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Smart Energy Meter

Kiran M R[1],Karthik V[2],Veeresh P R[3],Apoorva P R[4] ,Poornima S[5]

[1]Professor, [2] student,[3]student, [4]student, [5]student
Department of Electrical and Electronics Engineering P E S Institute of Technology and Management, Shimoga

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Abstract -Energy management is a critical aspect of modern smart grids, requiring real-time monitoring and analysis of electrical power consumption to enhance efficiency and sustainability. This paper presents the design and implementation of a Smart Energy Meter for daily monitoring of electricity usage, aimed at providing consumers with real-time data and insights to optimize energy consumption. The system is built using an Arduino Uno microcontroller interfaced with current and voltage sensors to measure power usage accurately. The collected data is processed and transmitted to an IoT-enabled platform, allowing users to access real-time consumption statistics through a web-based dashboard or mobile application. The proposed system not only provides instant feedback on power usage but also integrates features such as automatic alerts for excessive consumption, remote monitoring, and data logging for historical analysis. By leveraging IoT technology, consumers and utility providers can analyze consumption patterns, detect anomalies, and implement energy-saving strategies. Additionally, the system can be extended to support automated billing and load management applications.

Key Words: *Automation, IOT Technology, Sensors*

1.INTRODUCTION

A smart energy meter is an innovative device designed to revolutionize the way electrical power consumption is monitored and managed in residential, commercial, and industrial settings. Unlike traditional meters, which require manual readings and offer limited data, smart energy meters provide real-time, accurate, and detailed insights into energy usage. This project focuses on developing a smart energy meter that enables daily monitoring of electrical power consumption, allowing users to track their energy usage patterns effectively. By integrating advanced technologies such as IoT, data analytics, and communication systems, the proposed solution empowers users to optimize their energy consumption, reduce electricity bills, and contribute to a more sustainable future. Furthermore, the system's ability to provide instant feedback on energy usage promotes energy efficiency and supports the global transition toward smarter and greener energy management practices. Now a days many consumers doesn't able to know whether the bill generated by the person who came from electricity board belongs to them or not. And at the same time the consumers were confused about the high bill usage so for this we came up with a project in that the consumer can be able to closely track their usage and spending. In this project consumption of energy i.e., units consumed by that meter will be displayed on the 16X2 LCD provided and at the same time any internet enabled devices through Transmission Control. So, whenever there is vary in count that is units in the energy meter get change, these values are displayed on LCD. Due to manual electricity billing, there are some errors. To overcome those errors, we came with a proposed system that working of energy meter. Smart energy meters are advanced devices designed to provide real-time monitoring and management of electrical power consumption in homes and businesses. The primary purpose of these meters is to enhance energy efficiency and empower consumers with detailed insights into their energy usage patterns. Unlike traditional meters that offer only monthly readings, smart energy meters enable daily monitoring, allowing users to track their consumption on an hourly or even minute-by-minute basis.

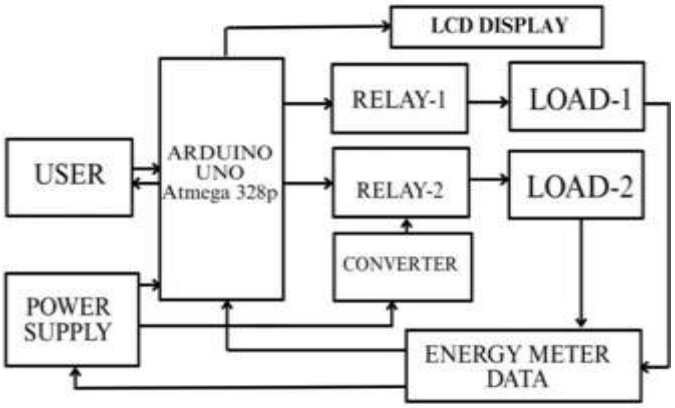

Fig -1: Block Diagram

2. HARDWARE AND SOFTWARE COMPONENTS

In this project, the hardware and software functions are combined to make the system reliable. Arduino IDE is the brain of this project. This section will present a full description of the hardware of the smart meter. The material is selected due to lightweight property. Here is a mentioned. The way of the interaction of the various components used to create our smart meter. the Arduino IDE is the controller of the entire system. Arduino IDE: Arduino hardware is programmed using a Wiring-based language (syntax and libraries), similar to C++ with some slight simplifications and modifications, and a Processing-based integrated development environment. Arduino is programmed using Arduino IDE that has been develop

1. ARDUNIO MICROCONTROLLER

   Arduino is open-source microcontroller and software development environment and easy to use and understand hardware and software. Arduino is a single

board microcontroller has programming language is a simple 'C' and 'C++' type programming language and C language is easy to learn. Arduino microcontroller is fast made by "Interaction Design Institute Ivrea" in Ivera, Italy; it has aim was design low cost and cheap microcontroller board. Arduino uses expansion circuit board knows as shield. It has facility to GPD, GDM, and Bluetooth, motor and other facility.

2. CURRENT SENSORS (ACS 712)

The ACS712 is a Hall-effect-based linear current sensor IC designed for precise and non-intrusive current measurement. It provides an analog output voltage proportional to the current passing through the device. Key features include: • Technology: Utilizes the Hall effect to detect the magnetic field generated by current flow, ensuring electrical isolation between the sensor and the measured circuit. • Input Range: Available in variants for different current ranges (e.g., ±5A, ±20A, ±30A). • Output: The sensor provides an analog voltage output that changes linearly with the current, typically centered at 2.5V for 0A. • Accuracy: High accuracy and sensitivity, suitable for both AC and DC current measurement. • Electrical Isolation: Ensures safe measurement without direct electrical connection to the circuit.

3. LCD DISPLAY

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. An LCD (Liquid Crystal Display) is a widely used technology for displaying information in various electronic devices. It operates by manipulating liquid crystals between two layers of polarized material to control light transmission.

4. RELAY MODULE

A relay module is an electronic component used to control high-power devices such as motors, lights, or appliances using a low-power signal from a microcontroller or other control system. It acts as a switch that allows the microcontroller to turn devices on or off without directly handling the high voltage or current associated with those devices. The relay module typically consists of an electromagnet (the relay), a set of contacts, and a control circuit. When a low-voltage signal is sent to the relay, the electromagnet inside the relay is activated, causing the contacts to close or open, thereby completing or breaking the circuit of the connected high-power device.

5. CONVERTERS

Converters are critical devices in electrical and electronic systems, enabling the transformation of electrical energy into forms suitable for specific applications by modifying voltage, current, or frequency. They are broadly categorized into AC-DC converters, DC-DC converters, DC AC converters, and AC-AC converters. AC-DC converters, also known as rectifiers, convert alternating current (AC) into direct current (DC), essential for powering devices like smartphones and computers. These often include diodes and capacitors to ensure a stable output. DC-DC converters adjust DC voltage levels, either stepping them up or down, and are commonly used in portable electronics, renewable energy systems, and electric vehicles for efficient power management.

6. PYTHON LIBRARIES

Python libraries are collections of pre-written code that provide reusable functions and modules to help streamline development and improve productivity. These libraries are designed to perform specific tasks or offer additional functionality that can be easily integrated into Python programs. Popular libraries include NumPy and pandas for data manipulation and analysis, Matplotlib and Seaborn for data visualization, TensorFlow and Porch for machine learning, and Flask and Django for web development. Python libraries are widely used because they save time, reduce the need for redundant coding, and provide well-tested solutions to common programming challenges. Many libraries are open-source and actively maintained, making Python a versatile language suitable for various applications, from scientific computing to web development and artificial intelligence.

3. EXPECTED OUTCOME

This system is designed to monitor and control electrical devices remotely. It starts with a power supply that provides electricity to all components. An energy meter measures the power usage of connected devices and sends this information to an Arduino controller (ATmega328p), which acts as the brain of the system. Arduino gathers the data and controls the devices based on instructions from the user. It enables remote control. The relays act like switches that turn connected devices, labeled as Load-1 and Load-2, on or off as needed. An LCD display shows real-time information, such as power usage, making it easy for the user to monitor the system. Through a phone or computer, the user can access and control the devices connected to this system, providing convenient and efficient energy management. The system alerts the user when it short circuit, it includes the energy forecasting is to predict future energy consumption and thereby effective energy management by the machine learning, by using machine learning concept the system can predict future usage and estimation of the cost we can be predicted, The result of a smart energy meter uses application which helps to monitor and manage electricity usage in real time. The Arduino collects data from the energy meter and sends it to the cloud on a smartphone or laptop, allowing users to track the consumption of electricity. Further users can view live updates to identify the high energy consumption patterns. This project makes easy to optimize energy usage, reduced electricity costs, controlled and to create a more energy-efficient environment, through a simple and user-friendly interface and using machine learning we can predict the consumption gives estimated cost to consumers.

Fig -2: User Interface

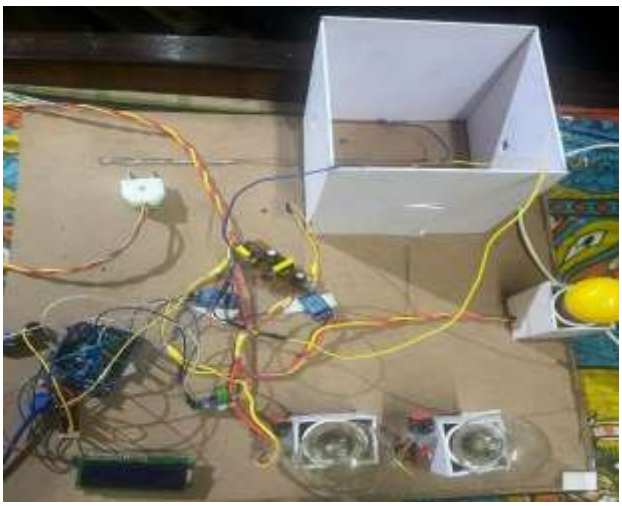

Fig -: Working model

4. CONCLUSIONS

Smart energy meters integrated with machine learning represent a transformative innovation in energy management. They provide accurate, real-time monitoring of energy usage, enabling consumers and utility providers to make informed decisions that enhance efficiency, reduce costs, and promote sustainability. With advanced capabilities such as demand forecasting, anomaly detection, dynamic pricing, and appliance-level monitoring, these systems optimize energy consumption patterns, mitigate fraud, and ensure grid stability. Additionally, they play a critical role in integrating renewable energy sources and facilitating the transition to smart grids and smart homes. By leveraging the continuous learning capabilities of machine learning, smart energy meters adapt to evolving user behaviors, emerging technologies, and dynamic energy requirements. This makes them a crucial component in achieving global energy efficiency goals, reducing carbon footprints, and supporting the development of smarter, greener communities.

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