Automated Fault Detection in Three-Phase Transmission Lines Using Raspberry PI And Arduino Nano

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Abstract- *This project aims to develop automated fault detection and protective system for a three-phase transmission line using Raspberry Pi and Arduino Nano. The Arduino monitors each phase using current sensors to detect various faults such as overcurrent, single-line-to-ground, line-to-line,double line-to-ground and three-phase faults. Sensor data is transmitted to the Raspberry Pi, which processes the information and uploads it to an IoT platform for remote monitoring and analysis. When a fault is detected, relays are triggered to disconnect the affected phase, while LEDs indicate the fault status locally,buzzer is activated to give an immediate audible alert and an LCD displays real-time system information. A GSM module sends instant SMS alerts to maintenance personnel andAdditionally, a GPS module provides the exact location of the fault to speed up the maintenanceresponse. This integrated setup ensures fast fault detection, accurate reporting, and reduced downtime in power transmissionsystems. Enhancing system reliability, overall safety and efficiency of three phase transmission infrastructure.*

Keywords- Raspberry pi,Arduinonano, GSM Module, GPS, Relay,16*2LCD,LED, LL, LG, LLL, Transmission line, etc.

I. INTRODUCTION

This project focuses on developing a smart fault detection and monitoring system for three-phase power transmission lines using embedded systems and IoT technology. The setup includes an Arduino Nano that continuously reads current values from sensors connected to each phase. If any abnormality—such as a sudden rise in current or a pattern indicating a fault—occurs, the Arduino takes immediate action by triggering relays to isolate the affected phase and lighting up LED indicators to signal the issue.To enhance remote supervision, the Arduino sends fault data to a Raspberry Pi, which acts as a gateway to the IoT platform, where data is logged and visualized. Additionally, a GSM module sends alert messages to inform technical staff about the nature and location of the fault. A local LCD display ensures real-time updates on system conditions. This approach enables automated fault response, remote diagnostics, and reliable monitoring of transmission line health, reducing the risk of damage and service disruption.

II. LITERATURE REVIEW

[1]Transmission line fault detection using wavelet transform (Anurag.D.Borkhade, Assistant Professor)

Proper detection of various faults occurring on the transmission line is very essential. In this paper, detection and classification of some these faults is done based on the information conveyed by the wavelet analysis of power systems transients. Maximum norm values, maximum detail coefficient, energy of the current signals are calculated from the Wavelet Toolbox in MATLAB/Simulink. Maximum norm value and energy of the signals detects the fault and threshold detail coefficient classifies the fault into different types such as L-G, L-L-G, L-L-L.

[2]Gamit V, Karode V, Mistry K, Parmar P, Chaudhari A. Fault Analysis on Three Phase System by Auto Reclosing Mechanism, IJRET: International Journal of Research in Engineering and Technolog, 2015, 4(5).

In any electrical system, due to overvoltage or over current line--ground fault, line to line fault, line-line-line fault and line-lineline-ground faults occur. The electrical substation is supply the power to the consumers means industries or domestic can have failures due to any of the fault which can be temporary or permanent. These faults lead to damage to the power system equipment. In this work, effort has made to design an reclosing mechanism in case of permanent or temporary fault. The TimerIc-555 has been used to give the time duration of fault. Circuit breaker is used for disconnecting the line at fault instant and connecting on clearance of fault. Reclosing mechanism resets the supply line after small interruption in the event of temporary fault or it remains in tripped condition in case of permanent fault.

[3]G. Sharma, O. P. Mahela, M. Kumar and N. Kumar, "Detection and Classification of Transmission Line Faults Using Stockwell Transform and Rule Based Decision Tree," 2018 International Conference on Smart Electric Drives and Power System (ICSEDPS), Nagpur, India, 2018, pp. 1-5, doi: 10.1109/ICSEDPS.2018.8536006.

This paper presents an algorithm for detection and classification of different types of the power system faults occurring on the transmission line to provide the effective protection to the line against these faults. The proposed technique uses Stockwell transform based multi-resolution analysis of the current signals for detection of the faults and rule based decision tree for classification of faults in the power system network. Faults investigated in this research work include line to ground (LG) fault, double line (LL) fault, double line to ground (LLG) fault and three phase fault with the involvement of the ground (LLLG). Proposed study is performed in MATLAB/Simulink environment.

[4] Fault Detection and Classification in Three Phase Transmission Line Using (Dr.D.Kavitha, May 2018)

The If we look at the present Transmission line fault discovery system, there are several problems, many of which include lack of professed labour, increased drawbacks and also time- consuming process. Automating a process is infamous to break numerous or all of similar problems handled in the conventional processes. This is one similar attempt to produc ean easy and cost-effective outcome which is applicable in the approaching power transmission fault detection systems for electricity providers and drivers at stages or stations. The IOT base three phase Transmission fault discovery system can spot the broken- down or denounce when there are line breaks or closes down the power force through the defective line until the driver shuts down the entire line once he confirms the fault. The system continuously monitors the whole line fault in sequence for 3 lines videolike R, Y, B Phases. formerly there's fault is detected the system sends the notice to the line monitoring station, it also provides the information about the defective line and the distance at which the line is broken. The system is also able of transferring the line voltage to the monitoring station.

[5] Bipasa Bimalendu Patra "Necessity for future smarter nation with Sustainable Trend- Smart Grid", PRATIBHA: International Journal of Science, Spirituality, Business and Technology (IJSSBT), Vol. 6, No. 2, September 2018, pp. 35- 41, ISSN (Print) 2277-7261

Transmission line is the most crucial device of the power system. The power and commitment requirement had developed up to an exponential scale with regard to the recent system, and the most crucial operation of a transmission line is to transfer electric power from the source point to the distribution system. The explode between limited production, and a colossal claim has enhanced the priority of reducing power losses. Losses such as transmission loss and also the supposed factors as much as possible nearest to the physical losses other than technical losses, another parameter is the foremost factor it possess the reactive power and voltage deviation are significant for long-distance power line transmission. Fault analysis is a critical focusing problem in power system engineering in virtual to remove fault in short time and return to normal power system as early as possible with nearly no interruption. Fault detection, however, line breaking the transmission line is also challenging task to study fault as well as to enhance the reliability of the system.
The GSM module served to transmit information to the relevant authorities.

III. EXISTINGSYSTEM

Existing methods for protecting three-phase transmission lines often rely on manual monitoring and basic protection mechanisms such as circuit breakers. These methods can be slow to react and may not detect faults until significant damage occurs. Additionally, the lack of real-time alerts and the inability to precisely isolate the faulty phase often leads to extended downtime and increased maintenance costs. Furthermore, these systems are usually not automated, requiring constant human intervention to monitor and handle faults.

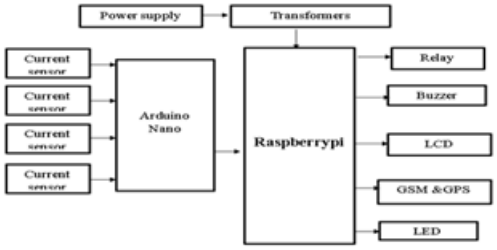
IV. PROBLEMSTATEMENT

In modern power systems, transmission lines play a vital role in delivering electricity from generation units to distribution networks. However, these lines are prone to various types of faults, such as single-line-to-ground, line-to-line, double-line, and three-phase faults, which can lead to equipment damage, power outages, and reduced system reliability. Traditional fault detection methods often rely on manual inspection and delayed fault diagnosis, making them inefficient and unsuitable for real-time monitoring.

Furthermore, factors such as overloading, voltage fluctuations, poor cooling, and reactive power imbalances contribute to transformer and line failures. Given the wide geographic spread of power infrastructure, it becomes challenging to monitor and manage every component effectively.

Therefore, there is a critical need for an automated, real-time monitoring and fault detection system that can quickly detect faults, isolate affected phases, notify maintenance personnel, and enable remote monitoring—thus improving the efficiency, safety, and reliability of the power transmission network.

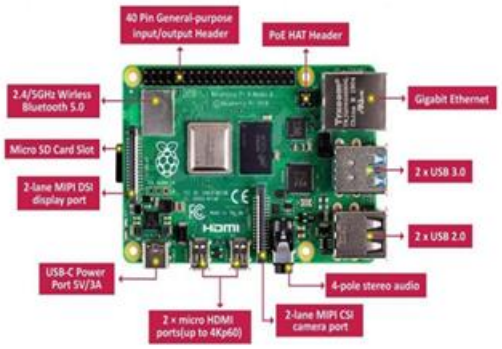
V. BLOCK DIAGRAM



VI. HARDWARE COMPONENTS USED

Raspberry PI:

Raspberry Pi 4 Model B is one of the most popular Raspberry Pi single-board computers. Raspberry Pi is a low-cost, compact, and powerful single-board computer widely used in various engineering applications. In electrical power systems, it can be effectively used for fault detection in three-phase transmission lines. By interfacing sensors and Arduino Nano with the Raspberry Pi, real-time monitoring and data processing can be performed. The Raspberry Pi can analyze the incoming data to detect abnormalities such as short circuits or open circuits, and identify the type and location of the fault. This helps in improving system reliability and reducing downtime in power distribution networks.



GSM Module:

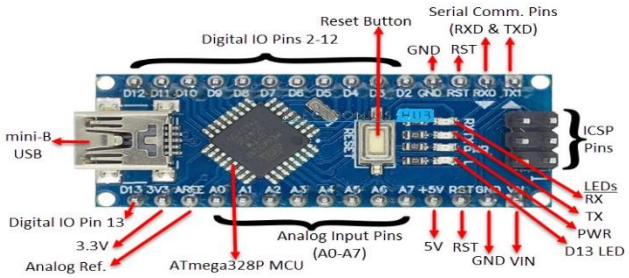
GSM,orGlobalSystemforMobilecommunications, is the prevalent (major) world's most popular cell phone technology. Cell phones use a cell phone service carrier'sGSM network by searching for cell phone towers nearby. (GSM)is a globally used standard for digital cellular communication. A GSM compresses and digitizes the data and then sends it down in a channel with two client data streams, each of which is allocated to a unique time slot. The digital system is capableof transporting 120 Mbps to 64 kbps of data rates. There are several cell sizes in a GSM network such as macro, micro, pico, and umbrella cells. All cells vary based on the region. There are five different cell sizes in a GSM network macro, micro, pico, and umbrella cells.

RelayModule:

Relay modules serve as interface devices that enable the transfer of signals and information between different devices or systems. They act as a bridge, allowing low-powered digital electronics, such as microcontrollers like ArduinoorRaspberry Pi, tocontrol high-powereddeviceslike motors or lighting circuits.

Arduino Nano:

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 (Arduino Nano 3.0) or ATmega168 (Arduino Nano 2.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack, and works with a Mini-B USB cable instead of a standard one. The Nano was designed and is being produced by Gravitech.

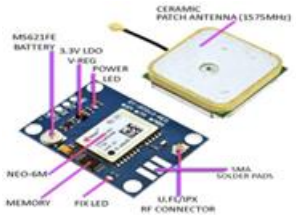


Current sensor:

Current flowing through a conductor causes a voltage drop. The relation between current and voltage is given by Ohm's law. In electronic devices, an increase in the amount of current above its requirement leads to overload and can damage the device.Measurement of current is necessary for the proper working of devices. Measurement of voltage is Passive task and it can be done without affecting the system. Whereas measurement of current is an Intrusive task which cannot be detected directly as voltage.

GPS:

Global Positioning System (GPS) is a satellite-based system that uses satellites and ground stations to measure and compute its position on Earth.GPS is also known as Navigation System with Time and Ranging (NAVSTAR) GPS.GPS receiver needs to receive data from at least 4 satellites for accuracy purpose. GPS receiver does not transmit any information to the satellites.This GPS receiver is used in many applications like smartphones, Cabs, Fleet management etc.



Buzzer:

A buzzer or beeper is a sound-signal device that is either mechanical, electromechanical, or piezoelectric (and more commonly just "piezo"). Common applications for buzzers and beepers include alarm units, timers, trains and user-input confirmation of, for instance, a click on a mouse or a press on a keyboard.

VII. FAULT CATEGORIZATION

Symmetric faults in a three-phase system, if the fault is equally affecting all three phases, then it is referred to as a symmetric or a balanced fault. faults an unbalanced fault or asymmetric fault causes unequal impact of fault on each of the three phases. Symmetric faults typically account for around 5% of the total faults. Asymmetric Asymmetric faults are also categorized as LL or Line to Line fault, LG or Line to Ground fault and LLG or Double Line to Ground fault.

Fault of Line to Line is a short circuit between two lines, due to ionization of air, or when lines make physical contact with each other, for instance, due to broken insulator.

LG Fault is a one-line to ground short circuit resulting from physical contact through lightning or storm.

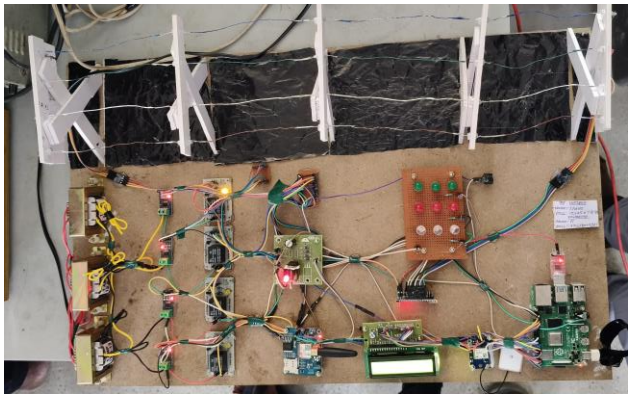
LLG fault is developed when two lines are in contact with the ground and with each other. Storm damage is responsible for this predominantly. Transient faults in a circuit, when a fault decreases with the power disconnection for some short interval and then connected back, the fault is called a transient fault.

VIII. WORKING PRINCIPLE

The three-phase transmission fault detection system using Raspberry Pi and Arduino Nano is designed to detect, locate, and alert for faults in power transmission lines with high accuracy. A step-down transformer reduces 230V AC to 12V to safely power the circuit. Current sensors are connected to each phase to continuously monitor the flow of current. When a fault such as an overload, short circuit, or open circuit occurs, abnormal current levels are detected based on Ohm's Law, and this data is processed by the Arduino Nano. In response, the Arduino activates relays to disconnect the faulty phase for protection. It also turns on a buzzer and blinks an LED corresponding to the affected phase, providing immediatevisual and audible fault indication.

The Raspberry Pi, acting as the main controller, receives fault data from the Arduino and uses a GPS module to determine the exact fault location. This information is sent via a GSM module as an SMS alert to the maintenance team. A 16x2 LCD display shows real-time fault status and location on-site. This system offers an efficient, automated method for fault detection and alerting in three-phase transmission lines, enhancing safety, response time, and system reliability.

IX. FINALIMPLEMENTATION



X. CONCLUSIONS

The conclusion Raspberry pi and Arduino Nano based protective system for three-phase transmission lines enhances the reliability and safety of electrical networks by automatically detecting and responding to faults. By integrating current sensors, relays, an LCD display, and a GSM module, the system ensures real-time monitoring and swift disconnection of faulty phases, minimizing potential damage. This automated approach improves efficiency in power transmission, reduces downtime, and provides timely alerts for maintenance. Overall, the system offers a cost-effective and intelligent solution for safeguarding electrical infrastructure.

XI. FUTURESCOPE

The future of fault detection and analysis in three-phase transmission lines is promising, with technological advancements poised to make systems more intelligent, efficient, and responsive. The integration of smart grid technology, AI, machine learning, advanced communication methods, and increased automation will significantly enhance fault detection and response times. This will lead to more reliable power distribution systems,

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