

Smart Distribution Board and Smart Plug

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Abstract - Every day, thousands of accidents occur around the world as a result of electrical problems or breakdowns. A quick response time will help to limit the number of fatalities and financial damages associated with these events. As a result, we propose a system that will identify or detect any electrical system defects and warn the user in real time. The system also delivers information about the real time power factor, energy consumption, etc. In an electrical system, proper power factor reduces the load on the electrical distribution system, promotes energy efficiency, lowers electricity costs, and reduces the likelihood of equipment instability and failure.

The distribution board will be connected to several sensors such as a current sensor, voltage sensor, and power sensor. Using an esp8266-based microcontroller, the sensors read data and transfer it to a Raspberry Pi-based server. The Raspberry Pi uses algorithms to process the data and then sends the results to a cloud platform like Firebase, which is connected with a cross-platform application. A smart plug will be available that can be used to control and monitor specific appliances using an app. The software also sends out alerts when hazardous weather conditions, such as thunderstorms or lightning, threaten electrical equipment, allowing the user to turn them off remotely to protect them.

Key Words: Energy consumption, current sensor, voltage sensor, raspberry pi, smart plug

1. INTRODUCTION

Power is the soul of the universe when it comes to electricity, and "ELECTRICITY" is the word that today reigns supreme. As a result, correct usage of this resource is extremely vital to us. The traditional approach needs an individual and agent to physically come to the house and take the readings, then report the amount due to the household or business. As a result, numerous consumers are filing complaints against KSEB because of their large and incorrect bill amounts. As a result, a user-friendly energy consumption monitoring and warning system could help to reduce unnecessary energy consumption and, to some extent, reduce arguments over electricity bills. The detection and correction of power factors is a crucial consideration since a change in power factor might result in hefty fines from the KSEB. Proper power factor improves energy efficiency, lowers electricity costs, and reduces the probability of device instability and failure. Several accidents have occurred as a result of electrical system malfunctions. There is currently no effective alerting or warning system in place. The main goal of the project is to create a Smart Distribution Board with

various sensors and a cross-platform application that can alert users to any surges in the electrical system, provide real-time energy consumption, and provide necessary alerts and warnings, as well as a system to detect power factor variation and alert users.

1.1 Problem Statement

The majority of industrial and home equipment is extremely sensitive to electrical problems, and replacing it would be prohibitively expensive. A robust system is necessary that functions as an additional layer of protection for the equipment by detecting weather and electric surges early and providing warnings via handheld devices, reducing the danger of disaster. Users should be informed of their energy consumption in real time so that they can be reminded to use electricity wisely, which will assist to prevent consumer disputes with KSEB over large and inappropriate electricity bill amounts.

1.2 Energy Consumption Monitoring And Warning System

Consumers will receive real-time data about their energy consumption thanks to a module (main energy metre) that uses several sensors. It also alerts the customer if there are any problems with the system.

1.3 Voltage Fluctuation Warning System

If there is a voltage fluctuation, the voltage monitoring unit will detect it and notify the user. It can even disconnect appliances from the circuit (or switch off the main mcb), however this is a completely optional and scalable function.

1.4 Alerting System Based On Harsh Weather Condition

This clever feature will be beneficial to our project. It alerts the user to take precautions in the event of severe weather, as reported by reputable weather predicting companies such as Accuweather.

1.5 Smart Plug

Smart Plug is a device that allows us to control appliances remotely via a cross-platform app. We can even keep track of the appliance's current and voltage consumption. The smart plug allows you to operate and monitor your appliances from a distance. We can use smart plug to isolate the appliance in the event of any malfunctions or weather surges. A relay module, current sensor, power converter, and

NodeMCU module make up the smart plug. The information is uploaded to the Firebase cloud. The smartphone app allows users to operate and monitor the smart plug.

1.6 Cross-Platform Application

We developed the cross-platform programme "smart db" to assist users in tracking real-time energy use and efficiently controlling appliances. It makes the consumer more aware of their energy consumption and expenses. The software will notify the user of any weather surges, such as thunderstorms and lightning, so they may take appropriate action. It also sends out notifications to users about scheduled power outages, real-time energy bills, and so on. The app aids in the correction of power factor. If a lagging power factor is identified, the user will be notified in real time so that he or she can use the smart plug to turn off the power factor decreasing equipment remotely.

2. LITERATURE REVIEW

2.1 Iot Based Smart Home & Short Circuit Protection & Detection System

This study proposes using IOT to manage household appliances, automate the home system over the internet, and safeguard the appliances from short circuits. This Internet of Things (IoT)-based Home Automation system seeks to operate all of your smart home's equipment via internet protocols or cloud-based computing. This is accomplished utilising a Node MCU for cloud data transfer, an MCB to protect equipment by switching the circuit, and an LCD panel to display updates.

2.2 A Smart Distribution Box Controller For Customer-Based Operations

The design of a smart distribution box controller is proposed in this study in order to let consumers control or regulate their energy use during off-peak and peak hours. During peak times, the smart system assigns different loads to different priorities and removes non-priority loads. It also monitors the voltage, frequency, current and sunlight. Results show 25 % reduction of energy consumption and cost savings up to 40 % are possible with the use of smart distribution box.

2.3 Arduino Based Single Phase Fault Detection System Using Iot

This study discusses a new single-phase fault detection and switching system based on Arduino that is shown over the internet. Current transformers are used to monitor current levels, and the output current is fed into a 1 to 5 converter unit to convert it to voltage. This voltage is sent onto the Arduino's adc pin, which converts it to digital and responds appropriately if a fault condition (sc or oc) occurs. The fault is displayed on the LCD display as well as on the The ACS712

Current Sensors available on the internet are made to work with microcontrollers such as the Arduino. The Allegro ACS712ELC chip is used in these sensors. Full scale values of 5A, 20A, and 30A are available for these current sensors. Each of these gadgets has the same basic functional operation. The scale factor at the output is the only variation, as seen below. LEDs. To give end users with an uninterrupted power supply, a relay driver and relay circuit are utilized to convert single phase loads of the city electrical distribution system to the other permissible phase. The fault clearing switch is used to manually inform the system that the issue has been cleared.

2.4 Automatic Power Factor Correction Unit Using Arduino

This study describes one method for overcoming power losses caused by low power factor in common household and small industrial equipment. The AC load voltage and current were measured using a sampling rectified sine wave in this paper. A precision rectifier was devised and implemented using an op-amp for rectification. In both situations of voltage and current, sampling began when the input wave crossed the horizontal axis. Furthermore, a remedial method was developed based on this study to attain a power factor near to unity.

3. COMPONENTS

3.1 Node MCU

For Node MCU, an open-source firmware, open source prototyping board designs are available. The name "NodeMCU" was created by combining the words "node" and "MCU" (micro-controller unit). The term "NodeMCU" refers to the firmware rather than the accompanying development kits. Both the firmware and prototyping board designs are open source. Lua is the firmware's scripting language. The firmware is based on the eLua project and was produced with the Espressif Non-OS SDK for ESP8266. It incorporates lua-cjson and SPIFFS, among other open source projects. The ESP8266 allows all of the components' sensor data to be sent to a cloud database. It also assists in the control and monitoring of the components.

3.2 Voltage Sensor

The ZMPT101B AC Single Phase voltage sensor module is based on a high-precision ZMPT101B voltage transformer. This is a great way to measure AC voltage with an open-source platform like Arduino, ESP8266, or Raspberry Pi. Many electrical projects require engineers to work directly with measurements with a few basic characteristics, such as excellent galvanic isolation, wide range, high precision, and good consistency.

3.3 Current Sensor

On the internet, you may find ACS712 Current Sensors that are designed to operate with microcontrollers like the Arduino. These sensors use the Allegro ACS712ELC chip. These current sensors can handle full scale values of 5A, 20A, and 30A. Each of these devices performs the same basic function. The only difference is the scale factor at the output, as seen below.

3.4 Relay Module

A relay is an electrically actuated switch that can be turned on or off, allowing or disallowing current flow, and it may be controlled using low voltages, such as the 5V provided by the NodeMCU pins. A relay module, which is an electrical switch, is controlled by an electromagnet. The electromagnet is activated by a separate low-power pulse from a microcontroller. When activated, the electromagnet pulls to open or close an electrical circuit.

3.5 Power Monitor

The PZEM-004T Multi-function AC Power Monitor is extremely popular in electrical consumption measurement projects. It can measure voltage, current, power, and energy, which are all electrical variables that are interrelated. The unit may simply interact with Arduino and other hardware using the code library. When compared to other sensors on the market, the values from this sensor are extremely accurate.

3.6 Hi Link Hlk Pm01 5v/3w Switch Power Supply Module

HLK-PM01 is a 5V/3W Switch Power Supply Module with a plastic enclosure that is PCB mounted isolated switching step-down power supply module. It has a 3 Watt power rating and can provide 5V DC from 120V AC to 230V AC. This is perfect for our project, which requires a 5 volt mains supply. Low temperature increase, low power, excellent efficiency, and high dependability are just a few of the benefits of these modules.

3.7 ESP32

The ESP32 is a low-power system-on-a-chip (SoC) microcontroller featuring dual-mode Bluetooth and built-in Wi-Fi. The ESP32 series includes antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, filters, and power-management modules, and is powered by a Tensilica Xtensa LX6 CPU, which is available in dual-core and single-core versions. It's a substitute for the ESP8266 microcontroller, with several analogue pins.

3.8 DHT11

Temperature and humidity are measured by the DHT11 sensor. A specialised NTC for temperature measurement is

included in the sensor, as well as an 8-bit microcontroller for serial data output of temperature and humidity measurements. The sensor is calibrated at the manufacturer, making it simple to connect to other microcontrollers.

3.9 Mq2 Flammable Gas And Smoke Sensor Module

This is an analogue and digital output semiconductor gas sensor module. This module uses the MQ2 Smoke & Flammable gas sensor as a gas sensing element. It doesn't require any extra components; all you have to do is connect the Vcc and ground pins. The threshold value for digital output can be easily set using an on-board potentiometer. Using this module, we can connect the MQ2 Smoke & Combustible Gas Sensor to any Microcontroller, Arduino, or even the Raspberry Pi. Because it is sensitive to smoke, this Gas Sensor module can be used to detect fires. The MQ2 Gas Sensor can detect flammable/combustible gases such as LPG, Propane, and Hydrogen.

3.10 Ky-026 Flame Sensor Module

The KY-026 Flame Sensor Module for Arduino detects infrared emitted by flames. The module has both digital and analogue outputs, as well as a sensitivity control potentiometer. Often seen in fire alarm systems. The KY-026 is equipped with a 5mm infrared receiver LED, an LM393 dual differential comparator, a 3296W trimmer potentiometer, six resistors, and two indicator LEDs. Both analogue and digital inputs are available on the board.

3.11 Raspberry Pi

In the United Kingdom, the Raspberry Pi Foundation collaborated with Broadcom to create a line of small single-board computers. The Raspberry Pi 4 is powered by a Broadcom 64-bit quad-core A72 ARM v8 CPU that runs at 1.5GHz. The latest Raspberry Pi model includes Bluetooth 5.0, BLE, gigabit ethernet, and 802.11ac Wi-Fi at 2.4GHz and 5GHz. Two USB 3.0 ports, two USB 2.0 ports, a micro-SD slot for data storage, and a USB 2.0 port for loading operating systems are all included. Two micro-HDMI connections (one of which supports 4k@60p), a two-lane MIPI DSI display port, a two-lane MIPI CSI camera port, and a four-pole stereo audio port are all included on the Raspberry Pi 4.

4. COMMUNICATION PROTOCOL FOR SOFTWARE IMPLEMENTATION

MQTT is a publish-subscribe protocol for reading data from Internet of Things devices. The data is shared in the most effective way feasible. It's really light, and it allows for more scalability. Because it is a publish/subscribe protocol, it collects data with less bandwidth than other protocols. It makes it possible for two devices to communicate with one another. Devices can be subscribed to any subject. When the other client published the message, the broker forwarded it

to any client who has subscribed. It is possible to keep track of a large amount of data.

It's also bidirectional, which makes remote monitoring easier.

The MQTT dashboard application acquires real-time values using the MQTT protocol. Cell phones can capture numerical data on water quantity parameters including pH and turbidity over time. As a result, the operator does not wish to visit the pumping station to verify these values.

His cell phone will store the specific values, which he will be able to check at any moment.

5. BLOCK DIAGRAM

The Smart Distribution Box is depicted in this block diagram. The Energy Consumption Monitoring System, Power Factor Detection System, and Current Detection System all send data to the Distribution board. The acquired data is analysed inside the Smart Distribution Board unit before being transferred to the cloud. Raspberry Pi is used to establish the cloud base, which allows users to access the unit from afar. Smart plug is also embedded with the cloud to enable home automation systems, and these data may be accessed and controlled using the cross-platform app. As a result, the user can use the cross-platform software to monitor and operate the device.

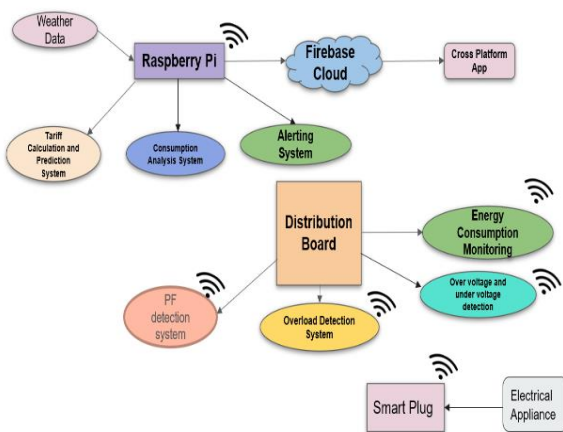


Figure 1: Block Diagram of the System

6. SMART ENERGY METER

Voltage, Current, Power, Energy, Frequency, and Power Factor are all monitored in real time by the primary Energy Meter. For the metering application, PZEM-004T-100A is used. The data from the smart metre is fed into an ESP8266 module, which uses the MQTT protocol to send the data to the Firebase database. The Raspberry Pi receives and processes the data from the database. The results, as well as real-time energy consumption statistics, are sent to a

Firebase database, which is incorporated into a cross-platform app.



Figure 2: Developed Smart Meter

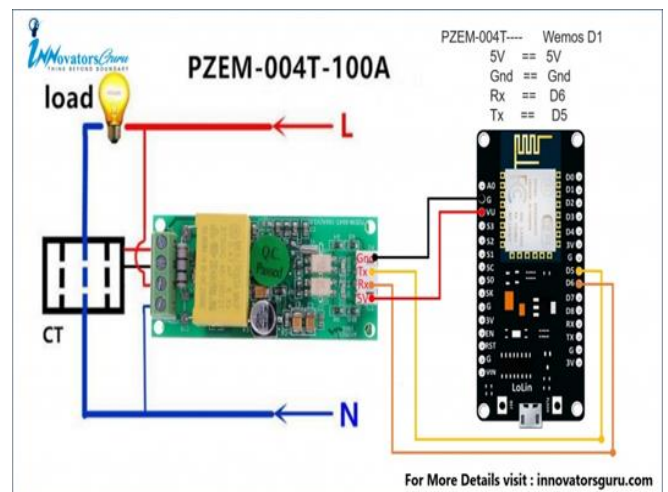


Figure 3: Smart Meter Circuit Diagram

7. SMART DISTRIBUTION BOARD

Consumption, power, voltage, current, frequency, and power factor are all factors to consider. Following the ELCB are the MCBs for each sub circuit. Current sensors are connected to the MCB's output phase line to monitor real-time current. The Distribution Board will be protected by a smoke sensor, a flame sensor, and a DHT sensor. The Energy Metering Module is wirelessly connected to the Raspberry Pi via the MQTT protocol. Other sensors are directly linked to the Raspberry Pi's GPIO ports.

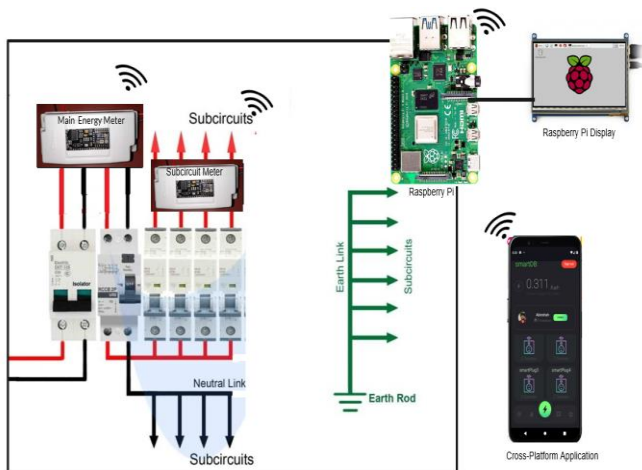


Figure 4: circuit diagram of smart distribution board

8. SMART PLUG

The smart plug is used to control and monitor appliances remotely. In the event of any faults or weather surges, we can isolate the appliance using smart plug. It also gives the real time consumption of the appliance connected to it. The smart plug consists of a relay module, ACS712 current sensor, HLK-PM01 5V/3W power converter and a ESP8266 NodeMCU module. The ESP8266 module helps in collection and processing of data from smart plug. The smart plug is integrated with the firebase real time database with helps in the controlling and monitoring using the cross-platform application.

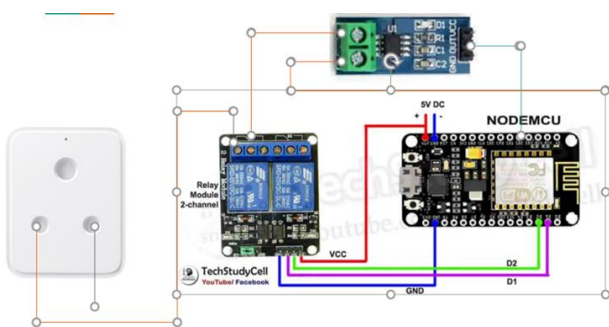


Figure 5: Smart Plug Circuit Diagram



Figure 6: Developed Smart Plug

9. SUB CIRCUIT METER

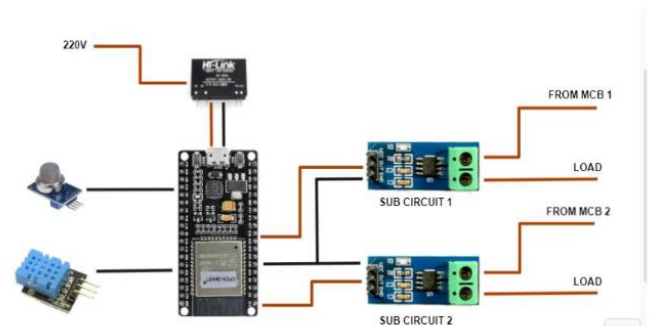
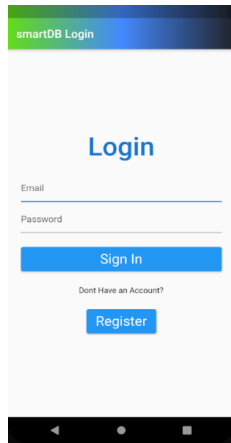


Figure 7: Sub Circuit Meter

This project requires the use of a sub circuit metre. The Smart Distribution board is made up of the sub-circuit and components. These components provide the best electrical fire protection available. It's also set up to separate the electrical supply in the event of a critical breakdown and notify problems through a cross-platform app. The ACS712, DHT11, Smoke sensor, and Flame sensor are the most common sensors utilised. The current sensor in the subcircuit metre that is attached to each subcircuit and can be used to notify of overload, overcurrent, and other issues is the ACS712. The DHT11 temperature and humidity sensor module, as well as the MQ2 flammable gas and smoke sensor module, are used to detect fires since they are sensitive to combustible gases. All of these sensors are linked to an ESP8266 NodeMCU, which collects data and sends it to a Firebase database. Using the cross-platform programme, the Raspberry Pi gets these data from the database and processes and analyses it to provide alerts in the event of any abnormalities.

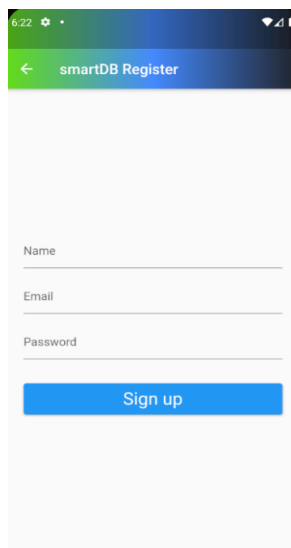
10. CROSS-PLATFORM APPLICATION

10.1 Login Page



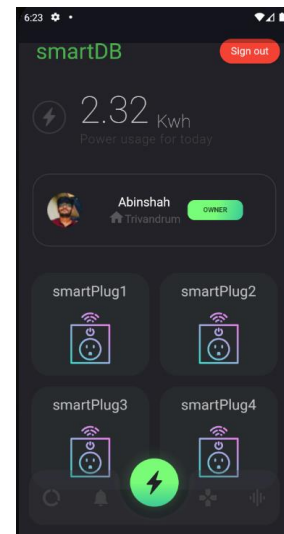
This is the first window that appears when the application is launched. This page explains how to utilise Firebase Authentication to log into an existing user account. If the user forgets his password, he can change it. Otherwise, he can Create an Account by pressing the Register button if he is a newbie.

10.2 Registration Page



This page guides the user through the process of creating a new account by asking for his name, email address, and a safe password. To validate the user's legitimacy, an OTP will be given to their email address. After successfully registering an account, the user will be automatically logged in.

10.3 Home Page



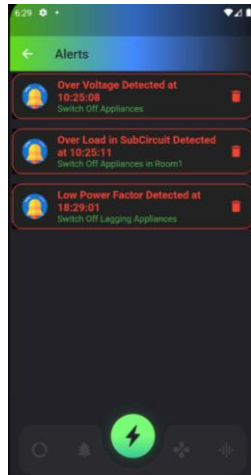
This is our app's landing page. On the top, the current power usage is indicated. Smart Plug switches were also offered. The app allows the user to control the appliance at any time. Below the Real-time power usage metre is the user's name. Through the bottom panel, the user may go to several Sub Sections such as Usage Status, Alerts, SmartDB Status, and Usage Report.

10.4 Usage Status



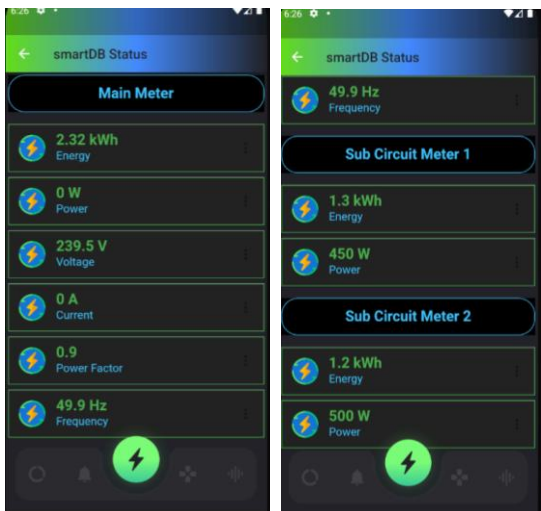
The Usage Status gives an overview about the Consumed Units, Current per unit rate, Units left, Energy charge prediction current months, Energy usage prediction etc.

10.5 Alerts



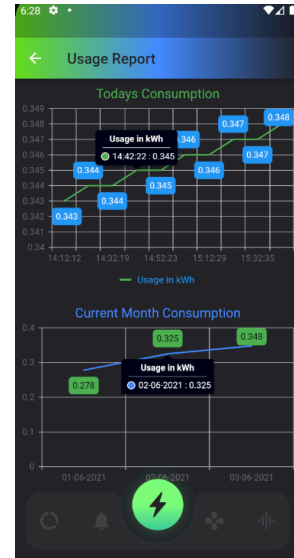
This portion of the app allows us to access the app's notifications and alerts. If the sensor units mounted on the Smart Distribution Board detect any Over Voltage or Low Power Factor, the user will be warned. Weather surges such as thunderstorms, lightning, and other natural disasters will be forecasted so that people can prepare. It also sends out notifications to users about scheduled power outages, real-time energy bills, and so on.

10.6 SmartDB Status



The SmartDB Status subsection can be used to monitor the Main Energy Meter and the Sub Circuit Meter. This feature allows you to monitor the main meter's energy, power, voltage, current power factor, and frequency. The Sub Circuit Meter that is attached to the Smart Distribution Board can also be monitored for Energy and Power usage.

10.7 Usage Report



11. CONCLUSIONS

Our project, dubbed "Smart Distribution Board," is a significant upgrade to the traditional distribution board, giving an additional layer of protection and safety. If there are any defects, such as short circuits, voltage fluctuations, overload, and so on, the user will be notified in real time via the app, allowing them to take appropriate action and avoid serious losses to life and property. The app notifies users when severe weather conditions such as lightning, thunderstorms, and other events occur, which is one of the leading causes of electrical appliance damage. In order to avoid large fines from the electricity board and to boost efficiency, our proposal also includes automatic power factor modifications. By giving real-time consumption data to users, our solution encourages them to utilise energy wisely and improves their quality of life.

ACKNOWLEDGEMENT

The authors would like to acknowledge Department of Electrical and Electronic Engineering, Mar Baselios College of Engineering and Technology, A.P.J Abdul Kalam Technological University, Trivandrum, for the support. We'd also want to thank Mr.Rejish Babu for his assistance.

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