Walchand College of Engineering, Sangli.

(Government -Aided Autonomous Institute)

Department of
Electronics Engineering

A Mini Project 4 Report on

IoT-based Smart Electric Meter

Submitted by

Om Ajit Patil	2020BTEEN00058
Gauri Sanjay Salve	2020BTEEN00071
Sanket Bajrang Thorat	2020BTEEN00076

Under the Guidance of

Dr. S.G.Tamhankar

Electronics Engineering
Dept, WCE, Sangli.

Year 2022-2023

CERTIFICATE

Walchand College of Engineering, Sangli

(An Autonomous Institute)

DEPARTMENT OF ELECTRONICS ENGINEERING

This is to certify that, the project report entitled

"IoT-based Smart Electric Meter"

Submitted by

Om Ajit Patil	2020BTEEN00058
Gauri Sanjay Salve	2020BTEEN00071
Sanket Bajrang Thorat	2020BTEEN00076

is a record of student's own work carried out under my supervision and guidance during the academic year

2022-2023

Dr. S.G.Tamhankar
(Project Guide)

External Examiner

Declaration

We hereby declare that the work which is being presented in the project entitled,

"IoT-based Smart Electric Meter"

is an authentic record of our own work during 1st semester of 3rd year,

under the guidance of Dr. S.G.Tamhankar.

I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Name	**Roll No.**	**Sign**
Om Ajit Patil	2020BTEEN00058	
Gauri Sanjay Salve	2020BTEEN00071	
Sanket Bajrang Thorat	2020BTEEN00076	

Date: 22/05/22
Place: WCE,Sangli.

Acknowledgement

To turn out our idea of “IoT-based Smart Electric Meter” into reality we took several efforts. These efforts would have been meaningless if our guide Prof. Dr. S.G.Tamhankar had not guided us during difficulties and problems. We express a deep sense of gratitude towards all the Asst. Professors of the Electronics Department as they provided well support and guidance during the project. We are also grateful to the non- teaching staff as they provided all the required equipment and tools useful for the project. Finally, we wish gratefulness to all those people who contributed to our project directly or indirectly.

Abstract

The IoT-based smart electric meter is a revolutionary solution that integrates sensors, communication modules, and data analytics to provide real-time monitoring and accurate measurement of electricity consumption. It enables two-way communication between consumers and utility companies, empowering consumers to make informed decisions about energy usage and assisting utility companies in optimizing energy management and billing. This technology enhances efficiency, promotes energy conservation, and improves the overall reliability of electric metering systems.

CONTENTS

1. INTRODUCTION

An IoT-based Smart Electric Meter is a project that changes the way we measure and monitor our electricity consumption. This innovative device utilizes Internet of Things (IoT) technology to gather real-time data on electricity usage and transmit it wirelessly to a centralized data hub for analysis and monitoring. With the integration of advanced sensors, the Smart Electric Meter can provide valuable insights into energy consumption patterns, helping consumers make informed decisions about their energy usage and reducing their overall carbon footprint. The use of this technology can lead to increased energy efficiency and cost savings, making it an attractive option for both residential and commercial users. This introduction only scratches the surface of the benefits and potential applications of IoT-based Smart Electric Meters, which are quickly becoming an essential component of the smart grid infrastructure.

2. PROJECT IDEA

2.1 Problem statement

Design a system which is capable of solving problems faced by Primitive Smart Electric Meter.

2.2 The solution we propose

The IoT-based smart electric meter is a modern and innovative solution that leverages the power of the Internet of Things (IoT) to transform traditional electric metering systems. This advanced metering technology combines sensors, communication modules, and data analytics to provide real-time monitoring, accurate measurement, and efficient management of electricity consumption. By enabling two-way communication between consumers and utility companies, the smart electric meter empowers users to make informed decisions about their energy usage, promotes energy conservation, and facilitates effective billing and energy management practices. With its ability to provide real-time data and insights, the IoT-based smart electric meter enhances efficiency, reliability, and sustainability in the field of electric metering.

3. LITERATURE REVIEW

1. "Design and Implementation of IoT Based Smart Energy Meter" by T.S. Mahadeva Swamy. This paper presents an IoT-based smart energy meter that can monitor and control energy consumption. It includes the use of sensors to gather data on energy usage and the implementation of IoT technology to transmit the data wirelessly to a central server for analysis and monitoring.

2. "An IoT Based Smart Metering System for Efficient Energy Management" by Vishwas B. Lokare and Prashant R. Nair. This paper discusses the design and implementation of an IoT-based smart metering system that provides real-time monitoring of energy consumption. It includes the use of machine learning algorithms to analyze the data and provide insights into energy consumption patterns.

3. "Internet of Things (IoT) based Smart Grid: A Review" by Chander Prakash et al. This paper provides a comprehensive review of the IoTbased smart grid technology, including the implementation of smart meters for energy monitoring and management. It also discusses the challenges and opportunities for the integration of IoT technology in the smart grid infrastructure.

4. BLOCK DIAGRAM

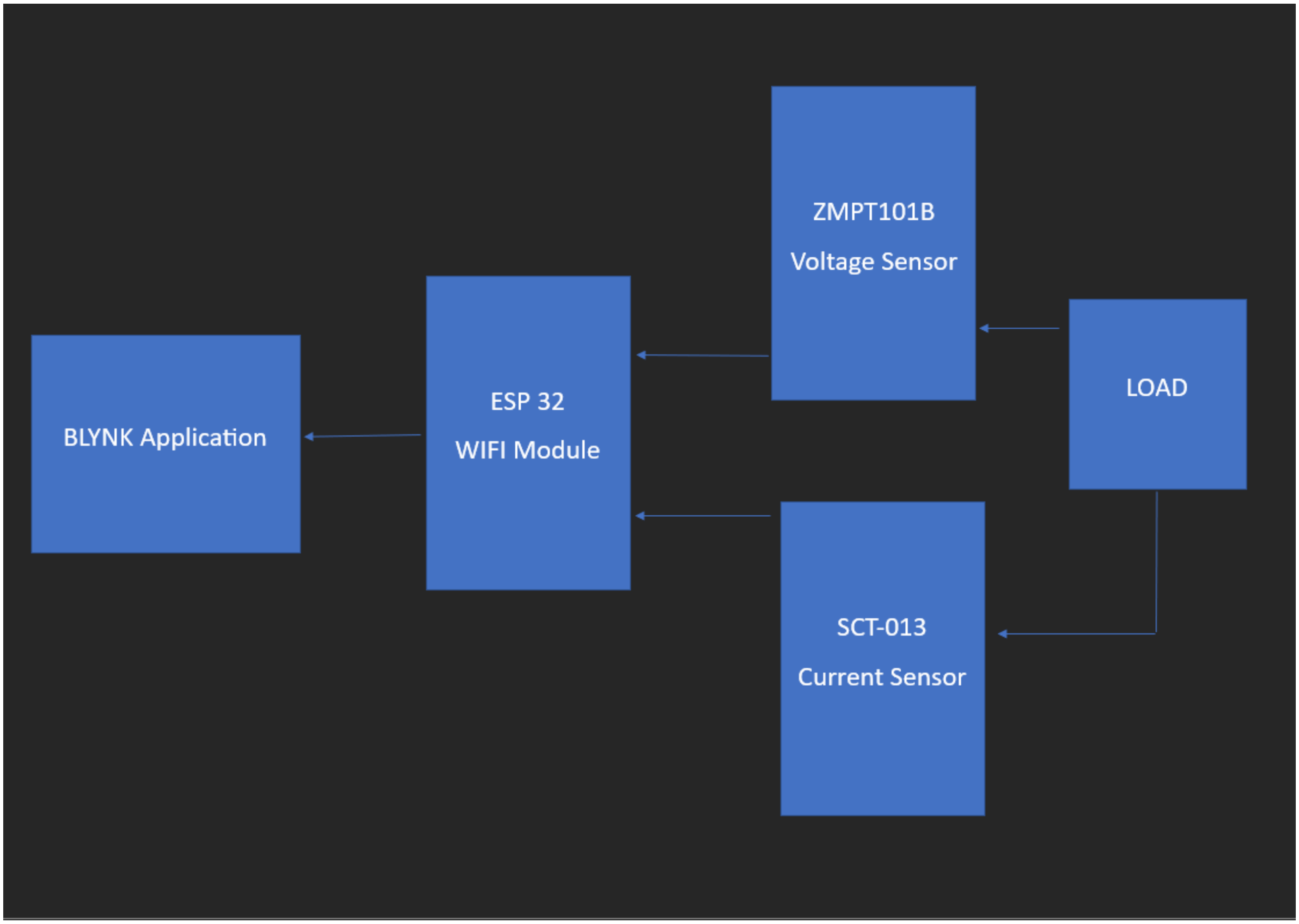


Fig. 1 Block diagram of system

5. System Architecture

5.1 ESP32 WIFI Module

5.1.1 Description:

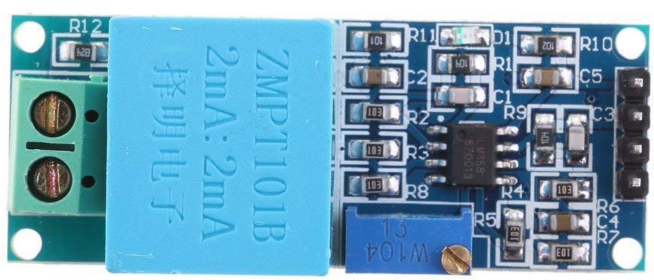
The ESP32 is a versatile and powerful WiFi module that combines robust processing capabilities with built-in wireless connectivity. It is widely used in various Internet of Things (IoT) applications, including home automation, industrial automation, and smart devices

5.1.2 Specifications of ESP32:

1. Microcontroller: The ESP32 module is powered by a dual-core Xtensa LX6 microprocessor, running at up to 240 MHz. It offers advanced processing capabilities, making it suitable for both compute-intensive and real-time applications.
2. Wireless Connectivity: The ESP32 module supports 2.4 GHz Wi-Fi, making it compatible with standard 802.11 b/g/n protocols. It also includes Bluetooth Low Energy (BLE) support, enabling seamless communication with other Bluetooth devices.
3. Memory: The module typically comes with a generous amount of memory for efficient data storage and program execution. It includes 520 KB of SRAM and 4 MB of flash memory, which is expandable using external SPI flash.

4. GPIO Pins: The ESP32 module offers a significant number of general-purpose input/output (GPIO) pins, allowing for easy interfacing with sensors, actuators, and other peripheral devices. The exact number of GPIO pins may vary depending on the specific ESP32 module variant.
5. Analog-to-Digital Converter (ADC): It features a 12-bit analog-to-digital converter, which enables precise measurement of analog signals from external sensors. This makes it suitable for applications that require accurate sensor readings.
6. Operating Voltage: The ESP32 module operates at a voltage range of 2.2V to 3.6V, making it compatible with a wide range of power supply options.
7. Development Environment: The ESP32 is supported by an extensive software development ecosystem, including the popular Arduino IDE, MicroPython, and the Espressif IoT Development Framework (ESP-IDF). This allows developers to choose the programming language and development environment that best suits their needs.

5.2 Voltage Sensor ZMPT101B



5.2.1 Description:

The ZMPT101B is a voltage transformer module specifically designed for measuring alternating current (AC) voltage. It is commonly used in applications where precise voltage monitoring is required. The ZMPT101B is a compact and easy-to-use voltage transformer module. It is designed to convert high voltage AC signals into lower voltage signals that are suitable for measurement or processing by microcontrollers or other electronic devices. The module features high accuracy and reliability, making it suitable for various AC voltage monitoring applications.

5.2.2 Specifications of ZMPT101B:

1. Input Voltage Range: The ZMPT101B module is specifically designed to measure AC voltage in the range of 0-250V. It can accurately convert high AC voltages into low voltage signals for measurement or further processing.
2. Output Voltage: The module provides a low voltage output signal that is directly proportional to the input AC voltage. The output voltage is typically around 0-5V or 0-3.3V, making it compatible with most microcontrollers and electronic devices.
3. Output Interface: The ZMPT101B module generally provides an analog output, which can be connected to an analog-to-digital converter (ADC) input of a microcontroller or used for other analog signal processing purposes.
4. Accuracy: The module offers good accuracy for voltage measurements, typically within a few percentage points. However, the exact accuracy may depend on factors such as calibration and the quality of the specific module.
5. Frequency Range: The ZMPT101B module is designed to work with AC voltages in the frequency range of 50Hz to 60Hz, which covers the standard power supply frequency used in most countries.
6. Isolation: The ZMPT101B module is not electrically isolated, which means it does not provide galvanic isolation between the input and output sides. Therefore, appropriate precautions should be taken to ensure proper safety measures are in place when using this module.
7. Size and Form Factor: The ZMPT101B module is typically compact and has a standardized form factor, making it easy to integrate into various electronic projects. It often comes in a small PCB module with labeled input and output terminals for easy connection.

   Overall, the ZMPT101B voltage transformer module is a reliable and accurate solution for measuring AC voltages in a variety of applications. Its compact size, compatibility with microcontrollers, and ease of use make it popular for projects involving AC voltage monitoring, power analysis, and energy management.

5.3 Current Sensor SCT-013-030:

5.3.1 Description:

The SCT-013-030 is a non-invasive current sensor commonly used for measuring alternating current (AC) in various applications. It offers a convenient and safe method for monitoring current without the need for direct electrical contact. The SCT-013-030 is a split-core current transformer designed for measuring AC current flowing through a conductor. Its split-core design allows for easy installation without the need to disconnect the current-carrying wire. The sensor detects the magnetic field generated by the current and provides an output signal proportional to the measured current, enabling accurate current monitoring in a non-intrusive manner.

5.3.2 Specifications of Current Sensor SCT-013-030:

1. Current Rating: The SCT-013-030 is designed to measure alternating currents up to 30 Amperes. It can accurately sense current flow within this range.
2. Output Signal: The sensor provides an analog output signal that is proportional to the measured current. The output is typically in the form of an AC voltage or current, depending on the specific model and configuration.
3. Frequency Range: The SCT-013-030 is designed to work with AC currents in the frequency range of 50Hz to 60Hz, which is commonly found in power systems worldwide.

4. Non-Invasive Design: The split-core design of the sensor allows for easy installation without the need for interrupting the circuit or physically touching the current-carrying wire. This feature enhances safety and simplifies installation.
5. Turns Ratio: The SCT-013-030 has a specific turns ratio, which determines the output signal's scaling factor. It is typically mentioned in the datasheet of the sensor and may vary depending on the specific model.
6. Output Interface: The sensor usually provides an analog output that can be connected to an analog-to-digital converter (ADC) input of a microcontroller or other measuring devices for further processing.
7. Accuracy: The accuracy of the SCT-013-030 depends on various factors, including the calibration and the quality of the specific sensor. It is advisable to consult the sensor's datasheet or specifications to understand its accuracy and potential limitations.
8. Size and Form Factor: The SCT-013-030 comes in a split-core design, allowing it to be easily clamped around the current-carrying wire. The sensor is typically compact and lightweight, making it suitable for a wide range of applications.

6. WORKING

- A load like a bulb is been connected to the AC voltage source.
- The SCT-013 current sensor will measure the current flowing through the bulb.
- ZMPT101B Voltage sensor will calculate AC voltage.
- The calculated values of current and voltage are then sent to ESP32 wifi module
- The power consumed by the load will be calculated by the ESP32 module in terms of watt and KWh.
- This data will be sent to the Blynk Iot Application as well as the serial monitor.
- As it is IoT based project, the user need not to be connected to same Wifi network as that of the Esp32.

7. OUTCOMES

1. Development of an IoT-based smart electricity meter that can measure energy consumption in real-time and enable remote monitoring and control of appliances.

2. Development of a user-friendly interface that displays real-time energy consumption data and provides suggestions for energy-saving.

3. Evaluation of the effectiveness of the smart meter in reducing energy consumption and its potential for cost savings.

8. CONCLUSION

The IoT-based smart electric meter represents a significant advancement in the field of electric metering. By integrating sensors, communication modules, and data analytics, this technology enables real-time monitoring, accurate measurement, and efficient management of electricity consumption. The two-way communication between consumers and utility companies empowers users to make informed decisions about energy usage, promotes energy conservation, and facilitates effective billing and energy management practices. The smart electric meter contributes to enhanced efficiency, reliability, and sustainability in the realm of electric metering. With its ability to provide real-time data and insights, the IoT-based smart electric meter plays a pivotal role in shaping a more intelligent and connected electrical grid for a greener and more sustainable future.

9. FUTURE SCOPE

1. Renewable Energy Integration: The smart electric meter can play a crucial role in integrating renewable energy sources, such as solar panels and wind turbines, into the electrical grid. By providing real-time data on energy generation and consumption, the meter can facilitate the optimal utilization of renewable energy and enable seamless integration with the existing grid infrastructure.

2. Time-of-Use Pricing: Implementing time-of-use pricing models with the smart electric meter allows for dynamic pricing based on peak and off-peak electricity demand. This incentivizes consumers to shift their energy usage to off-peak hours, promoting energy efficiency and reducing strain on the grid during high-demand periods.

3. Grid Security: With the increasing threat of cyber attacks on critical infrastructure, ensuring the security of the electrical grid becomes crucial. The smart electric meter can incorporate advanced security features and encryption protocols to safeguard against unauthorized access and potential vulnerabilities, enhancing the overall security of the grid.

4. Demand Response Programs: The smart electric meter can enable effective demand response programs by providing real-time data on energy consumption. This allows utility companies to incentivize consumers to reduce their electricity usage during peak demand periods, thereby improving grid stability and reducing the need for additional generation capacity.

10. COST ESTIMATION

Sr No.	Component	Quantity	Cost
1.	ESP 32 WIFI Module	1	450
2.	Voltage Sensor ZMPT101B	1	140
3.	Current Sensor SCT-013-030	1	350
4.	Bulb	1	100
5.	Resistor	2	20
6.	Capacitor	1	60
7.	Jumper wires	20	60
		TOTAL =	₹1180/-

11. References

i. "Design and implementation of IoT based Smart Energy Meter" by T.S. Mahadeva Swamy, D. Dharani, and K. Gnanambal. International Journal of Pure and Applied Mathematics, vol. 118, no. 24, pp. 495- 503, 2018.

ii. "IoT-Based Smart Energy Meter for Efficient Power Management" by A. M. Ahmed, A. A. Almohammadi, and M. H. Almohammadi. International Journal of Advanced Computer Science and Applications, vol. 10, no. 3, pp. 390-396, 2019.

iii. "IoT-Based Smart Energy Meter for Efficient Power Management" by A. M. Ahmed, A. A. Almohammadi, and M. H. Almohammadi. International Journal of Advanced Computer Science and Applications, vol. 10, no. 3, pp. 390-396, 2019.

The references provided offer a comprehensive overview of the design and implementation of IoT-based Smart Electric Meters for energy management and monitoring. They cover topics such as the integration of advanced sensors, the use of machine learning algorithms for data analysis, and the implementation of IoT technology for real-time data transmission and monitoring.