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IoT Based Smart Workshop Energy Monitoring and Automation System

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ABSTRACT

The IoT Based Smart Workshop Energy Monitoring and Automation System is designed to monitor, manage, and optimize electrical energy consumption in workshops using Internet of Things (IoT) technology. Workshops commonly operate multiple electrical machines, lighting systems, fans, and other equipment, which can lead to excessive energy consumption and inefficient utilization. The proposed system provides real-time monitoring of electrical parameters such as voltage, current, power, and energy consumption using suitable sensors and a microcontroller. The collected data is transmitted through an IoT platform, allowing users to remotely monitor energy usage through a mobile or web-based interface. The system can also automate electrical appliances based on predefined conditions, operating schedules, or user commands. Automatic switching helps reduce unnecessary power consumption and improves workplace safety by preventing equipment from remaining switched on when not required. Energy consumption data can be stored and analyzed to identify high-consumption equipment and improve overall energy efficiency. The proposed system provides a low-cost, scalable, and user-friendly solution for smart workshop management. By combining energy monitoring with automation, the system supports efficient power utilization, reduces operational costs, and contributes to the development of intelligent and sustainable workshops.

Keywords: IoT, Smart Workshop, Energy Monitoring, Automation, Energy Management, Sensors, Microcontroller, Real-Time Monitoring, Power Consumption, Smart Control

Introduction

The rapid development of **Internet of Things (IoT)** technology has made it possible to connect electrical devices, sensors, and control systems through the internet for real-time monitoring and automation. In workshops, a large number of electrical machines, lighting systems, fans, tools, and other equipment are used regularly. Improper management of these devices can result in unnecessary energy consumption, increased electricity costs, and inefficient use of electrical resources. Therefore, an intelligent system is required to monitor energy consumption and automate electrical equipment effectively.

The **IoT Based Smart Workshop Energy Monitoring and Automation System** is proposed to provide an efficient solution for managing electrical energy in a workshop environment. The system uses sensors to measure important electrical parameters such as **voltage, current, power, and energy consumption**. A microcontroller collects and processes the sensor data and sends it to an IoT platform through a suitable communication network. Users can monitor the workshop's energy consumption remotely using a mobile or web-based interface.

In addition to monitoring, the system provides **automatic control of electrical appliances**. Devices can be switched ON or OFF according to predefined conditions, schedules, or user commands. This helps prevent unnecessary operation of equipment and improves energy efficiency. The collected data can also be analyzed to identify high-energy-consuming devices and support better energy management.

Thus, the proposed system combines **real-time energy monitoring, IoT connectivity, and automation** to create a smarter, safer, and more energy-efficient workshop.

Literature Review

The integration of **Internet of Things (IoT)** technology with energy monitoring and automation has received considerable attention in recent years. Researchers have developed various systems for monitoring electrical parameters, controlling appliances remotely, and improving energy efficiency. These studies provide a foundation for the development of an IoT-based smart workshop energy monitoring and automation system.

Several researchers have proposed **IoT-based energy monitoring systems** that use current and voltage sensors with microcontrollers to measure real-time electrical consumption. The measured parameters are generally transmitted to cloud platforms, where users can monitor power consumption through mobile or web applications. Such systems help users identify excessive energy usage and improve energy management.

Studies on **smart home and industrial automation** have demonstrated the use of microcontrollers such as Arduino, ESP8266, and ESP32 for remote control of electrical appliances. Relay modules are commonly used to switch loads ON and OFF based on user commands or predefined conditions. These approaches can also be applied to workshop environments for controlling lights, fans, machines, and other electrical equipment.

Research on **energy management systems** has further highlighted the importance of collecting historical consumption data. Analysis of this data can help identify high-energy-consuming devices, detect abnormal consumption, and reduce unnecessary power usage. Cloud-based monitoring also allows users to access energy information remotely.

However, many existing systems focus mainly on either **energy monitoring or appliance automation**. The proposed system combines both functions in a single IoT-based platform specifically designed for workshop applications. It aims to provide real-time monitoring, remote control, automated operation, and improved energy utilization in a cost-effective manner.

Behaviour Analysis Module

The **Behaviour Analysis Module** in the IoT Based Smart Workshop Energy Monitoring and Automation System is used to analyze the energy consumption and operating behaviour of electrical equipment in the workshop. The module collects data such as voltage, current, power, energy consumption, operating duration, and switching frequency from the monitoring system.

The collected data is analyzed to identify **normal and abnormal energy-use patterns**. For example, if a machine consumes unusually high power or remains ON for a longer period without proper usage, the system can identify this condition. Similarly, repeated switching or unexpected power consumption can be detected and reported to the user.

The module can also compare current energy consumption with previous readings to determine consumption trends. Based on these patterns, the system can support automatic actions such as switching OFF unnecessary loads or generating alerts for abnormal conditions.

Main Functions

- Monitoring equipment operating behaviour
- Analysis of voltage, current, power, and energy data
- Detection of abnormal power consumption
- Identification of unnecessary equipment operation
- Comparison of current and historical energy usage
- Generation of alerts and notifications
- Supporting automatic ON/OFF control
- Improving overall workshop energy efficiency

Proposed Methodology

The proposed **IoT Based Smart Workshop Energy Monitoring and Automation System** is designed to monitor electrical energy consumption and automatically control workshop equipment. The methodology consists of sensing, data processing, IoT communication, behaviour analysis, and automation.

1. Data Sensing

Electrical sensors are connected to the workshop loads to measure parameters such as **voltage, current, power, and energy consumption**. These sensors continuously collect real-time electrical data from machines, lights, fans, and other equipment.

2. Data Processing

A microcontroller such as **ESP32/ESP8266** receives the sensor readings and processes the collected data. The controller calculates important parameters and checks whether the equipment is operating within predefined limits.

3. IoT Communication

The processed data is transmitted through a **Wi-Fi network** to an IoT/cloud platform. This enables real-time monitoring of workshop energy consumption through a mobile or web-based interface.

4. Behaviour Analysis

The system analyzes energy consumption patterns, operating duration, and switching behaviour. It identifies abnormal or unnecessary energy usage by comparing present readings with predefined limits and previous consumption data.

5. Automation and Control

Based on the analyzed data, the system can control electrical loads using **relay modules**. Equipment can be switched ON/OFF automatically according to schedules, operating conditions, or user commands.

6. Monitoring and Alerts

The user can view real-time energy information and receive alerts when abnormal consumption or predefined threshold conditions are detected.

Overall Flow

Electrical Loads → Sensors → ESP32/ESP8266 → Data Processing → IoT Platform → Behaviour Analysis → Automation/Alerts → User

System Architecture

The **IoT Based Smart Workshop Energy Monitoring and Automation System** follows a layered architecture in which electrical parameters are sensed, processed, transmitted, analyzed, and used for automated control. The architecture integrates hardware components, IoT communication, cloud storage, data analysis, and user interaction.

1. Sensing Layer

The sensing layer consists of **voltage and current sensors** connected to workshop electrical loads. These sensors continuously measure electrical parameters such as voltage, current, power, and energy consumption.

2. Processing and Control Layer

An **ESP32/ESP8266 microcontroller** acts as the main processing unit. It receives sensor data, processes the measurements, and checks them against predefined conditions. It also generates control signals for connected electrical appliances.

3. Communication Layer

The processed information is transmitted through **Wi-Fi** to an IoT/cloud platform. This layer provides communication between the workshop hardware and the monitoring application.

4. Cloud and Data Analysis Layer

The IoT platform stores and displays the collected energy data. The **Behaviour Analysis Module** analyzes consumption patterns, operating duration, and abnormal energy usage. Historical data can be used to identify trends and improve energy management.

5. Automation Layer

Relay modules are used to control workshop loads such as **lights, fans, and selected electrical equipment**. Based on predefined conditions, schedules, or user commands, the system can automatically switch loads ON or OFF.

6. User Interface Layer

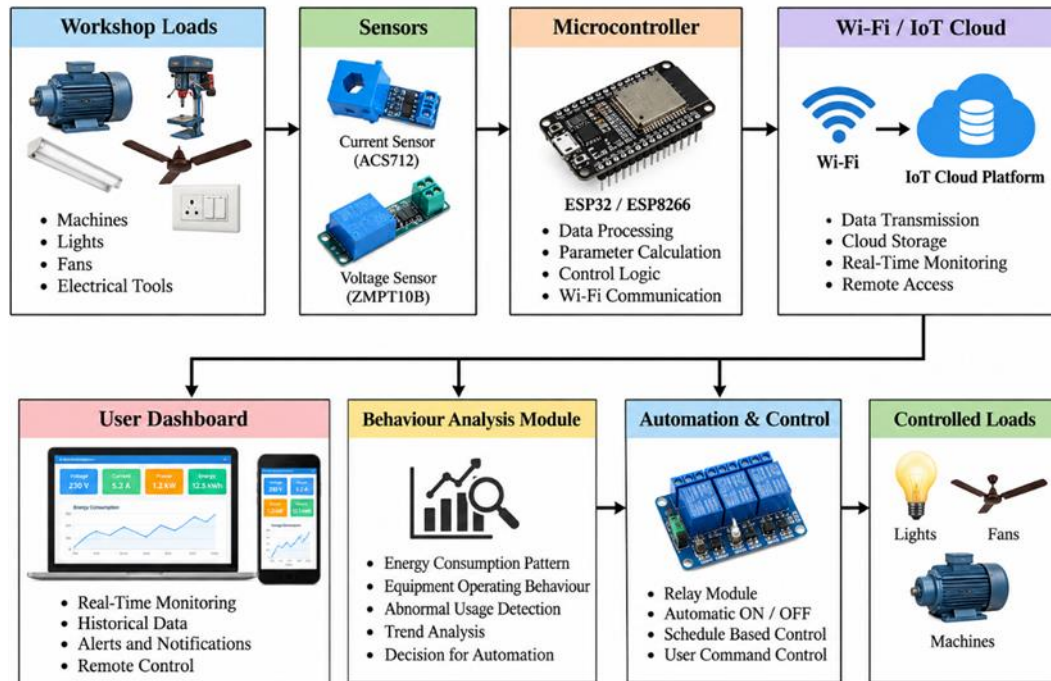
A **mobile or web-based dashboard** allows the user to monitor real-time energy consumption, view historical data, receive alerts, and control connected devices remotely.

System Architecture Flow

Workshop Loads → Sensors → ESP32/ESP8266 → Wi-Fi → IoT/Cloud Platform → Data Analysis → Dashboard

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** Relay Control → Electrical Loads **



Conclusion

The **IoT Based Smart Workshop Energy Monitoring and Automation System** provides an effective solution for monitoring and managing electrical energy consumption in a workshop environment. The proposed system integrates **sensors, ESP32/ESP8266, Wi-Fi communication, IoT cloud technology, behaviour analysis, and relay-based automation** into a single system.

1. The system enables real-time measurement of important electrical parameters such as voltage, current, power, and energy consumption. The collected information can be monitored remotely through a web or mobile dashboard, allowing users to understand energy usage and identify unnecessary consumption. The Behaviour Analysis Module further helps in detecting abnormal consumption patterns and equipment operating behaviour.
2. Automation allows selected electrical loads to be controlled automatically according to predefined conditions, schedules, or user commands. This can reduce unnecessary energy usage and improve the operational efficiency of the workshop. The system also provides a scalable platform that can be extended with additional sensors, loads, and intelligent energy-management features.
3. Overall, the proposed system demonstrates how **IoT and automation can be combined to create a smart, efficient, and user-friendly workshop environment**, supporting better energy management, remote monitoring, and intelligent control of electrical equipment.

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