PREPAID ENERGY METER
WITH
SMART MONITORING SYSTEM

A PROJECT REPORT

Submitted by

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in partial fulfilment for the award of the degree

of

BACHELOR OF ENGINEERING

IN

ELECTRICAL AND ELECTRONICS ENGINEERING

KNOWLEDGE INSTITUDE OF TECHNOLOGY

ANNA UNIVERSITY: CHENNAI 60002

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BONAFIDE CERTIFICATE

Certified that this project report **"PREPAID ENERGY METER WITH SMART MONITORING SYSTEM"** is the bonafide work of **"DINESH KUMAR P (611220105008), JAYAGANTH T (611220105015), RAVINTHAR P (611220105027), SIVASANKAR C (611220105033), THIRUMALAI V(611220105041), SANJAY M K(611220105314)"** who carried out the project work under my supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

Energy is very precious for the living beings in recent times. The Energy consumption is consistently as increases as the population increases so the need power is also increases, the revenue in electricity system is increasing and also gets hard to monitoring each system. It is quite impossible to check out the consumer's residence at regular intervals and monitoring the real time power consumption. And the consumer are also unable to the real time power consumption and energy losses, The reader will notify the consumer about the value of consumption in a certain interval period. In this project, a new procedure of using NODE MCU to monitor and control the energy meter power supply by remotely disconnect and reconnecting the service of a particular consumer. A notification is sent to the utility central server and consumer through Wi-Fi module whenever the load consumption is exceeding the consumer desired value. The NODE MCU and WEB page handle the Billing difficulties, Real- time Monitoring the load consumption.

Keywords—IOT, Smart Monitoring, Prepaid System.

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CHAPTER-1
INTRODUCTION

1.1 INTRODUCTION

Electricity is one of the most important blessings that science has given to mankind. The Proposed system “Prepaid Energy Meter with Smart Monitoring System” using Controller and IOT is a simple and effective way to automate the process the Billing, Controlling and Monitoring the load consumption. The system consists of Node MCU (Microcontroller), PZEM-004T(Sensor), Relay, Web page. The System involves the use of Controller to control the flow of power to the Load. The system typically consists of Node MCU, equipped with a PZEM-004T sensor that detects the power, voltage, current consumed by load. The sensor is connected to Controller, which control the relay to disconnecting and reconnecting power to the Load. When the Load reached the Desired value, the controller give instruction to the relay to stop the flow Energy into the load. The Desired value can alter by using IOT interface by the Consumer Need through Web page. Overall, The Prepaid Energy Meter with Smart Monitoring System using Controller and IOT is a simple and reliable way to automate the process of Billing, Control and Monitoring the power consumption in Real time. It can be used in a variety of applications, such as in agricultural or industrial settings, where maintaining a consistent power supply is important

4.4 OBJECTIVES

i. To obtain the pre-paid recharge system for the existing energy meters.
ii. To develop a module to monitor the load consumption.
iii. To create user friendly platform to monitor the real time status of the Energy.

CHAPTER 2

LITERATURE REVIEW

1. SMART ENERGY METERING AND POWER THEFT CONTROL USING ARDUINO AND GSM – 2nd International Conference for Convergence in Technology(I2CT) in 2017.

Electricity is one of the most important blessings that science has given to mankind. But this energy used by unauthorized person cause losses to utility and also pollutes the environment. Losses in electricity energy sector can come under two sets: technical and managerial. Technical losses of electrical energy are caused due to the functional tendency of the equipment used from generating station to the distributing station. Non-Technical losses are due to lack of utility labor interference periodically. These losses are much higher in developing countries like India. The proposed system consists of digital energy meter, an Arduino (microcontroller), GSM modem and SSR. After switching power on the Arduino and the GSM modem, turn on the SSR and connects the energy meter to load via SSR. Then read the EEPROM and display the current data. Arduino checks the readings from voltage and two current sensors i.e. PT and CT respectively. It measures the current sensor difference between two CT, supply voltage variation from the utility to protect the customer equipment. Solid state relay will disconnect and reconnect the supply by the microcontroller instruction given.

2. A SMART PREPAID ENERGY METERING SYSTEM TO CONTROL ELECTRICITY THEFT – International Conference on Power, Energy and Control(ICPEC) in 2013.

Electricity theft includes tampering meters to show a low meter reading, stealing electricity bypassing a meter, billing irregularities and unpaid bills. Billing irregularities comprise inaccurate meter reading taken by bribed service man and intentional fixing of the bill by office staffs in exchange of illicit payments from the consumer. Some of the technical ways to detect pilferage are use of central observer meter at secondary terminals of distribution transformer, harmonic generator, genetic support vector machines, extreme learning machine, power line impedance technique. However, these technical approaches can be effectively implemented only if proper communication is ensured between the central control station and the appropriate test points. Recently, prepaid energy meters based on GSM network has been proposed. These meters incorporate the facility of prepaid metering system and remote load control. This prepaid metering system can be further matured to address the problem of electricity theft. In this paper, we have proposed a GSM based prepaid energy metering system which deals with different aspects of electricity theft. The proposed system prevents irregularities of billing, reluctance of consumers to pay bills in time, meter tampering and bypassing.

3. ARDUINO BASED SMART ENERGY METER USING GSM – Institute of Electrical and Electronics Engineering(IEEE) in 2019.

The proposed metering system in this paper offers to automate this process thereby eliminating fallacies and dishonest behavior. It promotes a paperless environment where the meter updates will be directly sent to the user via SMS. The proposed meter is a modification of the available smart meters. Implemented using Arduino microcontroller and GSM, it provides bidirectional communication between the user and meter. Ease of reading and load disconnection/re-connection are some of the traits that make this proposed metering system a better alternative to prevalent systems. The manufacturing cost of the proposed meter is calculated to be less than that of prevalent meters offering similar features. When put into full-scale manufacturing, the cost can be further reduced. As the nation progresses towards becoming digital with the upcoming smart cities, the proposed metering system is a major step that overcomes the shortcomings of the existent meters. The paper further covers a thorough literature survey, the proposed system specifications, the software and hardware implementations followed by the conclusion of the paper.

4. DEVELOPMENT OF AN INTERNET BASED PREPAID ENERGY METER– Institute of Electrical and Electronics Engineering(IEEE) in 2017.

Energy meters are used to measure the amount of energy consumed by domestic, commercial and sometimes industrial users. With the growing population of energy consumers, smart meters are timely innovation which eases the energy management system. Utility companies can monitor consumption, automatically disconnect defaulting consumers, update tariff, and have a secured database and consumption pattern of a mapped location. The consumers on the other end can also monitor their energy consumption in real-time, recharge their accounts, monitor tariff rates and hence improves the demand response. Unfortunately, the energy sector is bedevilled by several challenges resulting from the deployment of electricity smart meters. They are energy theft, cyber-attacks, mismanagement and erroneous billing etc. and thus, various research aspects to curb the challenges have been ongoing. This paper proffers a solution of reducing human involvement in energy management for both utility companies as well as consumers. All the monitoring and control features are provided access via a dedicated web portal, anywhere, anytime provided there is Internet connection.

5. SMART ENERGY METER – International Journal of Engineering Science and Computing(IJESC) in 2018.

Electricity is one of the vital requirement for sustainment of contents of life. It should be used very judiciously for its proper utilization. But in our country we have lot of locality where we have surplus supply for the electricity while many areas do not even have access to it. Our policies of its distribution are also partially responsible for this because we are still not able to correctly estimate our exact requirement and still power theft is prevailing. On the other hand consumers are also not satisfied with the services of power companies. Most of the time they have complaints regarding statistical errors in the monthly bills. With this we can monitor meter and track if any fault is there or not. In previous meter a circular metal strip rotates and according to that rotation we calculate the consumption. But our meter works on pulse which Is created according to previously and we previously connected android board which monitor the pulse and according to pulse the bill is generated. With the help of this project we are aiming to receive the monthly energy consumption from a remote location directly to centralised office. In this way we can reduce human efforts needed to record the meter readings which are till now recorded by visiting every home individually.

CHAPTER 3

EXISTING SYSTEM

3.1 INTRODUCTION

The post-paid recharge system for energy meters is a widely used method by utility companies to bill consumers for their electricity usage. This process involves measuring the energy consumption by the meter and generating a bill based on that recorded data. Upon receiving the bill, the consumer is required to make the payment to the utility company**.** The energy meter serves as a critical device in this system, as it records the energy usage and stores the data for future reference. The accuracy of the energy meter is essential, as it is the primary source of information used to generate the bill. After the payment is made, the utility company manually updates the energy meter with the new credit amount. However, advancements in technology have made it possible to remotely update the credit through a network connection. The post-paid recharge system offers the advantage of ensuring that consumers do not run out of credit or lose power unexpectedly. The utility company is responsible for maintaining adequate credit levels to meet the consumer's energy needs. However, this system does require a certain level of responsibility on the part of the consumer. They must ensure that they have enough funds to pay their energy bill on time and avoid any late payment penalties. Overall, the post- paid recharge system for energy meters is a dependable and efficient method for utility companies to bill consumers for their electricity usage.

3.2 BLOCK DIAGRAM

The existing system block diagram is shown below in Figure.3.1. As the Power supplied from line in left side and power delivered to the load in right side the power consumed will be monitored and displayed in LED Display and the data will be calculated and stored in the Processor.

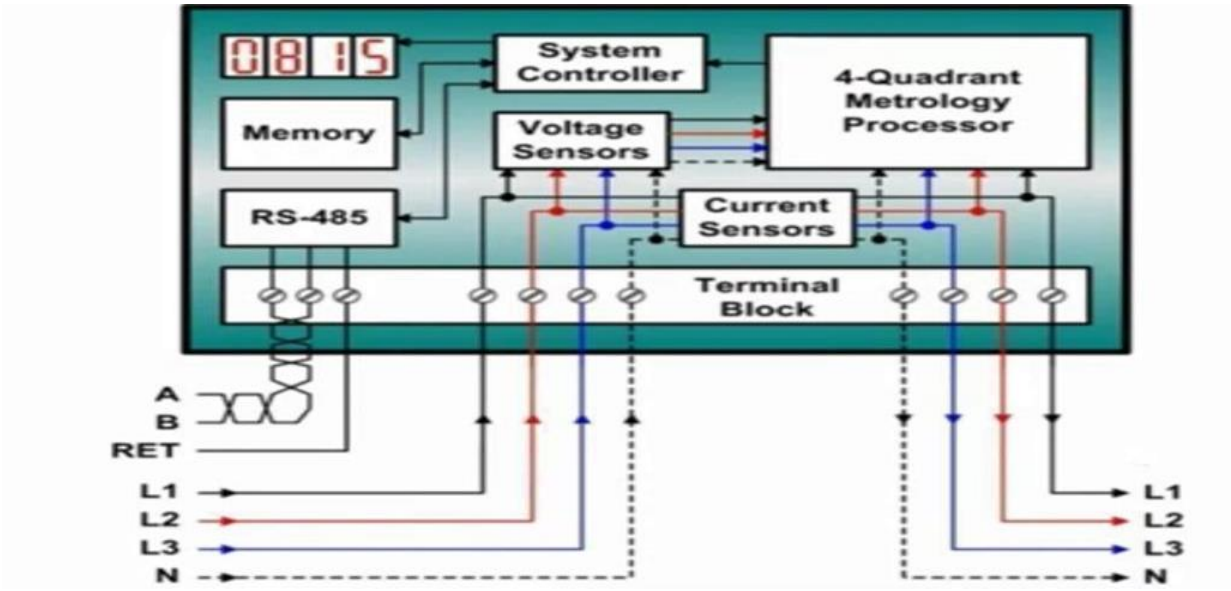

Figure.3.1:Block Diagram

3.3 Disadvantages

I. Potential for high bills: With a post-paid system, customers may use more energy than they realize and end up with unexpectedly high bills. This can be a particular problem for customers who have variable usage patterns or who are not good at managing their energy consumption.

II. Late payment penalties: If a customer fails to pay their bill on time, they may be subject to late payment penalties and disconnection of service. This can be particularly problematic for low-income households who may struggle to pay their bills on time.

III. Disputes over billing: Customers may dispute their bills if they believe they have been charged incorrectly or if they have concerns about the accuracy of their meter readings. This can be time-consuming and frustrating for both the customer and the utility Company .

IV. Inconvenience of payment: Customers may find it inconvenient to have to pay their bills manually, whether in person or online, rather than being able to recharge their meters on the go.

V. Limited access to electricity: In some areas, post-paid systems may be the only option available, which can be problematic for low-income households or those without access to traditional payment methods.

CHAPTER 4

PROPOSED SYSTEM

4.1 Introduction

A smart energy meter works on communication directly with wireless data protocol, so there will be precise reading and there's no necessary for a meter reader to take energy meter reading in consumer premises. There are so many different merits of smart energy meter such as:

- User new smart energy meters send precise reading on a regular interval in sequence about customer's energy usage to utility (Electricity provider). So, the bills will be proper and labor cost is reduced for taking a reading in consumer residents.

- If the consumer did not pay the energy bill within time, the utility can remotely disconnect the service (line) of a particular consumer and after payment, the service continues to the consumer. So we can avoid sending an employee to cut off energy from the network and again to reconnect their connection.

- Whenever the power quality is not maintained from the distribution supply, then the customer equipment can be protected by disconnecting and reconnecting to the supply by relay.

The proposed system consists of Node MCU, PZEM-004T, and Relay. After switching power on the Node MCU, turn on the Relay and connects the power line to load via Relay. Then read the value and display the current data. Controller checks the readings from sensor. If the value reaches the desired value the controller send a notification to the consumer and if it exceeds the controller sends information to relay to stop the flow of power to the system. Also, the Web page and Node MCU helps the utility for power disconnection when the bill is not

cleared by the customer. From customer point, this is a benefit to monitoring their daily/monthly consumption, voltage fluctuation and gets disconnected from the supply.

4.2 BLOCK DIAGRAM

The Block Diagram of proposed method is displayed in the below Figure.4.1. The components are connected between the load and power supply as shown.

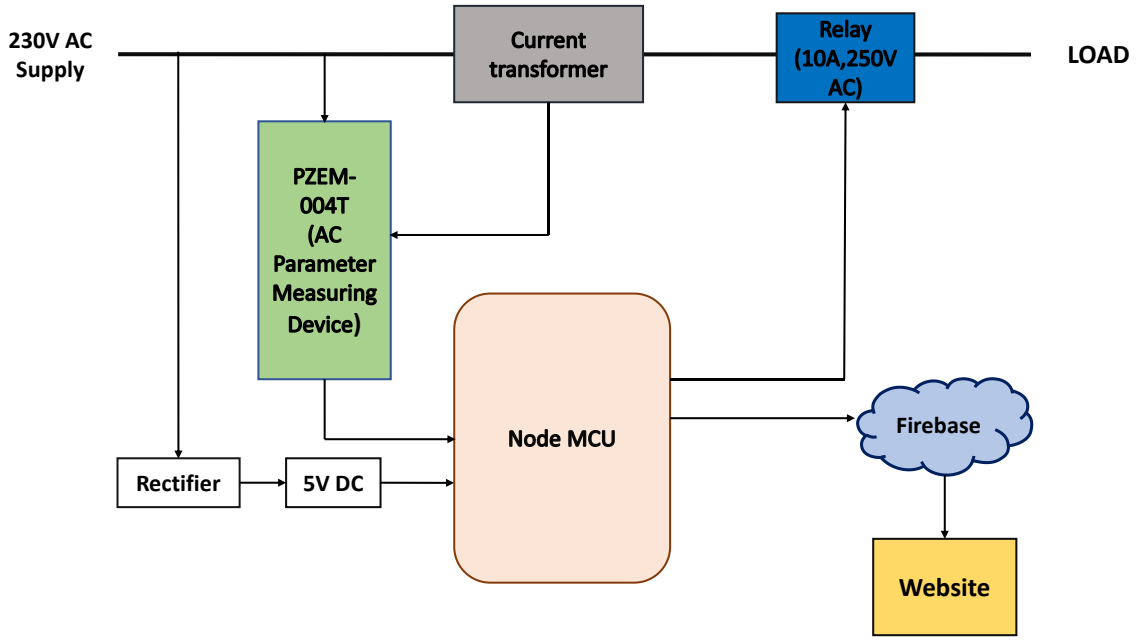

Figure.4.1:Proposed Block Diagram

4.3 Hardware Description

The selection of hardware is very important in the existence and proper working of any of the software. When selection hardware, the and capacity requirements are also important.

- **NODE MCU V3**
- **RELAY**
- **PZEM-004**

4.3.1 Node MCU V3

The Microcontroller used in the proposed method is Node MCU Version. 3 is displayed in the Figure.4.2

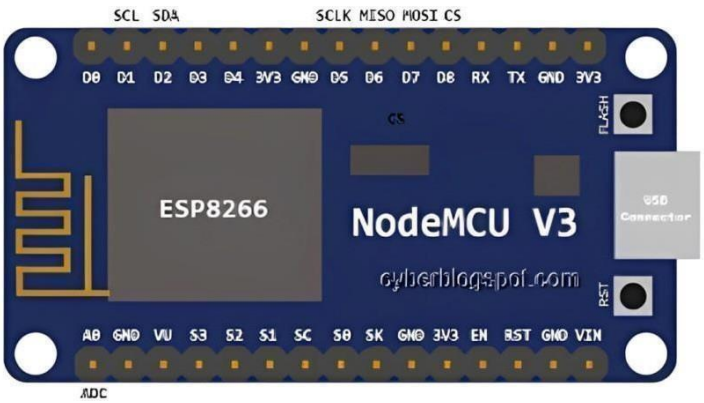

Figure.4.2: Node MCU

The best way to develop quickly an IoT application with less Integrated circuit to add is to choose this circuit "NODE MCU". Today we will give a detailed Introduction on NODE MCU V3. It is an open-source firmware and development kit that plays a vital role in designing a proper IoT product using a few script lines. The module is mainly based onESP8266 that is a low-cost Wi-Fi microchip incorporating both a full TCP/Ip stack and microcontroller capability. It is introduced by manufacturer Espress if Systems. The ESP8266 NODE MCU is a complex device, which combines some features of the ordinary Arduino board with the possibility of connecting to the internet.

In our project, It acts as the brain of the system. It actually controls the relay signal either to turn on or off. It also process the data sent by the PZEM 004T module and sends the data over the firebase cloud.

It also has inbuilt Wi-Fi feature that can be used to send the data over the cloud and to the website.

4.3.1.1 Features of Node MCU

a) Open-source.

b) Arduino-like hardware.

c) Status LED.

d) Micro USB port.

e) Rest/Flash Buttons.

f) Interactive and Programmable.

g) Low cost.

h) ESP8266 with inbuilt Wi-fi.

i) USB to UART converter.

j) GPIO pins.

k) Arduino-like hardware IO.

l) Advanced API for Hardware IO, which can dramatically reduce the redundant work for configuring and manipulating hardware.

m) Code like Arduino, but interactively in Lua script.

n) Nodejs style network API.

o) Event-driven API for network applications, which facilitates developers writing code running on a 5mm*5mmsized MCU in Nodejs Style.

p) Greatly speed up your IOT application Developing Process.

q) Lowest cost WI-FI.

r) Less than $2 WI-FI MCU ESP8266 integrated and easy to prototyping development kit.

s) We provide the best platform for IOT application development at the lowest cost.

4.3.2 Relay

A relay is an electrically operated switch. Current flowing through the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.

Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example, a low voltage battery circuit can use a relay to switch a 230V AC main circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12v relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most Ics(chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

4.3.2.1 Relay On

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. For further information about switch contacts and the terms used to describe them please see the page on switches. Most relays are designed for PCB

mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay. The Relay On circuit diagram is shown in the Figure.4.3.

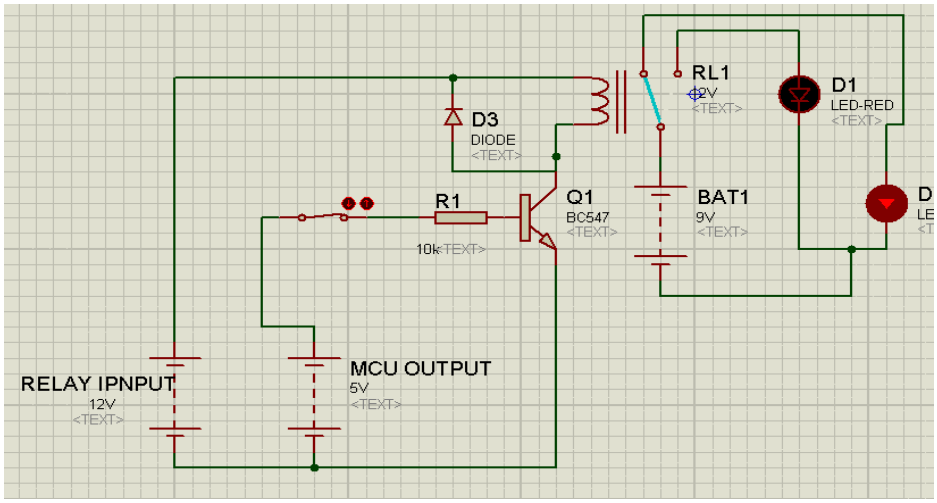

Figure.4.3: Relay in ON State

4.3.2.2 Relay Off

When a relay is off, there is no current flowing through the coil and the switch contacts are open, which means the circuit is not connected. It's like a gate that is closed, not allowing anything to pass through. The relay off circuit diagram is shown in Figure.4.4.

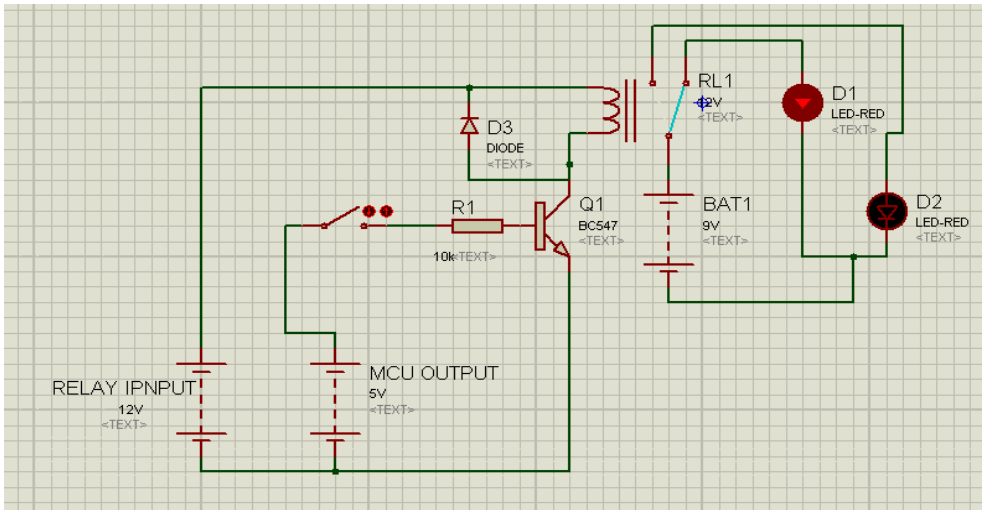

Figure.4.4: Relay in OFF State

This also means that there is no voltage being applied to the output terminals of the relay, so any devices or components connected to those terminals will not be powered or affected. In other words, the relay is in a deactivated state when it is off.

4.3.3 PZEM-004T V3.0

The PZEM-004t V3.0 module is a digital AC voltage and current sensor that is commonly used in DIY projects and industrial applications. It can measure the voltage, current, power, energy, and frequency of an AC circuit. The Sensor is shown in the Figure.4.5.

Figure.4.5: PZEM-004T

The module has a built-in transformer that isolates the voltage measurement from the power supply, making it safe for use with high voltage circuits The PZEM-004t V3.0 module has a communication interface that allows it to be connected to a microcontroller or other digital device for data processing and monitoring. The module uses a TTL serial interface to communicate data, and it supports a range of communication protocols including Modbus-RTU, ASCII, and simple serial output the PZEM-004t V3.

Overall the PZEM-004t sensor module is a versatile and reliable digital sensor that is well- suited for a range of AC voltage and current measurement.

4.4 Software Description

Software requirements are a list of features and functions that a software system must have in order to meet the needs of its users. It is a detailed description of what the software is supposed to do and how it should behave. These requirements guide the development team in building the software and serve as a basis for testing and evaluating the final product**.** This section summarizes the Software needed by the system for this project.

- **Arduino IDE**
- **IOT server (Firebase)**
- **Embedded C**

4.4.1 Arduino Software (IDE)

Arduino is a platform for electronics that is open-source and includes both simple hardware and software. The boards of Arduino are capable of interpreting various inputs such as a light on a sensor, a button press, or a tweet and then produce an output, such as turning on an LED or operating a motor. The microcontroller on the board can be instructed by sending a series of commands to it. The Arduino programming language, which is based on Wiring, is used to give the instructions and the Arduino Software (IDE), which is based on Processing, is used to write and compile the code.

Arduino has been used as the central processing unit for countless projects, ranging from ordinary objects to advanced scientific equipment. A global community of creators, including students, hobbyists, artists, programmers, and professionals, has come together around this open-source platform. They have contributed a vast amount of practical knowledge that is easily accessible and can benefit both beginners and experienced users.

Arduino originated at the **Ivrea Interaction Design Institute** as a user- friendly tool for quick prototyping, specifically targeting students with no prior knowledge of electronics or programming. Once it gained popularity among a broader audience, the Arduino board evolved to address new demands and challenges, expanding its range from basic 8-bit boards to products suitable for IOT applications, wearable devices, 3D printing, and embedded environments. All Arduino boards are fully open-source, which means that users can create them independently and modify them to suit their specific requirements. Similarly, the software is open-source, and it is continually evolving through the contributions of users worldwide.

Arduino also simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems.

Some of the major advantages of Arduino IDE include the following

- **Cross-platform** – Arduino was originally developed at the Ivrea Interaction Design Institute as a user-friendly tool designed for quick prototyping, primarily targeting students without any prior experience in electronics or programming.

- **Simple, clear programming environment** – The Arduino Software (IDE) is a programming environment that is simple Friendly for beginners while also providing flexibility for advanced users. For educators, it is particularly useful because it is based on the Processing programming environment, which is already familiar to students learning to program in that environment. Therefore, students can quickly understand how the Arduino IDE works.

- **Open source and extensible software –** The Arduino software is an open-source tool that is available for extension by experienced programmers. The language can be expanded using C++ libraries, and those who want to gain a deeper understanding of the technical aspects can transition from Arduino to the AVR C programming language on which it is based. Additionally, users can integrate AVR- C code directly into their Arduino programs if they wish to do so.

- **Abundant Libraries –** The Arduino IDE provides access to a large number of libraries, allowing users to quickly and easily add functionality to their projects**.** Libraries in the Arduino IDE are easy to use, as they provide pre-written functions that can be used directly in the user's code. This saves users a lot of time and effort, as they do not have to write the entire code from scratch important for beginners who may not have the expertise to develop their libraries from scratch.

- **Community Contributions –** The Arduino community actively contributes to the development of libraries, ensuring that they remain up-to-date and relevant. Users can also contribute to the development of libraries by creating their libraries and sharing them with the community.

- **Compatibility with Third-Party Libraries –** The Arduino IDE supports third-party libraries, allowing users to access a more extensive range of libraries and functionality. This makes it possible to integrate existing code and functionality into the user's project quickly.

4.4.2 Embedded C

Embedded C refers to a set of language extensions for the C programming language, which was developed by the C Standards Committee. It addresses the commonality issues that arise from using C extensions across different embedded systems. Embedded C programming requires non-standard extensions to the C language to support enhanced microprocessor features like fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

In 2008, the C Standards Committee extended the C language to address these capabilities by providing a common standard for all implementations to adhere to. Embedded C includes several features that are not available in standard C, such as fixed-point arithmetic, named address spaces, and basic I/O hardware addressing.

Despite these differences, Embedded C shares most of the syntax and semantics of standard C, including the main () function, variable definitions, datatype declarations, conditional statements (if, switch case), loops (while, for), functions, arrays and strings, structures and unions, bit operations, macros, and more.

Embedded C Programming is the soul of the processor functioning inside each and every embedded system we come across in our daily life, such as mobile phone, washing machine, and digital camera. Each processor is associated with embedded software. The first and foremost thing is the embedded software that decides functioning of the embedded system. Embedded C language is most frequently used to program the microcontroller.

Earlier, many embedded applications were developed using assembly level programming. However, they did not provide portability. This disadvantage was overcome by the advent of various high-level languages like C, Pascal, and

COBOL. However, it was the C language that got extensive acceptance for embedded systems, and it continues to do so. The advantages are shown in the Figure.4.6.

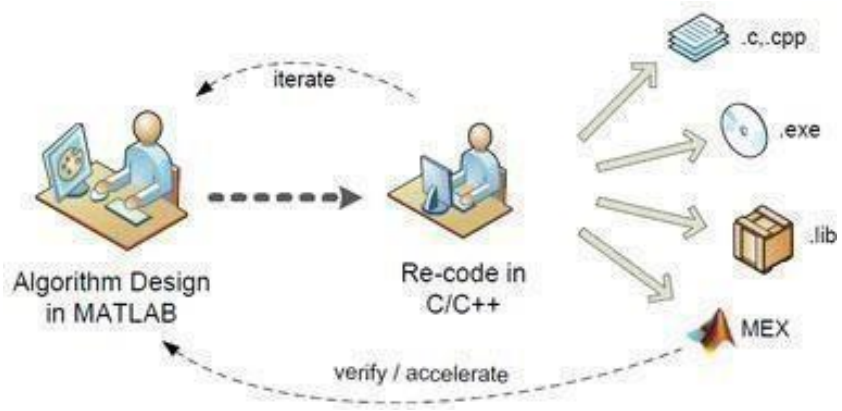

Figure.4.6: Advantages of using Embedded C

The C code written is more reliable, scalable, and portable; and in fact, much easier to understand. C language was developed by Dennis Ritchie in 1969.

C language is a middle-level language as it supports high-level applications and low-level applications. Before going into the details of embedded C programming, we should know about RAM memory organization.

Salient features of the language:

- C language is a software designed with different keywords, data types, variables, constants, etc.
- Embedded C is a generic term given to a programming language written in C, which is associated with a particular hardware architecture.
- Embedded C is an extension to the C language with some additional header files. These header files may change from controller to controller. The microcontroller 8051 #include<reg51.h> is used.

The embedded system designers must know about the hardware

architecture to write programs. These programs play prominent role in monitoring and controlling external devices. They also directly operate and use the internal architecture of the microcontroller, such as interrupt handling, timers, serial communication, and another available feature.

4.4.3 Firebase

Firebase is an inclusive platform for creating mobile and web applications, offering developers an array of tools and services that simplify the development process. Its major advantage is that it enables developers to quickly build high-quality applications without worrying about infrastructure**.** The platform's services are designed to streamline development, such as the Real-time Database, a cloud-hosted NoSQL database that allows data to be stored and synchronized in real-time, enabling users to collaborate and share data in real-time. Firebase's authentication service is also noteworthy, providing secure authentication and user management features such as email and password authentication, social media authentication, and anonymous authentication**.**

Developers can use Firebase's cloud messaging service to send notifications and messages to users across multiple platforms, keeping them engaged with their applications. Additionally, Firebase offers hosting, cloud functions, analytics, and storage, with hosting allowing developers to deploy and host their web applications on Firebase servers, and cloud functions enabling them to write and deploy server less functions that respond to events**.**

Firebase analytics provides developers with insights into user behavior and app performance, while Firebase storage allows them to store and retrieve user-generated content such as images, videos, and other files. Overall, Firebase is a powerful and flexible platform that is ideal for mobile and web application development, particularly for those who need to create scalable, real-time applications with complex data synchronization and user management features.

4.4.3.1 Steps to use Firebase

Step 1: Go to the website provided

Link: https://firebase.google.com/

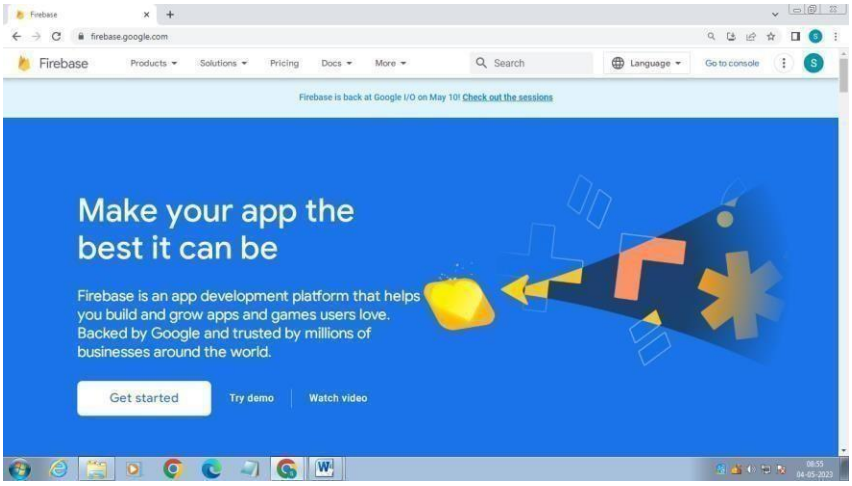

Figure.4.7:Step 1

- Step 2: Click on Get Started and Create your project

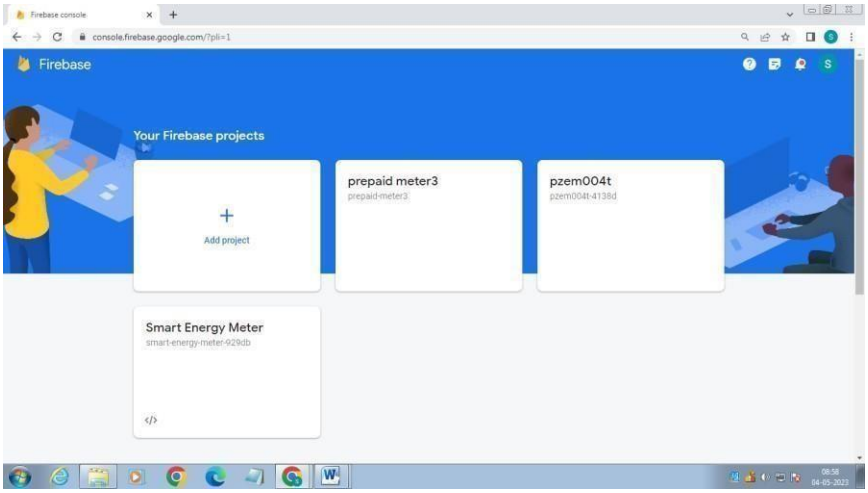

Figure.4.8:Step 2

- Step 3: Customize the firebase based on your project

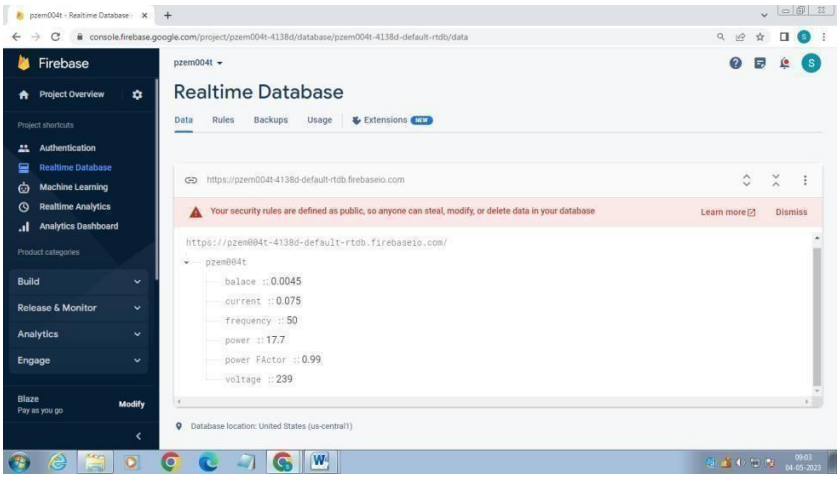

Figure.4.9: Step 3

By using the above steps one can be able to customize and use the Firebase as per the requirements of the project**.** Google also offers free analytics tools such as web traffic monitoring.

CHAPTER 5

RESULT AND DISCUSSIONS

Prepaid energy meters are becoming increasingly popular due to their convenience and cost-effectiveness. By implementing a prepaid energy meter using Node MCU and PZEM004T, users can recharge their meters in advance and avoid unexpected bills. The Node MCU is an open-source development board that provides a convenient platform for building IoT devices, while the PZEM004T is an energy metering module that accurately measures energy consumption.

The system works by using the PZEM004T to measure energy consumption and communicate with the Node MCU over a serial connection. The Node MCU then sends this data to a web server or mobile application, which displays the user's remaining balance and energy usage in real-time. When the user's balance runs low, they can easily recharge their meter using a variety of payment methods, such as online payments, mobile payments, or physical recharge vouchers.

One of the benefits of using Node MCU and PZEM004T for prepaid energy metering is their ease of use and flexibility. The system can be easily customized to fit the needs of different users, and can be integrated with a wide range of payment gateways and user interfaces. Additionally, the system can be used in a variety of settings, such as homes, businesses, and public utilities.

5.1 Hardware Setup

The below Figure.5.1 shows the hardware connected in order to make possible of the prepaid energy meter. The micro controller is the brain of this system where all the calculations and other process would occur.

Figure.5.1: Hardware Setup

5.2 Firebase Output

The below figure.5.2 shows the real-time data received from the ESP8266 micro controller. The data are updated in real time to the website. It can be viewed using mobile or pc.

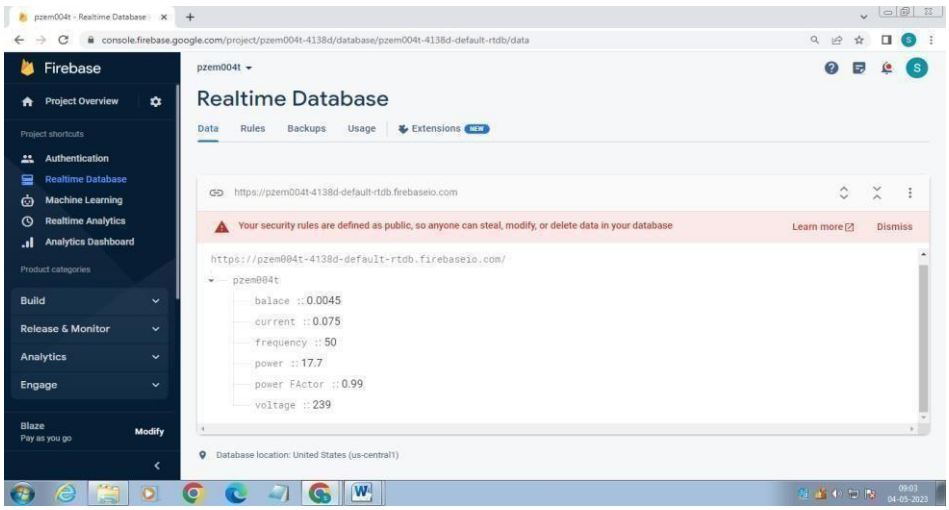

Figure.5.2: Firebase Output

5.3 With Balance

The below table.5.1 shows the output of system with remaining balance. The factors such as voltage, current, power, frequency, balance can be viewed in a dynamic website and the real-time data will be transferred to the firebase.

Table.5.1: **Prepaid Energy Meter Initial Recharged with 100 Rs.**

S.No	Parameters	Value	Units
1	Voltage	247.00	Volts
2	Current	0.07	Amps
3	Power	17.40	Watts
4	Frequency	50	Hz
5	Balance	100	Rs

5.4 Without Balance

The below Table.5.2 shows the output of system without remaining balance. The factors such as voltage, current, power, frequency of the previous state can be viewed in a dynamic website and the real-time data will be transferred to the firebase.

Table.5.2:**Prepaid Energy Meter After Energy Consumption Balanced with 0 Rs**

S .No	Parameters	Value	Units
1	Voltage	247.10	Volts
2	Current	0.08	Amps
3	Power	18.40	Watts
4	Frequency	50	Hz
5	Balance	0.0	Rs

CHAPTER 6

CONCLUSION AND FUTURE ENHANCEMENTS

6.1 Conclusion

As the world transitions towards cleaner and more sustainable energy sources, prepaid energy meters using Node MCU and PZEM004T can play a key role in promoting energy efficiency and conservation. By providing real-time information on energy usage and encouraging users to monitor and manage their energy consumption, these systems can help reduce overall energy demand and minimize the environmental impact of energy use.

6.2 Future Enhancements

As a future scope, the system can be further enhanced by incorporating features such as automatic load shedding during peak hours, integration with renewable energy sources, and remote monitoring and control of energy consumption. As such, the development and deployment of prepaid energy meters using Node MCU and PZEM004T offer a promising path towards a more sustainable energy.

REFERENCES

1. Smart Energy Metering and Power Theft Control using Arduino and GSM, 2nd International Conference for Convergence in Technology (I2CT) in 2017.
2. A Smart Prepaid Energy Metering System to Control Electricity Theft, International Conference on Power, Energy and Control (ICPEC) in 2013.
3. Development of an Internet Based Prepaid Energy Meter, Institute of Electrical and Electronics Engineers (IEEE) in 2017.
4. Arduino Based Smart Energy meter using GSM, Institute of Electrical and Electronics Engineers (IEEE) in 2019.
5. Smart Energy Meter, International Journal of Engineering Science and Computing (IJESC) in 2018.
6. Design and Development of Prepaid Energy Meter with Smart Monitoring System using IoT, International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET) in 2020.
7. IoT Based Prepaid Energy Meter with Smart Monitoring System, International Journal of Engineering Research and Technology (IJERT) in 2021.
8. Design and Implementation of a Smart Prepaid Energy Meter using IoT and Cloud Computing, in International Journal of Electrical and Computer Engineering (IJECE) in 2020.
9. An IoT-based Prepaid Energy Meter with Smart Monitoring System for Domestic Applications, Journal of Control and Instrumentation in 2021.
10. Design and Implementation of a Smart Prepaid Energy Meter using IoT and GSM Technologies, in the International Journal of Innovative Technology and Exploring Engineering (IJITEE) in 2021.

11. IoT-based Smart Prepaid Energy Meter with Automated Billing and Monitoring System, in Journal of Electrical Systems and Information Technology in 2021.
12. Design and Implementation of a Prepaid Energy Meter with Smart Monitoring System using MQTT in International Journal of Advanced Research in Computer Science and Electronics Engineering (IJARCSEE) in 2020.
13. IoT-based Smart Prepaid Energy Meter with Online Payment System, in International Journal of Innovative Technology and Creative Engineering (IJITCE) in 2021.
14. Smart Prepaid Energy Metering System using IoT and Raspberry Pi in Journal of Information Technology and Engineering in 2021.
15. IoT-based Smart Prepaid Energy Meter with Real-time Monitoring System in Journal of Electrical Engineering and Technology in 2021.

APPENDIXES

Source Code

```
#include<ESP8266WiFi.h
> #include<WiFiClient.h>
#include<ESP8266WebSe
rver.h> #include
<PZEM004Tv30.h>
#include
"FirebaseESP8266.h"
#include
"addons/TokenHelper.h"
#include
"addons/RTDBHelper.h"


#define RELAY1 D2
PZEM004Tv30 pzem(D3,D4); //RX/TX0
const char* ssid = "Home Lan (C32-9789707004)";//Replace with your network SSID
const char* password     = "Siva@2170";//Replace with your network
password//LiquidCrystal_I2C lcd(0x27, 16, 2);
float current =0.0;
float power =0.0;
float voltage =0.0;
float pf =0.0;
int frequency = 0;
float prepaidBalance = 0.0;
float rechargeAmount=0.0;
#define API_KEY "AIzaSyApIrxsSaL0aD2jHa31bwdMKiXeDgk7oNY"
//Without http:// or https:// schemes

#define DATABASE_URL "pzem004t-4138d-default-rtdb.firebaseio.com/";
FirebaseData fbdo;
```

```
FirebaseAuth
auth;
FirebaseConfi
g config; bool
signupOK =
false;
ESP8266WebServer
server(80); String page =
"";
void setup()
{
//lcd.init();
//lcd.backlight();
pinMode(RELAY1,
OUTPUT);
Serial.begin(115200);
WiFi.begin(ssid,
password);
while (WiFi.status() != WL_CONNECTED)
{
delay(500);
Serial.print(".");
}
Serial.println(WiFi.localIP
)); server.on("/", []()
{
page = "<html><head><title>Smart Energy Meter using IoT</title></head><style
type=\"text/css\">";
page += "table{border-collapse: collapse;}th {background-color: green ;color:
white;}table,td {border: 4px solid black;font-size: x-large;";

page += "text-align:center;border-style: groove;border-color:
rgb(255,0,0);}</style><body><center>";
```

```
page += "<h1>Smart Energy Meter using IoT</h1><br><br><table
style=\"width: 1200px;height: 450px;\"><tr>";

page +=
"<th>Parameters</th><th>Value</th><th>Units</th></tr><tr><td>VOLTAGE</td
><td>"

+String(voltage)+"</td><td>Volts</td></tr>";
page


+=

"<tr><td>CURRENT</td><td>"+String(current)+"</td><td>Amperes</td></tr><tr>
<td> Power Factor</td><td>"+String(pf)+"</td><td>XXXX</td>";

page+=

"<tr><td>POWER</td><td>"+String(power)+"</td><td>Watts</td></tr><tr>";
  page+=

"<tr><td>FREQUENCY</td><td>"+String(frequency)+"</td><td>HZ</td></tr><tr>";
  page+=

"</tr><tr><td>Balance</td><td>"+String(prepaidBalance,1)+"</td><td>RS</td></tr>";
page += "<html><head><title>Recharge </title></head><body><form action='/'
method='post'><label for='amount'>Enter Units required:</label><input type='text'
   id='amount'                              name='amount'><inp
                                            type='submit'
value='Recharge'></form></body></html>";
page += "<meta http-equiv=\"refresh\" content=\"4\">"; server.send(200,
"text/html", page);
});
server.begin();
config.api_key =
API_KEY;
config.database_
rl =
DATABASE_URL;
```

```
if
(Firebase.signUp(&c
onfig, &auth, "",
"")){
Serial.println("ok");
signupOK = true;
}
else{
Serial.printf("fail
d");
}
config.token_status_callback = tokenStatusCallback; //see addons/TokenHelper.h
Firebase.begin(&config, &auth);
Firebase.reconnectWiFi(true);
}
void loop()

{
server.begin();
server.handleClient();
float energyConsumption = (power / 1000) * 1.0; prepaidBalance -= energyConsumption;
if (prepaidBalance <= 0.0) {

Serial.println("Prepaid balance is low. Please
recharge."); Serial.print("Enter recharge amount (in
units): "); delay(1000);
while (Serial.available() == 0);
rechargeAmount =
Serial.parseFloat(); prepaidBalance
+= rechargeAmount;
Serial.print("Prepaid balance is now
"); Serial.print(prepaidBalance);
Serial.println(" units.");
```

```
digitalWrite(RELAY1, prepaidBalance > 0.0 ? HIGH : LOW);
}
else {
digitalWrite(RELAY1,
HIGH); voltage =
pzem.voltage(); current
pzem.current(); power
= pzem.power();
frequency =
pzem.frequency(); pf =
pzem.pf();
if (Firebase.ready() && signupOK ) {
if (Firebase.RTDB.setFloat(&fbdo, "pzem004t/voltage : ",voltage)){
Serial.print("voltage: ");
//lcd.println(voltage);
Serial.print(voltage);
}
else {
Serial.println("FAILED");
}
if (Firebase.RTDB.setFloat(&fbdo, "pzem004t/current : ", current)){
Serial.print("current: ");
//lcd.println(current);
Serial.print(current);
}
else {
Serial.println("FAILED");
}
if (Firebase.RTDB.setFloat(&fbdo, "pzem004t/power : ", power)){
Serial.print("power: ");
Serial.println(power);
}
```

```
else {
Serial.println("FAILED");
  }
if(Firebase.RTDB.setFloat(&fbdo, "pzem004t/frequency : ",
frequency)){ Serial.print("freqency: ");
Serial.println(frequency);
}
else { Serial.println("FAILED");
}
If(Firebase.RTDB.setFloat (&fbdo, "pzem004t/power factor: ", pf)){ Serial.print ("power
Factor: ");
Serial.println (pf);
}
else { Serial.println("FAILED");
}
if(Firebase.RTDB.setFloat(&fbdo, "pzem004t/balance : ", prepaid
Balance)){ Serial.print("Balance: ");
Serial.println(prepaid Balance);
}
else { Serial.println("FAILED”);}}}
```

LIST OF PUBLICATION

Dr.P.A.Gowrisankar, P.Dinesh Kumar, T.Jayaganth, P.Ravinthar, C.Sivasankar, V.Thirumalai, M K.Sanjay, published a paper on the title of "**SMART PREPAID ELECTRIC ENERGY METER MONITORING SYSTEM USING MACHINE LEARNING AND INTERNET OF THINGS(IoT)"** in **International Journal of Recent Trends in Multidisciplinary Research(IJRTMR)** May-June 2023, Vol3(3), 01-05, ISSN No: 2583 0368.