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AUTOMATIC TARIFF CALCULATION WITH WIRELESS ENERGY METER

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Abstract: The current energy meter reading system relies on human labor, which has drawbacks such as computation errors, customer absences during billing, and additional costs associated with the billing procedure. The proposed system overcomes these limitations by implementing an automatic wireless energy monitoring and tariff calculation system. The system uses a digital energy meter, PIC16F72 microcontroller, ZigBee wireless communication modules, LCD display, optocoupler, relay circuit, and regulated power supply. The energy meter generates pulses proportional to electrical energy consumption. These pulses are detected using an IR sensor and processed by the microcontroller to calculate consumed energy units. The measured data is transmitted wirelessly to the Electricity Board (EB) section through ZigBee communication. At the EB section, automatic tariff calculation is performed based on predefined electricity rates. The billing information is transmitted back to the consumer side and displayed on the LCD screen. The system also includes an automatic load disconnection feature using a relay in case the electricity bill is not paid within the due date. The proposed system provides accurate billing, reduced manpower, real-time monitoring, improved efficiency, and secure wireless communication. The project can be effectively used in smart homes, industries, and modern automated energy management systems.

Keywords: ZigBee, Energy Meter, Wireless Communication, Automatic Billing, PIC16F72, Smart Metering, Tariff Calculation.

1. INTRODUCTION

Electricity is one of the most important resources in modern society and plays a vital role in domestic, commercial, and industrial applications. With the rapid growth of population and industries, the demand for electrical energy is continuously increasing. Therefore, efficient monitoring and management of electricity consumption have become necessary to ensure proper utilization of energy resources. In traditional electricity billing systems, meter readings are collected manually by visiting each consumer's location. This method requires a large amount of manpower and time, and it often results in human errors, delayed billing, inaccurate readings, and increased operational costs. In many cases, consumers may not be available during meter reading, which further complicates the billing process. Moreover, conventional systems do not support real-time monitoring of electricity usage and are unable to detect electricity theft efficiently. To overcome these limitations, smart energy monitoring systems are being developed using
Embedded system and wireless communication technologies. Automation in energy metering improves efficiency, reduces human intervention, and provides accurate and transparent billing. Wireless communication technologies such as ZigBee are widely used in smart metering applications because of their low power consumption, reliability, and cost-effectiveness. Smart monitoring systems also support real-time data transmission, which helps both consumers and electricity boards to monitor energy consumption effectively.

This research is designed to automate the electricity billing process using wireless communication technology. The proposed system continuously monitors energy consumption and automatically calculates the electricity tariff based on the consumed units. The system uses a digital energy meter, PIC16F72 microcontroller, Zig Bee communication modules, IR sensor, LCD display, relay circuit, and regulated power supply. The energy meter generates pulses proportional to electrical energy consumption, and these pulses are detected by the IR sensor. The microcontroller processes the pulse signals and converts them into energy units. The calculated data is transmitted wirelessly to the Electricity Board section through ZigBee communication.

At the receiver side, the Electricity Board system automatically calculates the tariff according to the predefined electricity rates. The billing information is then displayed on the LCD screen at the consumer side. The system also includes a relay mechanism that can disconnect the power supply automatically if the bill payment is overdue. This feature improves power management and minimizes revenue loss for the electricity department.

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The proposed system provides several advantages over conventional billing systems. It reduces manual effort, improves billing accuracy, enables real-time monitoring, and lowers operational costs. Zig Bee technology provide fast and secure wireless communication while consuming very low power. The system also improves transparency in electricity billing and supports modern smart grid applications. Due to these advantages, the project can be effectively used in smart homes, industries, commercial buildings, and automated energy management systems.

2. DESCRIPTION

The project is designed to automate the process of electricity monitoring and billing using wireless communication technology. The main objective of this system is to reduce human effort, eliminate manual errors, and provide accurate electricity billing through automatic tariff calculation. In conventional electricity billing systems, meter readings are collected manually by electricity board employees, which is time-consuming, costly, and prone to errors. The proposed system overcomes these limitations by implementing a smart wireless energy monitoring system.

The system mainly consists of two sections: the Consumer Side Module and the Electricity Board (EB) Side Module. The consumer side contains a digital energy meter, IR sensor, PIC16F72 microcontroller, ZigBee transmitter, LCD display, relay circuit, and regulated power supply. The Electricity Board side contains a ZigBee receiver, personal computer, and tariff calculation software. The energy meter generates pulses according to the electrical energy consumed by the load. These pulses are detected by the IR sensor and sent to the microcontroller for processing.

The PIC16F72 microcontroller continuously counts the pulses generated by the energy meter and converts them into electrical energy units in kilowatt-hours (kWh). The calculated units are displayed on the LCD screen and transmitted wirelessly to the Electricity Board section through ZigBee communication. ZigBee technology is used because it provides reliable, low-power, and low-cost wireless communication suitable for smart metering applications

Energy Meter:

An energy meter is used to measure electrical energy consumption in kilowatt-hours (kWh). It records the amount of electricity used by the load. In this project, the energy meter generates pulses according to power consumption. These pulses are detected by the IR sensor and processed by the microcontroller. The measured data is used for automatic tariff calculation and wireless monitoring.

Regulated Power Supply:

A regulated power supply provides stable DC voltage to the circuit. It converts AC supply into regulated DC voltage. It ensures proper and reliable operation of all components. It consists of a transformer, rectifier, filter, and voltage regulator. It supplies constant power to the system.

Load:

The load represents electrical appliances or devices that consume electrical power. The energy consumed by the load is measured by the energy meter. Different loads generate different pulse rates based on power consumption. The system continuously monitors the load usage. It helps in calculating energy consumption accurately.

Block Diagram:

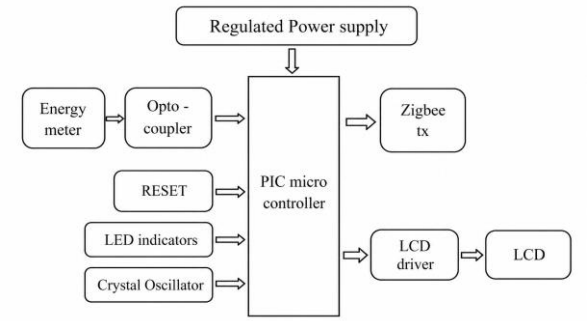

Fig 1 Block Diagram of Consumer Module

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IR Sensor:

The IR sensor is used to detect pulse signals from the energy meter. It senses the blinking LED pulses generated by the meter. The detected signals are sent to the microcontroller for processing. It provides accurate and reliable pulse detection. It helps in measuring energy consumption.

PIC16F72 Microcontroller:

The PIC16F72 microcontroller is the main control unit of the system. It receives pulse signals from the IR sensor and calculates energy units. It controls the LCD display, ZigBee communication, and relay operation. It performs all processing and monitoring functions. It manages the overall operation of the system.

Relay Circuit:

The relay circuit is used to control the electrical load automatically. It disconnects the power supply if the electricity bill is not paid within the due date. The relay improves system safety and power management. It acts as an automatic electrical switch. It helps reduce electricity revenue losses.

Circuit Diagram:

The flow chart explains the complete working process of the system. The energy meter measures the electrical energy consumed by the load and generates pulses according to power consumption. These pulses are detected by the IR sensor and sent to the PIC16F72 microcontroller for processing. The microcontroller calculates the consumed energy units and displays them on the LCD screen. The data is transmitted wirelessly through ZigBee to the Electricity Board side for tariff calculation. The bill amount is displayed, stored for future records, and the relay disconnects the supply if payment is overdue. Finally, the process continues continuously for real-time monitoring and automatic billing

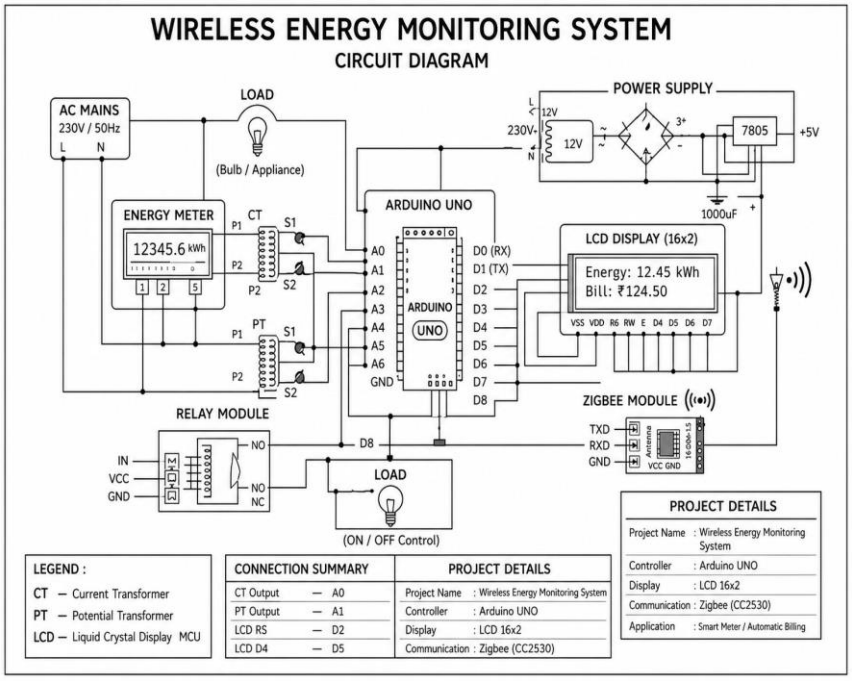

Fig 2 Circuit Diagram

3. Flow Chart

The flow chart shows the working process of automatic tariff calculation using wireless communication. It explains measurement, data transmission, and automatic billing operation.

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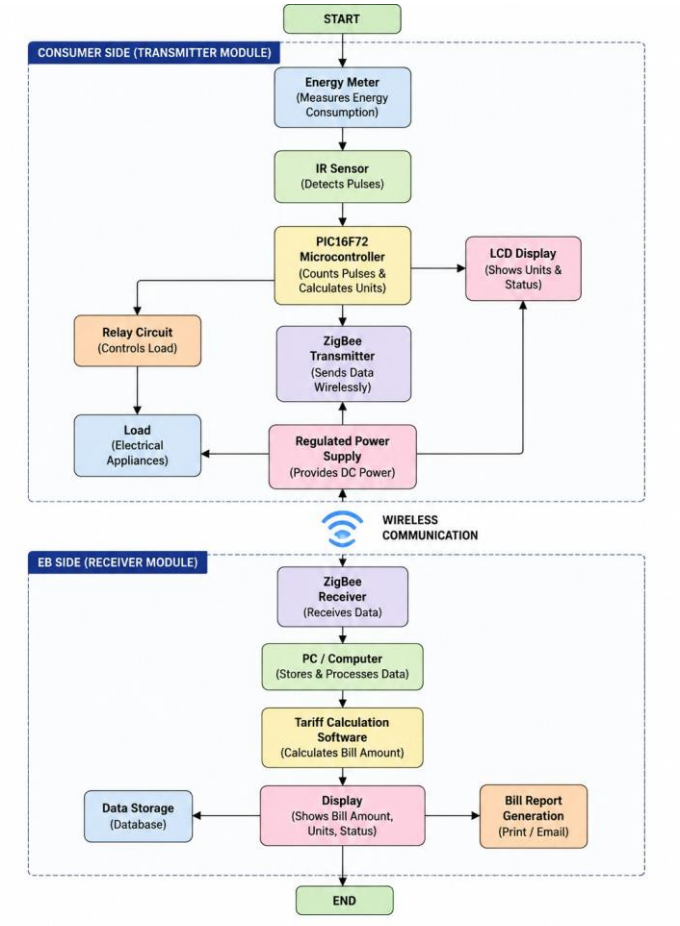

Fig 3.1 Flow Chat of Automatic Tariff Calculation with Wireless Energy Meter.

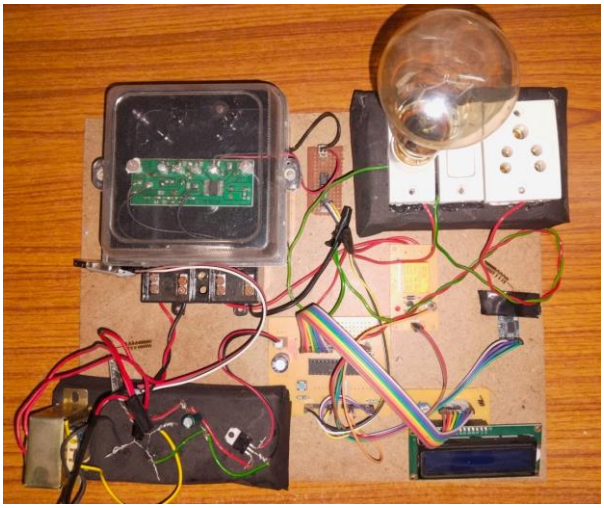

Fig 3.2 Final Prototype

The final prototype of the "Automatic Tariff Calculation with Wireless Energy Meter" system was successfully designed and tested. It consists of an energy meter, PIC16F72 microcontroller, ZigBee modules, LCD display, relay circuit, and regulated power supply. The system accurately measures energy consumption and transmits data wirelessly using ZigBee communication. The consumed units and bill amount are displayed on both LCD and PC. The relay circuit automatically controls the load during overdue payment conditions. The prototype provides real-time monitoring, accurate billing, reliable wireless communication, and efficient energy management. It reduces manual effort and supports smart metering applications.

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4. LCD AND PC OUTPUT RESULT

The LCD display shows the consumed energy units, tariff amount, and system status in real time. The PC receives the transmitted data through ZigBee communication and performs automatic tariff calculation. Both the LCD and PC provide accurate monitoring and billing information for efficient energy management.

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The LCD helps consumers monitor their electricity usage continuously. The PC maintains billing records and displays energy consumption details. The system ensures reliable wireless communication and accurate tariff calculation. It improves transparency and efficiency in the electricity billing process.

Fig 4.1 Sample LCD Output Units: 0.0006 KWH | Bill: 0.0015 INR

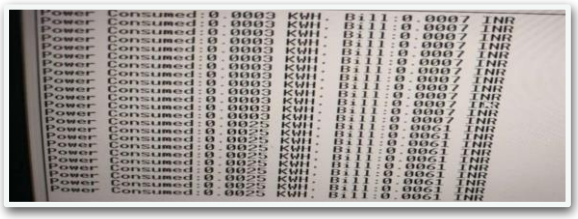

Fig 4.2 Sample PC Terminal Output

The sample PC terminal output displays real-time electricity consumption and billing information. It shows pulse count, energy units consumed, tariff amount, and system status. The output confirms successful ZigBee wireless communication between the transmitter and receiver modules. It helps maintain accurate billing records and monitor consumer energy usage efficiently. The result demonstrates the reliability and accuracy of the automatic tariff calculation system.
The PC terminal continuously receives data from the consumer module and updates the billing information automatically. It enables real-time monitoring of energy consumption and tariff calculation. The displayed data helps in reducing manual errors and improving billing efficiency. The output verifies the successful implementation of the wireless energy monitoring and automatic tariff calculation system.

4.1 : Observation Table & Calculation:

S No.	Load used	Units displayed (kwh)	Bill amount INR	Zigbee transmission
1	100 W bulb	0.0003	0.0007	Successful
2	100 W bulb	0.0006	0.0015	Successful
3	100 W bulb	0.0025	0.0061	Successful
4	Continuous operation	Increasing continuously	Increasing continuously	Successful

Fig 4.2 Pulse-Based Energy Calculation

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The system uses a digital energy meter with a pulse rate of 3200 impulses/kWh. The pulses generated by the energy meter are directly proportional to the electrical energy consumed by the load.

Pulse Calculation
For a 100 W bulb operating for 60 seconds: Result:
Pulses = 5.33 pulses/minute Power per Pulse
Result:
PF = 0.3125 watt per pulse Unit Calculation
Total pulses in one hour:
Total Pulses = 5.33 × 60 = 320 Result:
Units = 0.1 kWh per hour Daily Consumption
For 24 hours operation:
Units = 0.1 × 24 Result:
Units = 2.4 kWh Tariff Calculation
Assuming electricity tariff rate = Rs 5 per unit: Bill = 2.4 × 5
Result:
Bill Amount = Rs 12

The calculation confirms the proper working and accuracy of the automatic tariff calculation system. The results show that energy consumption and billing information can be calculated automatically and transmitted wirelessly using Zig Bee communication.

5. CONCLUSION

The system was successfully designed using embedded systems and ZigBee wireless communication technology for automatic electricity monitoring and tariff calculation. It accurately measures energy consumption, performs automatic billing, and transmits data wirelessly with reduced manual effort and billing errors. The system provides real-time monitoring, reliable communication, automatic load control, and improved efficiency in electricity management. It can be effectively used in residential, industrial, and smart energy management applications.

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