Design and Development of Pre-paid electricity billing using Raspberry Pi2

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Abstract

This paper proposes, a real time Raspberry Pi 2 based prepaid electricity billing meter to monitor household electrical appliances. This automated prepaid electricity meter is used to measure the voltage, current, power and finally number of units consumed by the customer. The proposed system has an intelligent energy distribution with fixed power supplied by Electricity Board (ED). The consumption of power varies from customer to customer; the variation of power consumption is monitored and controlled by automated electricity billing system. Moreover monitoring of home appliances is developed either manually, remotely and with the help of GSM. The main objective of this paper is to provide low cost and flexible automated prepaid electricity meter. Electricity bill automatically sends to customer through GSM Module and gives an alert message to the customer. This automated prepaid electricity meter is able to collect the number units consumed by the customer at their respective house.

Keywords: Raspberry Pi 2, 71M6543F Microcontroller, Current transformer, relay, Buzzer, GSM sim 900A and Mobile phone.
I. INTRODUCTION

The Generation, transmission and distribution of electrical energy involves many operational activities. The losses are implicated in generation and can be technically defined, but transmission and distribution losses cannot be precisely quantified with the sending of the information. This illustrates the involvement of nontechnical parameter while transmissiting and distributing the electricity. The overall technical losses happened naturally and are caused due to power dissipation while transmitting the power through transmission lines transformers, and other power system components. Technical transmission and distribution loses are computed with the information about total load and the total energy bill. While technology improving, we should also note the increasing immoral activities. Power theft is also not ignorable crime and at the same time it is directly affected the economy of the nation. Electricity theft a social evil, so it has to be eliminated completely. Power consumption and losses have to be closely monitored so that the generated power is utilized in a most efficient manner. The system avoids mostly the illegal usage of electricity. At this point of technological development, the problem of illegal usage of electricity can be solved electronically without human control. The implementation of this system will save large amount of electricity, and there by improving economy and electricity will be available for more number of consumers in highly populated country such as INDIA [1, 2, 3, 4].

The present work is focused on the development of energy meter based prepaid electricity billing system to avoid default consumer the electricity theft, to reduce the human efforts and time. The present developed system is tested and observed and it is working successfully and consistently. This system not only reduces the labour cost but also increases the accuracy of meter reading and saves huge amount of time. Since this system is digitally controlled system, the speed of the operative services is drastically enhanced and the manual transaction is maximum avoided.

The main objective of the present work is the measurement of voltage, current, power, frequency, power factor and units consumed by using Raspberry Pi 2. The Raspberry Pi 2 is ARM Cortex Processor, which is 32-bit processor. The measurement of voltage, current, power, frequency and units consumed is done with help of Single phase energy meter and 71M6543F Microcontroller with high accuracy. The measurement values are sent to Virtual Network Connections (VNC) server with wireless network VNCs are able to display the values from minute to minute. The remaining part of the paper is divided into sections as follows. Section II discusses the description of hardware and software and section III gives the experimental results and conclusions are discussed in section IV.
II. GENERAL DESCRIPTION OF THE HARDWARE AND SOFTWARE

Block diagram

The experimental setup is as shown in Figure 1 which consists of Raspberry Pi, Relay, Buzzer, GSM Module, 71M6543F microcontroller, current Transformer.

![Block diagram of pre-paid energy meter.](image)

**Fig 1**: Block diagram of pre-paid energy meter.

A. Hardware Description

The main power supply is applied to current transformer through single phase energy meter and it is input to the 71M6543 microcontroller. The 71M6543F microcontroller has 22 Bit ADC. The controller is used to convert analog voltage to digital values, because Raspberry Pi accepts only digital values. The suitable software is developed in Raspberry Pi for data processing after receiving the required data from a load through current sensor. Raspberry Pi 2 based Pre-paid electricity billing system is designed and tested with known watts of load and the performance of the system is quite satisfactory. This system can be enhanced as a remote management system by writing appropriate software [1, 2].

A.1. Raspberry Pi 2:

Raspberry pi is a Linux operating system. The Raspberry Pi 2(2835) consists of a model B. It is 32-bit processor and credit size computer system. RAM size of Raspberry Pi 2 Model B+ is 1GB. A 900MHz quad-core ARM cortex-A7 CPU (Central Processing Unit). It is a 40 GPIO pins. It can be masked anywhere, behind television sets, within
walls. It produces high interpretation. It provides basic computer functions like word processing, web browsing etc[5].

A.2. Relay

A relay is an electrical switch that opens and closes under the control electrical circuit. In the original form, the switch is operated by an electromagnet which is used to open or close one or many sets of contacts. A relay is able to control an output

A.3. Buzzer

A buzzer or beeper is a signaling device, usually it is an electronic device which is used in automobiles, household appliances such as a microwave oven, or game shows. Nowadays, it is more popular to use a ceramic-based piezoelectric sounder which makes a high-pitched tone. Usually these were hooked up to "driver" circuits which varied the pitch of the sound or pulsed the sound on and off. It indicates the wronging to alert the condition [7].

A.4. GSM Module

GSM is a global system for mobile communication. Its frequency range is 850-1900 Mhz. It is a wireless communication system between the Raspberry pi2 to Mobile phone and requires a SIM (Subscriber Identity Module) card like as mobile phone to achieve communication with the network. GSM is used to send the alert electricity billing data. By using GSM, the electricity billing data is processed by Raspberry Pi and the data is transferred to the customer.

A.5. 71M6543F Microcontroller

71M6543F microcontroller is a 4th generation of polyphaser metering Systems-on-chips (SoCs). It's clock frequency is 5MHz. The 71M6543F of RAM is 5KB, ultra low power operation in active, battery modes, 64KB of flash memory and 22-bit delta sigma ADC (analog to digital conversion). It can be programmed with code and data during meter operation [8].

A.6. Current Transformer

Current transformer (CT) is a type of transformer that is used to measure AC Current. It produces an alternating current (AC) in its secondary which is direct proportional to the AC current in its primary. Current transformers, together with voltage transformers (VTs) or potential transformers (PTs), which are designed for measurement, are known as an Instrument transformer. The Current Transformer (C.T.), is a type of “instrument transformer” that is designed to produce an alternating current in its secondary winding which is proportional to the current being measured in its primary [9].
B. Software Description

Raspberry Pi is a new Processor. It has a number of languages to write a program is C, C++, Java, python2 and python3. In this work C++ is used.

C++ is a very powerful programming language. As the name indicates its the advanced level of C programming with Inheritance, object orientations and operator overloading. But here I want to mention only the basic steps of C++ programming. The abbreviation of OOPS is object oriented programming language. Object Orientation is a concept of dividing the entire system inters of classes and working through it’s instances and known as objects [10, 11].

The flow chart of Prepaid energy meter based electricity billing with GSM module authentication using Raspberry Pi processor and Software are presented in fig 3.

Algorithm

Algorithm is representation of working process of a particular task in terms if theoretical as shown in figure.

Sequence of operation for pre paid energy meter in electricity system:

The following sequence of operation has been followed for controlling the electricity theft of energy meter.

Step 1: Initialize GPIO pins to read or write data on to port.

Step 2: Initialize the Relay, Buzzer, GSM module to prepaid energy meter.

Step 3: To open QT server.

Step 4: To login the client if customer is to pay the amount in electricity department in first.

Step 5: To display the voltage, current, power, frequency, power factor, unit consumed and balance amount.

Step 6: if check units is below 15units indication of warning using buzzer and send SMS to customer phone number then client pay the amount.

Step 7: The client is not pay amount the entire load will be OFF.

Flow chart

The flow chart of Prepaid energy meter based electricity billing with GSM module authentication using Raspberry Pi processor and Software are presented in Figure 2.
START

Authentication using SIM card

To display voltage, current, power, frequency, power factory, units consumed, and balance amount.

Unit=1555

NO

The buzzer will be ON

Displays recharge the server application immediately

Load the units into Raspberry Pi 2

To display voltage, current, power, frequency, power factory, units consumed, and balance amount.

Decrement units count in Raspberry pi 2

YES

To turn OFF the prepaid energy meter

Give the warning to user in SMS

STOP

Fig 2: Flowchart of the entire work
### EXPERIMENTAL SETUP

The design includes an energy meter interfaced to the microcontroller through current transformer. The energy meter will measure the energy consumed and sends it to the microcontroller ADC (analog to digital conversion) port. Here the microcontroller converts the analog value from energy meter into digital values. The measured quantity will give the power consumption value, which is given to the Raspberry Pi 2. Here Raspberry Pi 2 is continuously used to monitor the meter reading and gives weekly information about the number of units consumed by the customer and also indicates the price per unit. The information is being sent to the both customer and electricity department. When the balance of units are less than the minimum limit prescribed by the electricity board, Raspberry Pi 2 microcontroller interrupts the relay to disconnect load automatically and no power will be supplied to the house. The buzzer is also attached to the Raspberry Pi 2 through relay to alert the user which indicates low balance of units. In this system the customer was given a unique ID number for every energy meter. This ID number is interlinked to SIM card. GSM module is connected to the Raspberry Pi 2, which is used to transfer the data of the user meter from Raspberry Pi to remote station by GSM wireless module. The meter reading is stored in database of Raspberry Pi 2 system.

The result of the experimental setup is shown in Figures 3, 4, 5, 6 and 7.

![Fig 3: Screen shot of the entire work of prepaid energy meter](image-url)
Fig 4: Screen shot of the entire connection of the work

Fig 5: Screen shot of the display the values in screen
Fig 6: Screen shot of the graph of the values of voltage, current, power and units consumed.

Fig 7: Screen shot of the sms from GSM module for low balance.
IV CONCLUSION

This system enables the electricity service provider to read meter reading regularly without the person visiting to each house so most probably the manual meter reading will be avoided. Customers will get weekly update the power consumption by means of SMS. Power theft can be avoided totally by this prepaid automated electricity meter and also gives information about the number of units consumed with price per unit. This system facilitates to make effective usage of electricity thereby it will help to minimize the power crisis in our country and improves the economy of electricity board.

REFERENCES