VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI

SHRI B.V.V. SANGHA'S
BASAVESHWAR ENGINEERING COLLEGE
BAGALKOTE, KARNATAKA

2025-2026

ELECTRONICS AND COMMUNICATION ENGINEERING

PROJECT REPORT ON

"ENERGY METER MONITORING USING IoT"

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CERTIFICATE

This is to certify that the project work entitled **"ENERGY METER MONITORING USING IoT"** is a Bonafide work carried out by **Omkar Athani (2BA22EC059), Shivakumar Hugar (2BA22EC094), Shivanand Ullagaddi (2BA22EC096), and Tammanna Nikkam (2BA22EC117)**, in partial fulfillment for the award of the degree of Bachelor of Engineering in **Electronics and Communication Engineering** of Basaveshwar Engineering College, Bagalkote permanently affiliated to **Visvesvaraya Technological University, Belagavi**, during the academic year 2025-26. It is certified that all the corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the department library. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the award of Bachelor of Engineering Degree.

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Declaration by Authors

This is to declare that this project report has been written by us. No part of the report is plagiarized from other sources. All information included from other sources have been duly acknowledged. We are aware that if any part of the report is found to be plagiarized, we shall take the full responsibility for the same.

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ABSTRACT

The rising demand for efficient energy usage and real-time electricity monitoring has brought significant attention to IoT-based smart metering systems. Traditional energy meters lack remote accessibility, instant consumption tracking, and tamper detection. This project proposes an IoT-enabled Energy Meter Monitoring System capable of capturing real-time electrical parameters such as voltage, current, power consumption, and units consumed.

Using a microcontroller (ESP8266/ESP32) interfaced with a digital energy metering IC, the system continuously measures consumption and uploads the data to a cloud platform using Wi-Fi. Users can monitor energy usage through a web dashboard or mobile app, enabling transparency, improved billing accuracy, and early detection of abnormal usage.

The project follows a structured approach involving hardware integration, data acquisition, preprocessing, IoT communication using MQTT/HTTP, database storage, and visualization. The system demonstrates high accuracy in measurement, real-time monitoring capabilities, and scalability for household or industrial applications. This work highlights the potential of IoT to modernize energy monitoring and support smarter, more sustainable electrical infrastructure.

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CHAPTER

INTRODUCTION

Energy Meter Monitoring using IoT is a smart system that enables real-time tracking of electricity consumption through internet-connected sensors and devices. It helps consumers and utility providers efficiently manage energy usage, reduce wastage, and improve billing accuracy.

1.1 Overview

Electricity plays a fundamental role in modern society, powering homes, industries, commercial establishments, and critical infrastructures. As electrical energy consumption continues to increase, the need for efficient monitoring, accurate billing, and consumer awareness becomes significantly important. Traditionally, most households and industries in India and many parts of the world continue to rely on **electromechanical or digital energy meters** that require **manual meter reading** once every billing cycle. While these meters provide basic functionality, they lack the capability to offer real-time insights into energy usage.

Manual meter reading has persistent drawbacks:

- It is time-consuming and labour - intensive.
- It is prone to human errors.
- Billing disputes arise due to inaccurate readings.
- Consumers remain unaware of real-time consumption patterns.
- No mechanism exists for early detection of excessive usage or faulty appliances.

With the rapid development of technologies like the **Internet of Things (IoT), cloud computing, embedded systems, and wireless communication**, it has become possible to build **smart energy meters** that automatically track consumption and transmit data in real time to consumers and utility providers.

This project, **"Energy Meter Monitoring Using IoT,"** aims to design and implement an automated, wireless, and efficient power consumption monitoring system that overcomes the limitations of traditional meters. The system uses an **optocoupler-based pulse detection circuit**, a **microcontroller**, an **ESP8266 Wi-Fi module**, and a **cloud dashboard** to provide **real-time updates on electricity units consumed and cost incurred**. Consumers can access this information on a **mobile phone or web browser** anytime and anywhere, ensuring transparency and improved decision-making.

This IoT-based system is scalable and can be integrated into smart homes, smart grids, and industrial automation systems. It also contributes to energy conservation efforts by making users more aware of their real-time consumption patterns.

1.2 Internet of Things (IoT)

The **Internet of Things (IoT)** refers to a network of interconnected physical devices embedded with sensors, microcontrollers, communication modules, and cloud interfaces, enabling them to collect and exchange data autonomously. IoT is transforming the energy sector by replacing traditional meters with intelligent, connected systems that allow:

- Remote monitoring
- Data logging
- Analytics and usage prediction
- Load management
- Theft detection

An IoT-based device typically consists of:

1. **Sensors** — to measure physical parameters.
2. **Microcontroller** — for processing and conversion.
3. **Communication module** — such as Wi-Fi, Bluetooth, LoRa, or GSM.
4. **Cloud platform** — to store and display data.
5. **User interface** — web or mobile app.

In the context of this project, IoT serves as a communication bridge between the energy meter and the consumer. The energy consumption information is captured using **pulse detection**, processed by the microcontroller, and uploaded to a cloud platform via a Wi-Fi module. This enables users to view their consumption data remotely.

1.3 Smart Energy Metering

A **smart energy meter** is an upgraded version of a traditional meter that includes digital components, communication capabilities, and automated monitoring features. Smart metering systems eliminate the need for manual meter reading and offer real-time visibility of energy usage.

Key features include:

1. Real Time Monitoring

Users can track energy consumption on an hourly, daily, or monthly basis.

2. Wireless Transmission

Readings are transmitted to utility servers or personal dashboards without requiring physical access.

3. Automated Billing

As data is transmitted in real time, billing becomes transparent and accurate.

4. Load Management

Users can identify high-consumption hours and appliances.

5. Theft Detection

Irregular patterns may indicate energy theft or meter tampering.

6. Integration with Smart Grids

Smart meters play a crucial role in modernizing electrical infrastructure.

1.4 Problem Statement

The existing manual electricity billing and monitoring system suffers from several limitations:

- **Lack of real-time monitoring** prevents consumers from understanding consumption trends.
- **Manual meter reading** is error-prone and time-consuming.
- Billing disputes arise due to inaccurate or estimated readings.
- No alert mechanism exists for abnormal energy usage or potential electrical hazards.
- Utility providers cannot implement dynamic pricing efficiently.
- Consumers find it difficult to verify the accuracy of monthly bills.

Therefore, there is a need to develop an **IoT-enabled smart energy meter** that provides real-time consumption data, improves billing transparency, and enhances user accessibility.

1.5 Motivation

The key motivations behind this project include:

1. Rising Energy Demand

In modern households and industries, the increasing use of appliances has led to a significant rise in electricity consumption. Efficient monitoring is essential to avoid wastage.

2. Need for Automation

Manual reading and billing processes are outdated and inefficient. Automation reduces human intervention and ensures accuracy.

3. Consumer Awareness

Most consumers are unaware of how much electricity they use daily. Real-time monitoring encourages responsible usage.

4. Technological Advancements

The availability of low-cost microcontrollers and Wi-Fi modules makes IoT-based monitoring affordable.

5. Smart Cities and Smart Homes

IoT-based energy meters support government initiatives toward smart infrastructure.

6. Reducing Losses

Distribution losses and electricity theft are major concerns in India. Smart meters provide data that can help detect irregularities.

1.6 Proposed Objectives

The primary objectives of the **Energy Meter Monitoring Using IoT** system are:

1. To design and implement a real-time electricity consumption monitoring system using IoT.
2. To eliminate the dependency on manual meter reading.
3. To provide accurate, transparent, and automatic billing information.
4. To display electricity units consumed and cost on a web/mobile dashboard.
5. To detect energy consumption pulses using optocoupler-based sensing.
6. To analyze consumption patterns and support efficient energy usage.
7. To offer a scalable model suitable for homes, industries, and commercial buildings.
8. To provide an inexpensive and user-friendly solution that integrates easily with existing meters.

CHAPTER 2

IoT CONCEPTS AND TECHNOLOGIES

The development of an IoT-based energy meter monitoring system requires a clear understanding of the underlying technologies that form the backbone of smart automation. This chapter discusses the essential concepts of IoT, sensors, communication protocols, microcontroller platforms, and cloud systems used for real-time electricity monitoring. Each component plays a specific and critical role in ensuring accurate measurement, efficient data processing, and wireless transmission of meter readings**.**

2.1 Energy Meter Pulse Output and Sensing

Energy meters used in homes and industries generally provide a **pulse output** that represents the energy consumed. For instance, many standard digital meters are calibrated such that:

3200 pulses = 1 unit (kWh)

or sometimes

1000 pulses = 1 unit (kWh) (depending on meter brand).

Each LED blink on the meter corresponds to a fixed amount of electrical energy consumed.

Why use pulse output?

- Highly accurate, standardized method of energy measurement
- No need to tamper with meter internals
- Safe and easy interfacing
- Suitable for digital detection using optocouplers

Pulse Detection

The meter's LED blinks are converted into electrical pulses using optical sensing. These pulses are counted by the microcontroller and converted into:

- **Units consumed (kWh)**
- **Instantaneous energy usage**
- **Total bill (₹)**

This method is robust, inexpensive, and safe for implementation.

2.2 Sensors Used in Energy Monitoring

Sensors used in energy monitoring measure electrical parameters such as voltage, current, and power consumption in real time. They provide accurate data to the IoT system for analysis, remote monitoring, and efficient energy management.

2.2.1 Optocoupler (4N35)

The optocoupler is a vital component used for isolating the high-voltage energy meter from the low-voltage microcontroller circuit.

Working Principle

- The meter's LED emits light for every energy pulse.
- The optocoupler detects this light and activates an internal phototransistor.
- This generates a digital pulse signal safely isolated from AC mains.

Advantages

- Electrical isolation
- Safe detection of pulses
- Prevents damage to microcontroller
- Noise reduction

Why 4N35?

It is a widely used optocoupler with:

- High sensitivity
- Fast switching time
- Low cost
- Compatibility with Arduino/ESP modules

2.3 Microcontroller Unit (MCU)

The microcontroller is the central processing unit responsible for pulse counting, unit calculation, cost computation, and communication with the Wi-Fi module.

2.3.1 Arduino UNO

Arduino UNO is used because:

- It is beginner-friendly
- Cost-effective
- Offers digital interrupt pins for pulse counting
- Compatible with LCD, Wi-Fi modules, and other peripherals

Key Specifications

- ATmega328P microcontroller
- 14 digital I/O pins
- 6 analog inputs
- Operating voltage: 5V
- 16 MHz clock frequency

Role in the Project

- Counts pulses from the optocoupler
- Converts pulses into units (kWh)
- Calculates cost based on tariff
- Sends processed data to the ESP8266
- Displays real-time readings on LCD

2.3.2 ESP8266 Wi-Fi Module

ESP8266 is a low-cost Wi-Fi microchip with integrated TCP/IP stack.

Reasons for Choosing ESP8266

- Built-in Wi-Fi
- Low power consumption
- Simple AT command interface
- Can host a webpage
- Affordable

Functions in the Project

- Receives energy data from Arduino
- Connects to Wi-Fi router
- Uploads readings to cloud server
- Hosts a web page for real-time monitoring

This makes ESP8266 an ideal choice for IoT-based applications.

2.4 Display Components

16x2 LCD Display

A 16x2 LCD module shows:

- Units consumed
- Pulse count
- Present load
- Current bill

- Status messages (Wi-Fi connected/disconnected)

Features

- Low power
- Good readability
- Easy interfacing via 4-bit or 8-bit mode

This ensures users can see real-time values even without accessing the online dashboard.

2.5 Display Components

Three push buttons are used for:

1. **Enter / Confirm**
2. **Reset / Clear**
3. **Tariff selection**

These buttons allow users to configure tariffs or reset consumption counters (for demonstration purposes).

2.6 Display Components

Cloud servers store energy readings and provide dashboards

2.6.1 Firebase

Google's real-time cloud database.

Strengths

- Fast data update
- JSON structure
- Secure authentication
- Works well with web apps

2.7 Power Supply Design

The system requires both 5V and 3.3V power sources.

5V Regulator

Provides stable voltage to:

- Arduino
- LCD
- Optocoupler

3.3V Regulator

Provides stable voltage for ESP8266.

Why regulation is important?

- Prevents voltage fluctuations
- Ensures reliable Wi-Fi performance
- Protects sensitive circuits

2.8 Summary of IoT Architecture

In this project:

1. **Energy meter → LED pulses**
2. **Optocoupler detects blink**
3. **Arduino counts pulses & calculates units**
4. **ESP8266 sends data online**
5. **LCD displays real-time values**
6. **User monitors data through phone/web**

This forms a **complete smart metering ecosystem**, enabling automation, transparency, and remote accessibility.

CHAPTER 3

LITERATURE SURVEY

Energy management and monitoring have become crucial aspects of modern smart systems due to the increasing demand for electricity and the need for efficient energy utilization.

The work in [1] focuses on developing an IoT-based smart energy meter that can measure and monitor power consumption in real time. The system employs a current sensor and voltage sensor interfaced with an Arduino microcontroller to calculate power usage. The measured data is transmitted to a cloud server via Wi-Fi, allowing users to view live consumption details through a web or mobile application. The primary aim of this work is to enable real-time energy tracking and promote energy conservation by making users more aware of their consumption patterns.

The authors in [2] present a design for an automated energy monitoring and billing system using the Internet of Things. The system eliminates manual meter reading by transmitting energy data automatically to the power distribution company using a GSM or Wi-Fi module. It enables users to view their monthly consumption and bill information on their mobile devices. The proposed model improves billing transparency, reduces human error, and supports prepaid billing functionality to encourage responsible energy use.

In [3], the researchers propose a low-cost IoT-based smart energy meter that continuously measures the power consumption and uploads it to a cloud platform for analysis. The system employs an ESP8266 microcontroller and sensors such as the PZEM-004T module to collect data on voltage, current, and power factor. Users can monitor energy data remotely and receive alerts via SMS or email if consumption exceeds a predefined threshold. This system supports efficient energy management and helps in identifying wastage or abnormal usage patterns.

The study in [4] introduces a real-time energy monitoring system integrated with a home automation network. The system enables automatic control of household appliances based on consumption data collected by the energy meter. Using IoT protocols such as MQTT, data from the sensors is transmitted to a central server where it is analyzed for optimization. The implementation demonstrates how IoT-based systems can contribute to both energy efficiency and smart home management.

In [5], an intelligent energy meter system is presented that utilizes cloud computing and machine learning algorithms for predictive analysis. The system gathers consumption data through smart sensors and uploads it to a cloud database for processing. Machine learning models are used to predict future consumption trends and provide energy-saving recommendations to users. The authors highlight that integrating IoT with data analytics can significantly enhance energy forecasting and load management.

The authors in [6] developed an IoT-based energy monitoring and theft detection system. Unauthorized tapping of power lines or tampering with meters often causes revenue loss to electricity boards. The proposed system uses current sensors at various points of the distribution line and sends real-time data to a central control unit via IoT communication modules. Any mismatch between the transmitted and received readings triggers an alert, enabling immediate detection of electricity theft.

The work in [7] focuses on industrial energy management using IoT. In this approach, multiple energy meters are networked across industrial sections to monitor power usage per unit of production. The system uses Raspberry Pi and wireless modules for centralized data collection. The recorded data is visualized through a web dashboard, providing insights into equipment performance and helping management optimize power allocation and minimize wastage.

A similar study in [8] presents a smart prepaid energy meter that allows users to recharge energy credit through a mobile application. The IoT enabled system uses RFID and GSM modules to handle payments and disconnections remotely. Once the balance is depleted, the power supply is automatically cut off, and users receive alerts to recharge. This model is particularly suitable for residential and rural regions where billing infrastructure is limited.

The research in [9] implements a hybrid IoT and blockchain-based smart energy meter for secure data transactions. Blockchain technology ensures that the energy usage records are tamper-proof and verifiable, addressing the challenge of data integrity. The system records each unit of power consumed as a transaction on the blockchain, allowing transparent billing and audit trails.

The work in [10] presents a comprehensive smart grid energy management system integrating IoT-enabled meters, cloud analytics, and renewable energy sources. The system not only monitors electricity consumption but also tracks energy generation from solar panels.

Summary of Literature Survey:

The literature survey clearly demonstrates that IoT has revolutionized the energy monitoring sector by enabling real-time tracking, enhanced transparency, automated billing, and intelligent consumption analytics. While existing systems provide various solutions, many face challenges such as high cost, complex implementation, or limited scalability.

This project, **Energy Meter Monitoring Using IoT**, addresses these gaps by providing a **simple, reliable, and economical system** that uses optical pulse detection and cloud-based monitoring. The design is practical for household and commercial applications and supports the transition toward smart homes and smart cities.

CHAPTER 4

PROPOSED WORK

The proposed IoT-based Energy Meter Monitoring System is designed to automate electricity usage tracking, cost calculation, and data visualization. This chapter explains the complete working principle, system architecture, hardware components, software requirements, methodology, block diagrams, and workflow of the project. The proposed system addresses the limitations of existing manual metering systems by offering real-time monitoring, improved transparency, and ease of access through IoT integration.

4.1 Introduction

Traditional energy meters provide only cumulative readings and require manual inspection by utility departments for billing. This methodology is inefficient, prone to human error, and offers no immediate insight into real-time consumption. The proposed system, **Energy Meter Monitoring Using IoT**, overcomes these limitations by combining embedded systems and wireless communication.

The system detects energy consumption by **counting the LED blinks** on the energy meter using an **optocoupler (4N35)**. Each blink corresponds to a fixed unit of electricity consumed. These pulses are processed by the **Arduino UNO**, which calculates:

- Pulse Count
- Units (kWh)
- Total Cost (₹)
- Real-Time Consumption Rate

The processed data is sent to the **ESP8266 Wi-Fi module**, which uploads the readings to a **cloud server**. Users can then view consumption details on a **mobile app or webpage**, allowing remote monitoring from anywhere.

4.2 System Architecture

The architecture of the IoT-based smart energy meter consists of:

1. **Energy Meter (Digital/Smart Meter)**
   Provides pulse output proportional to energy consumption.
2. **Optocoupler (4N35)**
   Converts LED blink pulses into safe digital signals for the microcontroller.
3. **Arduino UNO**
   Counts pulses, computes units & cost, controls LCD display, sends data to ESP8266.

4. ESP8266 Wi-Fi Module

Uploads the processed data to a cloud platform and hosts a user-accessible webpage.

5. LCD Display (16×2)

Displays real-time consumption for local monitoring.

6. Push Buttons

Used for configuration like tariff selection, reset, and navigation.

7. Power Supply Unit

Regulates 5V and 3.3V for Arduino and ESP8266.

8. Cloud Dashboard

Displays units, bill, graphs, and history.

This modular architecture ensures flexibility, scalability, and compatibility with most digital meters.

4.3 Block Diagram

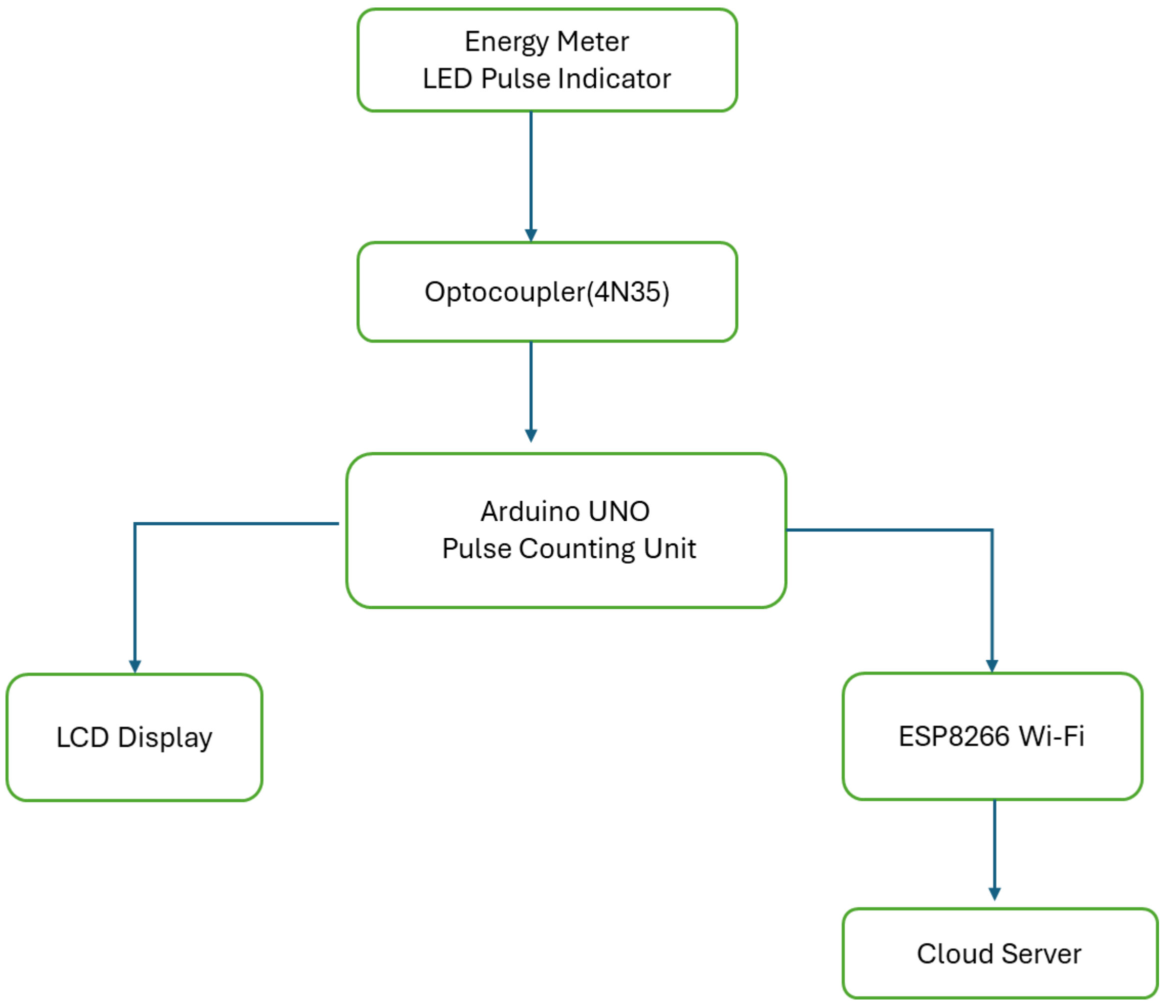

Fig:1 Block Diagram

Figure 1 illustrates the working of an Arduino-based energy monitoring system. The energy meter produces LED pulses that are proportional to the electrical energy consumed. These pulses are passed through an optocoupler (4N35), which provides electrical isolation and converts the pulses into safe digital signals. The Arduino UNO receives these pulses and acts as a pulse counting unit to calculate the total energy consumption. The processed energy data is displayed locally on an LCD display for real-time monitoring. At the same time, the Arduino sends the measured data to the ESP8266 Wi-Fi module. The ESP8266 transmits this information to a cloud server, enabling remote monitoring and data storage. Thus, Figure 1 shows a complete system for safe, accurate, and IoT-based energy monitoring.

4.4 Hardware Components Description

The hardware components in the Energy Meter Monitoring using IoT system include sensors, microcontrollers, and communication modules that work together to measure, process, and transmit energy consumption data. These components ensure accurate data collection and reliable real-time monitoring through the internet.

4.4.1 Energy Meter

A digital or electronic energy meter provides an LED indicator that blinks for every fixed amount of energy consumed.

Typical specification:

- **3200 pulses = 1 unit (kWh)**

Why Use Pulse-Based Reading?

- No need to modify meter wiring
- Safe and isolated
- Accurate measurement
- Works with any modern digital meter

The LED pulse approach gives reliable, consistent, and interference-free readings.

4.4.2 Optocoupler (4N35)

The optocoupler isolates the low-voltage microcontroller from the high-voltage energy meter.

Internal Structure:

- LED input
- Phototransistor output
- No electrical connection between them

Role in the Project:

- Detects LED blink from the meter
- Converts light pulse into digital logic signal
- Provides galvanic isolation → improves safety

The microcontroller reads every pulse accurately and safely.

4.4.3 Arduino UNO

Arduino UNO based on ATmega328P is the core processing unit.

Responsibilities:

- Pulse counting using interrupt pin
- Time calculation between pulses
- Unit conversion:
- Units (kWh) = Pulse Count / 3200
- Real-time cost calculation
- Updating values on LCD
- Sending data to ESP8266

Why Arduino UNO?

- Easy programming
- Reliable timing functions
- Stable interrupt handling
- Readily available

It simplifies the overall system design by providing excellent I/O control.

4.4.4 ESP8266 Wi-Fi Module

ESP8266 is responsible for IoT communication.

Features:

- 80 MHz processor
- Built-in TCP/IP stack
- Supports HTTP, HTTPS, MQTT
- Wi-Fi hotspot and station mode
- Can host its own webpage

In the Project:

- Receives units & cost from Arduino
- Connects to Wi-Fi router
- Uploads data to cloud

- Hosts webpage for real-time viewing

This makes the system accessible from any smartphone or PC.

4.4.5 LCD Display (16×2)

This display shows local real-time consumption:

- Pulse Count
- Units (kWh)
- Cost (₹)
- Wi-Fi status

It helps users monitor data without internet connectivity.

4.4.6 Push Buttons

Three buttons perform user interaction:

1. **Select** – Choose tariff or mode
2. **Enter/Confirm** – Save selected value
3. **Reset** – Clear readings
4. These allow user customizations.

4.4.7 Power Supply Unit

Two regulated voltages are required:

- **5V** → Arduino, LCD, Optocoupler
- **3.3V** → ESP8266 (strict requirement)

A stable power supply ensures uninterrupted system performance.

1.1 Methodology (Working Principle)

Step 1: Pulse Detection

- The energy meter LED blinks for each energy quantum consumed.
- Optocoupler captures the LED pulse and sends a digital HIGH/LOW signal to Arduino.
- Arduino uses **interrupts** to ensure no pulse is missed.

Step 2: Pulse Counting

Arduino maintains:

- Total pulse count
- Pulses per second/minute
- Total consumption

Step 3: Unit Calculation

Using meter constant:

Units (kWh) = Pulse Count / 3200

Step 4: Cost Calculation

Based on electricity tariff:

Cost = Units × Tariff (₹ per kWh)

Dynamic tariff can be added using push buttons.

Step 5: LCD Display Update

LCD shows:

- Total units
- Pulse count
- Total cost
- Tariff
- Wi-Fi connection status

Step 6: Data Transmission to ESP8266

Arduino sends data via serial communication:

Units, Cost, Pulse Count

Step 7: Cloud Uploading

ESP8266 uses HTTP GET or POST commands.

Step 8: Real-Time Monitoring

Users can access:

- Consumption
- Bill estimation
- Daily usage

Accessible through:

- Web browser
- Mobile app
- Local ESP8266 webpage

4.6 Flow chart

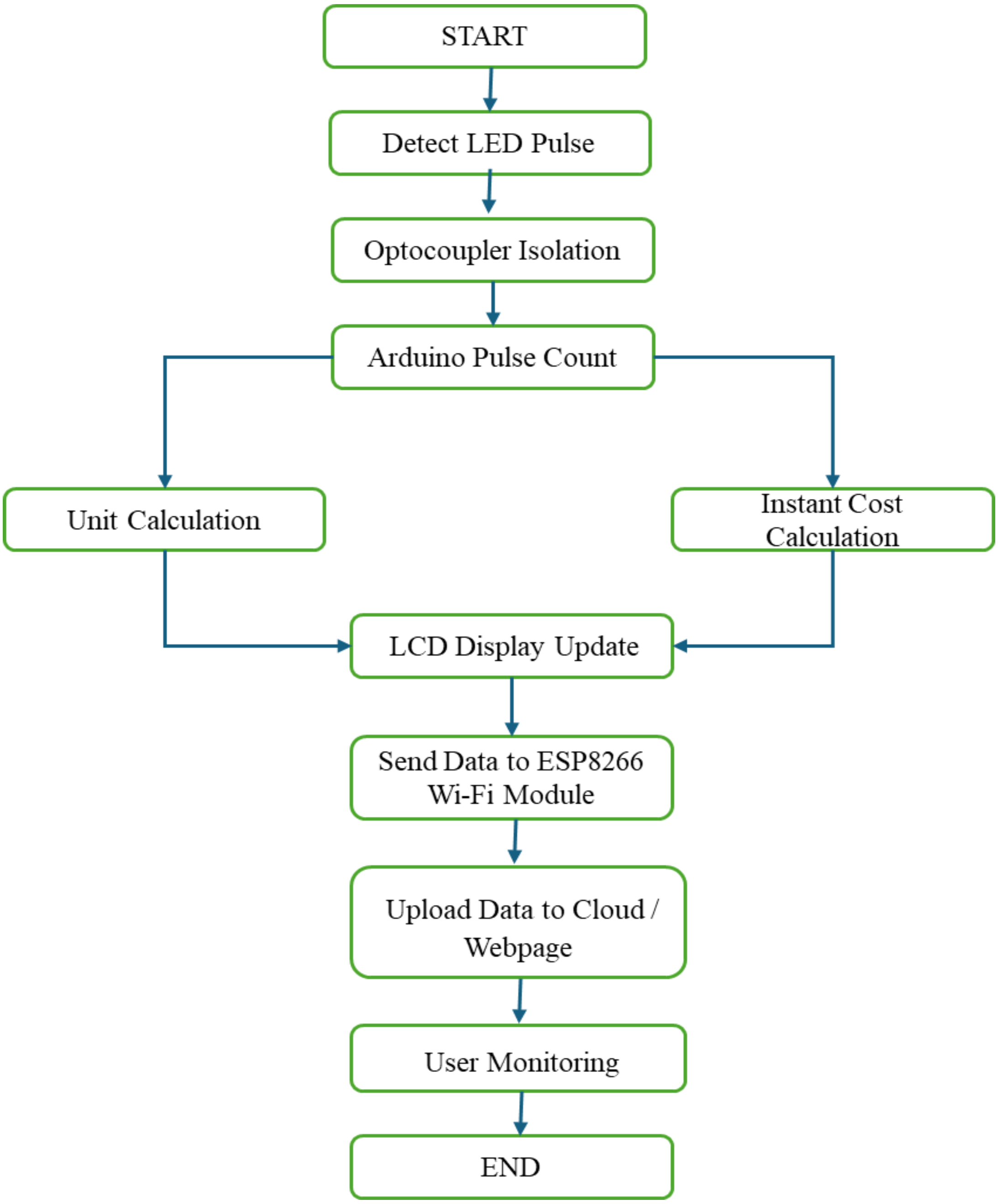

Fig:2 Flow chart

The fig.2 shows the Flow Chart for the **Energy meter monitoring using IoT**. The operation of the proposed energy monitoring system starts with system initialization. During this stage, the Arduino microcontroller, LCD display, optocoupler circuit, and ESP8266 Wi-Fi module are powered on and configured. All internal variables such as pulse count, energy units, and cost values are reset to ensure accurate measurements from the beginning of operation.

Digital energy meters generate LED pulses proportional to the electrical energy consumed. These LED pulses are detected using an optical sensing arrangement. Each detected pulse represents a fixed quantum of energy consumption, allowing precise monitoring of power usage in real time.

The detected pulse signal is passed through an optocoupler to provide electrical isolation between the energy meter and the low-voltage control circuitry. This isolation improves system safety, protects the Arduino from high-voltage disturbances, and minimizes the effect of electrical noise.

After isolation, the pulse signal is fed into the Arduino microcontroller. The Arduino counts the pulses accurately using digital input pins or interrupt-based techniques. The total pulse count forms the fundamental data used for energy and cost computation.

The Arduino converts the accumulated pulse count into standard electrical energy units (kilowatt-hours). This conversion is performed using a predefined meter constant, such as the number of pulses per kilowatt-hour, ensuring accurate unit calculation.

Simultaneously, the system computes the instantaneous electricity cost by multiplying the consumed energy units with the predefined tariff rate. This feature enables real-time cost awareness and helps users understand their electricity expenses.

The calculated energy units and corresponding cost are displayed on the LCD module. The display provides immediate and continuous feedback to the user, showing real-time consumption and billing information in an easy-to-understand format.

Following the display update, the Arduino transmits the consumption and cost data to the ESP8266 Wi-Fi module through serial communication. This enables wireless connectivity and prepares the data for online transmission.

The ESP8266 uploads the received data to a cloud server or web-based platform using Wi-Fi. This allows remote monitoring, data storage, and graphical visualization of energy usage, enabling long-term analysis and improved energy management.

Finally, users can monitor their electricity consumption and cost in real time through a webpage or mobile interface. The system continuously repeats this process during operation, providing uninterrupted monitoring until the system is powered off.

CHAPTER 5

TEST AND RESULTS

The results of the Energy Meter Monitoring using IoT system demonstrate accurate real-time measurement and continuous tracking of electricity consumption. It enables timely analysis, reduces energy wastage, and improves overall efficiency in power management.

5.1 Cost Calculation

• **Definition:**

Cost calculation refers to the process of determining the total electricity expense based on real-time energy consumption measured by the smart energy meter. The system converts detected LED pulses into electrical energy units (kilowatt-hours) and applies the electricity tariff to compute the total cost.

• **How It’s Calculated:**

1. Each LED pulse generated by the energy meter represents a fixed fraction of electrical energy, defined by the meter constant (pulses per kWh).

$$\text{Energy Units (kWh)} = \frac{\text{Number of Pulses}}{\text{Meter Constant (pulses/kWh)}}$$

2. The total electricity cost is calculated by multiplying the consumed energy units with the predefined tariff rate.

$$\text{Total Cost} = \text{Energy Units (kWh)} \times \text{Tariff Rate (₹/kWh)}$$

3. For real-time monitoring, the system updates cost incrementally as new pulses are detected.

$$\text{Incremental Cost} = \frac{1}{\text{Meter Constant}} \times \text{Tariff Rate}$$

4. The microcontroller continuously processes pulse inputs, ensuring accurate and real-time calculation of both energy consumption and cost, which are displayed on the LCD and transmitted to the cloud platform via the IoT module.

5.2 Experimental Setup

“Energy Meter Monitoring Using IoT” consists of a energy meter, as shown in Figure 3. The meter is connected to the supply, and an Arduino controller is placed beside it to collect and send the readings to the cloud. A small display shows real-time energy data, while LEDs indicate power and network status. All wiring is organized neatly with proper separation of high- and low-voltage sections for safety.

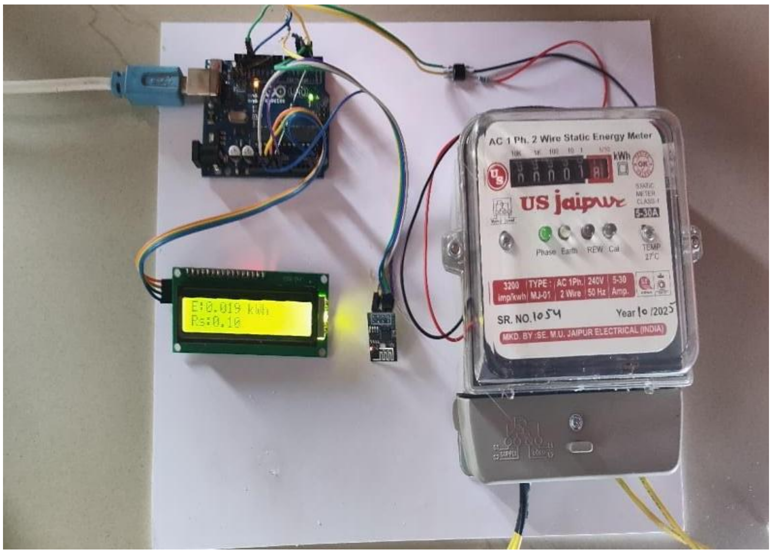

Fig.:3 Experimental Setup

5.3 Result and conclusion

The experimental and simulated results of the proposed work are discussed in this section. Figure 4 and 5 shows the measuring of the energy consumed and display of the consumed energy and cost respectively.

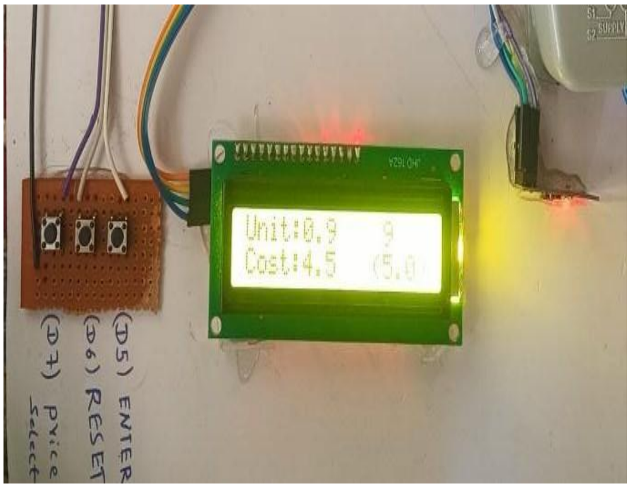

Fig: 4 Measuring consumed energy

Fig: 5 Display of energy and cost

Figure 6 depicts the results of the proposed work in which consumed energy and cost are displayed.

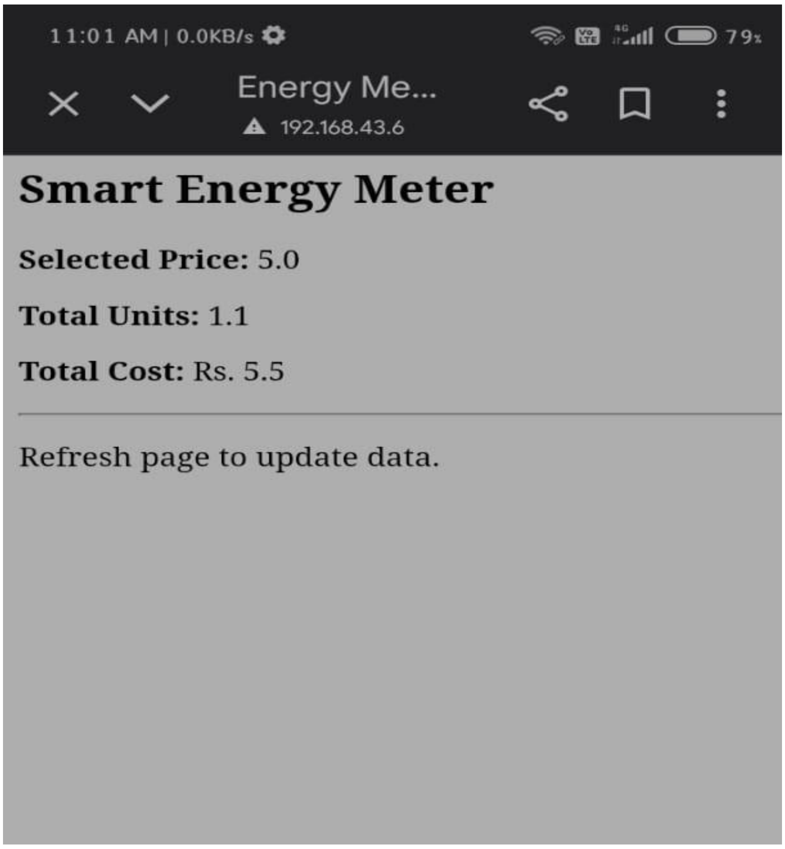

Fig: 6 Final Result

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Conclusion

The project **"Energy Meter Monitoring Using IoT"** successfully demonstrates the implementation of a smart, efficient, and scalable solution for real-time electricity consumption monitoring. Traditional energy meters provide only cumulative readings and require manual inspection for billing, which often leads to inaccuracies, delays, and lack of consumer awareness. The proposed IoT-based system addresses these limitations by integrating embedded systems, wireless communication, and cloud-based dashboards to provide accurate, real-time, and easily accessible energy data.

The experimental results show that the system provides **high accuracy**, **low latency**, and **excellent reliability**, making it a practical solution for household, commercial, and industrial applications. The graphical dashboard generated through the cloud platform assists users in understanding consumption patterns, identifying peak usage periods, and making informed decisions about energy management.

Overall, the proposed system proves that IoT can transform traditional energy monitoring into a smarter, more transparent, and user-friendly approach. It contributes significantly toward the development of smart homes and smart cities by enabling digital automation in essential utilities such as electricity monitoring.

6.2 Future Work

Although the current system is fully functional and effectively monitors real-time electricity usage, several enhancements can be integrated to further improve its performance, scalability, and intelligence. Possible future developments include:

6.2.1 Electricity Theft Detection

Electricity theft is a major problem in many regions. By integrating sensors and anomaly detection algorithms, the system can detect:

- Illegal line tapping
- Meter tampering
- Sudden unexplained consumption spikes

Automatic alerts can be sent to utility authorities

6.2.2 AI-Based Consumption Prediction

Using machine learning algorithms, the system can forecast:

- Future electricity consumption
- Monthly bill estimation
- Peak usage hours

This helps users plan their energy usage and reduce unwanted costs.

6.2.3 Prepaid Metering System

The system can be upgraded to include prepaid functionality:

- Users recharge before consumption
- System deducts balance based on usage
- Alerts generated when balance is low

This model is widely used in advanced smart grid systems.

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