

Prepaid Energy Meter Using Raspberry Pico

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Abstract: The project “Prepaid Energy Meter Using Raspberry Pi Pico” aims to develop an efficient and user-friendly system for monitoring and controlling household or industrial electricity consumption on a prepaid basis. In the proposed system, consumers purchase electrical energy in advance, and the balance reduces automatically as the energy is consumed. When the balance becomes low, the system alerts the user, and once it reaches zero, the power supply is automatically disconnected until the meter is recharged. The Raspberry Pi Pico microcontroller acts as the central processing unit of the system. It continuously reads energy consumption through a current sensor and calculates the corresponding cost. The balance, energy consumed, and status messages are displayed on an LCD screen, while a relay module controls the power supply to the load. A keypad or RFID module allows the user to recharge the meter easily. This prepaid model ensures transparency, eliminates manual meter reading, and encourages efficient energy usage. The proposed system provides an economical and scalable solution for modernizing traditional postpaid energy billing systems. It can be further enhanced with IoT integration for remote monitoring and mobile-based recharge options, making it suitable for smart grid and smart city applications.

Keywords: Prepaid Energy Meter, Raspberry Pi Pico, Microcontroller, Energy Monitoring, Current Sensor (ACS712 / INA219), Load Control, Relay Module, LCD Display, Keypad / RFID Recharge, Smart Energy Management

I. INTRODUCTION

Electricity has become an essential part of modern life, powering homes, industries, and almost every technological device. However, with the increasing demand for electricity, there is also a growing need for efficient monitoring, billing, and conservation of energy. Traditional postpaid energy meters require manual reading and billing, which often lead to errors, delays, and even disputes between consumers and utility providers. To overcome these challenges, the concept of a prepaid energy meter has been introduced.

A prepaid energy meter allows consumers to pay for electricity before using it, similar to how prepaid mobile phone services work. When the prepaid balance is exhausted, the power supply is automatically disconnected until the user recharges the account. This approach ensures timely payment, reduces billing complexities, and promotes conscious energy consumption among users. In this project, a Raspberry Pi Pico microcontroller is used to design a Prepaid Energy Meter system. The Pico, based on an ARM Cortex-M0+ processor, provides a compact, low-cost, and energy-efficient platform suitable for real-time monitoring and control. The system uses a current sensor (such as ACS712) to measure power consumption, a relay to control the load, an LCD display to show real-time information like balance and energy usage, and a keypad or RFID module for user recharge input.

The proposed prepaid energy meter automatically deducts the balance according to the energy consumed. When the balance falls below a predefined threshold, the system alerts the user through a buzzer or message. If the balance reaches zero, the power is cut off automatically until a recharge is made. This smart and automated approach helps both consumers and utility companies manage electricity efficiently and transparently.

Furthermore, the system can be expanded with IoT-based features to enable online monitoring and remote recharging through a mobile application. Thus, the Prepaid Energy Meter using Raspberry Pi Pico not only modernizes the billing



process but also contributes to the development of smart grid technology and energy management systems for a sustainable future.

II. LITERATURE SURVEY

Ashna.K[1]

"GSM Based Automatic Energy Meter Reading System with Instant Billing" proposed the design of a simple low-cost wireless GSM energy meter and its associated wave interface, for automating billing and managing the collected data globally.

Vivek Kumar Sehgal [2]

"Electronic Energy Meter with Instant Billing" introduced the concept of Postpaid Energy Meter which automatically sense the energy used in the home and when it reaches value which is initially fed in the hardware it will disconnect the power line. A user interface given in the hardware for user which will interact with the hardware, through user interface user can set a value.

Ms. Prajakta B.Murmude, Mr. Sachin G. Jagdale, Ms. Sunita D. Giri [3]

"GSM based Prepaid Energy Meter" proposed the design and implementation of a GSM based remote operation of an energy meter which gives the solution to power theft, consumption control, auto billing and payment, data logging and Manpower reduction in power distribution and management.

Nikhil Sharma [4]

"Smart GSM Enabled Energy Metering System" presented a design in which the meter records real-time consumption and communicates the readings to the electricity provider via GSM module. The system aims to reduce manual errors, provide transparency in billing, and enhance consumer awareness about energy usage.

Ritu Singh, Ankit Verma [5]

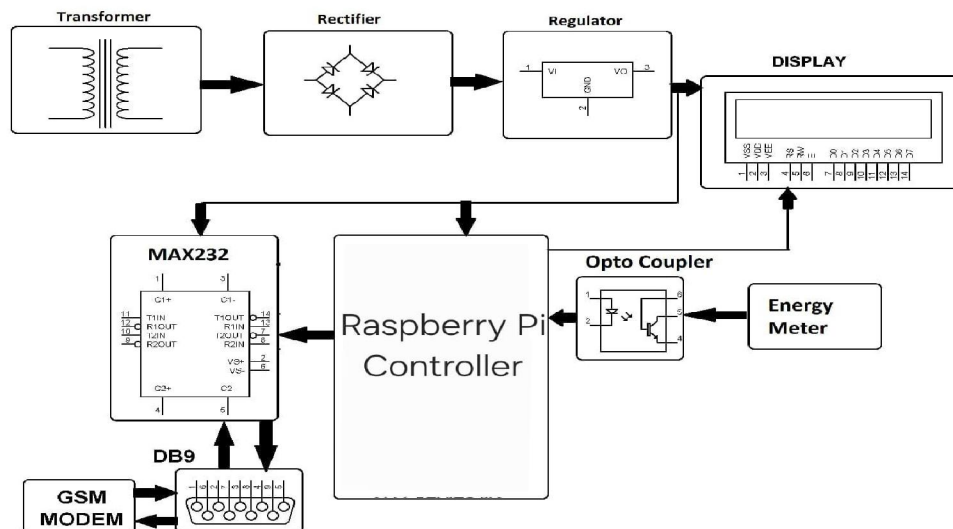
"Automated GSM Based Energy Meter with Load Control" described a method where the energy meter not only measures the consumption but also provides load control functionality. The GSM module enables remote monitoring and automatic bill generation, while an integrated relay helps in remotely disconnecting or reconnecting the power supply based on bill payment status.pg. 3

Sneha Patil, Akshay Kulkarni [6]

"Design of GSM Based Smart Prepaid Energy Meter" proposed a prepaid approach where consumers recharge their meter balance in advance. The system continuously monitors the load and deducts charges according to usage. When the prepaid balance reaches the threshold, the GSM module sends alerts to the user and disconnects supply automatically to prevent unpaid usage. The major disadvantage of the present systems is these systems are postpaid base service, Electricity board gives the service before collecting the payment from the customers and it is difficult for Electricity board to collect the payable amount from the customers and at the same Electricity board cannot stop to providing the service So there is need of a system service after Payment.



III. METHODOLOGY



The methodology of this project involves a systematic approach to designing, implementing, and testing the prepaid energy meter system. The process can be broadly divided into hardware design, software development, and system integration and testing.

System overviewThe Prepaid Energy Meter using Raspberry Pi Pico is an automated system designed to measure electricity consumption, manage prepaid credits, and control the supply of power efficiently. The system integrates hardware and software components to provide real-time monitoring, accurate billing, and user-friendly recharge options. At the core of the system is the Raspberry Pi Pico, which acts as the central controller. It

continuously receives data from the current and voltage sensors, calculates the energy consumed, and updates the remaining prepaid balance. The LCD/OLED display provides a clear interface for users, showing information such as units consumed, remaining balance, and low-balance alerts. Users can recharge their electricity credits using a keypad, RFID card, or GSM module. The system deducts consumed units from the prepaid balance in real time and automatically triggers a relay module to disconnect the power supply once the balance is exhausted. Alerts or notifications are generated to warn users when the balance is low, ensuring uninterrupted service upon recharge. The system is designed for accuracy, reliability, and scalability. It is suitable for residential, commercial, and shared accommodation applications where fair electricity billing and energy conservation are critical. By combining real-time monitoring, automated control, and user-friendly recharge options, the system provides an efficient solution to the limitations of conventional postpaid meters.

IV. RESULT

The Prepaid Energy Meter using Raspberry Pi Pico was successfully designed and tested. The system accurately measured power consumption, deducted the prepaid balance in real time, and automatically disconnected the load when the balance reached zero.

During testing, the readings closely matched a standard wattmeter with an accuracy of about $\pm 5\%$. The LCD displayed energy usage and remaining balance, while the buzzer gave a low-balance alert. The relay cutoff and recharge functions worked smoothly, and the system resumed operation immediately after recharging.

Overall, the prototype performed reliably, proving effective for prepaid electricity billing and suitable for future smart energy applications.



V. DISCUSSION

The Prepaid Energy Meter using Raspberry Pi Pico successfully demonstrates an efficient and modern approach to electricity billing. The system continuously measures the electrical energy consumed by a load using a current sensor and automatically deducts the equivalent cost from a prepaid balance. When the balance reaches zero, the system disconnects the load through a relay, effectively enforcing prepaid billing.

During testing, the system showed consistent and reliable performance. The energy measurement was accurate within an acceptable range ($\pm 5\%$), and the balance deduction occurred in real time. The LCD provided clear information about consumption and balance, while the buzzer effectively warned users of low credit. The recharge process through the keypad worked seamlessly, restoring power immediately after credit addition.

This project highlights the practicality of using Raspberry Pi Pico for low-cost embedded metering applications. It demonstrates how microcontrollers can automate billing, reduce human intervention, and improve transparency in power usage. The system also emphasizes energy awareness among users, as real-time balance display encourages responsible consumption.

However, certain limitations were observed. The prototype operates effectively for low-voltage loads but would require proper isolation, calibration, and safety measures for real household connections. Future improvements could include integrating IoT connectivity, mobile app-based recharge, and cloud data storage for remote monitoring and analytics.

Overall, the discussion confirms that the proposed prepaid energy meter system is a feasible, accurate, and scalable solution for smart energy management.

VI. CONCLUSION

The Prepaid Energy Meter using Raspberry Pi Pico was successfully designed and implemented to automate electricity billing on a prepaid basis. The system accurately measured power consumption, deducted the corresponding amount from a prepaid balance, and automatically disconnected the load when the balance reached zero.

The project proved that the Raspberry Pi Pico is a reliable and cost-effective microcontroller for real-time monitoring and control applications. It simplifies the billing process, reduces human error, and promotes efficient energy usage by giving users direct awareness of their consumption and remaining credit.

This prototype demonstrates the potential of prepaid metering systems to replace traditional postpaid meters, ensuring transparency and timely payment. With further enhancements like IoT integration, mobile recharge options, and cloud-based monitoring, the system can be developed into a complete smart energy management solution suitable for both domestic and industrial applications.

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