

Electrical Parameter Observation System

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ABSTRACT - Efficient monitoring of electrical parameters plays a very important role in maintaining safety, reliability, and energy efficiency in college infrastructures. In many educational institutions, electrical systems are used continuously for laboratories, classrooms, hostels, and administrative purposes. However, due to the lack of proper monitoring systems, energy wastage and unexpected faults are common problems.

This paper presents a simple, cost-effective, and practical Electrical Parameter Observation System designed specifically for college environments. The system is capable of continuously monitoring important electrical parameters such as voltage, current, power, and power factor using appropriate sensors and a microcontroller-based platform. The collected data is processed in real time and displayed locally, and it can also be transmitted for further analysis if required.

The proposed system helps in identifying abnormal operating conditions such as overloading, voltage fluctuations, and poor power factor. By detecting these issues early, the system supports preventive maintenance and reduces the chances of equipment damage. Additionally, it contributes to minimizing energy losses and improving overall system efficiency.

The design of the system is simple, easy to implement, and affordable, making it highly suitable for small-scale applications like colleges and training institutes. Overall, this system promotes better energy management and awareness among users.

INTRODUCTION

In today's world, electrical energy is one of the most essential resources for the smooth functioning of educational institutions. Colleges depend heavily on electrical systems for operating laboratories, classrooms, computer centers, lighting systems, and various other facilities. With increasing demand for electricity, efficient monitoring and management of electrical parameters have become very important.

In many colleges, electrical systems are not continuously monitored, which leads to several issues such as energy wastage, increased operational cost, overheating of equipment, and unexpected failures. These problems not only affect the performance of electrical systems but also reduce their lifespan and increase maintenance requirements. Therefore, there is a strong need for a reliable and continuous monitoring system.

Traditional electrical monitoring systems are often complex, costly, and difficult to maintain. Such systems are not always suitable for small-scale applications like college campuses, where a simple and affordable solution is required. This creates a gap between the need for monitoring and the availability of practical solutions.

To overcome these limitations, this paper proposes a simple and efficient Electrical Parameter Observation System. The system is designed using basic sensors and a microcontroller, making it easy to install and operate. It provides real-time monitoring of key electrical parameters and helps in detecting abnormal conditions at an early stage.

The main aim of this system is to improve energy efficiency, reduce electrical losses, and ensure the safe operation of equipment within the college infrastructure. Additionally, the system can also be used as a learning tool for students to understand practical electrical concepts.

LITERATURE REVIEW

Many researchers have focused on the development of electrical parameter monitoring systems to improve power quality and energy efficiency. These systems mainly measure voltage, current, and power in single-phase and three-phase supplies.

Several studies highlight the use of microcontroller-based systems for real-time data acquisition and display. Such systems provide accurate measurements and are widely used due to their low cost and ease of implementation.

Recent research emphasizes the importance of monitoring power factor and energy consumption in educational institutions. Efficient monitoring helps in reducing energy losses and improving overall electrical system performance.

Harmonic distortion analysis has gained significant attention due to the increasing use of non-linear loads. Studies show that devices such as computers and LED lights contribute to Total Harmonic Distortion (THD) in power systems.

Various techniques have been proposed for THD measurement using digital signal processing and embedded systems. These methods improve the accuracy of harmonic detection and help maintain power quality standards.

Some researchers have developed IoT-based electrical monitoring systems for remote access and control. These systems enable real-time monitoring through web or mobile applications, enhancing user convenience.

From the reviewed literature, it is observed that there is a need for a simple, cost-effective, and reliable system suitable for school environments. The proposed system addresses this gap by integrating parameter monitoring with THD analysis in an easy-to-use platform.

PROPOSED SYSTEM

The proposed system is designed to monitor important electrical parameters such as voltage, current, power, and Total Harmonic Distortion (THD) in a three-phase supply. It uses sensors and signal conditioning circuits to collect real-time data from the electrical system. The measured values are processed using a microcontroller for accurate analysis.

The system includes voltage and current sensors that continuously sense the input supply. These signals are converted into suitable forms using signal conditioning circuits. The microcontroller reads these values and calculates power and THD using programmed algorithms. This helps in understanding the quality of power in the system.

A digital display is used to show all measured parameters clearly. The system can display voltage, current, power, and harmonic distortion values in real time. This makes it easy for users to monitor electrical conditions without using complex instruments. It is useful for both laboratory and industrial applications.

The proposed system is designed to be cost-effective and easy to install. It reduces the need for multiple measuring devices by combining all functions into a single unit. The system improves safety by providing continuous monitoring and early detection of abnormal conditions.

Overall, the system provides a simple and efficient solution for electrical parameter observation. It helps in improving power quality analysis and ensures better performance of electrical equipment. The design is flexible and can be upgraded with IoT features for remote monitoring in future.

METHODOLOGY

1. System Initialization

When the system is powered ON, the microcontroller initializes all connected components such as voltage sensor, current sensor, signal conditioning circuits, and display unit. Default values and calibration settings are loaded for proper operation. This ensures the system starts in a stable condition.

2. Voltage Measurement

The voltage of the three-phase supply is measured using voltage sensing circuits. A voltage divider is used to step down the high voltage to a safe level suitable for the microcontroller. This allows accurate monitoring without damaging the controller.

$$V_{rms} = \sqrt{\frac{1}{N} \sum_{i=1}^N V_i^2}$$

3. Current Measurement

Current sensors are used to measure the current flowing in each phase. These sensors continuously detect load current and send signals to the controller. This helps in analyzing load conditions and power consumption.

$$I_{rms} = \sqrt{\frac{1}{N} \sum_{i=1}^N I_i^2}$$

4. Signal Conditioning

The output from sensors is not directly suitable for the microcontroller. Therefore, signal conditioning circuits are used to filter noise and adjust signal levels. This improves accuracy and reliability of the measured data.

5. Data Acquisition and Processing

The analog signals from sensors are converted into digital values using the ADC of the microcontroller. The controller processes these values and calculates parameters such as power and Total Harmonic Distortion (THD). This helps in evaluating power quality.

6. Harmonic Analysis (THD Calculation)

The system analyzes the waveform of the supply to detect harmonics. Using programmed algorithms, the microcontroller calculates THD values. This helps in identifying distortion in the power supply.

$$THD = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \dots + V_n^2}}{V_1}$$

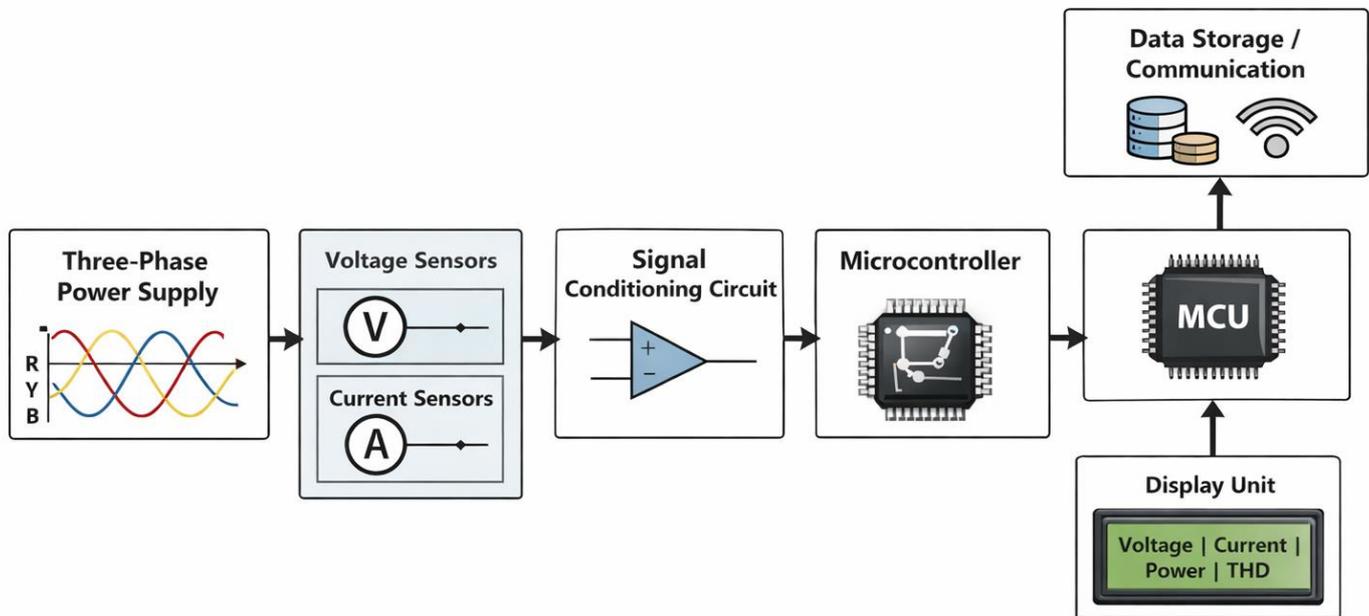
7. Display and Monitoring

All calculated parameters like voltage, current, power, and THD are displayed on a digital display. This allows users to monitor the system in real time. It makes observation simple and user-friendly.

8. Continuous Monitoring Operation

The entire process runs in a continuous loop. The system keeps sensing, processing, and updating values without interruption. This ensures real-time monitoring and quick detection of any abnormal condition.

BLOCK DIAGRAM



The overall system structure is shown in Fig. 1.

The block diagram represents the overall structure of the electrical parameter observation system. The system begins with a three-phase power supply, which acts as the main input source. This supply provides electrical energy to the entire setup, and it is essential for monitoring various parameters such as voltage, current, and harmonic distortion.

The next stage consists of sensors and signal conditioning circuits. Voltage sensors and current sensors are used to measure real-time electrical values from the three-phase system. Since the raw signals are not suitable for direct processing, signal conditioning circuits modify them into a proper range. This ensures accurate and safe data acquisition.

After signal conditioning, the processed signals are sent to a microcontroller unit. The microcontroller acts as the brain of the system. It continuously reads the input data, processes it, and calculates important parameters such as power and Total Harmonic Distortion (THD). The use of a microcontroller improves system accuracy and automation.

The calculated values are then displayed using a digital display unit. This allows users to easily monitor real-time electrical parameters. The display shows voltage, current, power, and THD values clearly, making the system user-friendly for industrial and laboratory applications.

Finally, the system may include communication or storage features for future analysis. The monitored data can be stored or transmitted if required. Overall, the block diagram shows a simple, efficient, and reliable system for monitoring electrical performance and detecting power quality issues.

HARDWARE IMPLEMENTATION

Circuit diagram

The hardware implementation of the proposed system is shown in Fig. 2.

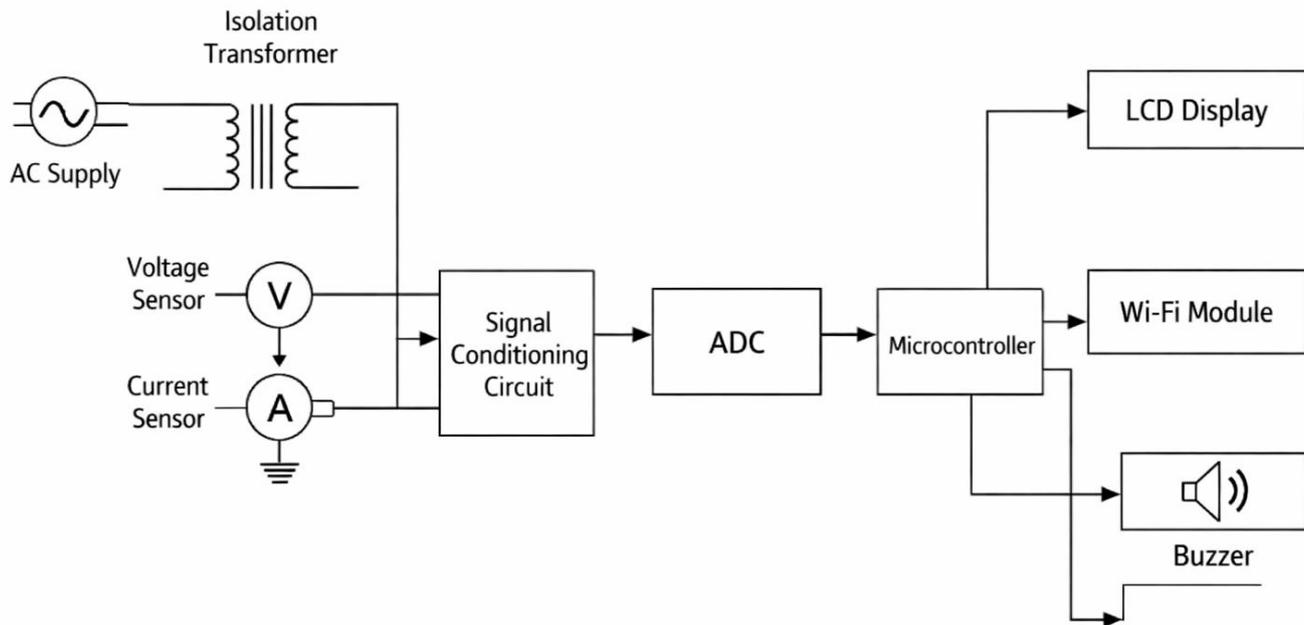


Fig. 2: Circuit diagram of Electrical Parameter Observation System

1. Power Supply Unit

The system uses a regulated DC power supply for proper working. A transformer steps down the AC voltage, which is then converted into DC using a rectifier. Filters remove noise, and a voltage regulator provides stable output. This ensures safe operation of all components.

2. Voltage Sensing Circuit

The voltage of the three-phase supply is measured using a voltage divider circuit. It reduces high voltage to a low level suitable for the microcontroller. This protects the system and allows accurate measurement.

3. Current Sensing Module

Current is measured using CT or Hall-effect sensors. These sensors give output signals proportional to the load current. The readings help in analyzing the load condition and power usage.

4. Signal Conditioning Circuit

Sensor outputs may contain noise or unwanted signals. Signal conditioning circuits are used to filter and stabilize these signals. This improves accuracy and ensures reliable data for processing.

5. Microcontroller Unit

The microcontroller acts as the main control unit. It collects data from sensors and processes it to calculate parameters like power and THD. It also sends data to the display unit.

6. Display Unit

A digital display such as an LCD is used to show all parameters. It displays voltage, current, power, and THD values clearly. This makes monitoring simple and user-friendly.

7. Harmonic Detection Circuit

This circuit helps in identifying waveform distortion in the supply. It supports the microcontroller in calculating Total Harmonic Distortion. This is useful for analyzing power quality.

8. Connecting and Protection Components

Proper wires, connectors, and protective devices like fuses are used. Good insulation and grounding are maintained for safety. This increases the reliability and life of the system.

10. Comparison Table

Parameter	Existing System	Proposed System
Monitoring	Limited	Real-time monitoring
Accuracy	Moderate	High
THD Detection	Not available	Available
Cost	High	Low
Efficiency	Medium	High

FUTURE SCOPE

The system can be upgraded by adding IoT-based monitoring. Users will be able to check electrical parameters from anywhere using a mobile or computer. This will make the system more flexible and easy to use.

A data logging feature can be included to store readings over time. These records can be used to study trends and compare performance. This will help in better analysis of power usage.

A mobile application can be developed for easy access and control. Users can receive alerts when values go beyond safe limits. This will improve safety and response time.

More accurate and advanced sensors can be used in future designs. This will improve measurement accuracy and reliability. It will make the system suitable for industrial use.

Artificial Intelligence can be added for smart monitoring. The system can detect patterns and predict possible faults. This will reduce manual checking and improve efficiency.

Additional parameters like frequency and power factor can be included. This will provide a complete analysis of power quality. It will increase the usefulness of the system.

The system can be made smaller and portable. This will make it easy to carry and use in different locations. It will be helpful for field testing and maintenance work.

RESULTS

The developed system was tested under different load conditions to evaluate its performance. The system successfully measured voltage, current, and power with good accuracy. The Total Harmonic Distortion (THD) values were also calculated and displayed in real time.

The observed results show that the system can detect voltage fluctuations and harmonic distortion effectively. Under non-linear loads, the THD value increased, indicating power quality issues. The system responded quickly to these changes, proving its reliability.

Overall, the results confirm that the proposed system is suitable for real-time monitoring and power quality analysis in educational and industrial environments.

1. THD vs Load Graph

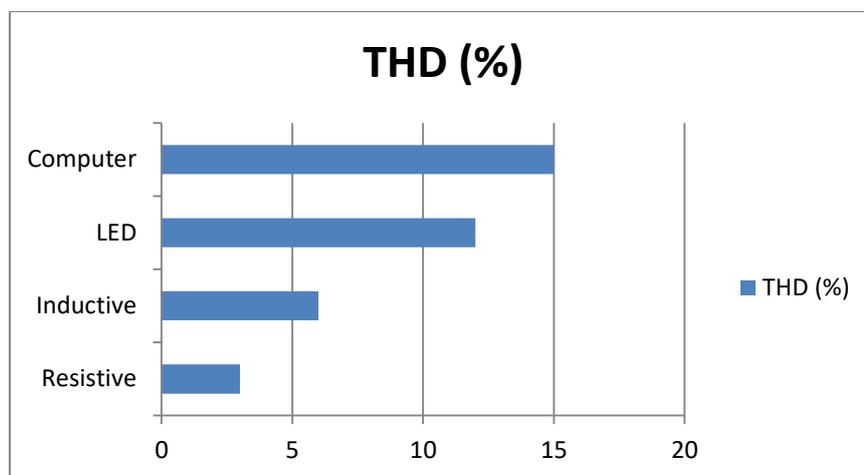


Fig. 6: THD variation under different loads

2. FFT (Fast Fourier Transform)

It is used to analyze the frequency components of the signal. The FFT spectrum represents the amplitude of fundamental and harmonic frequencies present in the electrical waveform.

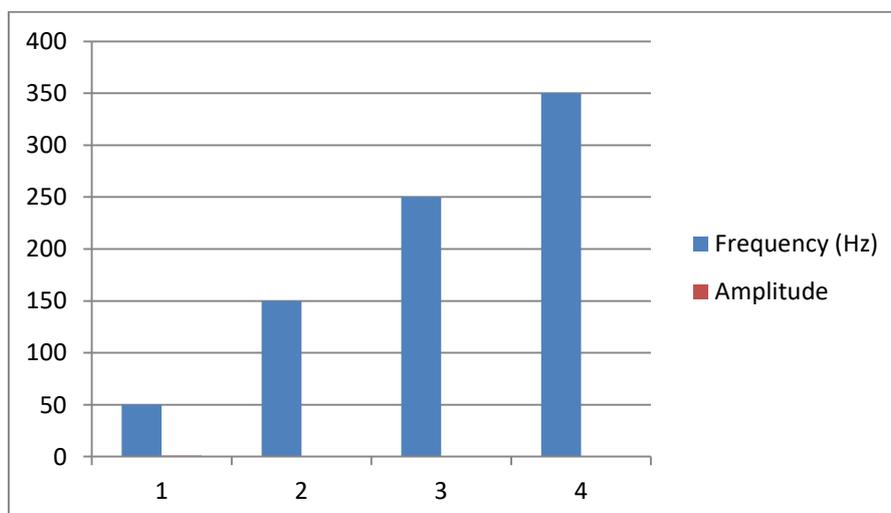


Fig. 7: Harmonic frequency spectrum using FFT

3. Voltage Waveform

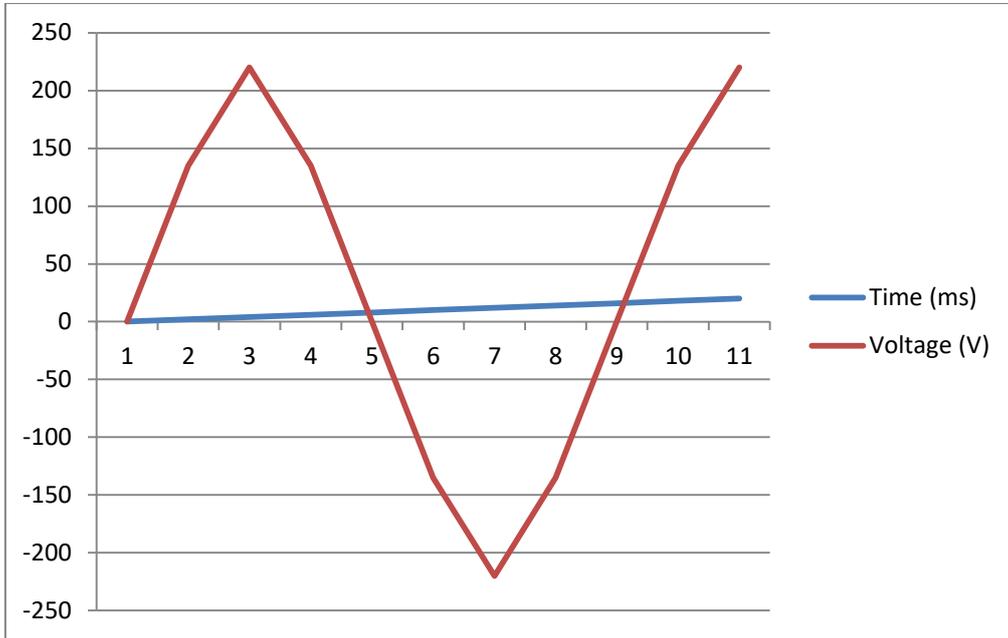


Fig. 4: Voltage waveform of AC supply

4. Current Waveform

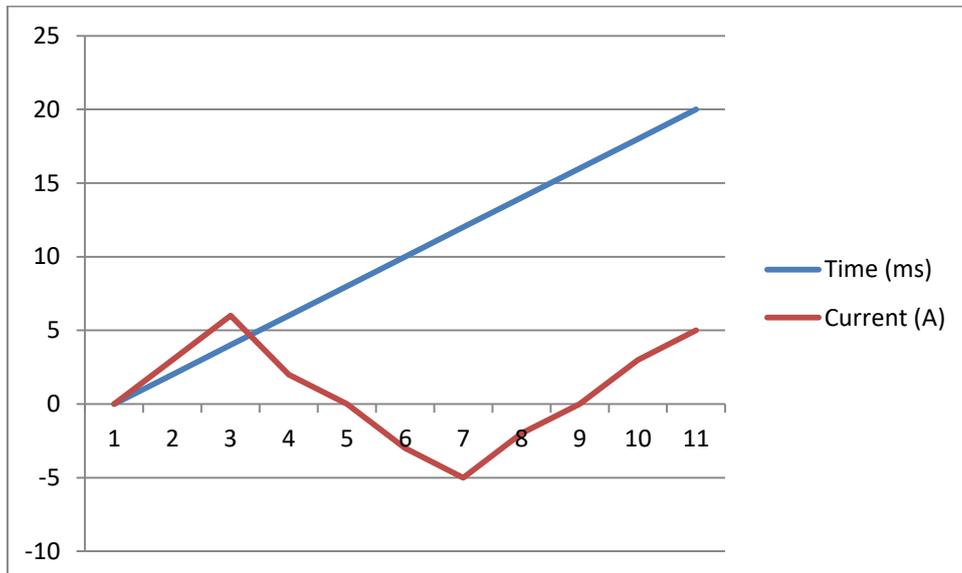


Fig. 5: Current waveform with harmonic distortion

CONCLUSION

The Electrical Parameter Observation System successfully monitors important parameters such as voltage, current, power, and Total Harmonic Distortion (THD) in a three-phase supply. The system provides accurate and real-time data using sensors and a microcontroller. It helps in understanding the overall condition of the electrical system. This makes it useful for both learning and practical applications.

The project improves power quality analysis by detecting harmonic distortion in the supply. By displaying THD values, it becomes easier to identify problems in electrical networks. This helps in taking corrective actions to protect equipment. The system also reduces the need for multiple measuring devices.

The design of the system is simple, cost-effective, and easy to use. It can be installed in laboratories, industries, and educational institutes. The use of digital display makes monitoring convenient and clear. The system can operate continuously with reliable performance.

In future, the system can be upgraded by adding IoT features for remote monitoring and data storage. Wireless communication can help users access data from anywhere. Additional features like fault alerts can also be included. Overall, the system is an efficient solution for electrical parameter observation and power quality improvement.

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