IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

Power Grid Failure Detection Based On Voltage And Frequency Variations

Y. Neelima[1] , K. Sri Gayathri[2] , M. Chaitanya[3] , S. Saishiva[4] , A. Dileep Kumar[5]
[1]Assistant Professor in Dept. of Electrical & Electronics Engineering
[2,3,4,5] UG Student, Dept. of Electrical & Electronics Engineerin
Christu Jyothi Institute of Technology & Science, Jangaon, Telangana, India

Abstract: *Millions of people are impacted by the essential problem of power grid failure, which has serious economic and social repercussions. There are several power generation units connected to the grid such as hydel, thermal, solar etc.to supply power to the load. These generating units need to supply power according to the rules of the grid. These rules involve maintaining a voltage and the frequency variations within limits. In this project we are going to implement the use of up-to-date technology in sensing the very low variations in frequency or voltage magnitude of a generator in a Power grid in which there may be many generators working in synchronism with the grid in terms of phase sequence, voltage magnitude and frequency.*

In today's practical Power grid as we all know many generators or power source are working together and to maintain stability between all, the detection and isolation of the sources falling out of synchronism, is of crucial significance as otherwise it would have caused the entire system to fail. Hence various techniques have been developed in industries and power plants (especially solar power plants) to keep all the generators and sources in synchronism with the Power Grid and in case of and failure detect and isolate the failed generator out of the grid and hence maintain a stable operation of the Power System. This Project presents an approach for detecting power grid failures using Peacefair Energy Monitor (PZEM) modules. By monitoring real- time voltage and frequency variations, the system identifies anomalies and predicts potential grid instability..

Keywords: PZEM- 004T, Voltage, Frequency, Power Grid

I. INTRODUCTION

The reliable operation of power grids is essential for modern society's functioning, as any disruption can lead to significant economic
losses and social unrest. Power grid failures can result from various factors such as equipment malfunction, natural disasters, or cyber-attacks. Timely detection of grid disturbances is crucial for mitigating their impact and ensuring uninterrupted power supply. Traditional methods for grid failure detection often focus on monitoring either voltage or frequency variations individually.

However, these methods may not capture the full spectrum of grid abnormalities or provide sufficient insight into system behavior. In our project we're implementing a strategy by contingency analysis which is used to study behavior of power system, when associated equipment gets outage .

A number of operating procedures can be analyzed in contingency conditions, such as the loss of a generator, a transmission line, a transformer, or a load. The power grid is a complex network of interconnected systems that require continuous monitoring to ensure reliable and efficient operation. However, power grid failures can occur due to various factors such as equipment malfunction, natural disasters, and human error, resulting in power outages, economic losses, and compromised public safety. These failures can be get wide power outages, outfit damage, and other serious consequences. As similar, its critical to descry synchronization failures as snappily as possible so that they can be addressed and averted from raising. The detecting power grid synchronization failure system on seeing frequency or voltage beyond the respectable range is truly important in that power generation systems, where different force sources are connecting analogous together for supplying the uninterruptible power force to a single loaded machine bar.

To address this challenge, a real-time power grid failure detection system is essential. This paper proposes a novel approach for power grid failure detection based on sensing frequency, voltage, current, and temperature parameters, transmitted in real-time through PZEM technology, enabling prompt detection and response to potential failures and enhancing the overall reliability and efficiency of power grid operation.

II. LITERATURE SURVEY

Power Grid failure detection, specifically focusing on voltage and frequency variations, involves monitoring these parameters and triggering alerts when they deviate from acceptable limits. This approach helps prevent grid synchronization failures, which can lead to power outages or other grid instability issues. We all know that voltage and frequency variations should be within certain limits, typically around 230V ± 10V and 50Hz

±2Hz. Systems are designed to detect when these limits are exceeded, indicating potential grid synchronization failures. These systems

can help prevent islanding, a situation where a feeder unit becomes disconnected from the main grid, potentially leading to power outages. Many systems utilize microcontrollers, like Arduino, to monitor voltage and frequency variations and trigger alerts or disconnects.

The Systems are designed to detect load variations that might cause frequency or voltage changes, which can be indicators of grid failure. Some systems classify faults based on the type of voltage or frequency variations, enabling more precise fault identification. Researchers often use simulations to test the performance and robustness of their detection systems. In past few decades the more concentration is employed on the topic of synchronization of power grid. As the level of life style of human being is upgraded and hence the energy requirement is also increased. To achieve the require mean the grid network is not sufficient therefore it is necessarily to take power from the nearby grid. So, it is much more important to have synchronization between the grid. By proper technique the main parameters such as voltage and frequency can be kept constant. Hence it is required to have the comparison between the technique is required for the cost effectiveness, efficiency, accuracy and reliability.

A power grid failure detection system aims to quickly identify abnormal conditions like voltage or frequency deviations in a power grid, potentially leading to power failures.

These systems often rely on sensors that monitor grid parameters like voltage and frequency, and then use algorithms to detect deviations from normal operating conditions. Once a failure is detected, the system can trigger actions like islanding (separating a faulty section from the grid) or switching to backup power sources to prevent a complete power outage.

III. PZEM-004T

The identifier PZEM-004T likely refers to the Peacefair PZEM-004T AC multi- function energy meter. It's a popular and cost- effective module used for measuring various electrical parameters in AC circuits.It Measures AC Voltage, AC Current, Active Power, Power Factor, Frequency, and Active Energy.The Voltage Ranges are 80-260V AC Current Range is Available in 10A (built-in shunt) and 100A (with external current transformer) versions,Power varies between 0-2.3kW (for 10A) or O-23kW (for 100A).The Communication protocol is TTL serial interface (UART) for data reading. Some versions also support Modbus RTU protocol. It utilizes a non-invasive current transformer (CT) or current coil to measure the AC current flowing through a wire without interrupting the circuit. The module communicates via a TTL serial interface, allowing it to be easily interfaced with microcontrollers like Arduino orESP32.

It is Ideal for DIY power monitoring projects, home energy monitoring, industrial equipment monitoring, and renewable energy systems. It's Accuracy Generally around 0.5% for voltage, current, power, and energy, and 1% for power factor. The Data Storage in Some versions have a power-down data storage function to save cumulative energy

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 1, May 2025 Impact Factor: 7.67

readings.The PZEM-004T typically communicates via a TTL serial interface using UART. The default baud rate is usually 9600 bps, with 8 data bits, 1 stop bit, and no parity. The Modbus RTU protocol is supported in some versions (especially V3), allowing it to communicate with microcontrollers like Arduino or ESP32 using standard Modbus libraries. The default slave address for Modbus communication is often 0xF8.

IV. METHODOLOGY

The system for detecting the failure of the power grid to adjust to the maximum or maximum power level is a function of the goal of continuous sensitivity to power and frequency of supply sources. In this system, the microcontroller detects the supply voltage and frequency with the help of an operating amplifier, and then these voltages and frequencies are matched with other supply voltages and frequency. If both are matched, then the microcontroller provides a highly sensible signal to transmit the driver to the IC then, the IC driver of the transmission driver switches to the load, where the lamp is directly connected. Similarly, if both can be compared the microcontroller closes the outgoing load with the IC driver. Here for display purposes, we can easily change the frequency of one source and the voltage and test the performance of the system by turning on or off the lamp. This system is directly connected to the wapda power supply and the LDC indicator is used here to detect supply voltages and the frequency of both sources.

1. Data Collection:

- Smart Meters: Smart meters provide real-time data on voltage, current, and power factor.
- Sensors: Other sensors, including those on circuit breakers, can gather specific data related to their operation and switching times.
- Communication Infrastructure: Wireless communication networks transmit data from sensors to a central control system.

2. Data Analysis:

- Pattern Recognition: Algorithms analyze the collected data to identify deviations from normal operating patterns.
- Thresholding: Pre-defined thresholds for voltage, frequency, and current are used to trigger alerts for potential failures.
- Machine Learning: Machine learning models can be trained on historical data to predict and detect future failures.

3. Failure Detection and Isolation:

- Fault Location: Techniques like terminal methods and tracer methods help pinpoint the location of faults in cables.
- Failure Isolation: Once a fault is detected, the system can isolate the failing component to prevent further damage and cascading failures.
- Fault Tolerance: Redundant pathways and other fault tolerance mechanisms can help maintain grid stability during and after failures.

V. PROPOSED SYSTEM

The power grid failure detection system works on the principle of continuous monitoring of critical power grid parameters such as frequency, voltage, and current. The system uses PZEM to detect any anomalies or deviations in these parameters, which are then transmitted to a microcontroller i.e, Aurdino UNO for processing and analysis. The microcontroller uses predefined thresholds and algorithms to determine if a potential failure is detected. If a failure is detected, the microcontroller sends an alert or notification to utility operators or maintenance through a buzzer. The alert or notification includes critical information such as the location and nature of the failure, enabling prompt action to

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

be taken to prevent or mitigate the failure. The system can also be integrated with existing power grid infrastructure, such as SCADA systems, to provide a comprehensive and real- time monitoring solution.

This system enables prompt detection and response to potential failures, reducing the likelihood of power outages and improving grid reliability.It helps to prevent accidents and injuries caused by power grid failures, ensuring a safer environment for utility workers and the general public. By minimizing power outages and reducing downtime, the system helps reduce economic losses resulting from power grid failures.It enables utility operators to respond quickly to potential failures, reducing the time and resources required for maintenance and repair.Hence This system provides real- time monitoring of critical power grid parameters, enabling utility operators to make informed decisions and take proactive measures to prevent failures. The system can be easily scaled up or down to accommodate changing grid conditions and can be integrated with existing grid infrastructure.It is cost-effective compared to traditional methods of power grid failure detection, which often rely on manual inspections and reactive maintenance.By reducing power outages and improving grid reliability, the system helps enhance customer satisfaction and reduce complaints.

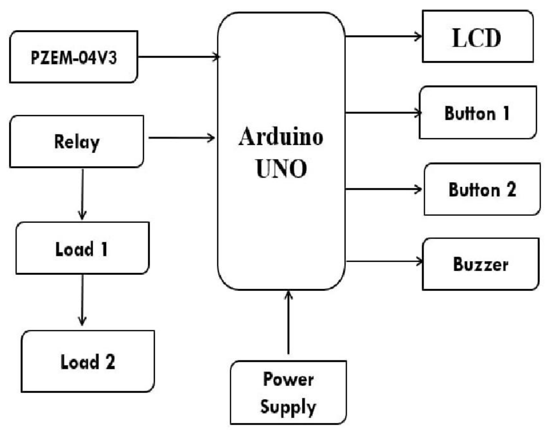

Fig: Block Diagram

VI. RESULTS AND DISCUSSION

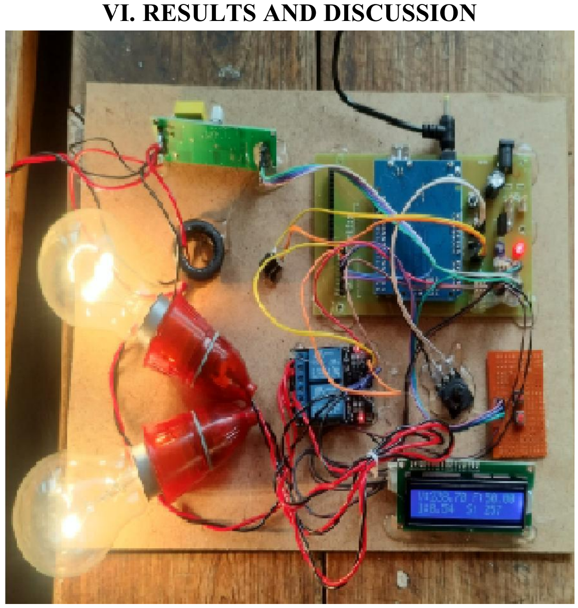

Fig: Prototype

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

Voltage detection is by done by varying the Potentiometer after reaching the acceptable Range the LCD displays that the voltage exceeded 230V and the Relay will be tripped and load of AC is protected. The Frequency detection is done before The tripping of the Light load the light flicker and frequency change will be displayed on the LCD. Hence a continuous Monitoring load and faults in frequency and Voltage is Done by using microcontrollers. IN this case the load Variation will be detected.

Voltage	Frequency	LCD Display Indication	Lamp Indication
=230V	50 Hz	Stable	On
<230V	<50 Hz	LowV &F	Off
>230V	>50 Hz	High V&F	Off

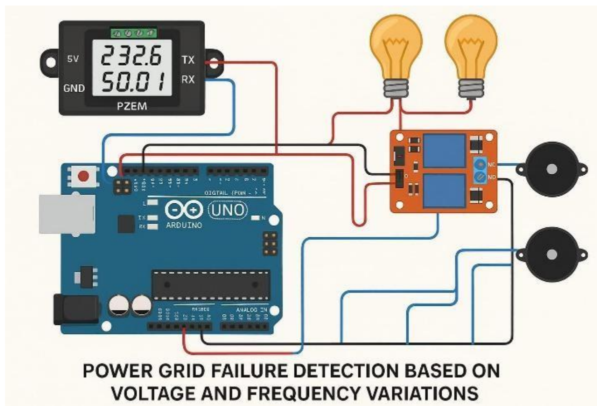

Fig: Schematic Diagram

VII. CONCLUSION

This paper gives brief idea about developing a system to detect the synchronization failure of any external supply source to the power grid on sensing the bad voltage and frequency. Number of distributed generators connected in parallel to the grid, to supply power to the load. Each generator having follow the rules of grid. These rules involve maintaining a voltage and frequency variation within limits. When any fault occurs on grid and due to this grid broken a rules and deviation occur in voltage and frequency. When deviation occur in grid feeder is mandatory to open from grid and this process is term as islanding. This prevent grid failure or blackout.

It is possible to have a power grid system that is smarter, more effective as well as efficient in its operation, thus proving to be more economical as compared to be the present installations. The challenge is a continuous and uninterrupted transmission which can be very well achieved with the implementation described by this project and in addition to the continuous transmission several other parameters i.e. the passive parameters are being observed regularly and any issues occurring in these, are taken into consideration and accordingly worked upon, thus making the process of management and recovery easier and effective. This system is less expensive as compared to the other system.

VIII. FUTURE SCOPE

The future of power grid failure detection based on voltage and frequency variations lies in integrating advanced technologies and refining existing methods to improve reliability and prevent outages. This includes using more sophisticated sensors, algorithms, and automation systems to detect and respond to deviations in voltage and frequency quickly and accurately. Furthermore, integrating these systems with other grid monitoring and control systems will create a more comprehensive and responsive power grid.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 1, May 2025
Impact Factor: 7.67

REFERENCES

[1] 1 Ali, A. 2001 Macroeconomic variables as common pervasive risk factors and the empirical content of the Arbitrage Pricing Theory. Journal of Empirical finance, 5(3): 221-240.

[2] Basu, S. 1997. The Investment Performance of Common Stocks in Relation to their Price to Earnings Ratio: A Test of the Efficient Markets Hypothesis. Journal of Finance, 33(3): 663-
682.

[3] Bhatti, U. and Hanif. M. 2010. Validity of Capital Assets Pricing Model. Evidence from KSE-Pakistan European Journal of Economics, Finance and Administrative Science, 3 (20).

[4] General Electric Instruments Constructionand Operating Principles, General Electric Meter and Instrument Department, West Lynn, Mass. 1949, chapter 7S.N. Singh, S.C. Srivastava, Electric power industry reconstructing in India, Present Scenario and future prospects, Senior Members, IEEE.

[5] N.Dhaka, Developing Islanding Arrangement Automatically for Grid on Sensing Voltage or Frequency Beyond Range,IJERMT Mag., vol.2, Mar2015, pp. 184- 187.

[6] G. F. Donald andH.W.Beatty,Standard Handbook for Electrical Engineers, Eleventh Edition, McGraw-Hill, New York,ISBN 0-07- 020974-Xpp. 3-64,3-65.

[7] General Electric, Electric Instruments Construction and Operating Principles, GeneraElectric Meter and Instrument Department, WestLynn, Mass.1949, chapter 7.

[8] S.N. Singh,S.C. Srivastava, Electric power industry reconstructing in India, Present Scenario and future prospects,SeniorMembers,IEEE.

[9] Sarfaraz Ahmad, DushyantBagul, Rahul Harijan, Prof.RahulJadav, "Comparative Analysis of techniques for fault detection of Grid Synchronization" International Research Journal of Engineering and Technology (IRIET), Volume 6, Issue 1, March 2019.

[10] Karan Gupta, Shreyas Gupta,KummadVerma, Anil Singh,Abhimanou Sharma, "DetectingPower Grid Synchronization Failureon Sensing Bad Voltage orFrequency Documentation"-International Journal of EngineeringResearch and General Science,Volume4, Issue 2. March-April, 2016.

[11]RohanSolanki,Divyesh Patel. YuvrajGharia, Duivik Sailor, Bhumit Patel,Ashish Protection of power grid Chaudhari, "Detection AndSynchronisation failure InternationalResearch Journal of Engineering andTechnology, Volume 03, Issue: 05,May-2016