# ENERGY MONITORING AND CONTROLLING IN SMART HOMES USING IoT


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**Dissertation submitted in partial fulfillment of the requirements for the degree of**

**BACHELOR OF ENGINEERING**

**Branch: ELECTRICAL AND ELECTRONICS ENGINEERING (SANDWICH)**

**of Anna University**

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**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

## PSG COLLEGE OF TECHNOLOGY

**(Autonomous Institution)**

**COIMBATORE – 641 004**

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Bonafide record of work done by


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# SYNOPSIS

With increasing populations and industrialization, energy management has become a critical challenge in this context, our project aims to address these issues by creating a system for energy monitoring and controlling using IoT.

The primary problem this project seeks to address is the inefficient management of energy resources. Moreover, energy controlling is a significant issue, resulting in substantial revenue losses for energy providers and imbalance in the distribution of resources. The lack of reliable energy monitoring and controlling mechanisms further compounds these problems. This project integrates data analytics to enable energy monitoring, controlling and demand prediction.

The project employs current and voltage sensor to monitor energy consumption, with data being time stamped and compiled into dataset. the further energy monitoring and controlling is forecasted using ESP8266 module. The gathered information is securely uploaded to the blynk cloud platform. Web application is developed for visualizing energy monitoring and controlling.

Overall, the project addresses the need for efficient energy monitoring, enabling users to make informed decisions to avoid unnecessary energy consumption of various appliances, while contributing to sustainability and resource conservation.

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# CHAPTER 1

# INTRODUCTION

The project introduces a comprehensive energy monitoring and controlling system designed to enhance efficiency and control in the realm of energy consumption. Leveraging voltage and current sensors, Arduino and oracle database platforms, and integration with Adafruit IO, this system offers a powerful solution for accurately measuring and calculating energy usage. Users can make informed decisions to optimize their power consumption, particularly during off-peak hours, leading to potential cost savings and resource conservation.

With a user-friendly web interface, the project facilitates remote monitoring and control, providing an intuitive platform for users to oversee their energy consumption and operate relays as needed. This introduction sets the stage for a closer examination of the project's advantages, including enhanced energy efficiency and data-driven insights, and an exploration of its future potential, such as customization, integration with renewable energy sources, and collaboration with utility companies for smart grid integration.

Furthermore, the inclusion of a relay-driven system and a solar-to-battery connection ensures uninterrupted power supply availability, even in the event of solar or grid outages. By seamlessly integrating solar and grid power, providing real-time feedback, streamlining payments, and incorporating IoT capabilities, this Smart Power Meter not only addresses the pressing need for sustainable energy management solutions but also sets a new standard for efficiency, convenience, and environmental responsibility in domestic areas.

## 1.1 OVERVIEW

The world is experiencing a growing concern over the sustainable utilization of energy resources. With increasing populations and industrialization, energy management has become a critical challenge. In this context, the project aims to address the issues by creating a sophisticated system for energy monitoring, theft detection, and demand prediction. This multifaceted approach is designed to provide real-time insights into energy consumption, enable the early detection of theft or irregularities, and empower users to make informed decisions about energy usage.

## 1.2 EXISTING SYSTEM

The Existing system is the normally used energy meter in every households which measures the amount of power consumed day by day and the information will be gathered manually only.

In the existing system, power consumption is measured at a fixed rate regardless of the time of day. This means that users are charged the same rate for electricity, regardless of whether it's during daylight hours or at night. There is no differentiation in cost based on the time of usage. Additionally, there are no measures in place to control heavy appliances based on the time of day, so they can be operated at any time.

## 1.3 PROPOSED SYSTEM

The proposed methodology aims to enhance the existing system by introducing dynamic pricing and control mechanisms:

**Dynamic Pricing:** The new system will introduce dynamic pricing for electricity. During solar hours when renewable energy sources are abundant, the cost of electricity will be lower. Conversely, during nighttime or peak demand hours, the cost will be higher. This encourages users to shift their energy-intensive tasks to the lower- cost periods, promoting energy efficiency.

**Time-of-Use Measurement:** The system will implement time-of-use (TOU) measurement, allowing users to be billed based on the time of day when energy is consumed. This will involve the use of smart meters or sensors to record power consumption during different time slots.

**Relay Control:** Heavy appliances, such as water heaters or air conditioners, will be equipped with relays. These relays can be controlled based on the time of day. Heavy appliances can be programmed to operate only during solar hours when the cost is lower, ensuring cost savings for users.

**User Interface:** The system will include a user-friendly interface, which allows users to monitor real-time energy costs, schedule appliance usage, and view historical consumption data. Users can customize appliance schedules and preferences.

**Automation:** The system can offer automation features where certain appliances, like electric vehicle chargers or pool pumps, can be set to run automatically during cost-effective hours. By implementing this proposed methodology, the system aims to promote energy conservation, reduce electricity costs for users, and optimize the use of renewable energy sources, ultimately contributing to a more sustainable and cost- effective energy ecosystem.

## 1.4 BLOCK DIAGRAM

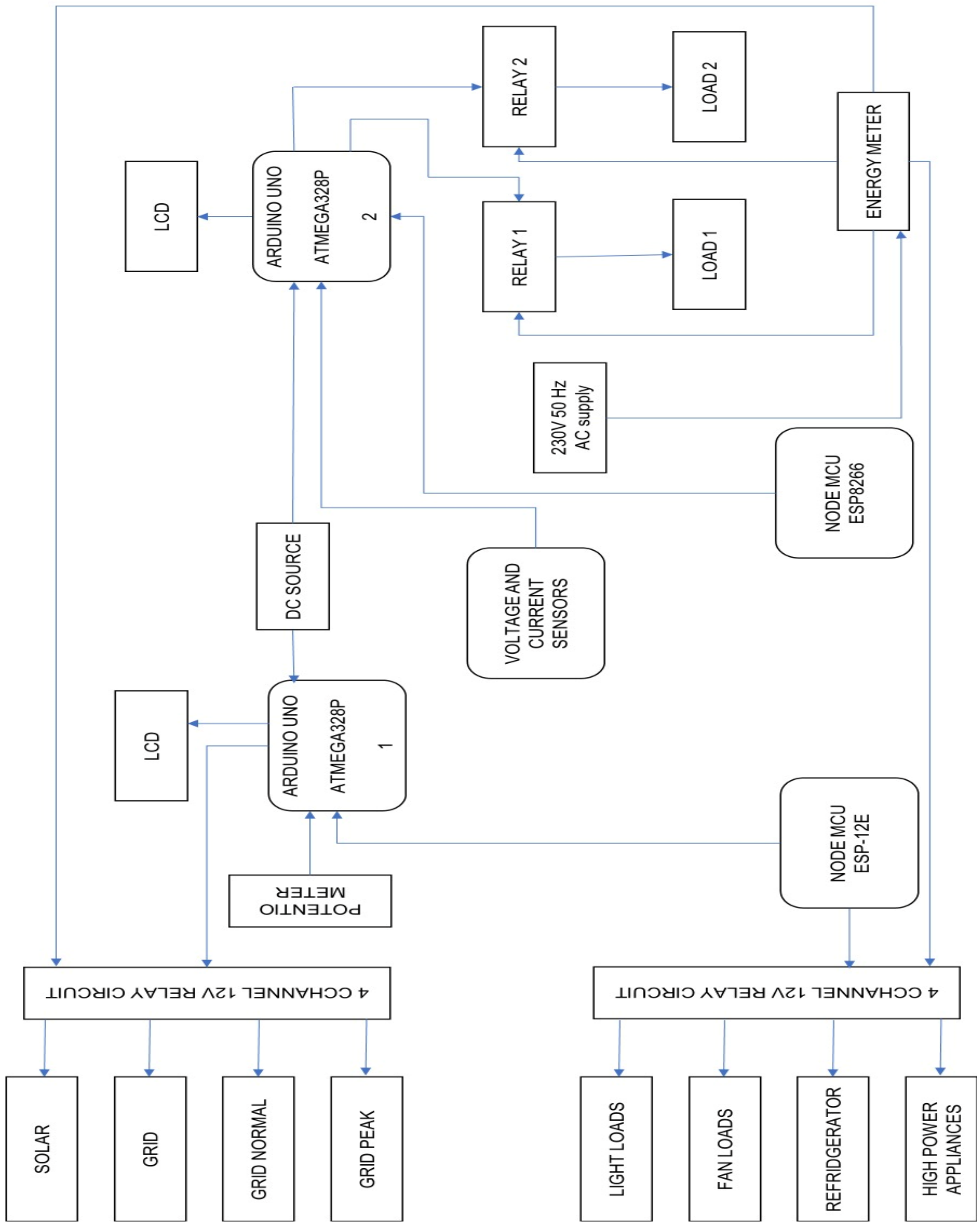



**Fig.1.1 Block diagram**

The block diagram encapsulates a comprehensive overview of the project's architecture and data flow, showcasing the integration of various components for efficient energy monitoring and management. Voltage and Current Sensors serve as the initial data sources, capturing real-time information about energy consumption. They feed this data to the Arduino board. Arduino Board acting as an intermediary, the Arduino board receives data from the sensors. It serves as the central processing unit, managing data flow and communication with other components. Then NodeMCU collaborating with the Arduino board, the Node MCU plays a crucial role in data analysis. It leverages its capabilities to process incoming data, possibly performing calculations or implementing algorithms for more refined insights into energy consumption patterns. Adafruit IO Platform, the Node MCU establishes a secure connection with the cloud-based Adafruit IO platform. This platform serves as a conduit for transmitting data securely to remote locations. By leveraging cloud infrastructure, the system ensures reliable and scalable data transmission. User-friendly Web Interface A standout feature of the system is its intuitive web interface, accessible remotely. This interface provides users with real-time insights into energy consumption data. Users can monitor energy usage trends, analyze historical data, and receive alerts or notifications. Moreover, the web interface enables remote control of electrical loads via relays, allowing users to toggle power sources on or off as needed and highlights the system's holistic approach to energy monitoring and management. By integrating hardware components like sensors, microcontrollers, and relays with cloud-based platforms and user interfaces, the system offers a comprehensive solution for energy efficiency and sustainability. This architecture not only enables real-time monitoring but also lays the groundwork for future innovations and enhancements in energy management technologies.

## 1.5 OVERVIEW OF THE PROJECT

In Chapter 2, the literature survey is discussed in detail. Diverse methodologies are explored and their advantages and difficulties are stated.

In Chapter 3, the project required, front-end and back-end languages and hardware components for the project are briefly discussed.

In Chapter 4, software implementation, flow of the website application of the project explained

In Chapter 5, the hardware implementation, energy monitoring and controlling through application are briefly discussed.

In Chapter 6, the future scope and conclusion f the project is discussed.

# CHAPTER 2
# LITERATURE SURVEY

In this chapter, the information gathered by studying the journals that are related to the project are discussed. The result of the patent search and the outcome of the literature review is presented.

## 2.1 Monitoring and Controlling of Smart Energy Meter with IoT

**Author:** Prakash Kumar Dewangan, Prakash Kumar Sen, Atul Kumar Dewangan

**Publication:** International Journal of Innovative Technology and Exploring Engineering (IJITEE),2019

**DOI:** 10.35940/ijitee. K2332.1081219

The main purpose of the plan is to build up an IOT base electrical energy meter interpretation show for units devoted and charge there upon over the internet. A smart energy meter whose blinking LED signal is interfaced to microcontroller during LDR the blinking LED flash 3200 times for 1 part the LDR sensor provide an interrupt every instance the meter LED flash to the programmed microcontroller, micro controller takes this considerate and display the it on an LCD accordingly interfaced to the microcontroller. the learn of the energy meter is also sent to Ethernet guard module individual fed from the micro-controller using level shifter IC and RS 232 link which pass on data in a straight line to a devoted web page for show anywhere in the planet. The power provide consists of a step-down transformer 230/12V which decreases the voltage to 12V AC. This is changed to DC using a bridge rectifier and it is then regulated to 5V by means of a voltage regulator which is requisite for the action of the microcontroller and additional mechanism.

## 2.2 Smart Energy Meter and Monitoring System using IoT

**Author:** K B Shiva Kuma, Rashmi, Bhavana, Prakyathi

**Publication:** NCETESFT - 2020 Conference Proceedings

**ISSN:** 2278-0181

The effort of collecting electricity utility meter reading. Internet of Things (IoT) present an efficient and coeffective to transfer the information of energy consumer wirelessly as well as it provides to detect the usage of the electricity the main intention of this project is measure electricity consumption in home appliances and generate its bill automatically using IoT. The energy grid needs to be implemented in a distributed topology that can dynamically absorb different energy sources. IoT can be utilized for various applications of the smart grid with distributed energy plant meter, energy generation and energy consumption meter smart meter, energy demand side management and various area of energy production.

## 2.3 IoT based Energy Meter with Smart Monitoring of Home Appliance

**Author:** Vishnu Kant V. Gavhane, Mayuri R. Kshirsagar, Mayuri R. Kshirsagar
**Publication:** 2021 6th International Conference for Convergence in Technology (I2CT)
**DOI:** 10.1109/I2CT51068.2021.9417886,2021

In this paper an Energy Meter with Smart Monitoring of Home Appliances based on the Internet of Things is built. This paper proposes a system which eliminates manpower by self-regulating meter readings and bill generation reducing the flaws which are one of the major causes for energy-related corruption. The demand for transparency in the domain of energy estimation has emerged as there isn't a verification facility. Arduino Mega 2560 is used as the central controlling unit in this system. For energy meter, the ZMPT101B voltage sensor and ACS712 current sensor are interfaced with a microcontroller. The readings of voltage, current, the power consumed, no. of units and the corresponding price are calculated and are displayed over the 16*2 LCD Display module. An Infra-red based flame sensor is used as a fire safety measure. Monitoring of home appliances is done by using an 8-channel relay module to which loads are connected and operated over voice commands using Google Assistant with IFTTT (If this then that) platform which is interfaced with IoT based Blynk app on mobile. A DHT11 sensor is used for monitoring the temperature and humidity inside the house. All the readings obtained from the sensor is sent over the ESP8266 Wi-Fi module to blynk cloud storage.

## 2.4 Design of IoT Based Smart Energy Meter for Home Appliances

**Author:** M Rupesh, N Anbu Selvan
**Publication:** ICACSE, Journal of Physics: Conference Series
**DOI:**10.1088/1742-6596/1964/5/052001, 2021

Communication technology development is increased day by day. Due to the development of communication technology, every product is manufactured with smart activities. From the past decade, most electric devices are executed automatically using the remote control. Internet of Things (IoT) is used to connect various devices easily with the help of sensors. All the connected devices are working automatically without any human interventions. The roles of human beings are only to manage and control the connected devices from a remote location. Electric meters also using the concept of IoT. This paper describes smart meter devices. This system's main purpose is to automatically read the number of current consumption units with LED light, calculate the amount, and display the messages to the user's website and user's smartphone. This system also issues the user's alert message when the current consumption unit crosses the limited level.

## 2.5 Controlling of Smart Energy Meter with IOT and Arduino UNO

**Author:** Andreas Unterweger, Fabian Knirsch, Clemens Brunner and, Dominik

**Publication:** International Journal of Innovative Technology and Exploring Engineering (IJITEE)

**DOI:** 10.35940/ijitee. K2332.1081219, 2021

The primary objective of this plan is to create an IOT base electrical meter interpretation show for dedicated units to charge over the internet. The smart meter has a blinking LED signal that is connected to a microcontroller. During LDR, the blinking LED signal flashes 3200 times for one part of the LDR sensor. The LDR sensor provides an interrupt for each instance that the meter LED flashes. The microcontroller takes this considerate and displays it on an LCD corresponding to the LED. The learn of the meter is also sent to an Ethernet guard module that is individually fed from the microcontroller using a level shifter IC. The RS 232 link passes the data in a direct line to a dedicated web page for display anywhere in the world. The power supply is composed of a stepdown transformer 230/12V that lowers the voltage to a 12V AC. The transformer is then regulated to 5V by a voltage regulator and additional mechanism.

## 2.6 Design of Smart Home Energy Management System

**Author:** Vaibhavi Sunil Yardi

**Publication:** International Journal of Innovative Research in Computer and Communication Engineering

**DOI:** 10.15680/ijircce.2015.0303094

In this paper it provides a homeowner the ability to automatically perform smart load controls based on utility signals, customers preference and load priority. The HEMs communication time delay to perform load control is analyzed, along with its residual energy consumption. The main aim is to design how each load performs when being controlled by the HEM unit and measure electrical measurements for the different loads. Demand response (DR) is defined as changes in electricity use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity. HEM system comprises a HEM unit that provides monitoring and control functionalities for a homeowner, and load controllers that gather electrical consumption data from selected appliances and perform local control based on command signals from the HEM system. A gateway, such as a smart meter, can be used to provide an interface between a utility and the data base for the electrical consumption is maintained.

## 2.7 A smart home energy management system using IoT and big data analytics approach

**Author:** A.R. Al-Ali; Imran A. Zulkarnaen; Mohammed Rashid; Ragini Gupta

**Publication:** IEEE Transactions on Consumer Electronics (Volume: 63, Issue: 4)

**DOI:** 10.1109/TCE.2017.015014 ,2021

This paper presents an Energy Management System (EMS) for smart homes. In this system, each home device is interfaced with a data acquisition module that is an IoT object with a unique IP address resulting in a large mesh wireless network of devices. The data acquisition System on Chip (SoC) module collects energy consumption data from each device of each smart home and transmits the data to a centralized server for further processing and analysis. This information from all residential areas accumulates in the utility's server as Big Data. The proposed EMS utilizes off-the-shelf Business Intelligence (BI) and Big Data analytics software packages to better manage energy consumption and to meet consumer demand. Since air conditioning contributes to 60% of electricity consumption in Arab Gulf countries, HVAC (Heating, Ventilation and Air Conditioning) Units have been taken as a case study to validate the proposed system.

# CHAPTER 3
# PROJECT REQUIREMENTS

## 3.1 SOFTWARE REQUIREMENTS

In the dynamic landscape of web development, efficient tools are indispensable. NetBeans stands out as a versatile Integrated Development Environment (IDE), accommodating multiple programming languages including Java and React JS. MySQL simplifies database management with its intuitive web interface, easing tasks like database creation, modification, and SQL query execution. Meanwhile, WampServer provides a comprehensive web development environment tailored for Windows users, bundling Apache, MySQL, and PHP to streamline local server setup and testing. Together, these tools empower developers to create and manage websites and applications with ease and precision.

### 3.1.1 ARDUINO IDE

The Arduino Integrated Development Environment (IDE) is a cross platform application that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards.

The Arduino IDE supports the languages C and C++ using special rules of codes structuring. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures. User-written code requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main () into a cyclic executive program with the GNU tool chain, also included with the IDE distribution.

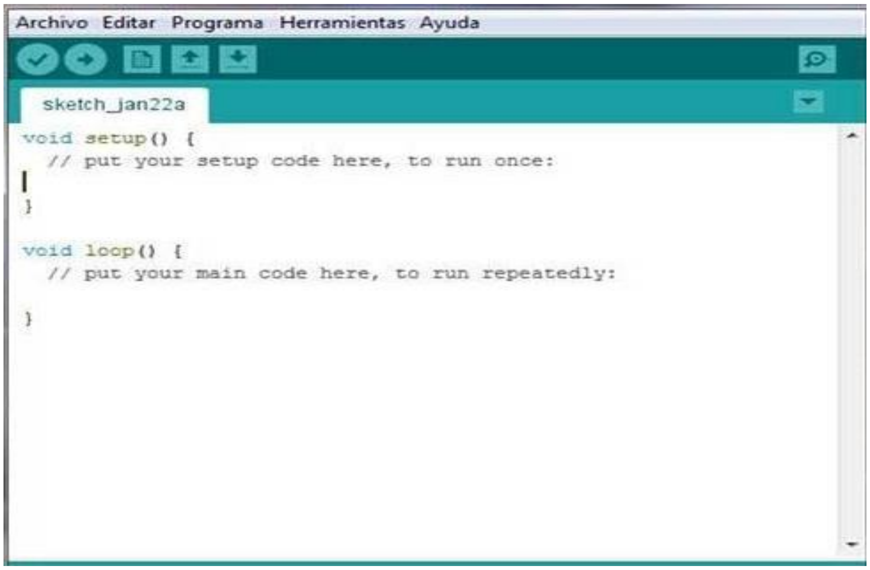



**Fig.3.1: Arduino Simple coding**

The boundary between an IDE and other parts of the broader software development environment is not well-defined; sometimes a version control system or various tools to simplify the construction of a Graphical User Interface (GUI) are integrated. Many modern IDEs also have a class browser, an object browser, and a class hierarchy diagram for use in object-oriented software development. Fig.3.1 shows the sample coding of Arduino IDE software.

### 3.1.2 INTELLIJ IDE

IntelliJ IDEA is an advanced integrated development environment (IDE) developed by JetBrains, designed to enhance the efficiency and productivity of software developers across various programming languages and frameworks. It provides a comprehensive suite of tools and features tailored to streamline the software development process, from writing code to debugging and deploying applications. Intelligent Code Assistance. The IDE offers advanced code completion, analysis, and suggestions based on context, significantly speeding up the coding process and reducing errors. It assists developers with smart code refactoring, making it easier to maintain and refactor codebases as they evolve.

Powerful Navigation and Search IntelliJ IDEA allows developers to easily navigate through large codebases with features like "Go to Declaration", "Find Usages", and "Navigate to Class/Symbol". This facilitates code exploration and understanding, enabling developers to work more efficiently. Version Control Integration. The IDE seamlessly integrates with popular version control systems such as Git, Subversion, and Mercurial, enabling developers to manage source code changes directly within the IDE. It provides features for committing changes, viewing history.

Built-in Terminal IntelliJ IDEA includes a built-in terminal window, allowing developers to execute command-line tools and scripts without leaving the IDE environment. This promotes a seamless development workflow and keeps all development tasks centralized. Testing Support the IDE offers comprehensive support for writing and running tests, including unit tests, integration tests, and code coverage analysis. Developers can create and execute tests within the IDE, leveraging support for popular testing frameworks.

## 3.2 FRONT-END LANGUAGES

Frontend languages are the client-side languages, used to build the user interface (UI) and functionality of websites or web applications that run directly in the user's web browser. These frontend languages and technologies work together to create engaging and interactive web experiences for users, ranging from simple static websites to complex web applications with rich user interfaces and functionality. The user interface of the system is developed using HTML, CSS, and Java Server Page (JSP). The part of the system allows users to interact with the warehouse management functionalities through a web browser.

### 3.2.1 Hypertext Markup Language (HTML)

Which stands for Hypertext Markup Language, is a fundamental building block of the World Wide Web. It serves as the standard markup language used to create and structure web pages. In essence, HTML provides a set of tags or elements that define the structure and content of a web page. Each HTML tag represents a specific element on the page, such as headings, paragraphs, images, links, and more. HTML documents are comprised of a series of nested elements that form a hierarchical structure, with each element contributing to the overall layout and presentation of the web page. At its core, HTML provides a framework for organizing and presenting information in a structured manner that is easily interpreted by web browsers. The structure allows browsers to render web pages accurately and consistently across different devices and platforms. HTML tags consist of opening and closing tags, with content placed between the two to define the element's purpose and attributes. Attributes provide additional information about an element, such as its style, behavior, or relationship to other elements. With the evolution of HTML standards, such as HTML5, the language has become increasingly powerful and versatile, supporting advanced features such as responsive design, semantic markup, and multimedia integration.

### 3.2.2 CASCADING STYLE SHEETS (CSS)

CSS, short for Cascading Style Sheets, functions as a styling language essential for defining the appearance of documents written in HTML or XML. It empowers web developers to shape the layout, visual presentation, and overall design of web pages, thereby ensuring uniformity and enriching the browsing experience. By crafting rules, CSS delineates how HTML elements should be showcased on various media platforms. These rules typically comprise selectors pinpointing specific HTML elements and declarations specifying the stylistic attributes to be implemented. These attributes encompass a wide range, including color, font size, margins, padding, borders, and more. CSS can be integrated into HTML documents internally via <style> tags, externally through separate CSS files linked to the HTML document, or directly within HTML elements using the style attribute.

CSS also supports the concept of cascading, where multiple style sheets can be applied to the same document, with styles cascading from one sheet to another based on their specificity and order of precedence. This allows developers to create modular and maintainable style sheets that can be easily reused and updated across multiple web pages. Additionally, CSS provides features for creating responsive designs that adapt to different screen sizes and devices, enhancing accessibility and usability. With its rich set of features and capabilities, CSS plays a crucial role in shaping the visual appearance and layout of modern web pages, enabling designers to create visually appealing and user-friendly interfaces for the web.

### 3.2.3 Java Server Pages (JSP)

Java Server Pages (JSP) is a technology used for developing dynamic web pages based on Java. It allows developers to embed Java code directly into HTML pages, enabling the creation of dynamic content that can interact with server-side data and logic. With JSP, developers can separate the presentation layer (HTML) from the business logic layer (Java), resulting in cleaner and more maintainable code. JSP pages are compiled into servlets by the web container during runtime, which are then executed to generate dynamic content. The compilation process improves performance by reducing overhead compared to interpreting JSP pages directly. JSP provides powerful features for building interactive web applications, including support for session management, database access, form handling, and more. It integrates seamlessly with Java EE technologies such as servlets, JavaBeans, and JDBC, allowing developers to leverage existing Java expertise and libraries. JSP pages can be easily integrated with other web technologies and frameworks, such as Java Server Faces (JSF), Spring MVC, and Struts, to create robust and scalable web applications. Despite its flexibility and power, JSP has certain drawbacks, such as its tight coupling of presentation and logic, which can lead to maintenance challenges in large-scale projects. Additionally, embedding Java code within HTML can make JSP pages less readable and harder to maintain.

## 3.3 BACKEND LANGUAGE

Backend languages, also known as server-side languages, are programming languages used to create the logic and functionality that runs on the server side of web applications. These languages are responsible for processing requests from clients, interacting with databases, and generating dynamic content to be sent back to the client's web browser. Backend languages work in conjunction with frontend languages, which are responsible for creating the user interface and interacting with users in the web browser. The back-end of the system utilizes MySQL database to store and manage warehouse component information securely.

### 3.3.1 My Structured Query Language (MySQL)

MySQL is an open-source relational database management system (RDBMS) that is widely used for storing and managing structured data. Developed by MySQL, MySQL is known for its reliability, scalability, and performance, making it a preferred choice for a wide range of applications, from small-scale websites to large-scale enterprise systems. MySQL uses a client-server architecture, where the MySQL server processes database requests from client applications and manages data storage, retrieval, and manipulation. Clients interact with the MySQL server using various interfaces and programming languages, such as SQL (Structured Query Language), PHP, Python, Java, and more. One of MySQL's key features is its support for SQL, a standardized language for managing relational databases. SQL allows users to perform various operations on the database, including creating, updating, and deleting data, as well as querying data information.

MySQL supports a wide range of SQL commands and functions, making it flexible and versatile for various database tasks. MySQL databases are organized into tables, which consist of rows and columns. Each column represents a specific data attribute, while each row represents a record or data entry. Tables can be related to each other through primary key foreign key relationships, enabling the creation of complex data models and ensuring data integrity and consistency. MySQL provides advanced features such as indexing, transactions, stored procedures, triggers, and views, which enhance performance, security, and functionality. Indexing allows for faster data retrieval by creating data structures that optimize search operations. Transactions ensure data consistency by allowing multiple database operations to be treated as a single unit of work that either succeeds or fails as a whole. Stored procedures and triggers allow developers to encapsulate business logic within the database, improving code modularity and maintainability.

## 3.4 HARDWARE REQUIREMENTS

### 3.4.1 GRID

The grid, in the context of this project, refers to the electrical power grid, a vast network of interconnected power generation, transmission, and distribution infrastructure. It serves as the backbone of our electrical supply system, enabling the transfer of electricity from power plants to homes, businesses, and various facilities. The grid plays a crucial role in supplying electricity to meet the demands of consumers. It encompasses power stations, substations, transformers, and high-voltage transmission lines that transport electricity over long distances. Communal parking areas often rely on the grid as a primary source of electrical power.

The grid typically draws energy from various sources, including coal, natural gas, nuclear, and renewable energy. In this project, the grid serves as one of the two primary sources for charging electric vehicles, providing power when solar energy is insufficient. Additionally, the system incorporates a switch mechanism to adjust charging rates during peak-demand periods, helping to optimize grid usage and promote grid stability. In the grid forms an integral part of the proposed Smart Power Meter system, offering a reliable and accessible source of electricity to support sustainable transportation solutions.

### 3.4.2 RELAY

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

A simple electromagnetic relay, such as the one taken from a car in the first picture, is an adaptation of an electromagnet. It consists of a coil of wire surrounding a soft iron core, an iron yoke, which provides a low reluctance path for magnetic flux, a moveable iron armature, and a set, or sets, of contacts; two in the relay pictured. The armature is hinged to the yoke and mechanically linked to a moving contact or contacts.

It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the Printed Circuit Board (PCB) via the yoke, which is soldered to the PCB.

When an electric current is passed through the coil, the resulting magnetic field attracts the armature and the consequent movement of the movable contact or contacts either makes or breaks a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open.

When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually, this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low voltage application, this is to reduce noise. In a high voltage or high current application, this is to reduce arcing.

### 3.4.3 REGULATOR

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection').

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators as Shown in Fig 5.2 to be used in logic systems, instrumentation, Hi-Fi, and other solid-state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and current. Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, such as the 7805 +5V 1A regulator shown on the right. They include a hole for attaching a heat sink if necessary.

### 3.4.4 BRIDGE RECTIFIER:

A bridge rectifier can be made using four individual diodes, but it is also available in special packages containing the four diodes required. It is called a full-wave rectifier because it uses the entire AC wave (both positive and negative sections). 1.4V is used up in the bridge rectifier because each diode uses 0.7V when conducting and there are always two diodes conducting, as shown in the diagram below. Bridge rectifiers are rated by the maximum current they can pass and the maximum reverse voltage they can withstand (this must be at least three times the supply RMS voltage so the rectifier can withstand the peak voltages). Please see the DIODES page for more details, including pictures of bridge rectifiers. Alternate pairs of diodes conduct, changing over the connections so the alternating directions of AC are converted to the one direction of DC.

### 3.4.5 TRANSFORMER

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in UK) to a safer low voltage.

The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up.

The ratio of the number of turns on each coil, called the turn's ratio, determines the ratio of the voltages. A step-down transformer has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage.

### 3.4.6 ARDUINO UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the

Arduino website. Layout and production files for some versions of the hardware are also available. "Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform. The ATmega328 on the Arduino Uno comes preprogrammed with a boot loader that allows uploading new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol. The Uno also differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

The Arduino project started at the Interaction Design Institute Ivrea (IDII) in Ivrea, Italy. At that time, the students used a BASIC Stamp microcontroller at a cost of $100, a considerable expense for many students. In 2003 Hernando Barragán created the development platform Wiring as a Master's thesis project at IDII, under the supervision of Massimo Banzi and Casey Reas, who are known for work on the Processing language. The project goal was to create simple, low-cost tools for creating digital projects by non-engineers. The Wiring platform consisted of a printed circuit board (PCB) with an ATmega168 microcontroller, an IDE based on Processing and library functions to easily program the microcontroller.

### 3.4.7 LIQUID CRYSTAL DISPLAY

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. An LCD is a small low-cost display. It is easy to interface with a micro-controller because of an embedded controller (the black blob on the back of the board). This controller is standard across many displays (HD 44780) which means many micro-controllers (including the Arduino) have libraries that make displaying messages as easy as a single line of code.

| **Pin No** | **Function** | **Name** |
|---|---|---|
| 1 | Ground (0V) | Ground |
| 2 | Supply voltage; 5V (4.7V – 5.3V) | Vcc |

| | | |
|---|---|---|
| 3 | Contrast adjustment; through a variable resistor | $V_{EE}$ |
| 4 | Selects command register when low; and data register when high | Register Select |
| 5 | Low to write to the register; High to read from the register | Read/write |
| 6 | Sends data to data pins when a high to low pulse is given | Enable |
| 7 | 8-bit data pins | DB0 |
| 8 | | DB1 |
| 9 | | DB2 |
| 10 | | DB3 |
| 11 | | DB4 |
| 12 | | DB5 |
| 13 | | DB6 |
| 14 | | DB7 |
| 15 | Backlight $V_{CC}$ (5V) | Led+ |
| 16 | Backlight Ground (0V) | Led- |

**Table.3.1: LCD Pin Details**

### 3.4.8 NODE MCU

NodeMCU is an open-source firmware and development board designed for IoT applications. It utilizes the ESP8266 Wi-Fi SoC from Expressive Systems, and its hardware is based on the ESP12 module. The NodeMCU ESP8266 development board features the ESP-12E module, which houses the ESP8266 chip with a 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at a clock frequency of 80MHz to 160MHz. NodeMCU has 128KB RAM and 4MB Flash memory for data and program storage.

**Pin Descriptions**

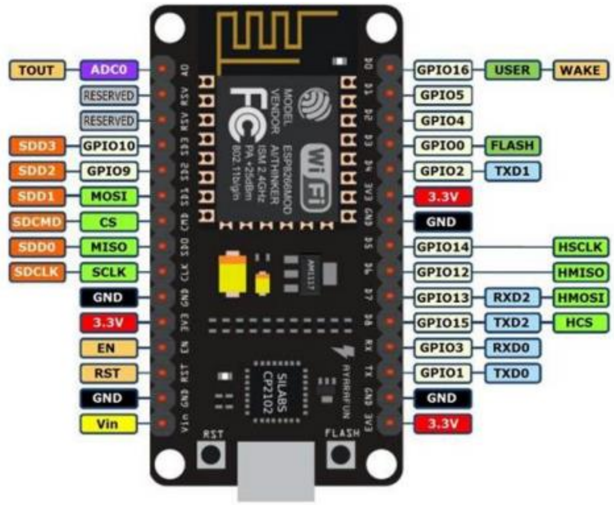



**Fig.3.2: Esp8266 NODEMCU Pinout**

| Pin Category | Name | Description |
|---|---|---|
| Power | Micro-USB, 3.3V, GND, Vin | Micro-USB: NodeMCU can be powered through the USB port<br>3.3V: Regulated 3.3V can be supplied to this pin to power the board<br>GND: Ground pins<br>Vin: External Power Supply |
| Control Pins | EN, RST | The pin and the button reset the microcontroller |
| Analog Pin | A0 | Used to measure analog voltage in the range of 0-3.3V |
| GPIO Pins | GPIO1 to GPIO16 | NodeMCU has 16 general purpose input-output pins on its board |
| SPI Pins | SD1, CMD, SD0, CLK | NodeMCU has four pins available for SPI communication. |
| UART Pins | TXD0, RXD0, TXD2, RXD2 | NodeMCU has two UART interfaces, UART0 (RXD0 & TXD0) and UART1 |

| | | |
|---|---|---|
| | | (RXD1 & TXD1). UART1 is used to upload the firmware/program. |
| I2C Pins | | NodeMCU has I2C functionality support but due to the internal functionality of these pins, you have to find which pin is I2C. |

**Fig.3.2 Pin description**

### 3.4.9 Voltage Sensor

The ZMPT101B is a voltage sensor module commonly used for measuring AC voltage in electronic and electrical circuits. This sensor provides a convenient and isolated means of converting AC voltage into a proportional analog output signal, making it suitable for various applications, including power monitoring and voltage measurement.

The ZMPT101B is based on a specialized transformer that isolates the input voltage from the output signal, ensuring electrical safety and preventing potential hazards. It is designed to work with AC voltages typically found in household and industrial environments.

The ZMPT101B is often used in conjunction with microcontrollers or data acquisition systems to measure and monitor AC voltage levels accurately. Its simple interfacing and ability to provide galvanic isolation make it a valuable tool for applications where electrical safety and precision are essential, such as in power quality monitoring, energy management, and industrial automation systems.

### FEATURES OF ZMPT 101B

- Output Signal: Analog 0-5V (goes to ADC of the microcontroller)
- Operating Voltage: DC 5V-30V.
- Measurement up to 250V AC. • Rated input current: 2mA.

### PIN CONFIGURATION:

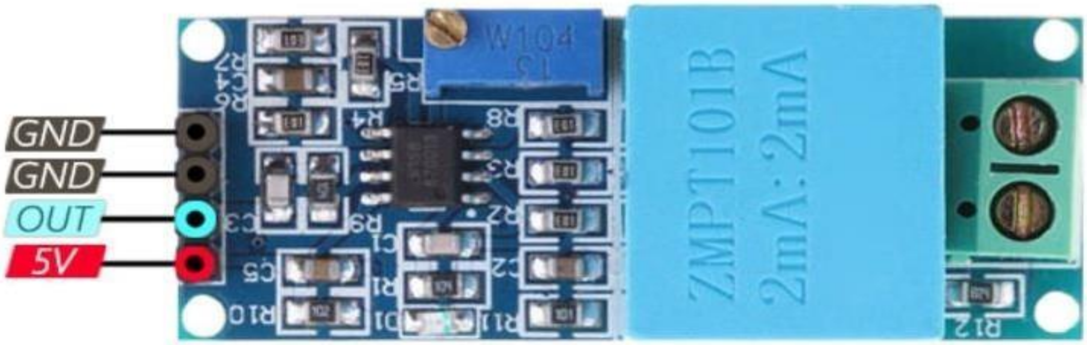



**Fig:3.3 ZMPT101B Pin Configuration**

- Voltage Input (VIN or VCC): This pin is used to connect the AC voltage source that you want to measure. It's the input connection where you provide the AC voltage you intend to measure. The voltage should match the specified input range of the sensor.
- Ground (GND): The GND pin is connected to the ground reference or the common ground of your circuit. It ensures a complete electrical path and serves as a reference point for the sensor module.
- Output (OUT): The OUT pin provides an analog output voltage signal that is proportional to the input AC voltage being measured. This signal can be connected to an analog input pin on a microcontroller or data acquisition system to read and process the voltage measurement.

# CHAPTER 4

# SOFTWARE IMPLEMENTATION

## 4.1 OVERFLOW OF WEBSITE DEVELOPEMENT

The energy monitoring website offers a straightforward login and registration process for new and existing users. Users can log in with their username and password, while new users can register by providing information such as username, password, email, contact number, energy meter number, and room number. Users can add new titles and URLs for monitoring through the "Add Title" page. Once submitted, the data is stored in the database and displayed on a list for verification. Users can update or delete titles and URLs using the respective options next to each entry, with changes saved in the database. This ensures the information remains accurate and up-to-date for users.

## 4.2 WEBSITE CREATION

Developing a Web application for Energy Monitoring involves creating a structured system to store and manage crucial information related to users and logistics.CSS Played a crucial role in styling the frontend elements, ensuring consistency, and enhancing visual appeal. CSS determined the layout, colors, fonts, and other stylistic aspects of the webpage, contributing to a cohesive and engaging user experience. HTML Served as the structural foundation of the webpage, defining the elements such as headings, paragraphs, forms, and columns. HTML organized the content and provided the framework for displaying user details and other information on the frontend page. Bootstrap Leveraged to expedite frontend development by utilizing pre-designed CSS styles and JavaScript components. Bootstrap facilitated the creation of responsive and visually appealing web pages, ensuring compatibility across different devices and screen sizes. JavaScript Enhanced the frontend page with interactivity and dynamic functionality. JavaScript enabled features like form validation, animations, and client-side data manipulation, enhancing user engagement and usability.

React.js Used as a JavaScript library for building user interfaces, particularly for single-page applications (SPAs). React.js allowed for the creation of reusable UI components and efficient state management, enabling a more modular and scalable frontend architecture. For the backend development, the Java programming language was employed. Java provided a robust and scalable environment for controlling the backend operations of the web application. It facilitated tasks such as managing HTTP requests, implementing business logic, and handling data processing. Oracle Database: Served as the backend repository for storing user details collected from the frontend page. Oracle Database, being a relational database management system (RDBMS), ensured data integrity, transaction management, and scalability. User details such as usernames, passwords, and other relevant information were stored securely within the database.

### 4.2.1 LOGIN PAGE

The login page as shown in Fig.4.1 is a web interface where users provide their credentials to gain access to a system, website, or application. It typically consists of input fields for username and password, along with a submit button to initiate the authentication process. Username and Password These are the credentials used by users to authenticate themselves on the login page. The username is typically a unique identifier associated with the user's account, while the password is a confidential string of characters known only to the user. Together, they serve as proof of identity during the login process. The process of verifying the identity of users who attempt to access a system or application. On the login page, the entered username and password are validated against records stored in a database or authentication server. If the credentials match, the user is granted access; otherwise, access is denied.


**Fig.4.1 login page**

### 4.2.2 REGISTRATION PAGE

Accessing the Registration Page as shown in Fig.4.2 by a new user, you navigate to the registration page to create a new account. This page allows individuals who don't have existing credentials to sign up for access to the system or platform. On the registration page, you're prompted to enter a new username and password. These credentials will serve as your unique identifier and secure access key respectively for logging into the system in the future. Additionally, the registration form requests your email address and contact number. These details are crucial for communication purposes, such as account verification, password reset, or important notifications related to the system. The registration form further asks for the energy meter number and room number. The energy meter number uniquely identifies your meter within the system, enabling accurate tracking and monitoring of energy usage. The room number specifies the location where the energy meter is installed, facilitating efficient management and organization of data. After filling out all the required fields in the registration form, you submit the information for processing.

The system validates the provided details to ensure completeness and accuracy before proceeding to the next step. Upon successful registration, the entered user information is securely stored in the backend database. This database serves as a repository for storing user accounts, credentials, and associated metadata, ensuring data integrity and accessibility. Following registration, you receive confirmation that your account has been successfully created. This message may include your username and further instructions for accessing the system. Once the registration process is complete, the system automatically redirects you to the login page. Here, you can use the newly created username and password to log in and access the system's features and functionalities.

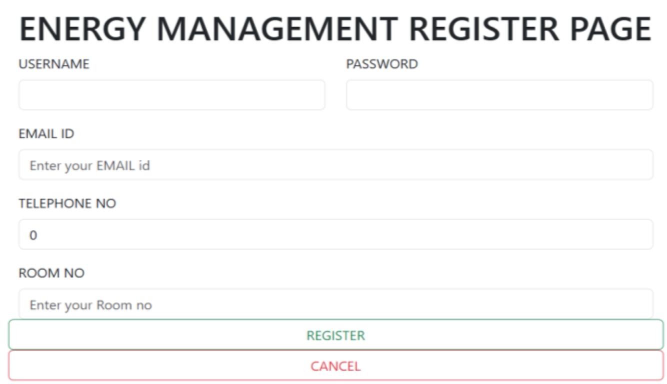



**Fig.4.2 Registration page**

### 4.2.3 LIST OF URL DETAILS

New users navigate to the navigation bar, which typically appears at the top of the webpage. Among the options available in the navigation bar, there is one labeled "Add Title." This option allows users to add a new title to the system. Selecting "Add Title" Option: Users click on the "Add Title" option in the navigation bar to initiate the process of adding a new title. This action redirects them to the "Add Title" page, where they can input the necessary information. Which stores the title in the database as shown in Fig 4.3

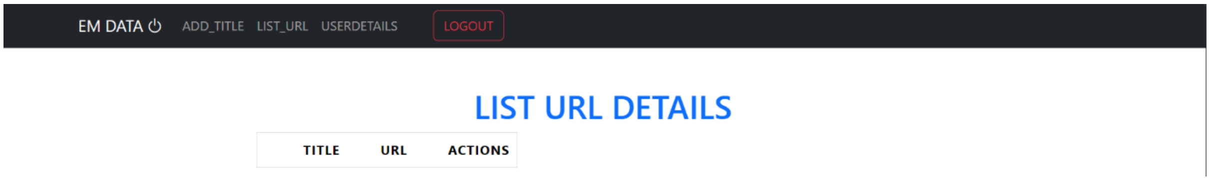



**Fig.4.3 list of URLs for users**

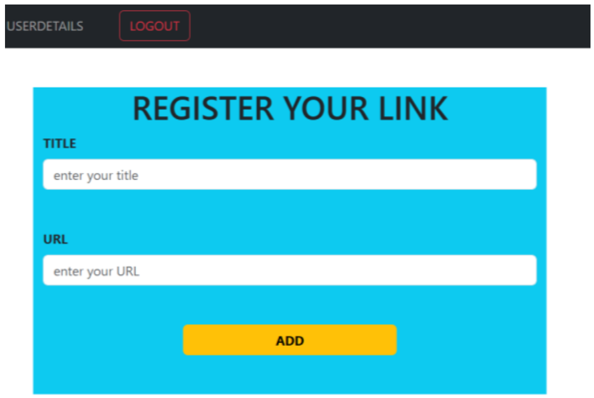



**Fig.4.4 Registration of URL**

Entering Title and URL: On the "Add Title" page, users are prompted to enter the title name and URL for the new title they wish to add which shows in Fig 4.4 These fields are mandatory, ensuring that essential information is provided for the new title. Submitting the Form: After entering the title name and URL, users submit the form to add the new title to the system. The system validates the input to ensure that both fields are filled in correctly before proceeding. And after confirmation it asks for 'ok' to ensure can store the information in database.

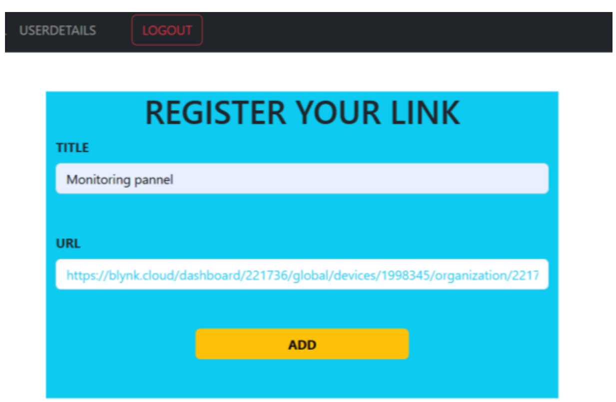



**Fig.4.5 Adding of new user URL and Title**

After adding the title and URL, users are automatically redirected to the "List of URL Details" page. This page displays a comprehensive list of all the titles and their corresponding

URLs that are currently available in the system. Viewing Recently Added Title and URL: Users can now see the recently added title and URL listed among the other titles on the "List of URL Details" page. This provides users with confirmation that their addition was successful and allows them to verify the accuracy of the information they provided. Upon successful submission, the title and URL are updated in the system's database which shows in Fig 4.5. This ensures that the newly added title is now part of the system's navigation structure and can be accessed by users. By Clicking the URL link, it will redirect to the monitoring page in which can access the energy consumption. Which shows in Fig 4.6

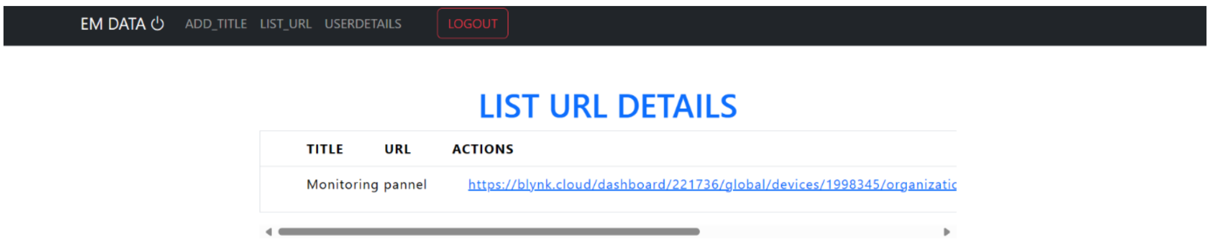



**Fig.4.6 User URL and Title**

## 4.3 UPDATE AND DELETE OF URL DETAILS

Users can add another new title through the navigation bar by selecting the "Add Title" option, which redirects them to the "Add Title" page. Here, they must fill in mandatory fields for title name and URL. After submission, the title and URL are updated, and users are redirected to the "List of URL Details" page, where the recently added title and URL are displayed. Users can repeat the process to add additional titles and links successfully.

For updating, users click on the "Update" option next to the title and URL they wish to modify. This action redirects them to the "Updating Page," in Fig 4.7 where they can make changes to the title name and URL link. Once the updates are completed, the new details are stored in the backend database, ensuring that the changes are saved and reflected in the system.

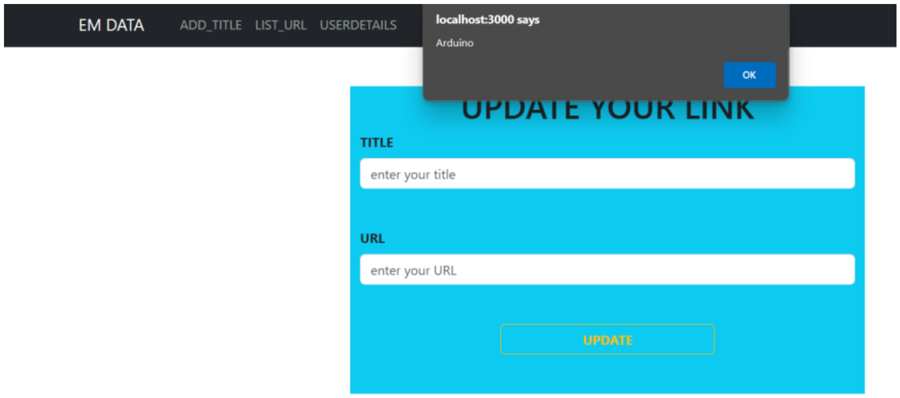



**Fig.4.7 Update of User URL and Title**

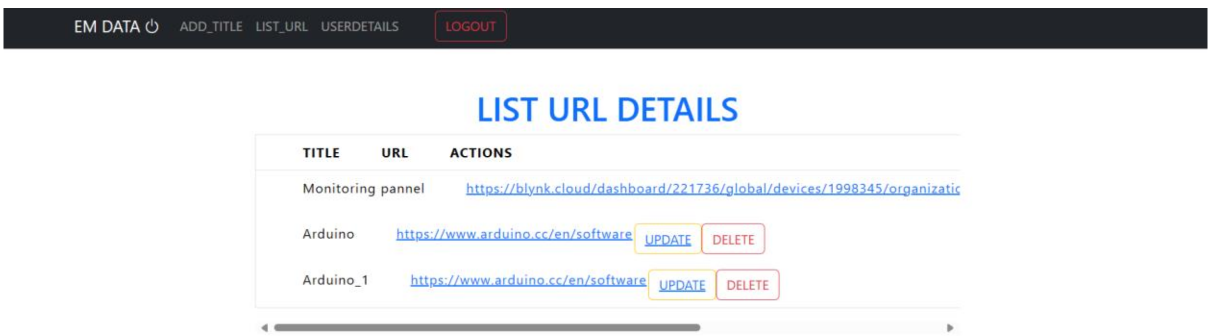



**Fig.4.8 Update list of User URL and Title**

If users wish to delete a title and its associated URL link, they click on the "Delete" option. This action redirects them to the "Deletion Page," where they can confirm their decision to remove the selected title and URL which shows in Fig 4.8. Upon completion of the deletion process, the title and URL are erased from the database.

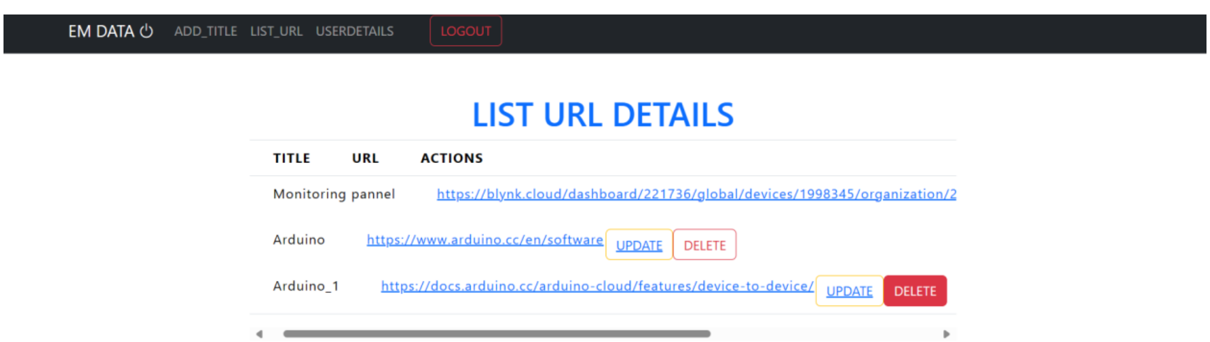



**Fig.4.9 Deletion of User URL and Title**

After updating or deleting a title and URL link, users are redirected back to the "List of URL" page which shows in Fig.4.9. Here, they can view the updated information or notice that the deleted title and URL have been removed. This ensures that users have an accurate and up-to-date view of the titles and URLs available in the system.

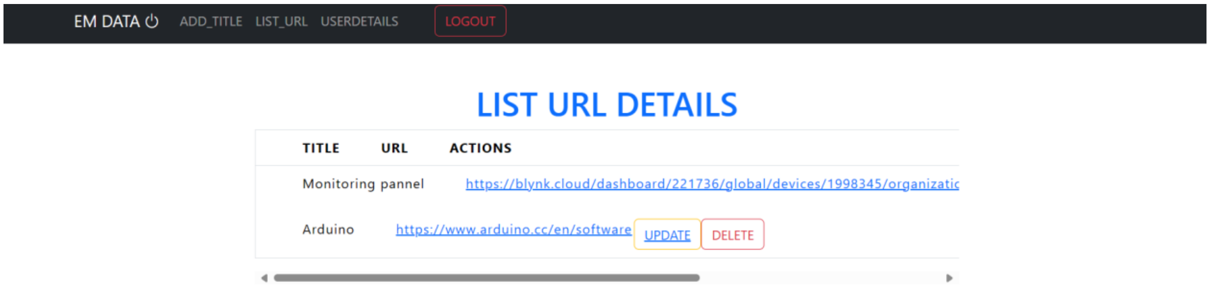



**Fig.4.10 Deletion list of User URL and Title**

# CHAPTER 5

# HARDWARE IMPLEMENTATION

## 5.1 REAL TIME MONITORING

### 5.1.1 PARAMETERS CALCULATION OF TOTAL LOADS

The system employs an energy meter having a of supply 230V AC power to various loads. The current sensor ACS712_20A and the voltage sensor ZMPT101B, respectively, are utilized to measure the current and voltage drawn by the loads. These measurements of the current sensor and the voltage sensor are then processed through Arduino. In Arduino the embedded code to calculate the power consumption shows in Fig.5.1. The calculated power is displayed on an LCD screen and transmitted to a web platform (BYINK) for remote monitoring which shows in Fig.5.2.


**Fig.5.1 Calculated Parameters**

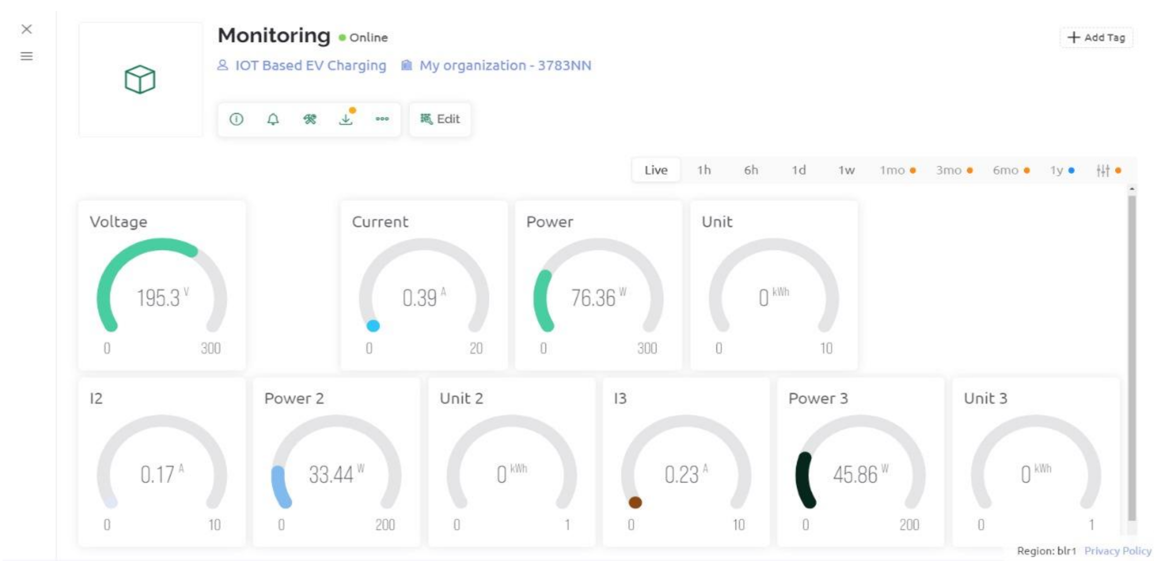



**Fig.5.2 Parameters on web platform**

### 5.1.2 CUT-OFF CALCULATION OF INDIVIDUAL LOADS

The cut-off calculation for individual loads is a vital aspect of energy management within the system. Load Monitoring with ACS712_05B Sensors. Each individual load is connected to a separate ACS712_05B current sensor. These sensors accurately measure the current drawn by each load, providing real-time data on their power consumption. Power Calculation Using the measured current (I) and the common voltage. This calculation provides insights into the energy usage of each load. Embedded Code Implementation the Arduino Uno, embedded with specific code, processes the measured power consumption data from each load. The code continuously monitors the cumulative energy consumption of each load. Threshold-based Cut-off The system is programmed with predefined thresholds for each individual load.

When the cumulative energy consumption of a load exceeds the designated threshold, the Arduino Uno triggers a cut-off mechanism. Automatic Cut-off Program acts Once the threshold is surpassed. This program interrupts the power supply to the load, effectively shutting it down to prevent further energy consumption. power calculation using the measured current(I) and the common voltage(V) the power consumed by each load is calculated using the formula of P=V*I*cosθ. The thresholds for cut-off can be set according to specific requirements and load priorities. For instance, a more critical load might have a lower threshold to ensure its uninterrupted operation, while non-essential loads may have higher thresholds. Efficient Resource Management By implementing automatic cut-off mechanisms based on energy consumption thresholds, the system ensures efficient resource management, Fig 5.4 shows the real time monitoring of each parameter and cut off of individual loads. It prevents excessive energy usage, minimizes wastage, and optimizes the overall energy consumption pattern. User Notification and Monitoring through the BLYNK web platform which shows in Fin.5.3 This allows users to stay informed about load status and take necessary actions if required.

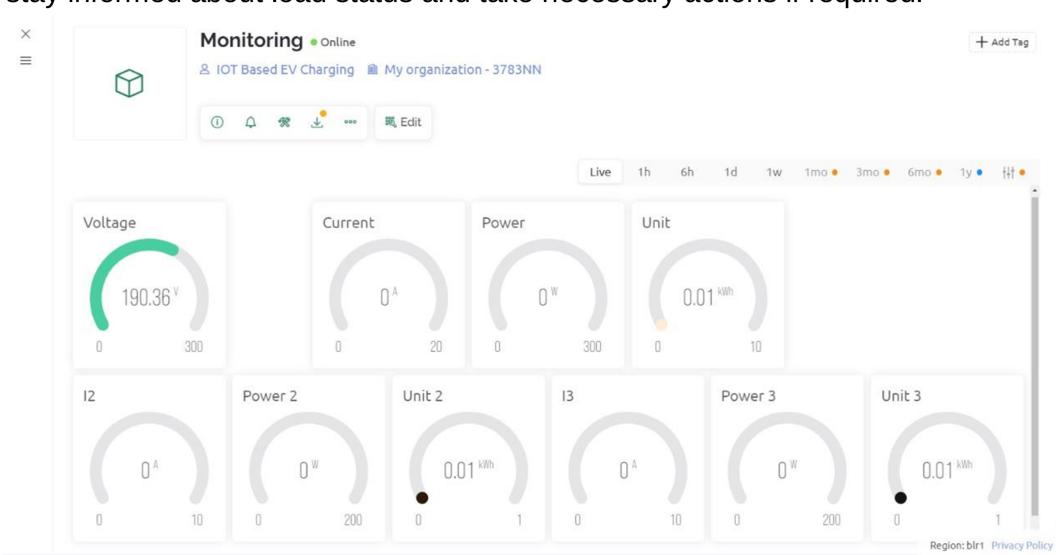



**Fig.5.3 cut off of individual load**

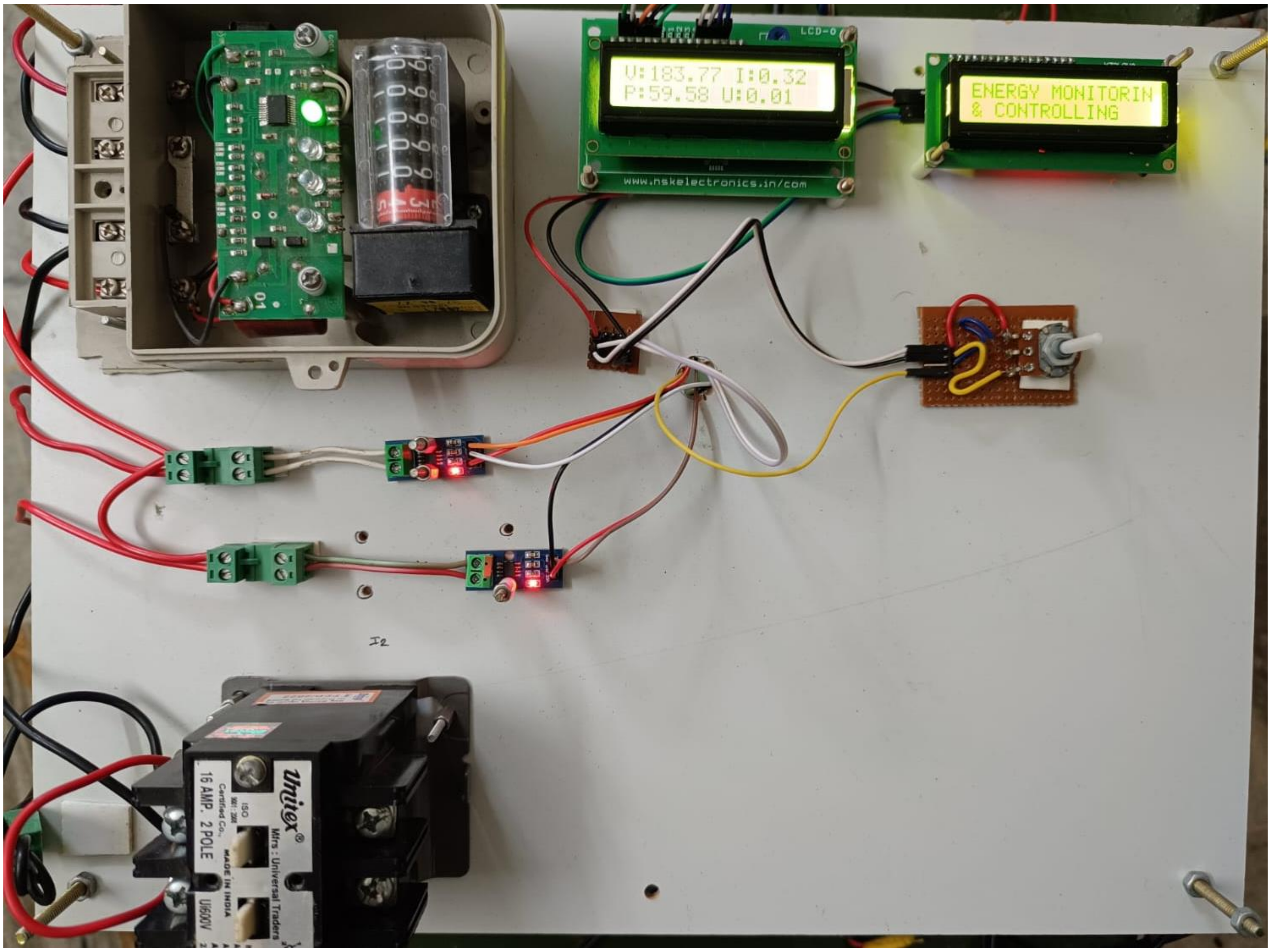



**Fig.5.4 Real Time Monitoring**

## 5.2 PROTOTYPE CONTROLLING

### 5.2.1 RELAY FUNCTIONS

The switching on and off of heavy and light loads within the system is seamlessly facilitated through the web platform Blynk, offering users convenient and remote control over the power distribution and load management. Integration with Blynk which shows in Fig.5.5. The system is integrated with the Blynk platform, allowing users to access and control various functionalities remotely through a user-friendly interface accessible via smartphones, tablets, or computers. Relay Control Within the Blynk interface, users are presented with controls corresponding to the four different relays: solar, grid, grid normal, and grid peak. Each relay is assigned a specific purpose in the power distribution and load management system. In the LCD display, "No_Connection" will appear when no relays are turned on which shows in Fig.5.6


**Fig.5.5 no connection of load**

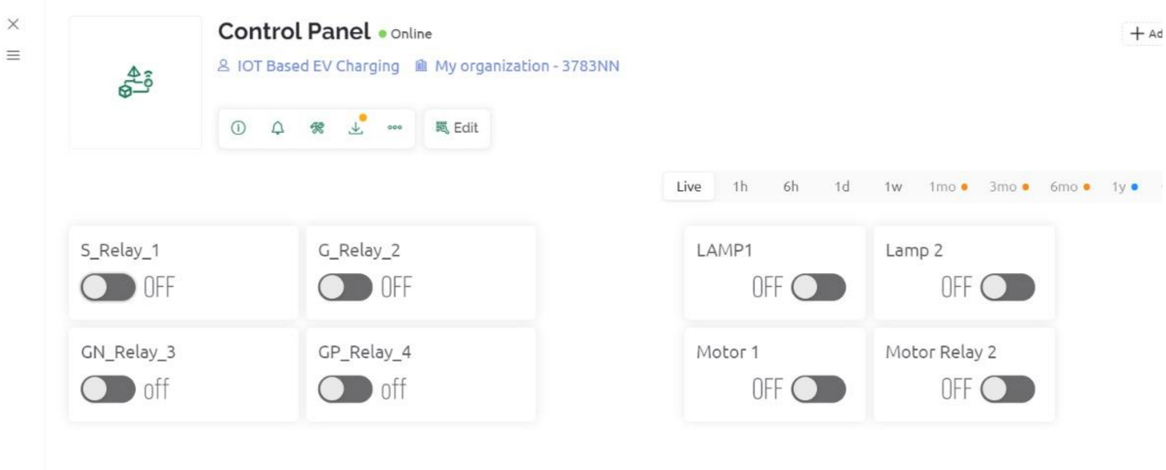


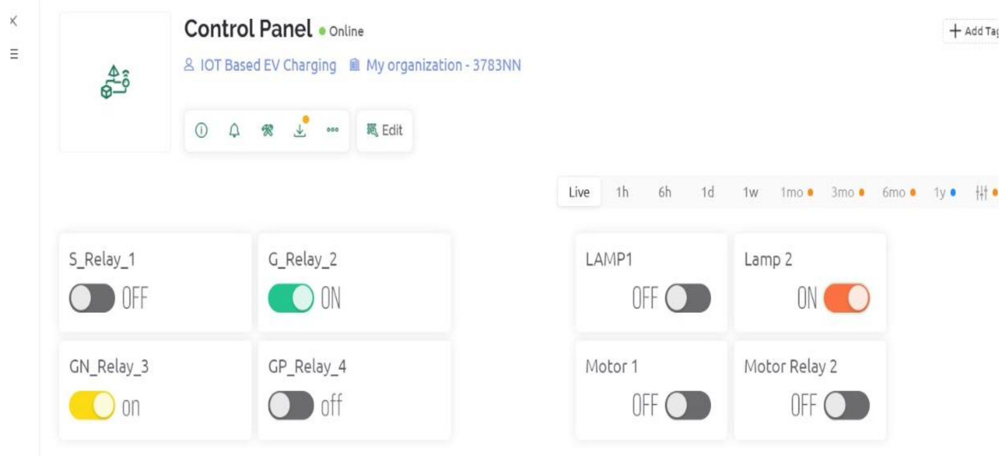

**Fig.5.6 no connection on Blynk**

### 5.2.2 RELAY FUNCTION ON GRID NORMAL

The Arduino controls a relay that manages the connection between the grid power source and a solar power source in grid normal condition. The Arduino receives control signals from the Blynk platform via a Node MCU module, enabling the user to remotely toggle the relay which is shown in Fig.5.7., when the relay receives an input signal from the Arduino, it closes, allowing the power supply connected to the relay to pass through and connect to light and heavy loads.

A potentiometer is connected to the Arduino and is used to set the desired power level or energy consumption. If the power level exceeds a set threshold (set to 10 units), the Arduino sends a signal to switch off the grid power relay and switch to solar power which is shown in Fig.5.9.

The Arduino also calculates the cost of energy consumption based on a rate of Rs 4.8 per unit. This information, along with the current power source (grid or solar), is displayed on an LCD screen for monitoring as shown in Fig.5.8.




. **Fig.5.7 Grid Normal connection on Blynk**


. **Fig.5.8 Grid Normally Connect on load**


**Fig.5.9 Grid Normally exceeds solar connected on load**

### 5.2.3 RELAY FUNCTION ON GRID PEAK

When activated manually through the Blynk platform which shown in Fig 5.11, the grid peak relay receives a signal via Arduino, causing it to energize into a normally closed state. This allows the output supply to connect with both light and heavy loads. If the unit exceeds 5 (adjusted by a potentiometer), the grid supply is disconnected, and the system switches to solar power as shown in Fig.5.12. During grid peak conditions, the cost per unit doubles compared to normal grid conditions as shown in Fig.5.10.


**Fig.5.10 Grid peak connected on load**

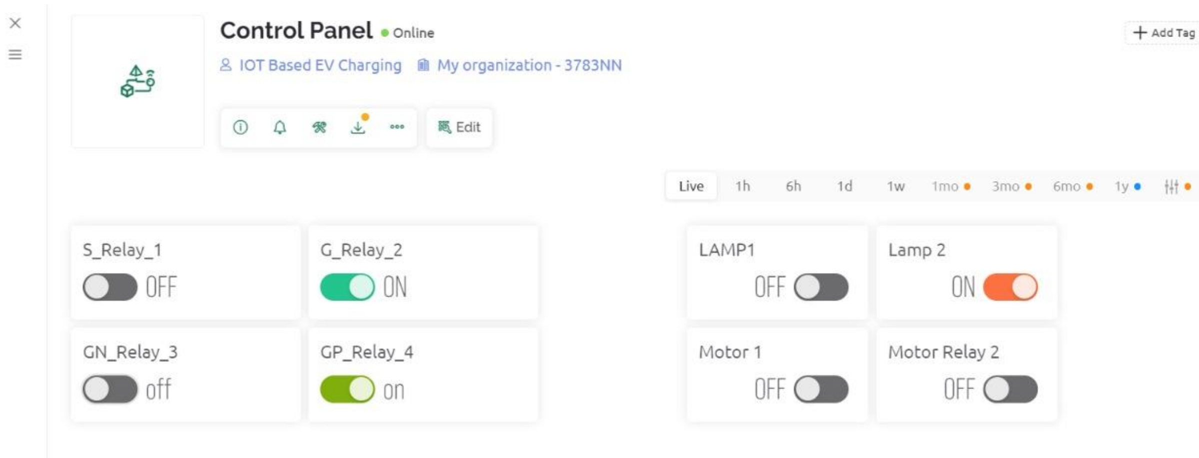



**Fig.5.11 Grid peak connected on load in Blynk**


**Fig.5.12 Grid peak exceeds solar connected on load**

### 5.2.4 RELAY FUNCTION ON SOLAR

The solar relay is manually activated via the Blynk platform as shown in Fig.5.13, and then it receives a signal from the Arduino to energize, leading to a normally closed state. The output of the solar relay is only connected to light loads and does not connect to heavy loads. Consequently, the units consumed on the solar relay contribute to savings in costs as shown in Fig.5.13.


**Fig.5.13 solar connected on load**

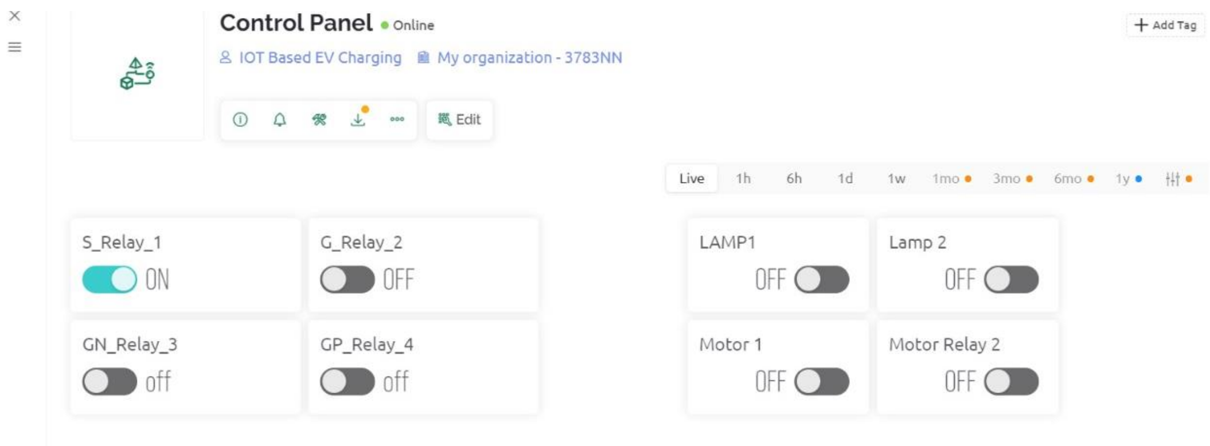



**Fig.5.14 solar connected on load in Blynk**

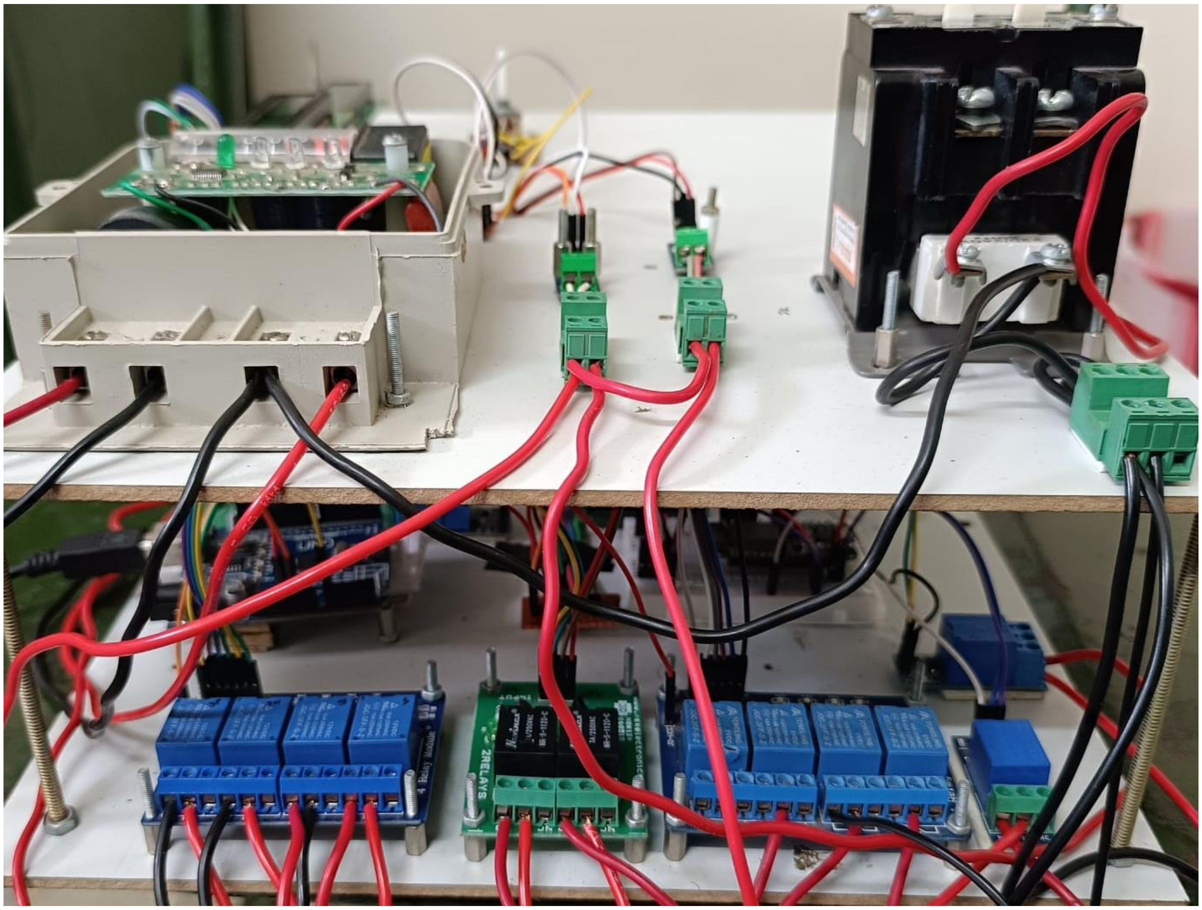



**Fig.5.15 Prototype controlling**

System for power distribution and load management, integrated with the Blynk platform for remote control and monitoring. Here's a breakdown Relay Control via Blynk Users can remotely control heavy and light loads through the Blynk platform, which offers a user-friendly interface accessible via smartphones, tablets, or computers. Grid, Solar, and Battery Integration The system includes relays for grid, grid normal, grid peak, and solar modes. These relays control the distribution of power based on tariff timing and energy consumption thresholds. During normal grid operation, both heavy and light loads are powered. During grid peak times, heavy and light loads are powered, but if consumption exceeds a certain threshold, the system switches to solar mode, powering only the light load to minimize costs. The system automatically switches between grid, grid peak, and solar modes based on predefined conditions such as energy consumption thresholds and tariff timing. The solar mode is powered by an inverted power supply through a battery, ensuring uninterrupted operation of light loads even during grid outages or low solar generation periods. Energy received through the solar mode is considered as savings cost, illustrating the efficiency and cost-saving benefits of utilizing solar power.

# CHAPTER 6

# CONCLUSION AND FUTURE SCOPE

## 6.1 CONCLUSION

The goal of the project was to install the Energy management in domestic household areas represents a significant advancement in sustainable power supply and consumption infrastructure. By intelligently integrating solar and grid power sources, monitoring voltage levels, streamlining payments, and incorporating Internet of Things (IoT) capabilities, this system offers an efficient and environmentally conscious solution for Energy management. The dynamic dual-source strategy prioritizes solar energy, harnessing the power of the sun when available, and seamlessly transitioning to the grid as needed. This not only optimizes costs but also significantly reduces the environmental footprint associated with power consumption.

The switch mechanism (Priority for switching ON and OFF) for peak-time pricing promotes responsible energy consumption, contributing to grid stability during periods of high demand. Additionally, the relay-driven system and solar-to-battery connection provide redundancy, ensuring uninterrupted charging availability even in the event of solar or grid outages. With IoT capabilities, the system enables remote monitoring, centralized management, and data-driven insights, paving the way for future optimizations and innovations in sustainable power availability solutions.

In this project sets a new standard for efficiency, convenience, and environmental responsibility in domestic household areas. It not only addresses the pressing need for sustainable energy management solutions but also serves as a blueprint for future advancements in smart home infrastructure for energy management. Advanced Energy Storage Integration: Incorporate advanced energy generation solutions like renewable source or other emerging technologies to further optimize energy usage and provide a more reliable power supply during periods of low solar output or grid outages.

## 6.2 FUTURE SCOPE

Looking ahead, can be applied in terms of Integration with Renewable Energy Sources, Advanced Machine Learning Algorithms, Dynamic Pricing Integration, Smart Grid Integration, Scalability and Interconnectivity fields for managing the power demand.

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