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Cloud-based Solutions for Over/Under Voltage Protection Device in Smart Cities (OVPD)

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Abstract

In developing countries, the basic problem is power fluctuation and uneven voltage, which leads to serious damage to electronic devices and electrical equipment. Power fluctuation and uneven voltage supply are significant problems in the lead industry. Under-voltage, over-voltage, brownouts, blackouts, spikes, etc., are common problems which are faced due to fluctuation. Using our project, we have attempted to resolve the problems of under-voltage and over-voltage. In our project, we will be using Arduino UNO as a control board, which will be used to calculate the input voltage and determine whether it is over-voltage, normal-voltage, or under-voltage. Depending on the input voltage, the relay will get on or off according to the command. Arduino UNO, on the other hand, sends data to the ESP8266 Node MCU. As soon as the ESP8266 Node MCU connects to the wifi network, the data will be sent to a Google sheets (with the help of API call). After the data is stored in google sheets, it will be processed, and then a graph will be created that will indicate when over-voltage and under-voltage occurred.

Keywords: Under-Voltage, Over-Voltage, Arduino UNO, ESP8266 Node MCU, Google Sheets

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1. Introduction

Ensuring that electrical and electronic equipment operates optimally requires maintaining power within specified limits. Electrical fluctuations are a primary cause of disruptions in power supply, leading to degradation and malfunction of many components. Such fluctuations can stem from unstable power sources and improper operations on power lines. While most homes are equipped with circuit breakers to protect electrical devices, these typically require manual activation to restore power after an outage. Addressing this challenge involves deploying devices capable of automatically disconnecting and reconnecting power, mitigating downtime effectively.

In this context, the paper focuses on achieving a specific objective related to the "Cloud-based Solutions for Over/Under Voltage Protection Device in Smart Cities (OVPD)." This entails exploring advanced cloud-based technologies that enhance the resilience of voltage protection systems across urban environments. By leveraging these solutions, cities can streamline operations, improve energy efficiency, and ensure continuous availability of electricity to critical infrastructure and services.

2. Motivation

In today's world, the reliability and stability of electricity delivery in developing countries pose significant challenges. Unstable power supply often leads to sudden voltage spikes that can damage appliances. To address this

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issue, we propose the development of a "Power Voltage Fluctuation Monitoring System with IoT". Despite achieving 100% household electrification in India, a survey conducted by government think-tank Niti Ayog, The Rockefeller Foundation, and Smart Power India reveals that 28% of consumers remain dissatisfied due to poor power quality, especially voltage fluctuations and power surges, which frequently cause appliance damage

3. Problem Statement

Power disruptions stemming from lightning strikes, short circuits, changes in power lines, and high-power household appliances often lead to fluctuations in electricity, both over and under the desired levels. Incorrect voltage remains a significant issue globally, posing a threat to critical electrical equipment in homes and industries. It is crucial to implement an efficient method for monitoring and documenting the status and trends of voltage operations.

Despite achieving universal household electrification in India, 28% of consumers express dissatisfaction with power quality, particularly due to voltage fluctuations and resulting damage to equipment, according to a survey conducted by government-funded think tank Niti Ayog, The Rockefeller Foundation, and Smart Power India. To address these challenges, we propose a solution aimed at monitoring power conditions. Our plan involves detecting sudden increases or decreases in power supply beyond specific thresholds. Upon detection, our system will capture relevant data points and transmit them to the cloud for storage and analysis. Users can then access this data remotely through cloud-based platforms.

4. Related Work

The focus of this paper is on a low-cost approach for measuring both AC and DC voltage as well as current utilising extremely low-cost components. A mobile phone can also be used to monitor the system. The project is aimed towards engineering students because most Voltmeter/Ammeters are somewhat pricey. Furthermore, the obtained data can be kept according to the needs. This ammeter/voltmeter also allows for easy addition of new capabilities. To keep costs down, the entire operation was carried out using the aid of the famous ATmega328p microcontroller.[1][2]

In this paper, discuss how poor power quality may result in power surges, spikes, and voltage fluctuations, which can result in flickering lights, failure of household electrical equipment, and interference with TV reception, among other things. This situation necessitates the installation of a protective system right now. Otherwise, electronic equipment' functionality and usability may be jeopardised. As a result, this article describes a prototype of an Arduino-based safety system that might safe- guard household electronics from voltage fluctuations caused by undervoltage or overvoltage problems.[3][4]

These research papers , which focuses on the project's goal of creating a low voltage and high voltage indication With the hardware, a project has been presented to simulate an overvoltage and Undervoltage protection. Our project's benefits include a wide single supply voltage range of 2.0 V DC to 36 V DC, a very low supply current drain (0.8mA) irrespective of supply voltage, and a low input bias current of 25mA. The ground is included in the input common-mode voltage range, as is a differential input voltage range equivalent to the power supply voltage. [5][6]

These authors focuses on the Power supply (mains) from power generating stations and the alternative sources have become part of life, especially in developing countries such as Nigeria. The need to transfer services from mains supply to alternative power source such as generator set when mains fails can hardly be over- emphasized. The incessant power outage from mains as well as unstable voltage and power surge of the mains which have destroyed numerous expensive loads in the system for the short time it is available have been addressed. These are some of the latest research papers which give us great insight into our project topic. [7][8]

Deals with the modern industrial world, many electronic and electrical control devices productivity. Because most of these devices are designed with the use of modern power electronics, they are characterized by an extreme sensitivity to power quality variations. This paper describes an overview of the theory and effects of voltage sag. Reference to non- rectangular events, and the procedure to evaluate the power systems performance regarding voltage sag, through using particular indices to assess equipment compatibility issues is presented.[9][10][11]

This suggested practice's goal is to guide users through the correct monitoring and data interpretation of electromag- netic events that create power quality issues. It specifies power quality phenomena to aid communication within the power quality community. This paper also establishes a consensus view on safe and appropriate ways for monitoring and analyz- ing the outcomes of electric power systems. It also provides a tutorial on power system disruptions and their frequent causes.[12][13]

5. Block Diagram

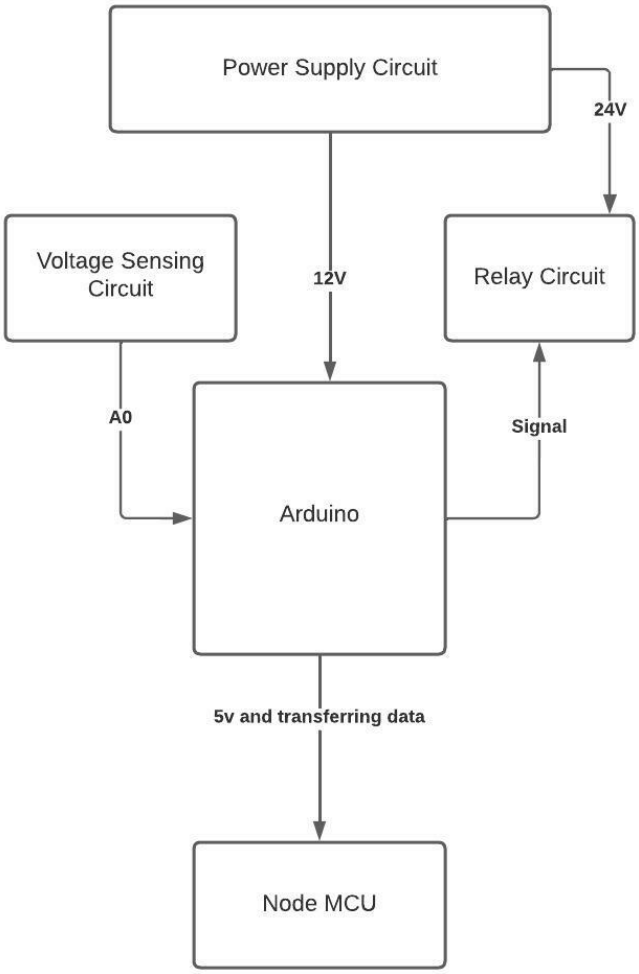

Figure 1. Working of OVPD

Step 1: Power Supply Circuit will firstly convert "AC voltage to DC voltage." Then Power Supply Circuit will give two output which is 24volt and 12volt for Relay Circuit and for Arduino UNO.

Step 2: Voltage Sensing Circuit will firstly "minimize" the voltage. And then send the minimize voltage to Arduino UNO.

Step 3: Arduino will read this in Analog and the convert the analog value to there respective Voltage Value. This Voltage value will determine whether the voltage is over-voltage, under-voltage, or normal-voltage. If it is over-voltage or under- voltage the relay will get "ON" and the load will not get the voltage. But if it is Normal voltage then the load will get the voltage and relay will be "OFF".

Step 4: Once the Relay is ON then also the reading will be check because if the read are normal again than Relay will be OFF and Load will get the voltage.

Step 5: Arduino UNO will send the data to esp8266 Node MCU and Node MCU will send this data to "Google Sheets".

6. Circuit Diagram

Power supplies that are transformer-less convert high AC input voltages (such as 120V or 230V) to DC output voltages. Using this output voltage, the Arduino, ESP8266, and relay circuit will be able to function properly.Then come's our Voltage Sensing Circuit which has a very low output signal, so the Arduino shouldn't be damaged, and this low analog signal is calculated in Arduino now.[14][15]

In this case, Arduino and ESP8266 play an essential role. The Arduino senses the voltage and gives the relay command to either turn it on or off and the next significant thing that Arduino does is to send a data to ESP8266. The ESP8266 will receive power from the Power Supply Circuit. As soon as the ESP8266 is connected to a configurable network, it will read the data from the Arduino and send it to Google Sheets.[16][17]

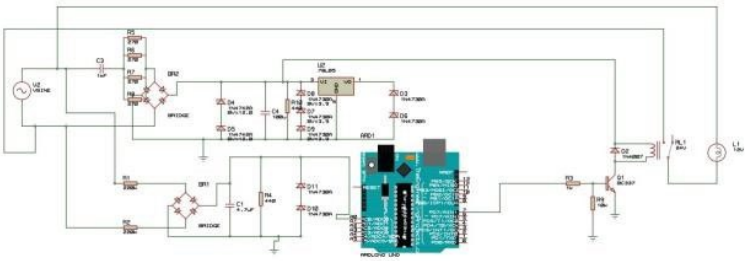

Figure 2. Complete Circuit diagram

7. Flow Chart

Step 1: We will read Analog Value from A0 and store it in max-point.
Step 2: Then we will compare it with over-voltage Analogvalue.
Step 2.1**:** If it is over-voltage then turn off the relay and loadvoltage will be zero.
Step 2.2**:** Else Compare it with under-voltage Analog value.
Step 2.1.1**:** If it is under-voltage then turn off the relay andload voltage will be zero.
Step 2.1.2: Else it is normal-voltage and relay will be on andload voltage will be on.
Step 3**:** It will send the max-point value to ESP after a delayof 5seconds.
Step 4**:** ESP will send this data to Google sheet or Cloud.

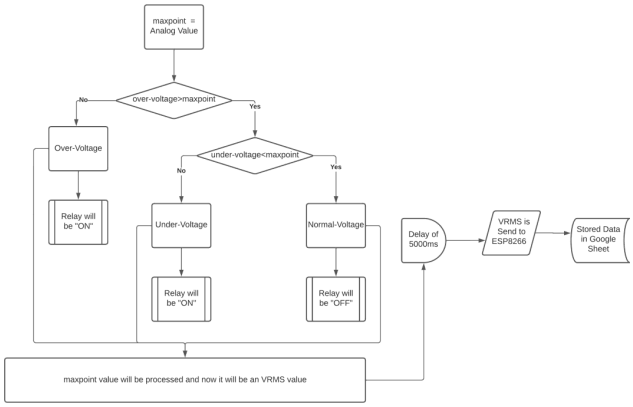

Figure 3. Complete Circuit Flow chart

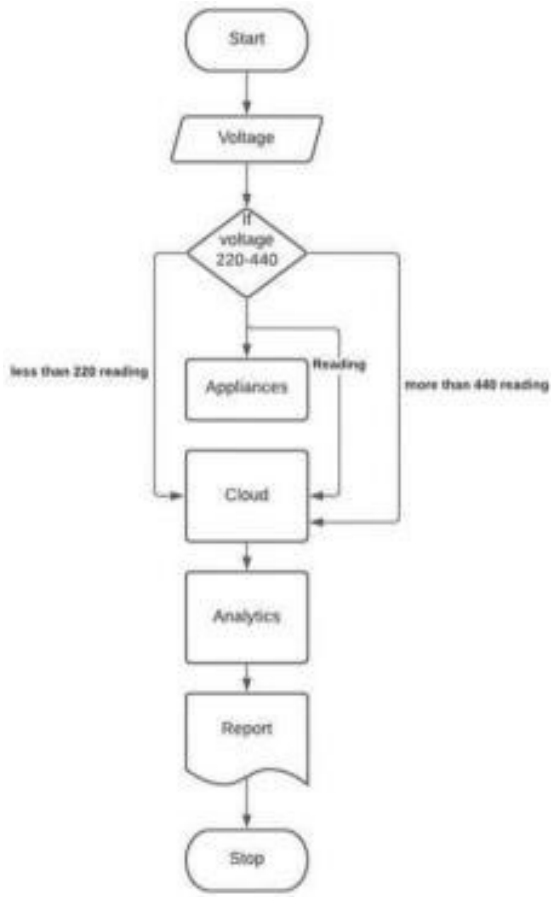

Figure 4. Cloud Report Analysis

These voltage supplies are being presented to the user via a live graphical representation chart. The analysis is made on the received supplies.

Analysis on things such as the under/over voltage occurrence frequency within 1 hr/ day/month/ year and so on. With the help of this voltage data, the voltage trends can be identified and thus actions can be carried out accordingly.

Therefore, the task of identifying irregularities is made easier by the generation of reports.

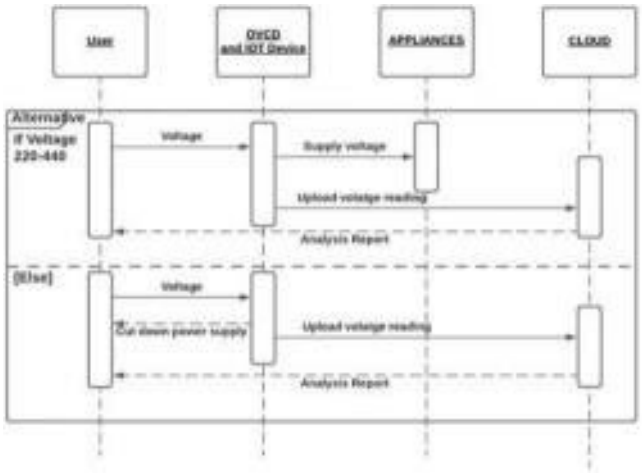

Figure 5. Sequence Diagram

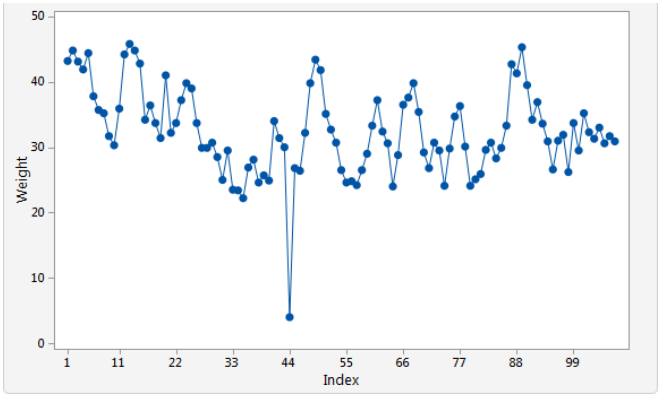

Figure 6. Weight Vs Index

8. Graph Analysis

Step 1: Look out for sudden shifts occurring : Use technique to know-how to decide whether or not uncommon observations or shifts imply mistakes or an actual alternate within the technique.

Look for uncommon observations, additionally referred to as outliers. Outliers will have a disproportionate impact on time collection fashions and convey deceptive results. Try to discover the reason for any outliers and accurate any statistics- access mistakes or dimension mistakes. Consider putting off statistics values which might be related to abnormal, one-time events, which might be additionally referred to as unique causes.

The following time collection plot suggests an outlier that became resulting from a statistics-access error. A technician by chance entered the price four with inside the worksheet as opposed to 40.

Step 2: Look for seasonal patterns occurrence: As an

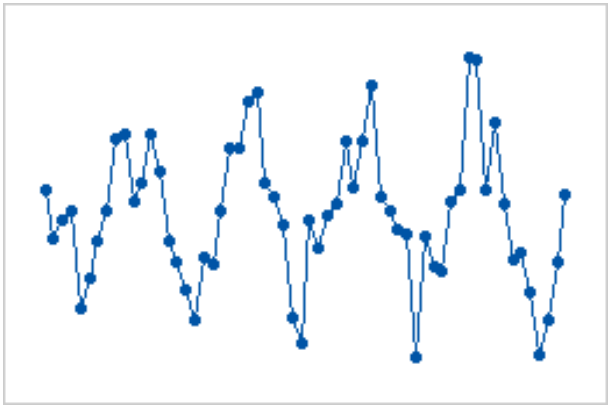

Figure 7. Seasonal Pattern

example, orders at a car part shop are low every Monday, boom throughout the week, and high on Fridays. A seasonal sample is an upward ascending and downward falling pattern that repeats repeatedly over the same time period. While seasonal trends always have the same defined period, cyclic movements are cycles of rising and falling record values that do not repeat constantly. Consequently, cyclical moves are usually longer and more variable than seasonal trends.[18]

Step 3: Find out if there is any trend pattern formed : Typically, a trend is an increase or decline in the first value over a long period of time. You can have straight lines or you can have curves in the fashion. Time series analysis can be used to validate facts and generate forecasts if your data shows a trend.

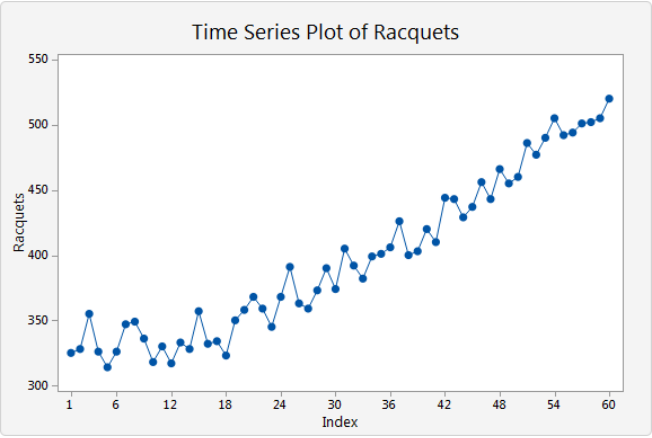

Figure 8. Racquets Vs Index

9. Results and Discussion

As the data is transmitted from Arduino to ESP, it is essentially the VRMS value. We then store this data in Google Sheets. As part of a future project, the data can be used in a web server using API calls, and CSV files can be retrieved from Google Sheets easily.

We will be able to create a dynamic dashboard with this information. The 1000 data stored in this project is not more than half a MB and we can easily use a Google sheet because we can use excel formulae and we can easily create graphs using the sheet.[19]

Time	Voltage
28/04/2022 15:18:56	228.72
28/04/2022 15:19:03	226.65
28/04/2022 15:19:11	224.58
28/04/2022 15:19:18	226.65
28/04/2022 15:19:24	227.69
28/04/2022 15:19:31	225.62
28/04/2022 15:19:38	227.69
28/04/2022 15:19:45	224.58
28/04/2022 15:19:52	228.72
28/04/2022 15:20:00	226.65
28/04/2022 15:20:07	229.76
28/04/2022 15:20:14	228.72
28/04/2022 15:20:21	224.58
28/04/2022 15:20:28	227.69
28/04/2022 15:20:35	225.62
28/04/2022 15:20:42	228.72
28/04/2022 15:20:49	226.65
28/04/2022 15:20:56	231.83
28/04/2022 15:21:03	225.62
28/04/2022 15:21:10	228.72
28/04/2022 15:21:18	230.79

Figure 9. Real Time data

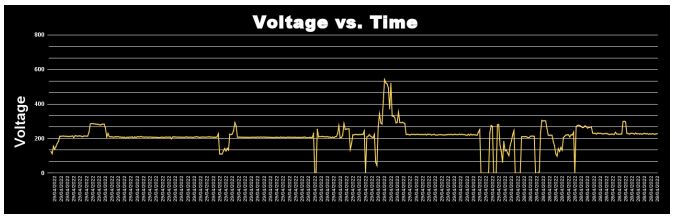

Figure 10. Real Time Graph

10. Conclusion

In developing countries like India, common electrical issues plague many households, affecting approximately 28% of the population daily. These issues include Over-Voltage, Under-Voltage, Blackouts, Brownouts, and Power Spikes. To address these challenges, we have developed a project focused on managing over-voltage and under-voltage conditions.

Our project features a smart cutoff device designed to automatically disconnect during over-voltage and under-voltage events, with a "Smart Start" feature that restores power when voltage levels normalize. Additionally, we have integrated a voltage monitoring system that logs data to Google Sheets, providing users with real-time electricity supply tracking.

The project utilizes Arduino and ESP microcontrollers due to their accessibility and compatibility with Arduino

IDE for programming. Arduino serves as the project's central controller, while ESP facilitates data transmission to the cloud (Google Sheets). Data is recorded every 7 seconds with an accuracy rate of 96%. The cutoff and turn-on times are set at 2 seconds and 3 seconds, respectively.

This Arduino UNO-based module represents a significant step in enhancing voltage protection and safeguarding electrical appliances. Given the prevailing issues with power outages, our module's design offers substantial advantages in managing and maintaining stable electricity supply.

11. Future Work

Future scope includes improving the accuracy of the model and application overall by:

- There is one more circuit that has to be connected, the CT circuit (the Current Transformer Circuit), and then we can make a PCB.
- After that, we will have to upgrade the circuit to work with 3phase.
- Implement a Real-Time Web Server and Data Base with a small amount of Big data analysis and cloud computing.

Acknowledgements.

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