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IoT Based Three Phase Power Failure Monitoring with Alert System

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Abstract: The goal of this effort is to use IoT-based smart sensing to monitor and safeguard a three-phase electrical distribution system. Voltage sensors are used to continuously measure the line's three-phase voltage, which the Arduino UNO then processes to identify variations like overvoltage. The Arduino controls the relay module to automatically separate the load in order to protect the appliances that are connected to the distribution poles based on these observed conditions. The prototype uses a lamp to show relay response and load behaviour. IoT monitoring and capacitor health monitoring are two applications for the ESP8266. In order to comprehend the state of the reactive compensation section, it examines and evaluates the charging and discharging behaviour of capacitors rather than controlling the capacitor bank. Additionally, real-time information are simultaneously updated to a web dashboard for remote monitoring and shown locally on an OLED display. Alert alerts are created for prompt action if any unusual behaviour or dangerous voltage conditions are found. Reliability is increased, preventive maintenance is supported, distribution failures are decreased, and sophisticated smart grid monitoring with IoT-based real-time visibility and alert systems is made possible.
Keywords: Fault monitoring, real time monitoring, power switching, dashboard, firebase.

I. INTRODUCTION

The foundation of contemporary infrastructure is made up of electrical power systems, which facilitate the seamless operation of residential communities, transit networks, industries, and communication systems. Three-phase networks are the most commonly used of the many power distribution topologies due to their high efficiency, steady load distribution, and capacity to transfer substantial amounts of power with little loss. However, these systems are susceptible to a number of electrical problems brought on by aged equipment, conductor cracking, insulation failure, weather, or human mistake. Voltage instability, transformer damage, feeder disruptions, widespread outages, and significant financial loss can result from such problems if they are not promptly identified and isolated. Because of this, rapid and precise fault detection is now crucial to guaranteeing three-phase distribution's safe, dependable, and continuous power deliver. Every phase of a distribution network's current and voltage parameters is continuously monitored by an Internet of Things-enabled three-phase fault detection system. It can identify anomalies like overcurrent, undercurrent, phase loss, and unbalanced loads all of which are signs of common faults including line-to-ground, line-to-line, or open-circuit conditions by analysing real-time data. Threshold-based algorithms or machine learning models are used for detection, allowing for precise fault classification and the production of instant alerts. By shielding vital infrastructure like transformers, circuit breakers, and feeders from serious harm brought on by protracted fault situations, this early warning capacity enhances the overall stability and dependability of the grid.

II. OBJECTIVES

The primary goals of this project are:
1) Real-Time Monitoring: Keep an eye on the three-phase power supply at all times.
2) Identify power outages and malfunctions such short circuit faults:
- Line-to-line error
- Line-to-ground malfunction
3) To offer automated fault detection and Défense.

III. EXISTING SYSTEM

Fault detection and protection in the current electric power distribution and transmission systems are primarily accomplished through the use of traditional techniques including circuit breakers, protective relays, and manual inspection. These systems use voltage transformers (VTs) and current transformers (CTs) to get fundamental electrical measurements.

Protective relays trip the circuit breaker to isolate the malfunctioning area. However, fault location is typically determined by manual analysis or by physically examining transmission lines, both of which require a lot of time and effort. GSM-based fault indicator systems are often used to transmit simple fault alarms to the control room, but they don't offer comprehensive problem analysis or real-time data. Additionally, advanced data visualization and continuous monitoring are not supported by these platforms. Existing methods frequently lead to delayed fault diagnosis, longer outage durations, greater maintenance costs, and an increased risk of transformer and equipment damage because they lack real-time monitoring, remote accessibility, and predictive analysis. The current defect detection systems don't integrate with contemporary IoT or smart grid platforms; instead, they function independently. It is challenging to find recurrent defect patterns or carry out preventative maintenance since sensor data is not kept or examined over time. Decisions may be made incorrectly or slowly as a result of alerts that are frequently restricted to basic fault warnings without comprehensive parameter information. Because of this, the system as a whole lacks flexibility, scalability, and real-time visibility, which lowers the efficacy of power system safety and monitoring.

IV. PROPOSED SOLUTION

A smart IoT- and GSM-based fault detection and monitoring system is suggested to address the shortcomings of current systems. This system uses sensors like voltage transformers (VTs) and current transformers (CTs) to continuously monitor three-phase voltage and current. In order to identify anomalous conditions like overvoltage, undervoltage, short circuits, or line-to-ground failures, an Arduino or microcontroller evaluates the data in real-time. When a fault is identified, the system automatically determines its position and categorizes its nature. The control room or maintenance crew receives real-time fault data, including fault kind and distance, from a GSM or IoT module (such the ESP8266). This reduces equipment damage and guarantees quicker reaction times.

V. METHODOLOGY

The suggested system uses voltage and current sensors coupled to an Arduino microcontroller to monitor a three-phase electrical distribution line. In order to identify anomalous circumstances like overvoltage, undervoltage, or malfunctions, the Arduino continuously measures and interprets these signals. The system determines the nature and distance of a fault before turning on a relay to protect the load by isolating it. An OLED display displays local measurements while the ESP8266 module simultaneously sends real-time data and alarms to a web dashboard for remote monitoring. In order to evaluate charging and discharging behaviour for reactive power analysis, the capacitor bank is also observed.

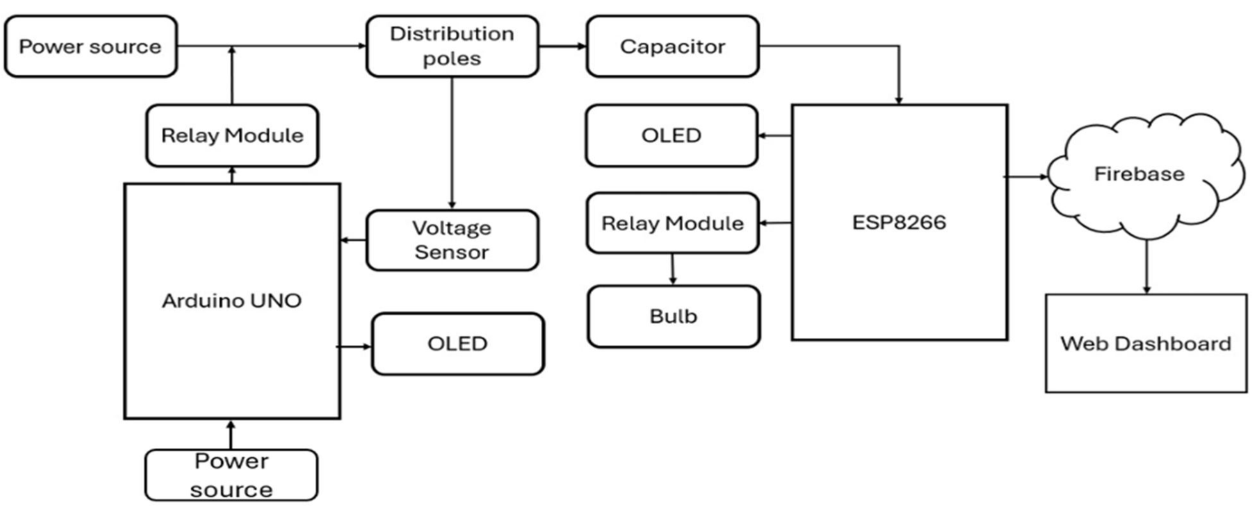

Fig: Block diagram.

A. *Power Input and Distribution stage*

The three-phase power line is the first part of the system, and it is routed via a relay module for secure isolation and switching. The distribution poles, where the main voltage is accessible, get the supply from the relay. These poles serve as the focal point for electricity flow and monitoring. At this point, continuous sensing is carried out to detect any variations. This serves as the cornerstone of the entire monitoring process.

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B. Voltage monitoring and Local display stage

Voltage changes are continuously monitored by a voltage sensor attached to the distribution poles. The sensor transmits data to the Arduino UNO for processing whenever there is a fluctuation. After analysing these variations, Arduino shows the voltage status or any warnings on the OLED screen. This makes it possible to monitor the power distribution line locally and in real time. The Arduino part does not regulate any loads; it just functions for observation and display.

C. Capacitor Monitoring done by ESP8266

The charging and discharging characteristics of the capacitors attached to the system are assessed. In order to identify errors, instability, or irregular charge cycles, the ESP8266 continuously monitors this capacitor activity. For easy viewing, this data is processed and shown on the OLED display of the ESP8266. Early detection of power conditioning problems is facilitated by tracking capacitor performance. This phase lessens reactive power issues and guarantees system stability.

D. IoT-Based Control and Load Operation Stage

A separate relay module that operates a lightbulb connected as the Internet of Things load is controlled by the ESP8266. The ESP8266 activates the relay to turn the light on or off based on preprogrammed conditions or remote commands. To guarantee steady switching, the relay is powered by an external power source. This illustrates the use of wireless communication for intelligent load control. The ESP8266's real-time control activities are reflected in the bulb.

E. Cloud Monitoring and Remote Dashboard Stage

The ESP8266 sends all processed data over Firebase to a web dashboard, including capacitor status, alarms, and load information. Any internet-connected device can be used by users to remotely monitor the system. The dashboard provides switching status, system alerts, and real-time updates. As a result, the project may be remotely supervised and is completely IoT enabled. It offers total transparency of the system's operation and improves safety.

VI. IMPLEMENTATION

Power line monitoring is the first step in the system's organized flow, where fault conditions are examined one after the other. In order to prevent risks, it initially looks for serious line-to-line errors that necessitate an instant shutdown. The system then uses the capacitor discharge behaviour tracked by the ESP8266 to assess line-to-ground conditions if there is no such issue. When an L-G defect is detected, the status is shown on the OLED display and LED bulb, and the same data is sent over the internet to the cloud dashboard. The system maintains constant monitoring and shows a normal status when the power line is operating regularly, guaranteeing effective fault detection and real-time visualization.

A. Before Line-to-Line (L-L) Fault

The electrical system functions normally and balanced prior to a line-to-line fault; the voltage across the lines stays constant, and there is no direct contact between phases; the circuit's capacitor charges continuously without interruption, indicating healthy line conditions; the ESP8266 keeps an eye on this stable charging behaviour and keeps the relay in the ON state, enabling the LED bulb to operate normally; the OLED display displays a normal status; and the system continuously updates the web dashboard with real-time data. The LED bulb and OLED display can display a "Normal" state because the ESP8266 detects this steady charging activity and maintains the relay ON. At this point, the online dashboard receives data on a regular basis for real-time monitoring without any load interruptions.

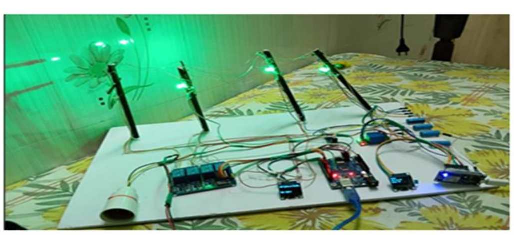

Fig: Before L-L Fault

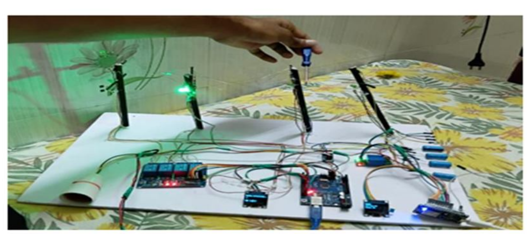

Fig: After L-L Fault

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B. After Line-to-Line (L-L) Fault

When two live conductors come into contact following a line-to-line failure, there is an abrupt increase in current and a significant voltage imbalance. The system detects this aberrant condition right away since it puts associated equipment at serious risk. In response, the ESP8266 initiates a shutdown procedure, turning off the relay to isolate the load. The OLED display displays the L-L fault status when the LED bulb is turned off to indicate a fault state. In order to enable remote monitoring and prompt remedial action to restore system safety, the problem information is simultaneously sent to the web dashboard. A line-to-line fault is a serious anomaly that has a significant fault current. In order to safeguard the circuit and any associated devices, the system recognizes this failure right away and starts a shutdown procedure. To disconnect the load and avoid damage or safety hazards, the relay is turned off. In order to ensure prompt awareness and remedial action, the fault condition is then updated on the display and relayed to the web dashboard.

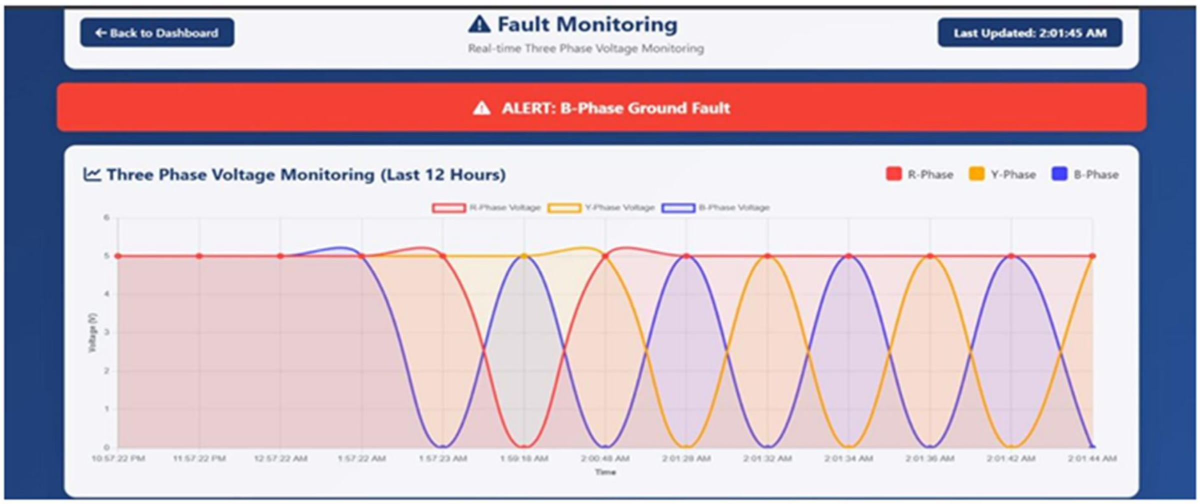

Fig: Line to Ground Fault Detection

C. Virtual Monitoring of Line-to-Ground Fault

Before The power line functions normally with steady voltage levels prior to the development of a line-to-ground fault. There is no current leakage to the ground because the system's capacitor is always charged. The ESP8266 maintains the relay in its typical state by keeping an eye on this consistent charging pattern. Real-time data is frequently updated on the online dashboard for remote inspection, and the LED bulb and OLED display indicate a healthy system status. A line-to-ground fault disrupts the voltage level by allowing a portion of the current to flow from the line to the ground.

VII. RESULTS

The suggested architecture uses an Internet of Things (IoT) method to monitor power lines and identify electrical defects in real time. In order to detect line-to-line (L-L) and line-to-ground (L-G) defects, it continuously assesses the state of the electricity lines. The system promptly initiates a shutdown upon detecting an L-L fault in order to protect equipment and guarantee safety. The model determines the fault condition and shows the fault status locally for an L-G problem while sending the data to a web dashboard. The system indicates a normal operational state if there is no malfunction. The web dashboard is updated with all fault and status data, allowing for remote monitoring and prompt decision-making. This concept enhances power line fault detection systems' dependability, security, and reaction time. Power line monitoring is the first step in the system's organized flow, where fault conditions are examined one after the other. In order to prevent risks, it initially looks for serious line-to-line errors that necessitate an instant shutdown. The system then uses the capacitor discharge behaviour tracked by the ESP8266 to assess line-to-ground conditions if there is no such issue. When an L-G defect is detected, the status is shown on the OLED display and LED bulb, and the same data is sent over the internet to the cloud dashboard. The system maintains constant monitoring and shows a normal status when the power line is operating regularly, guaranteeing effective fault detection and real-time visualization.

VIII. CONCLUSION

The difficulties of promptly identifying faults in electrical distribution networks are successfully addressed by the suggested Internet of Things-based power line fault detection and monitoring system. The technique avoids direct high-voltage sensing and guarantees safer operation by using a capacitor's charging and discharging characteristics as the main fault sensing mechanism. This behaviour is continuously observed by the ESP8266, which takes prompt While cloud connectivity offers real-time remote monitoring through a web dashboard, the integration of local indication through the LED bulb and OLED display enables prompt on-site defect recognition. Email notifications and automated alerts to the closest KEB office greatly speed up problem response times and increase maintenance effectiveness. The division of control (ESP8266) and monitoring (Arduino UNO) reduces processing overhead and improves system reliability.

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