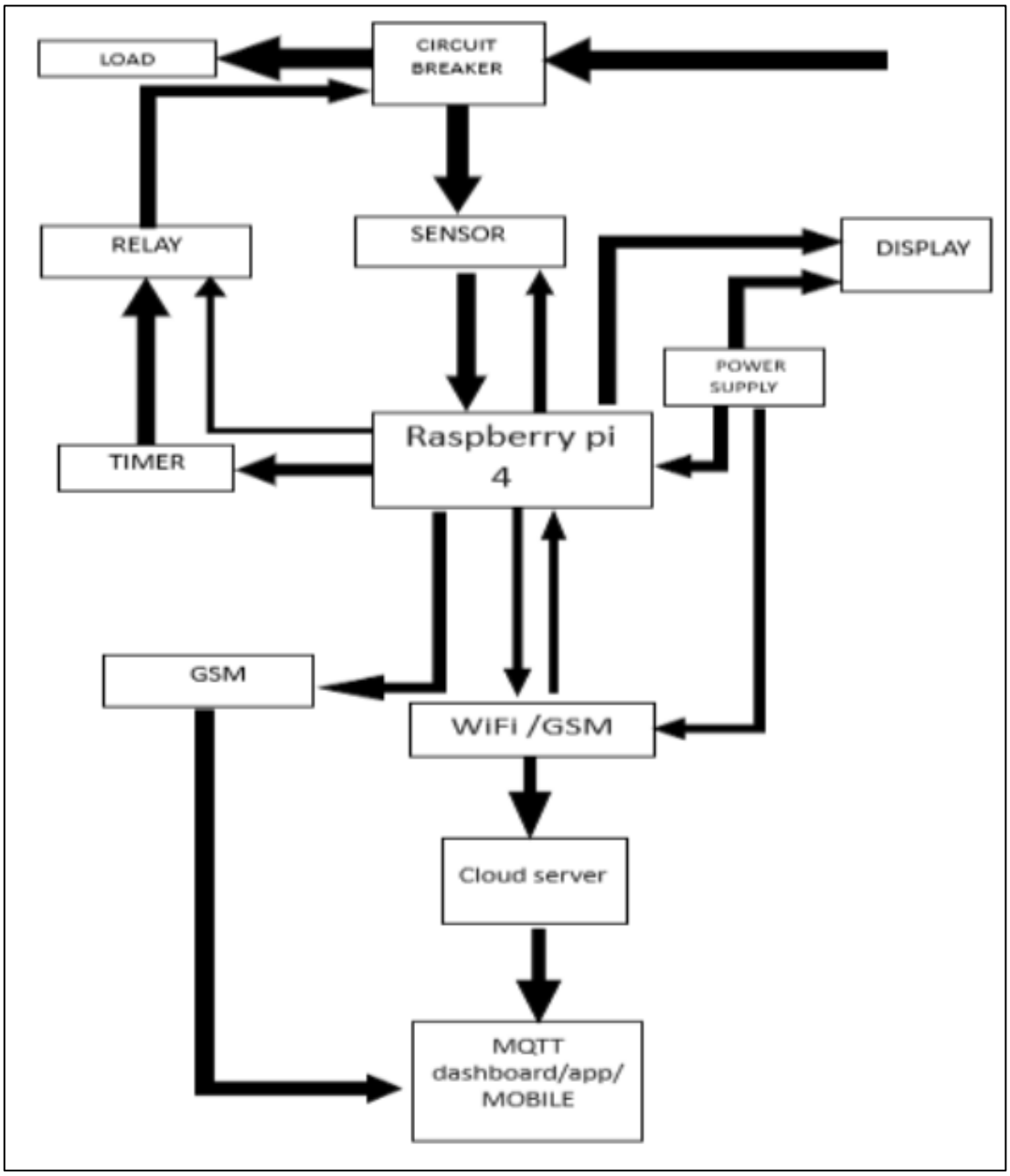

Fig1 Block Diagram

➢ *Block Diagram Description*

The whole project architecture has been illustrate inn the above given block diagram (fig:1) here it represents the AC line connection to sensors till the android application dashboard , how does it work, which equipment is connected to each other and in systematic manner such as the sensor are connected to the raspberry pi and controller is connected to GSM and various other components for the smooth operation and functions.

Therefore the sequence and systematic representation of the system function is quietly represented in simple manner and understandable format.

➢ *Flow Chart Description*

However the system architecture is briefly explained by the block diagram but here the flow chart deals with the loop of system that how it starts and checks the condition therefore execute the output depending to the input of the sensor data , it basically works under the predefined code condition that is mentioned for the reading data, checks and analysis the data and gives the output depending the data or value.

When system initialize all the device gets powered and starts communication with each other and checks the current condition and when it exceeds the defined the condition it will execute on ‘YES” or “NO” condition ,if it gets No then the normal operation will function but if goes with the Yes it will trip the breaker and send the SMS alert and call alert and recheck the current condition if still fault current remains the same it will trip circuit permanently but if the current becomes normal breaker will auto reclose the circuit breaker , resulting the power restoring.

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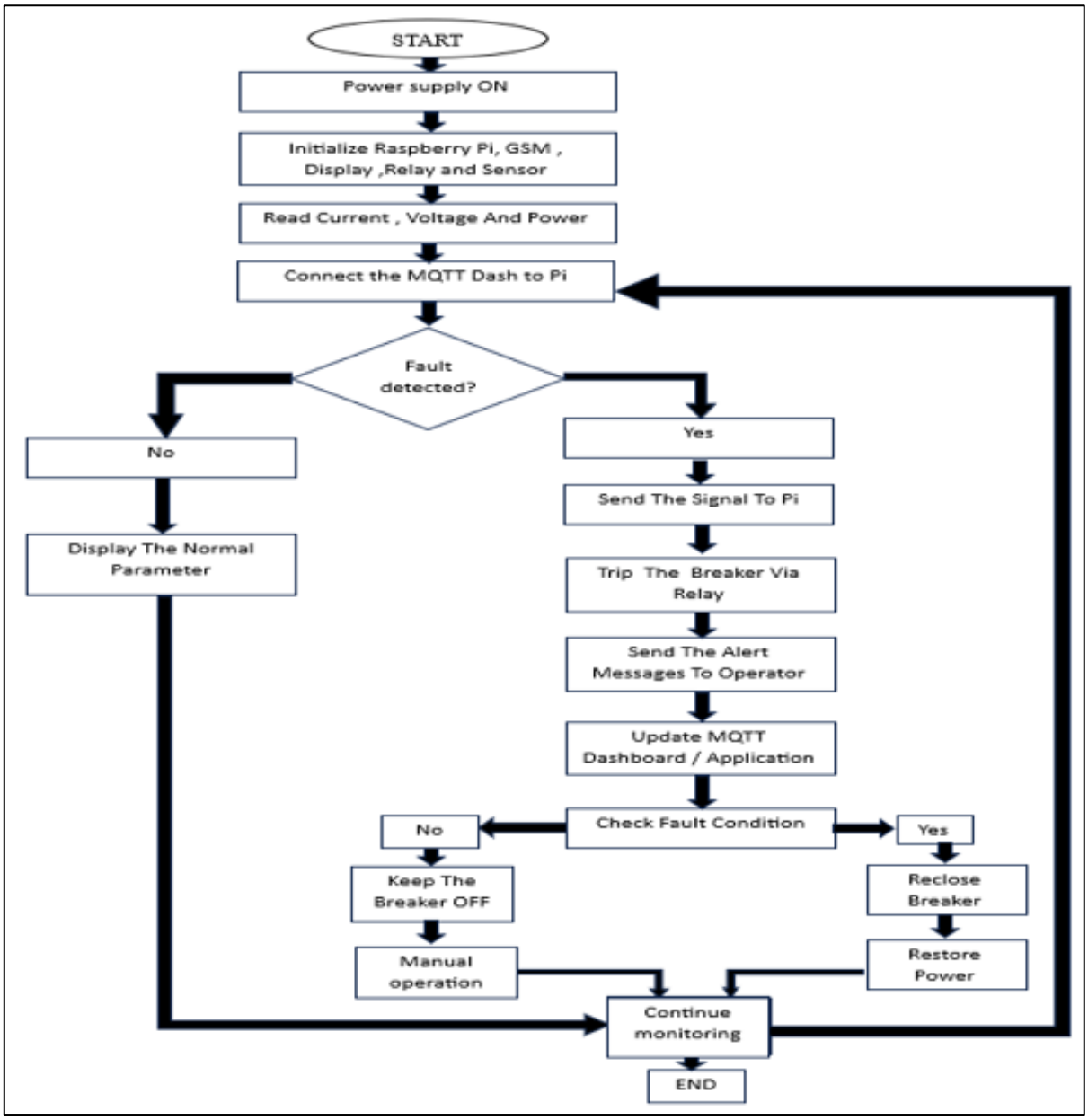

Fig 2 Flow Chart

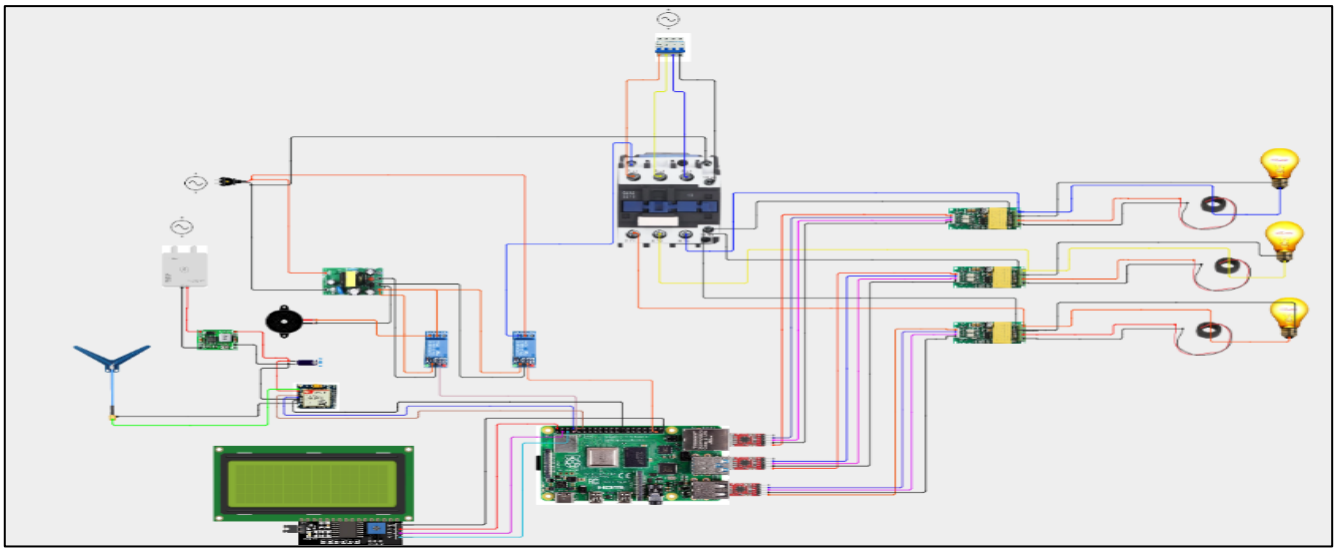

Fig 3 Circuit Diagram

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IV. PROBLEM STATEMEMT

As we being in Himalayan region most of natural phenomenon such as lighting striking and thundering as well Strom are very common and frequent so analysing this activity Electrical power systems are vulnerable to this kind of activity so frequent faults may occur such as symmetrical faults (three-phase faults) and unsymmetrical faults (single line-to-ground, line-to-line and double line-to-ground faults). These faults arise due to different condition , environmental conditions, equipment malfunction, or human error where natural phenomenon is the most and they result in abnormal currents, voltage imbalance, system instability and potential damage to electrical equipment. In many small-scale and educational setups, existing protection schemes are either too complex, expensive or lack real-time fault identification capability. Moreover, accurately distinguishing between symmetrical and unsymmetrical faults using a simple and cost-effective system remains a challenge at the diploma level. Therefore, there is a need to design and implement an efficient, low-cost fault detection system that can-

- Detect occurrence of faults in three phase.
- Differentiate between symmetrical and unsymmetrical faults.
- Provide fast indication or alert for fast protective action.
- Checks the line after the first trip and if it is normal current again auto-reclose the breaker if not then vice – versa .
- Improve the system reliability, safety, and monitoring capacity.

V. MATERIAL SELECTION

The components used in this project were selected based on reliability, accuracy, easy availability, low cost and compatibility with the system. Raspberry Pi 4 was selected as the main controller because of its fast processing speed and support for multiple communication modules. PZEM-004T(V-4) sensors were chosen for accurate measurement of electrical parameters such as voltage and current. SIM900A GSM module was selected for wireless fault communication and remote monitoring. A 3-phase contactor and relay were used for safe switching and protection of the electrical circuit. The selected materials help in improving the performance, safety and efficiency of the symmetrical and unsymmetrical fault detection and circuit breaker system with automatic reclosing circuit.

- *Raspberry Pi 4*

Raspberry Pi 4 is used as the main controller of the project. It processes the data received from the PZEM-004T sensors and controls the operation of the relay and contactor during fault conditions. The Raspberry Pi also communicates with the SIM900A GSM module for sending fault alerts and system information. It acts as the central unit for monitoring and controlling the symmetrical and unsymmetrical fault detection system with automatic reclosing circuit

- *Pzem-004t*

PZEM-004T is used in the project for measuring electrical parameters such as voltage, current, power and energy of the system. The sensor continuously monitors the line condition and sends the measured data to the Raspberry Pi 4 for processing and fault analysis. It helps in detecting abnormal conditions in the electrical circuit during symmetrical and unsymmetrical faults.

- *GSM Sim900a*

SIM900A GSM module is used in the project for wireless communication and fault notification. It is connected with the Raspberry Pi 4 to send fault alerts and system status messages to the user through mobile network communication. The module helps in remote monitoring of the symmetrical and unsymmetrical fault detection system with automatic reclosing circuit.

- *Three Phase Contactor*

3-phase contactor is used as a circuit breaker in the project for switching and controlling the three-phase power supply during fault conditions. It operates with the help of a relay signal from the Raspberry Pi 4 to trip or reconnect the circuit automatically. The contactor provides safe and reliable operation of the symmetrical and unsymmetrical fault detection system with automatic reclosing circuit.

- *20x4 LCD Display*

20x4 LCD Display is used in the project for displaying system parameters and fault status information. It shows values such as voltage, current, power and fault conditions received from the PZEM-004T and processed by the Raspberry Pi 4. The display provides easy monitoring of the system during operation**.**

- *Ch9102 TTL Converter*

CH9102 USB to TTL Converter is used in the project for serial communication between the Raspberry Pi 4 and pzem004T. It converts USB signals into TTL level serial signals for data transmission and programming purposes. The converter helps in stable communication and data transfer in the fault detection and monitoring system.

- *Hardware Testing:*

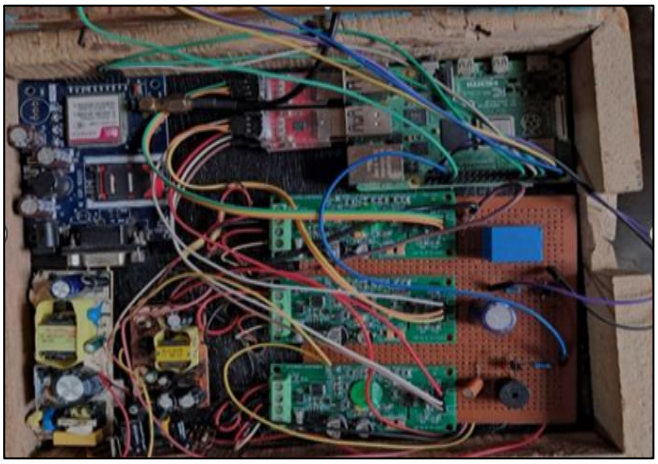

Fig 3 Hardware Testing (1)

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Fig 4 Hardware Testing (2)

VI. RESULT

The proposed symmetrical and unsymmetrical fault detection system with automatic reclosing circuit was successfully designed ,tested and implemented. During the testing process the system was able to detect different fault conditions accurately with the help of the PZEM-004T sensors. The measured electrical parameters such as voltage and current were continuously monitored by the Raspberry Pi 4, which acted as the main controller of the system. Whenever the current exceeded the predefined limit of 0.40 A, the system identified it as a fault condition and automatically operated the relay and 3-phase contactor to trip the circuit and protect the connected load from damage.

The automatic reclosing operation also worked successfully after fault detection. The system checked the line condition and reconnected the circuit when the fault was cleared. The SIM900A GSM module successfully provided communication between the system and the user by sending SMS alerts and call notifications during fault conditions. The user was also able to control the breaker remotely through SMS commands. By sending predefined commands such as “1” and “0”, the breaker could be switched ON and OFF without manual operation.

The project demonstrated reliable operation, fast fault detection, automatic protection and remote monitoring capabilities. The overall performance of the system was found to be efficient, safe and suitable for modern electrical protection and monitoring applications.

VII. FUTURE SCOPE

- Advanced fault analysis techniques can be added for more accurate fault identification and classification.
- The system can be upgraded for Extra high-voltage industrial and substation applications.
- GPS technology can be integrated for location tracking of faults in transmission lines.
- Impedence relay can integrated for actual fault location detection.

VIII. CONCLUSION

The symmetrical and unsymmetrical fault detection system with automatic reclosing circuit breaker was successfully designed and implemented using Raspberry Pi 4, PZEM-004T sensors, SIM900A GSM module, relay and 3-phase contactor. The system was able to detect different fault conditions accurately and automatically trip the circuit when the current exceeded the predefined limit of 0.40 A. The automatic reclosing operation and remote breaker control through SMS commands were also performed successfully and as well the MQTT dash real time monitoring and controlling is successfully executed. SMS alerts and call notifications helped in improving the monitoring and safety of the system. The project demonstrated reliable performance, fast operation and effective protection of electrical systems. Overall, the developed system provides a simple, efficient and low-cost solution for modern electrical fault detection and protection applications.

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