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Modeling and Design of a Prototype Representation of Feeder Protection and Monitoring using ESP32 Microcontroller

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ABSTRACT

The Feeder Protection and Monitoring System is a crucial component in modern electrical power systems. This system is designed to protect the electrical power network from faults that could lead to power outages or equipment damage. The use of microcontrollers in such systems has become increasingly popular due to their low cost and high flexibility. In this project, we propose the modeling and design of a prototype representation of a Feeder Protection and Monitoring System using the ESP32 Microcontroller.

The proposed system is designed to detect faults in the feeder and initiate protective actions to isolate the faulted section of the feeder. The system is also designed to monitor the health of the feeder, including parameters such as current, voltage, power, and frequency. The ESP32 Microcontroller is used as the central processing unit in the system due to its low cost, high processing power, and integrated Wi-Fi and Bluetooth capabilities.

The system design involves the integration of various sensors, including current transformers, voltage transformers, and temperature sensors. The sensor data is processed by the ESP32 Microcontroller, which then sends alerts and initiates protective actions if necessary. The system also includes a user interface, which allows the user to monitor the health of the feeder and perform diagnostic functions.

The proposed system has several advantages over traditional Feeder Protection and Monitoring Systems. It is more cost-effective, more flexible, and can be easily integrated into existing power networks. The system can also be remotely monitored and controlled using the integrated Wi-Fi and Bluetooth capabilities of the ESP32 Microcontroller.

In conclusion, the proposed Feeder Protection and Monitoring System using the ESP32 Microcontroller offers an innovative and cost-effective solution for protecting and monitoring electrical power networks. The system is designed to be scalable and can be easily modified to meet the specific needs of different power networks. The prototype representation of this system provides a foundation for further development and optimization of the system for practical use.

KEYWORDS: ESP32 Microcontroller, Feeder Protection and Monitoring, integrated Wi-Fi and Bluetooth capabilities, Remote Monitoring and control.

1. INTRODUCTION

Due to large consumption of power and low power resources, our power system may be subjected to problems like voltage fluctuations, surges, load shedding etc. Furthermore, the equipment used in the power system may malfunction due to some external source (tree branches fall over transmission lines, storms etc.) our system may collapse. Under the above mentioned circumstances, a fault current runs through the system and may damage the installed equipment's like generators, bus bars, transformers, distribution feeders, heavy induction motors or even the house hold equipment's. The power system must be protected from user end as well as the system equipment itself, hence protective devices are required to overcome these faults

I. Protective scheme used for bus bar in power system is differential protection but it often fails during CT saturation. This scheme is then improved by adding new feature developed from differential current using S- transform which ensure speedy response

II. Transformer is major equipment in power system which is mostly effected by voltage surges which causes the life of transformer to reduce. So, it must be protected using different relays to ensure proper functioning. Micro-controller based multidirectional relays are best to overcome these faults very effectively

III. Distribution feeders are protected against over current by conventional electromechanical (IDMT) relay. To get high response, high reliability and low-cost micro-controller based relays are used

IV. Most of conventional methods are being replaced by the new digital methods but the protection engineer must be familiar with both the conventional relays as well as the new microprocessor/ microcontroller-based relays to handle the system accordingly and must know which relay is more fast, more reliable, and most efficient in terms of operation as well as cost.

2. PROBLEM DEFINITION

In present scenario the equipment used in electricity transmission and distribution are manual type. Feeder can be protected from the over current condition. Industrial instruments failures have many causes and one of the main causes is over load. The primary of the distribution transformer or any other transformer is designed to operate at certain specific current if that current flowing through that instrument is more than the rated current, then immediately the system may burn because of over load. In this work for generating high current more loads are applied to the circuit, which will be tripped. To trip the circuit use is made of one relay which will be controlled through micro controller. When over load is occurred relay will trip the total circuit and buzzer will be on to indicate over load.

3. LITERATURE REVIEW

L. Ashok Kumar et al. [1] present an Adaptive protection scheme for feeders with the penetration of SEIG based wind farm. This work involves the development and evaluation of an adaptive over current feeder protection scheme and reclose with Sectionalizes feeder protection scheme to vanquish the impacts of wind-based DG which is highly intermittent in nature. MATLAB based software package for distribution system conductor sizing and protection coordination studies are also presented. Why Testing Digital Relays Are Becoming So Difficult Part 2[2] given by D. Vandiver III. In this work describes with the subject title and identifies some of the developing issues in testing what has here to fore been well understood protection elements. The authors commonly used in designing modern protection systems. Legacy test methods cannot properly address these complex relays nor simulate the power system adequately in order to prove their operational performance and compliance.

Why testing digital relays are becoming so difficult part 3 advanced feeder protection [3] given by B.Vandiver et al. The work presented reviews the new challenges and explains why new testing methods are required. As digital relays continue to develop and become more complex, Legacy test methods cannot properly quantify the health, status, and availability of these complex relays nor simulate the power system adequately in order to prove their operational performance and compliance. Modeling of Over current Relay with Inverse Characteristics for Radial Feeder Protection using Graphical User Interface [4] explained by M. Kezunovic et al. This work describes the modeling and implementation of over current relay with different over current characteristics using MATLAB/Simulink.Consequently, the performance of the Simulink block is validated and IDMT Standard inverse

characteristic curve is obtained for different values of Time Multiplier Settings and Plug Setting Multipliers. Implementation of micro controller based electromechanical over current relay for radial feeder protection [5] explained by Kunal. Jagdale et al. This work presents the design of electromechanical based relay as an educational lab trainer to compare the behavior of both relays in over current protection of radial feeder. The proposed system introduces the use of both electromechanical and microcontroller-based relays in a single panel in such a way that the system could be switched to either electromechanical or microcontroller-based relay setup. The fault is incorporated to the system by the insertion of low resistance path which leads to additional flow of current. Simulations are carried on Proteus and the hardware result shows that microcontroller-based relays are fast in operation having less time of operation, more efficient and have very low cost as compared to conventional electromechanical relays.

Feeder Configuration and Coordination of Protections for an Electric Substation [6] given by Pablo Parra et al. The work carries out the load distribution and the protection coordination. After carrying out the electrical survey of the medium voltage networks and collecting the system data, the power flow analysis is carried out under current and future conditions, both in maximum and minimum demand, which will provide relevant information on the voltage levels in the bars, consumption, and chargeability of the elements of the system. Implementation of Micro Controller Based Electromechanical Over Current Relay for Radial Feeder Protection given by Basit A. Khan et al. [7]. —Continuous power supply is one of the major concerns in modern world and for this purpose protection schemes must be efficient enough to overcome faults with minimum time. In this work presents the design of electromechanical and microcontroller (Arduino) based relay as an educational lab trainer to compare the behavior of both relays in over current protection of radial feeder. The proposed trainer introduces the use of both electromechanical and microcontroller-based relays in a single panel in such a way that the system could be switched to either electromechanical or microcontroller- based relay setup. It is designed for protection of two sections so that the concept of primary and secondary protection is observed. Microcontrollers based relay setup is coded with IDMT characteristics and requires the values of PSM and TMS for the calculation of operational time of relay to clear the fault. This trainer also displays the magnitude of fault current as well as operational time of relay required to clear the fault. The fault is incorporated to the system by the insertion of low resistance path which leads to additional flow of current. Simulations are carried on Proteus and the hardware result shows that microcontroller-based relays are fast in operation having less time of operation, more efficient and have very low cost as compared to conventional electromechanical relays.

Distance protection in 150/60 kV transformer 60 kV feeders: two real blackout case studies given by Claus Leth Bak et al. [8]. This work presented correct setting of protection relays are of major importance to the reliable operation of the power system. The root cause of two consecutive blackouts is analyzed and shown to origin from a combination of several minor errors which all can be related to an insufficient/wrong setting of the distance relays and their optional functions together with insufficient testing when putting into operation. Advanced Feeder Protection Applications given by Wayne Hartmann [9]. This work explained about the Industrial plant feeder protection challenges can occur from events within the plant and on the bulk power system to which the plant is connected. Advanced feeder protection platforms can help improve reliability (security and dependability), selectivity and extend protective functionality using advanced applications.

From the above literature review we have observed that the reliability of the system, stability of the system and durability of the system is less because of using electro mechanical relays. In order to overcome these disadvantages, we have focused a Microcontroller based Feeder Protection and Monitoring System. The Feeder Protection and Monitoring System includes an over current relay to provide over current protection for a transmission feeder / distribution feeder. This work also provides a monitoring capability which supports data storage and remote interaction with a user.

4. COMPONENTS

a) 3 Phase Ammeter And Volt Meter

Both of these devices are used in electric circuits but the major difference between a voltmeter and an ammeter is ammeter comes in handy for measuring the flow of current whereas the voltmeter comes in handy for measuring the voltage or emf across two points in an electric circuit.

Fig:1 Phase Ammeter And Voltmeter

b) Control MCB

When the current overflow occurs through MCB – Miniature Circuit Breaker, the bimetallic strip gets heated and deflects by bending. The deflection of the bi-metallic strip releases a latch. The latch causes the MCB to turn off by stopping the current flow in the circuit.

Fig:2 Control MCB

c) 230V \ 6V, 2 Amps Transformer

Input Voltage: 230V AC
Output Voltage: 6V or 0V
Output Current: 2 Amp
Mounting: Vertical mount type
Winding: Copper

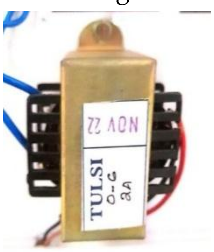


Fig:3 230V \ 6V, 2 Amps Transformer

d) 230V \ 12V, 2 Amps Transformer

Input Voltage: 230V AC
Output Voltage: 6V or 0V
Output Current: 2 Amp
Mounting: Vertical mount type
Winding: Copper

Fig:4 230V \ 12V, 2 Amps Transformer

AC to DC Converter & Buck Convert

Fig:5 AC To DC Converter & Buck Converter

e) 12V &5V DC Busbar

A busbar is an electrical junction used for collecting electric power from the incoming feeders and distributes them to the outgoing feeders. The main purpose of a busbar is to carry electricity and distribute it. Busbars are used to make the systems more efficient

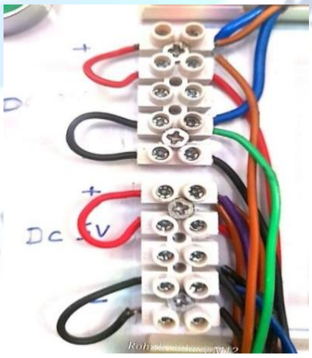


Fig:6 DC Busbar

f) Input & Output Card

It is collected the signals from push buttons as a input and given output of the card is given as a input to the ESP32 microcontroller

Here we are use 2 input output cards for total operation. Each card having 5 input and 5 output

Fig:7 Input & Output Card

g) ESP32 Microcontroller

ESP32 is created by Espressif Systems with a series of SoC (System on a Chip) and modules which are low cost with low power consumption.

This new ESP32 is the successor to the well-known ESP8266(became very popular with its inbuilt WiFi). ESP32 not only has Built in WiFi but also has Bluetooth and Bluetooth Low Energy. In other words we can define ESP32 as "ESP8266 on Steroids".

ESP32 chip ESP32-D0WDQ6 is based on a Tensilica Xtensa LX6 dual core microprocessor with an operating frequency of up to 240 MHz.

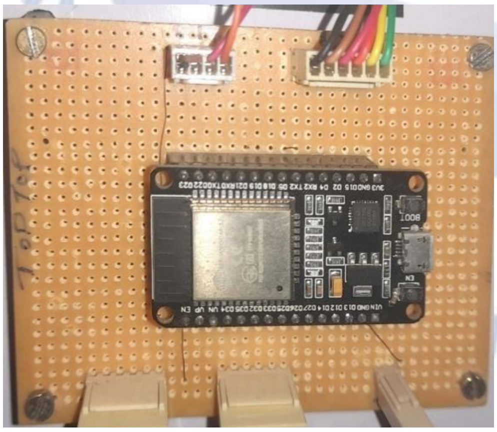


Fig:8 ESP32 Microcontroller

h) Contactor Diver

It is also known as output card. The input for this diver is from output of themicrocontroller.

Then the signal is given to the relays and the relay coil is operated by ac supply thenthe signal is transmitted to power circuit.

Then the power circuit switching operation is started

Fig:9 Contactor Diver

i) Diver Indicator Circuit

It is used to operate induction of the circuit. That means what where the switch is operated that indicated the led light is on\ off for this circuit the input is connected to the contactor diver and it is connected to the relays then the output signal is transmitted to the led's .when the switch is on then the red led is glow and theswitch is off green led is glow.

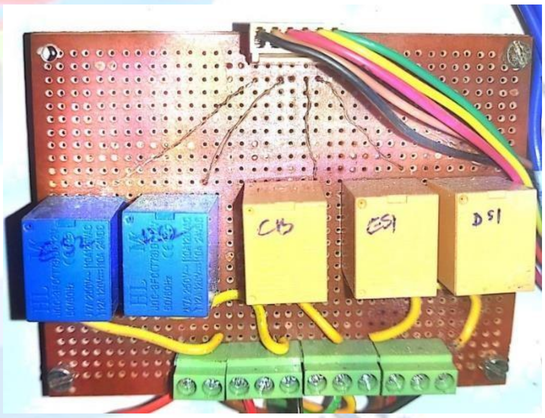


Fig:10 Diver Indicator Circuit

j) Push Buttons

Push button is used to operate the power circuit by manually to operate the pushbutton we required 12v dc supply.

To on the circuit red push button is used & off the circuit green push button is used.

Fig:11 Push Buttons

k) Indicating Lamps

It is used to indicate the operation of the circuit. For this lamp also required 12v dcsupply

Fig:12 Indicating Lams

l) 3-Phase MCB

The Three-Phase Breaker block uses three Breaker blocks connected between the inputs and the outputs of the block. You can use this block in series with the three- phase element you want to switch. The arc extinction process of the Three-Phase Fault block is the same as for the Breaker block.

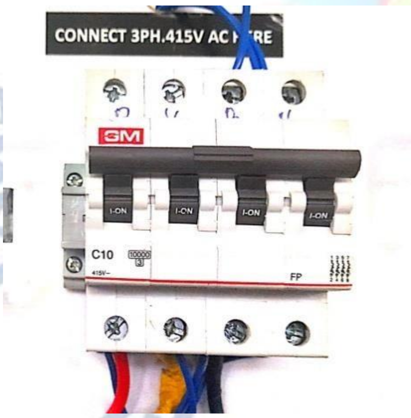


Fig:13 3-Phase MCB

m) Busbar Disconnectors

Conductors or conductors used to collect electric power from incoming feeders and then distribute that power to outgoing feeders. In general, the busbar acts as an electrical junction where all incoming and outgoing electrical currents meet.

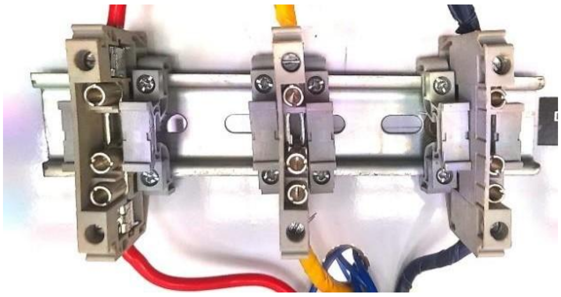


Fig:14 Busbar Disconnectors

n) Disconnector Switch

Disconnector isolator switch, or disconnector switch is used to de-energize the current for maintenance and service. In electric engineering, a disconnector is used to break the circuit found in the electrical distribution.

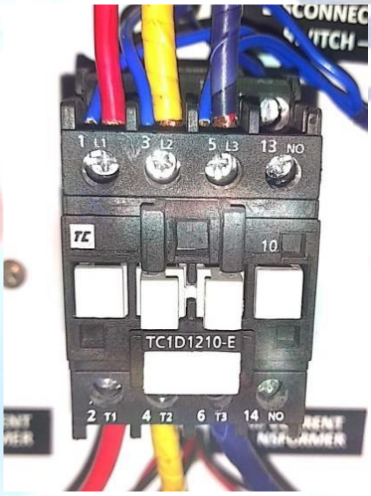


Fig:15 Disconnector Switch

o) Earth Switch

The earthing switch is used to interconnect and earth the phase and neutral conductors of an electrical installation to ensure the safety of personnel during servicing. 2-the Earthing Switch must be in "ON" position. Under these conditions, the installation is earthed.

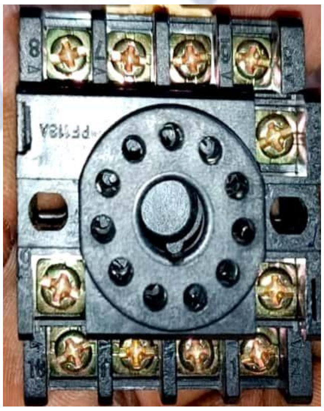


Fig:16 Earth Switch

p) Circuit Breaker

The circuit breaker is opened by applying pressure to the trigger. When there is a faulty current flowing through any part of the system, the trip coil of the breaker gets energized thereby moving away from each other, thus opening the circuit.

Fig:17 Circuit Breaker

q) Current Transformer

A current transformer is designed to maintain an accurate ratio between the currents in its primary and secondary circuits over a defined range. The alternating current in the primary produces an alternating magnetic field in the core, which then induces an alternating current in the secondary.

The current transformer is also used to protect the circuit from line faults and over currents.

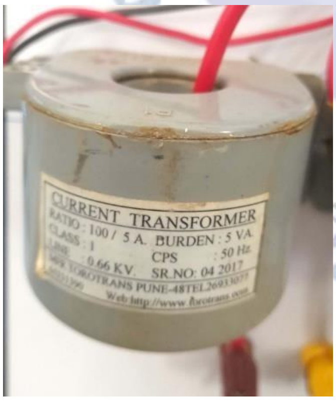


Fig:18 Current Transformer

r) Load Terminals

The load terminals are used to connect the load and measure the output of the load

Fig:19 Load Terminals

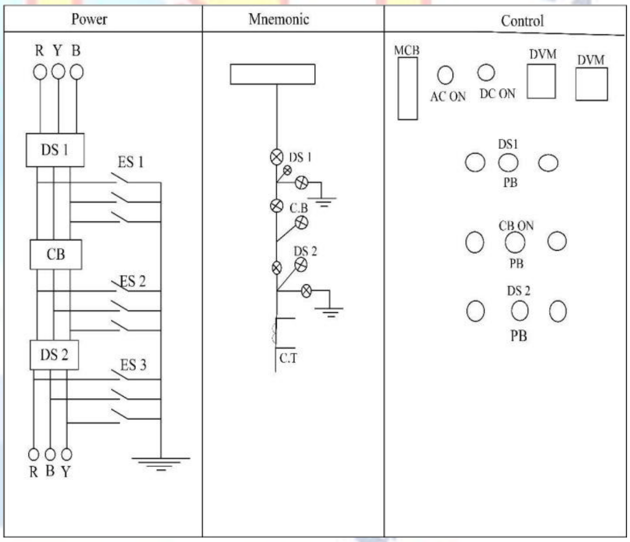
s) LCD Display

The lcd is used to display the output of the system which is operated through manualand

Fig:20 LCD Display

5. IMPLEMENTATIONS

a) Before Implementation:



Before implementing a microcontroller- based 220kV feeder demo sample operation and control through IoT, it is important to consider the following:

Feasibility study: A feasibility study should be conducted to ensure that the project is technically and economically feasible. The study should consider factors such as the availability of resources, the cost of implementing the project, and the benefits that the project is expected to bring.

System design: A system design should be developed that outlines the components required for the project, the architecture of the system, and the communication protocols that will be used to communicate between the different components.

Microcontroller selection: A suitable microcontroller should be selected that meets the requirements of the project, such as processing power, memory, and communication capabilities.

IoT platform selection: An IoT platform should be selected that is compatible with the selected microcontroller and provides the necessary features for remote monitoring and control.

b) After Implementation:

fig: 22 After Implementation

After The Implementation Of A Microcontroller- Based 220kv Feeder Demo Sample Operation And Control System Through Iot, The Following Steps Should Be Taken:

Testing: The System Should Be Tested Thoroughly To Ensure That It Is Functioning As Expected. This May Involve Testing The Communication Between The Microcontroller And The Iot Platform, Testing The Sensors, And Verifying That The System Can Monitor And Control The Feeder.

Optimization: After Testing, The System Should Be Optimized To Ensure That It Is Functioning Efficiently. This May Involve Fine-Tuning The Software, Adjusting The Sensor Placement, Or Making Changes To The Communication Infrastructure.

Deployment: Once The System Has Been Tested And Optimized, It Can Be Deployed In A Live Environment. This May Involve Installing The System At A Substation Or Other Location Where The Feeder Is Located.

Monitoring And Maintenance: Once The System Is Deployed, It Should Be Monitored Regularly To Ensure That It Is Operating Correctly. Maintenance Tasks Such As Software Updates, Sensor Calibration, And Hardware Repairs Should Be Performed As Needed To Ensure The System Continues To Operate Effectively.

Data Analysis: The System Should Be Configured To Collect And Store Data About The Feeder's Operation Over Time. This Data Can Be Analyzed To Identify Trends, Troubleshoot Issues, And Optimize The System's Performance.

User Training And Support: The Users Who Will Be Interacting With The System Should Be Trained On How To Use It Effectively. Technical Support Should Be Provided As Needed To Ensure That Users Can Troubleshoot Any Issues That Arise.

By Taking These Steps, It Is Possible To Develop And Deploy A Microcontroller- Based 220kv Feeder Demo Sample Operation And Control System That Can Be Remotely Monitored And Controlled Through Iot, Providing Improved Efficiency And Reliability In The Operation Of The Feeder.

6. RESULTS

CASE 1: DS1 IS ON , DS2 IS ON, CB IS ON & ES1 IS OFF , ES2 IS OFF

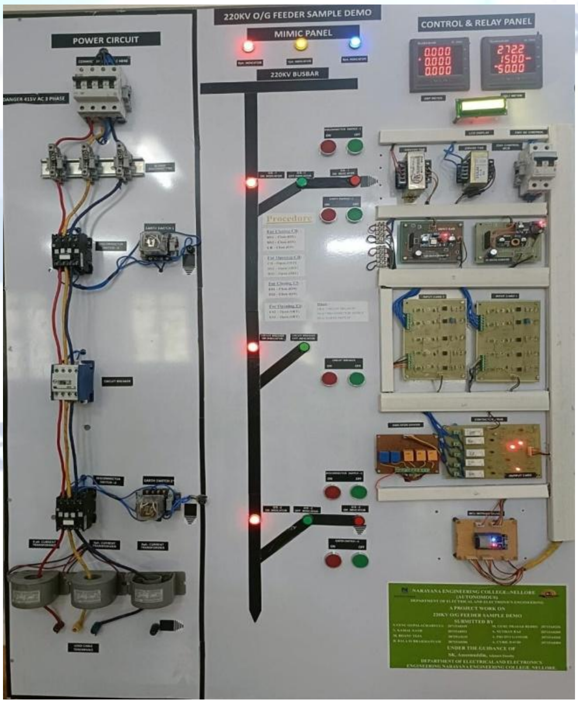


Fig: 23 Results Case 1

CASE 2: ES1 IS ON, ES2 IS ON &DS1 IS OFF, DS2 IS OFF, CB IS OFF

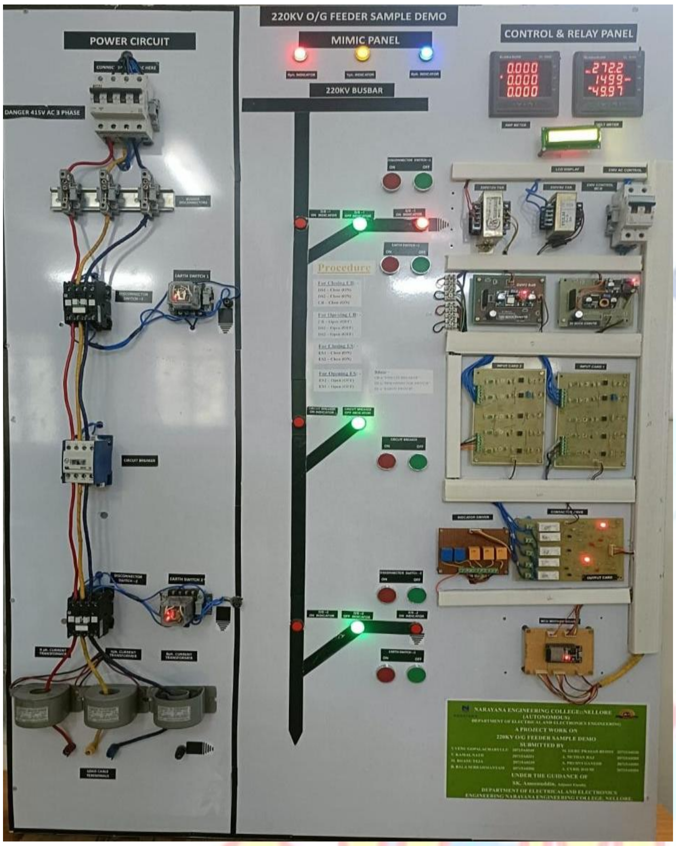


Fig: 24 Results Case 2

7. CONCLUSION

The project of microcontroller-based 220kv feeder demo sample operation and control through IoT is a comprehensive solution that aims to automate the operation and control of a high voltage power grid. The project uses a microcontroller-based system to monitor and control the flow of electricity on the feeder, while the IoT connectivity enables remote access and management of the system.

The main objective of the project is to provide a safe and reliable power supply to the end-users while optimizing the power distribution process to reduce energy losses and improve the overall efficiency of the system.

The microcontroller system monitors the voltage and current levels on the feeder and uses this information to control the switches and breakers to maintain the power flow within safe and optimal limits. The system also includes various sensors and monitoring devices that provide real-time information about the system's performance, which can be used to identify potential issues and improve the system's overall reliability.

The IoT connectivity enables remote access to the system, allowing operators to monitor and control the system from a centralized location. The system sends real- time data to the cloud, which can be analyzed using machine learning algorithms to identify patterns and trends in the power distribution process, providing valuable insights to optimize the system's performance.

In conclusion, the microcontroller-based 220kv feeder demo sample operation and control through IoT project is a comprehensive solution that addresses the challenges of managing a high voltage power grid. The project provides a safe and reliable power supply to end-users while optimizing the power distribution process to reduce energy losses and improve efficiency. The system's IoT connectivity enables remote access and management, allowing operators to monitor and control the system from a centralized location. The real-time data provided by the system can be analyzed to identify patterns and trends, providing valuable insights to optimize the system's performance.

8. FUTURE SCOPE

The microcontroller-based 220kv feeder demo sample operation and control through IoT project has several potential future scopes that can further enhance its functionality and efficiency.

One possible future scope is to integrate artificial intelligence (AI) and machine learning (ML) algorithms into the system to provide predictive maintenance and real- time fault detection. By using ML algorithms to analyze the real-time data collectedby the system, the system can predict potential failures and alert operators before they occur, minimizing downtime and optimizing system performance.

Another future scope is to incorporate renewable energy sources such as solar and wind power into the system. This would require the development of smart controllers that can manage the fluctuating output of renewable energy sources, ensuring a stable and reliable power supply.

In addition, the project could be extended to include a smart grid infrastructure that connects multiple feeders and allows for real-time power distribution management. This would enable the system to respond to changes in power demand and optimize power distribution across multiple feeders, further reducing energy losses and improving the overall efficiency of the system.

Another potential future scope is to integrate blockchain technology into the system to create a decentralized energy trading platform. This would allow for the trading of excess energy generated by renewable sources, enabling the system to become more self-sufficient and sustainable.

Overall, the microcontroller-based 220kv feeder demo sample operation and control through IoT project has several potential future scopes that can further enhance its functionality and efficiency, making it a highly adaptable and flexible solution for managing high voltage power grids.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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