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IOT BASED THREE PHASE UNDERGROUND POWER CABLE FAULT DETECTION

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Abstract
This paper presents a novel approach to three-phase underground power cable fault detection utilizing NodeMCU ESP8266, an open-source IoT platform. The proposed system integrates current and voltage sensors to continuously monitor the electrical parameters of underground cables. Leveraging the compact size, low power consumption, and Wi-Fi capabilities of NodeMCU ESP8266, real-time data is collected and transmitted to a central monitoring station. A fault detection algorithm, employing machine learning techniques, analyses the data to identify abnormalities indicative of cable faults. By leveraging the computational capabilities of NodeMCU ESP8266, the system can accurately localize faults along the cable length. Furthermore, the remote monitoring and control features enable timely response to fault events, thereby enhancing the reliability and resilience of underground power distribution networks. Experimental results demonstrate the effectiveness and reliability of the proposed fault detection system, showcasing its potential to significantly reduce downtime and maintenance costs associated with underground power cable failures.
Keywords: Three-phase Underground Power Cable, Fault Detection, NodeMCU ESP8266, Arduino Integrated Development, IoT Integration

I. Introduction

In the world of underground power distribution [9], ensuring smooth electricity flow is crucial, but when faults occur, it can lead to disruptions and inconveniences. That's where NodeMCU ESP8266 [3] and Arduino step in as our dynamic duo, offering a smarter way to detect faults in three-phase underground power cables [7] [1]. Picture NodeMCU ESP8266 as the eyes and ears underground, constantly monitoring cable conditions with its sensors and sending real-time data to Arduino, which acts as the brains, analyzing this information to spot any abnormalities that could signal a fault. By tea Ming up NodeMCU ESP8266 [3] and Arduino, we're not just simplifying fault detection [1] [2]; we're making it more effective and proactive. This integration empowers us to swiftly identify potential issues in the underground power network before they escalate into major problems [1], ensuring a more reliable and resilient electricity supply. With this innovative approach, even those unfamiliar with complex technical jargon can grasp the importance of our efforts to keep the lights on and the power flowing seamlessly.

Faults in cable can be classified into three types:

1.1 Open Circuit Fault [1]: An open circuit fault refers to a discontinuity or break in an electrical circuit, resulting in the interruption of current flow. Essentially, it creates a gap or breakage in the circuit, preventing electricity from completing its intended path and causing a loss of connectivity or function within the system.

1.2 Short Circuit fault [1]: A short circuit fault is an abnormal connection between two points in an electrical circuit with low resistance, causing a surge in current flow. It can lead to overheating, equipment damage, or fire hazards due to the excessive flow of electricity.

1.3 Earth fault [1]: An earth circuit fault, or ground fault, happens when an unintended electrical connection occurs between an active conductor and the earth. This fault can lead to electrical hazards, such as electric shocks or equipment damage, and is typically detected by ground fault circuit interrupters (GFCIs) to prevent accidents.

II. Literature Review:

NodeMCU ESP8266 reveals a promising avenue for enhancing the reliability and efficiency of fault detection systems. Several studies have demonstrated the feasibility and effectiveness of utilizing IoT devices like NodeMCU ESP8266 for real-time monitoring and diagnosis of faults in underground power cables. These systems leverage advanced sensing technologies and signal processing techniques to accurately detect and locate faults, thereby minimizing downtime and maintenance costs. Furthermore, research efforts have focused on optimizing communication protocols and integrating machine learning algorithms to improve fault detection accuracy and speed. Despite these advancements, challenges such as signal attenuation and noise interference remain, necessitating further exploration to develop robust and resilient fault detection solutions. Additionally, there is a growing emphasis on integrating renewable energy sources and smart grid technologies to enhance overall grid reliability and sustainability.

III. Methodology

3.1 Research and Requirement Analysis:

- Conduct a comprehensive review of existing literature on IoT-based fault detection systems and Bot Father methodology.
- Identify the specific requirements and objectives of the underground power cable fault detection system, considering factors such as accuracy, real-time monitoring, remote access, and scalability.

3.2 Hardware Setup:

- Acquire the necessary hardware components, including NodeMCU ESP8266 modules, sensors (such as current sensors, voltage sensors, and temperature sensors), and communication modules (like Wi-Fi modules).
- Design and assemble the hardware setup according to the specifications outlined in the requirement analysis phase, ensuring compatibility and reliability.

3.3 Software Development:

- Develop firmware for the NodeMCU ESP8266 modules to enable data acquisition from the sensors.
- Implement algorithms for fault detection and diagnosis based on collected sensor data, considering factors such as voltage drops, current fluctuations, and temperature variations.
- Integrate communication protocols (e.g., MQTT) for transmitting data to the cloud or a central server for further analysis.

3.4 Integration with Bot Father Methodology:

- Develop a chatbot interface using the Bot Father methodology to facilitate user interaction and system monitoring.
- Implement features such as real-time alerts, status inquiries, and fault notifications within the chatbot interface.
- Establish communication channels between the IoT devices and the chatbot platform, ensuring seamless integration and data exchange.

3.5 Testing and Validation:

- Conduct thorough testing of the integrated system to verify its functionality, reliability, and accuracy in detecting underground power cable faults.
- Evaluate the performance of the system under various operating conditions, including different fault scenarios and environmental factors.
- Validate the effectiveness of the chatbot interface in providing timely notifications and facilitating user interaction with the fault detection system.

3.6 Deployment and Field Trials:

- Deploy the IoT-based fault detection system in real-world underground power cable installations, taking necessary precautions and safety measures.

- Monitor the system performance during field trials, collecting data on fault detection accuracy, response time, and user feedback.
- Address any issues or challenges encountered during deployment, and iterate on the system design and functionality as needed.

3.7 Documentation and Reporting:

- Document the implementation process, including hardware configurations, software development, integration with the Bot Father methodology, testing procedures, and field trial results.
- Prepare a detailed report or journal article summarizing the findings, insights, and lessons learned from the project.
- Share the research outcomes with the academic and industrial communities through publications, presentations, and knowledge dissemination platforms.

IV. Working

The IoT-based three-phase underground power cable fault detection system utilizes NodeMCU ESP8266 modules, Arduino Integrated Development Environment (IDE), and the Bot Father methodology to ensure reliable and efficient monitoring of electrical parameters and prompt detection of faults. NodeMCU ESP8266 modules are strategically deployed along the underground power cable network, equipped with sensors to continuously measure parameters such as voltage, current, and temperature. The firmware programmed into the NodeMCU ESP8266 modules utilizes the Arduino IDE to process the collected sensor data in real-time, implementing fault detection algorithms to identify deviations from normal operating conditions indicative of potential faults or abnormalities.

Simultaneously, the NodeMCU ESP8266 modules interact with a chatbot interface created using the Bot Father methodology, facilitating user interaction and system monitoring. Through the chatbot interface, users receive real-time alerts and notifications regarding detected faults, enabling timely response and intervention. Users can query the system status, receive fault notifications, and initiate diagnostic procedures, fostering a user-friendly and intuitive interaction experience. This integration of real-time fault detection with user-friendly interaction through the chatbot interface streamlines fault localization and resolution, ultimately enhancing the overall efficiency and reliability of the underground power cable infrastructure.

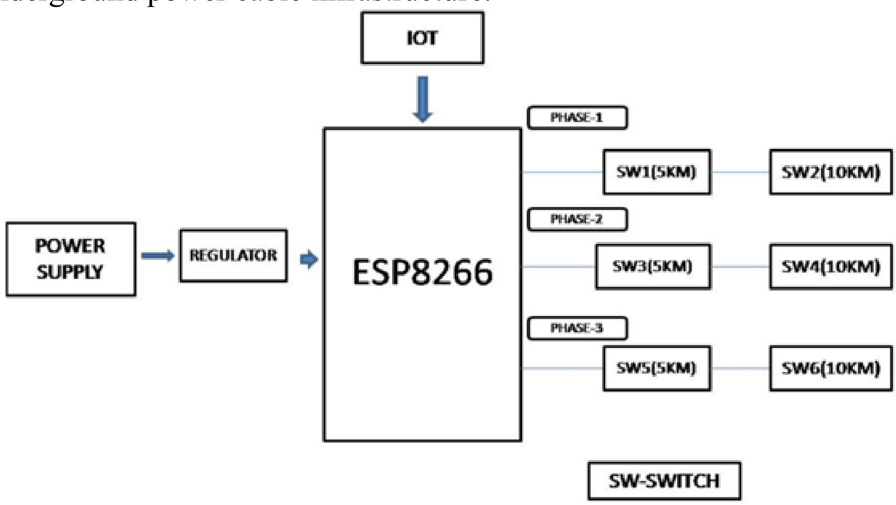

Figure 1: Block Diagram of Three phase underground power cable fault detection.

In the block diagram depicting a three-phase underground power cable fault detection project, the NodeMCU ESP8266 stands as the central component orchestrating the system's operations. Supported by a stable power supply regulated by a regulator, the NodeMCU ESP8266 serves as the brain of the setup, tasked with data acquisition, processing, and control.

Equipped with firmware containing fault detection algorithms, it interfaces with various sensors distributed along the underground power cable network to monitor crucial parameters like voltage, current, and temperature. Additionally, it interacts with three-phase switches strategically placed along

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the network, facilitating isolation of specific sections for maintenance or fault detection purposes. These switches play a pivotal role in controlling the flow of electrical power, allowing the system to respond swiftly to any detected abnormalities or faults. Together, these components form a robust framework for real-time monitoring and detection of faults in the three-phase underground power cable system, ensuring prompt intervention and maintenance to minimize downtime and optimize system reliability.

V. Components

5.1 NODEMCUEsp8266

Figure 2: NODEMCUEsp8266
The NodeMCU ESP8266 is a versatile and cost-effective Wi-Fi-enabled microcontroller development board, widely used in IoT projects. It features a powerful ESP8266 Wi-Fi module, allowing for wireless communication and connectivity. With its ease of programming using the Arduino IDE and Lua scripting language, the NodeMCU ESP8266 is popular for building smart devices, sensor networks, and home automation systems.

5.2 Resistor

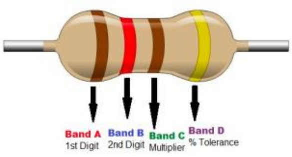

Figure 3: Resistor
In three-phase underground power cable fault detection, resistors are crucial components used for current sensing and voltage measurement. They help monitor the flow of current through the cable and detect abnormalities such as overcurrent conditions indicative of faults like short circuits or ground faults. Additionally, resistors can be incorporated into voltage divider circuits to facilitate accurate measurement of voltage levels across specific points in the cable network, aiding in the detection and localization of faults. Overall, resistors play a pivotal role in enhancing the accuracy and reliability of fault detection systems in underground power cable networks.

5.3 Switch

Figure 4: Switch
In three-phase underground power cable fault detection systems, switches are crucial components used to control the flow of electrical power through the cable network. These switches can be strategically placed at various points along the network to isolate specific sections for maintenance or fault detection

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purposes. By opening or closing these switches, the system can respond promptly to detected abnormalities, minimizing downtime and ensuring efficient fault detection and resolution. Additionally, switches may be operated manually or remotely, offering flexibility in managing the power distribution network.

5.4 Ribbon Wire

Figure 5: Ribbon Wire

In three-phase underground power cable fault detection systems, ribbon wire may be utilized for data transmission and communication between different components of the system. Due to its flat and flexible design, ribbon wire can be easily routed and organized within the underground environment, facilitating efficient connectivity between sensors, controllers, and monitoring devices. Its compact form factor and durable construction make it suitable for use in challenging underground conditions, enabling reliable data transmission for fault detection and monitoring purposes. Additionally, ribbon wire's standardized connectors and color-coding options simplify installation and maintenance, further enhancing the overall effectiveness of the fault detection system.

5.5 Voltage Regulator

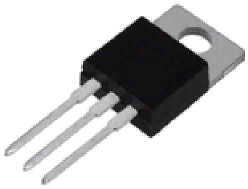

Figure 6: Voltage Regulator

In three-phase underground power cable fault detection, voltage regulators are crucial for maintaining a stable and consistent voltage supply to sensitive electronic components, such as microcontrollers and sensors. They ensure that these components receive the required voltage levels despite fluctuations in input voltage or load conditions. By stabilizing the voltage, regulators prevent damage to the components and ensure accurate and reliable operation of the fault detection system, enhancing its effectiveness in monitoring and detecting faults in the underground power cable network.

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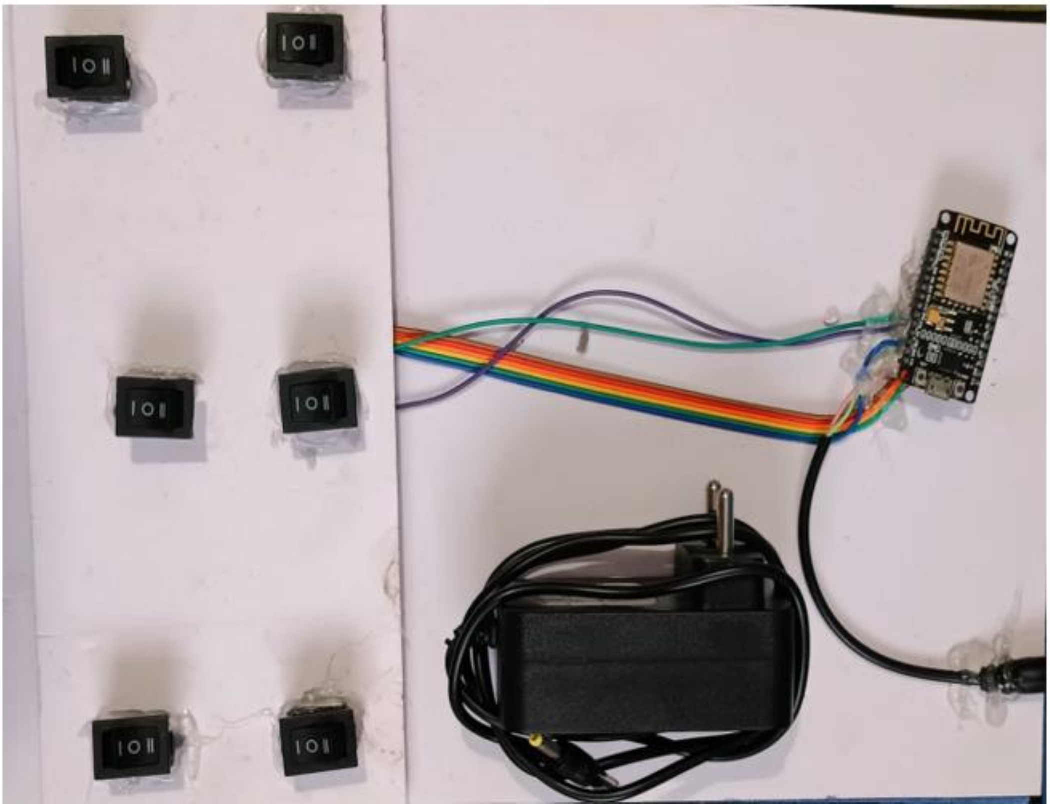

Figure 7: Hardware setup

VI. Pin Description Of Node MCUESP8266

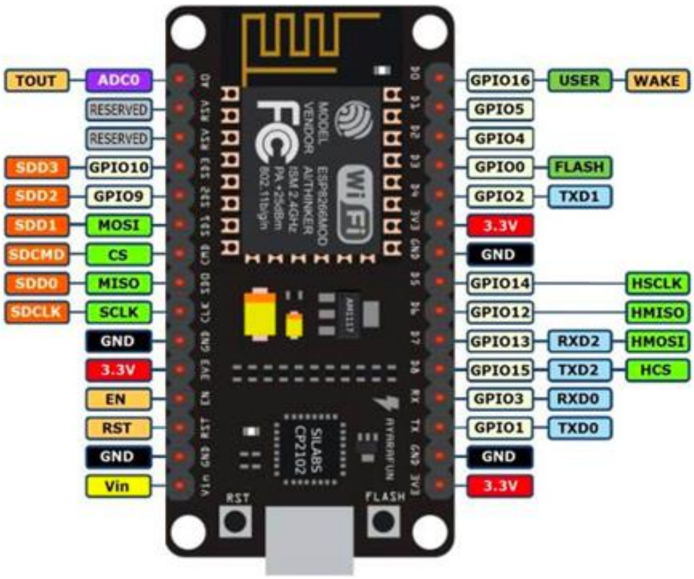

Figure 8: Pin description of NODEMCUEsp8266

The NodeMCU ESP8266 is a popular development board based on the ESP8266 microcontroller. Here's a brief explanation of its pinout:

Vin (Voltage Input): This pin is used to supply voltage to the board. It can accept voltages ranging from 5V to 12V.

GND (Ground): This is the ground pin, providing the reference voltage for the board's operation.

3V3 (3.3V Output): This pin outputs a regulated 3.3V voltage, which can be used to power external components if needed.

EN (Enable): This pin is used to enable the ESP8266 chip. It is usually pulled high to enable the chip. The NodeMCU ESP8266 is a popular development board for IoT projects, featuring the ESP8266 Wi-Fi module. Here are a few points about the pin description of the NodeMCU ESP8266:

Digital I/O Pins: PIO (General Purpose Input Output) Pins: The NodeMCU ESP8266 provides several GPIO pins (e.g., GPIO0 to GPIO16) that can be configured as either inputs or outputs for interfacing with external digital devices.
RX (Receive): This pin is used for serial communication to receive data.
TX (Transmit): This pin is used for serial communication to transmit data.
RST (Reset): This pin is used to reset the ESP8266 chip.
It's worth noting that GPIO pins can be configured for different functions depending on the programming requirements. Additionally, some pins have special functions related to certain communication protocols like SPI and UART. Understanding these pins and their functionalities is crucial when working with the NodeMCU ESP8266 board.

VII. Result

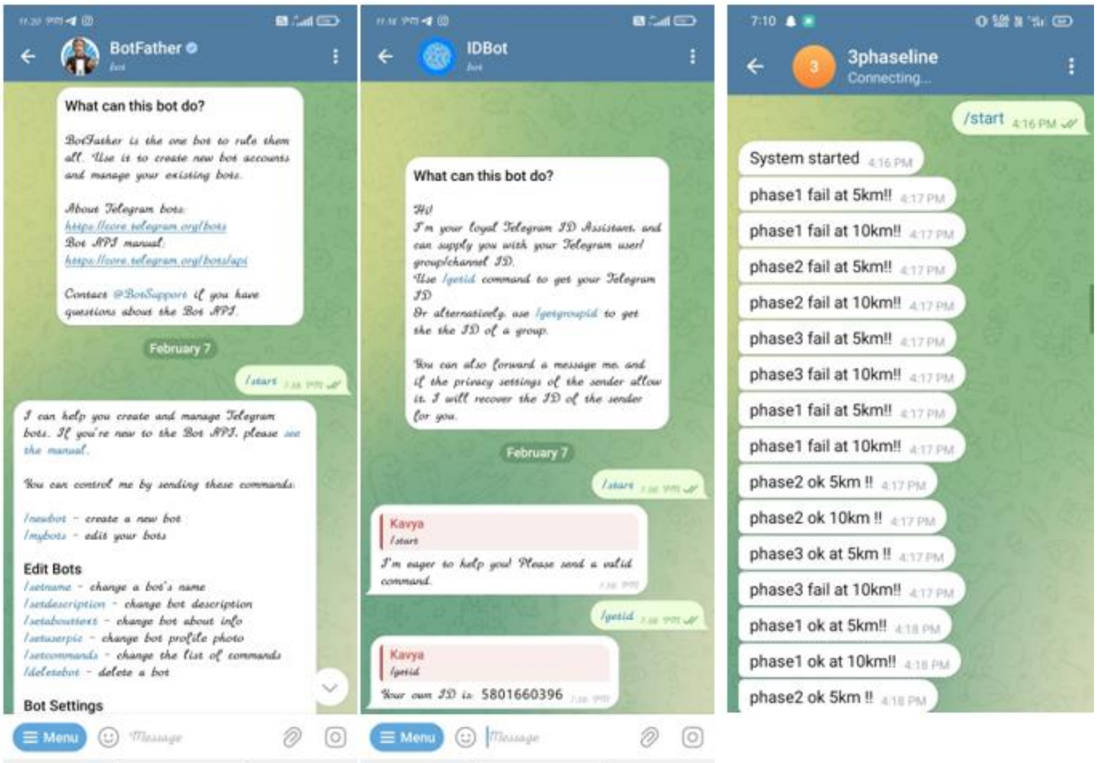

Fig a: Create BOT Father (Telegram)   Fig b: Create IDBot (Telegram)   Fig c: Displays Output (Telegram)

Fig a: Create Bot Father and click on start then create username get bot token. Copy bot token in code.
Fig b: Create IDBOT and click on start then get ID. Copy ID in code.
Fig c: After the system getting started, it will display whether the fault is present or absent in phase as shown in fig c.

VIII. Conclusion

The implementation of fault detection in three-phase underground power cables using NodeMCU ESP8266 presents a promising solution for enhancing the reliability and safety of power distribution systems. By leveraging the NodeMCU's capabilities for wireless communication and sensor interfacing, coupled with appropriate fault detection algorithms, it becomes feasible to monitor the integrity of underground cables in real-time. Through the deployment of sensors such as current and voltage sensors along with appropriate fault detection algorithms, the NodeMCU ESP8266 can detect various types of faults such as short circuits, open circuits, and insulation degradation. Upon detection of a fault, the system can promptly alert maintenance personnel, enabling swift intervention to minimize downtime and prevent potential hazards. Furthermore, the wireless connectivity of the

NodeMCU facilitates remote monitoring and control, allowing for efficient management of the power distribution network. Overall, the integration of NodeMCU ESP8266 in fault detection systems for underground power cables offers a cost-effective and scalable solution that enhances the resilience and operational efficiency of power distribution infrastructure.

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