RFID based Prepaid Electrical Energy Billing System

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***Abstract*: The demand of electricity goes on increasing every day due to increase in standardization of human life. At present situation every social activity depends on electricity. All transportation sector applications also depends on electricity in coming days due to shortage petrol and diesel and uncontrolled prices. The gap between generation and demand widening every day. It makes more challenging to electrical engineers to design power system to overcome present difficulties. The researchers are focusing on energy saving techniques rather than installation of new generation plants. The energy saving can also be achieved through the using efficient energy meter or efficient prepaid electricity billing system. This paper mainly focuses on RFID based prepaid electricity billing system.**

***Index Terms*: RFID, electricity, prepaid, utility, consumer.**

I. INTRODUCTION

The widely used conventional billing systems have many disadvantages. The accuracy of billing system mainly depends on performance of meters and its calibration techniques. It is calibrated and tested at new installation of consumer premises. After few years the conventional meter reading may be with errors, it makes a big challenge for consumers billing system. The revenue collection is slow process with less reliability, which results a insufficient fund for further developments of utility. It is essential to improve the revenue collection activities. The prepaid billing system helps in eliminating many disadvantages of the conventional billing system and it also encourages the effective utilization of electricity and reduction in theft considerations.

Recent technological advances have brought an appreciable exposure to various kinds of energy billing systems. One among such system is RFID based prepaid electricity billing system, which facilitates the method of "PAY" and "USE". This advanced energy billing model can be used, where the usage of electricity is prepaid one.

This advanced energy billing model is more advantageous for consumer and utility. It encourages the consumers to use their load very effectively and efficiently. It is more beneficial to electrical utility system, such as advance revenue collection, demand information and minimizes the waste use of electricity. This prepaid electricity billing system encourages national energy saving scheme. Advanced generated fund can be utilized for modernizing, updating the existing power system facilities more tremendously.

II. RELATED WORK

The electricity becomes a very critical factor for every nation. The advancement of nation depends upon irrigation, industries and transportation system. Every nation facing their own electricity installation problems due to huge investment and long term planning process. The research is focusing on implementation of energy conservation principles, reduction in transmission and distribution losses and innovative energy efficient devices or systems. The prepaid electricity billing system provides an efficient billing system opportunity to utility. The transmission and distribution system is struggling with 29% losses. Some percentage of loss is also from electricity theft.

In existing electricity metering system, the revenue collection from consumer requires officials, meter readers with provision of billing and consumers are paying their bills in nearby utility section offices. It is more problem to remote consumers.
This paper explains about the design of MCU based power utilization system in student dormitory. This design makes the use of intelligent IC card to store the information of quantity of electricity. It is very simple to design and easy to monitor. It comprises a 08051F206 MCU as a control unit and SLE4442 card (manufactured by Siemen).

It facilitate gathering students advanced electricity bill, achieve automatic control in order to manage the students. The wastage electrical energy can be controlled and managed effectively. Hence the electrical energy can be effectively controlled. Their by saving in electrical energy and budget is achieved[1].

This paper explains about prepaid electricity billing system, which is based on Raspbery Pi system for different class of consumers. The consumers may be above or below poverty is developed for house hold in real time. At current situation government or electricity board release a benefit for above or below poverty people in India. This system encourages benefits for both consumer and electricity board[2].

The main focus of this paperwork is related to an efficient Automatic Meter Reading (AMR) system. This system encourages a simple low cost wireless GSM energy meter and its related web interface for automatically billing and managing the collected data globally. The proposed system replaces the traditional meter reading methods and enables a remote access of energy meter by energy provider. They can monitor the meter readings regularly without the person visiting each hour.

This technique consists a GSM based wireless communication module with electronic energy meter and remote access facility. A P.C with a GSM receiver at the other end, which consists the database acts as billing point. The live meter reading from GSM enabled energy meter is sent back to the billing point periodically and these details are updated in a central database. User can access the developed web page details from anywhere in the world. The completed monthly usage and due bill is messaged back to the customer after processing the data[3].

This paper mainly focus on modernize electricity billing system using GSM. It mainly depends on TDMA (Time Division Multiple Access) technique with operating frequency about 900 MHz. The details power consumed in energy meter by the consumer is transferred to mobile using GSM. It gives the power consumption information at every instant to consumers. The power consumption increases above the set value, a warning with different tariffs. Consumer can turn ON and OFF their loads with a suitable password [4].

This paper explains about a design of a system that cloud automatically disconnects the electricity of customers temporary or/and permanent if bill is not paid over due date or dead line. This proposed system mainly consists KWh meter, actuator, sensor, communication devices and application. The commands (disconnect/ switch OFF) to actuator is based on customer billing performance, i.e if the customer did not pay the billing until dead line at the second month, then electricity will be disconnected to customer KWh meter. The KWh meter is permanently broken (switched OFF) , if customer did not pay the billing until the dead line of third month[5].

This paper mainly focuses on Automatic Meter Reading (AMR) in indoor environment. Its working is mainly based on WSN (wireless Sensor Network). This technique encourages the remote collection of utilities DATA. The utilities can be electricity distribution, gas consumption and water consumption. The power consumption can be controlled by remote technique. It encourages the improvement in power quality, power service. This technique also implemented in prepaid electricity billing [6].

This paper explains about Zimbabwe Electricity Supply Authority (ZESA) view of electricity service for low and medium income households. The main object of the paper is to understand the consumer's perception of the use of prepaid electricity meters versus the post paid systems in Zimbabwe [7].

This paper explains about the importance of electrical energy in human development activities. Electrical energy becomes very much critical for the development in industrial, transportation and irrigation sectors. At the same instant power theft becomes biggest problem for electricity distribution authority. This electricity theft causes proportional loss in revenue. This factor plays very critical role in the development of nation particularly in developing countries. This paper focuses on the use of smart energy meter by using "energy meter chip". It can be used for automatic metering and billing system. In this meter energy utilized and corresponding bill is displayed on LCD continuously and communicated to the controlling base station. The feedback from the consumers will help in identifying usage between authorized and unauthorized users. In this manner electricity theft can be controlled. Zigbee system is used for communication between the users and substations. GSM network is used for sending SMS to the local authorities regarding theft cases. This smart meter can be used as prepaid or postpaid systems [8].

This paper focuses on 'building energy management system'. It mainly helps to monitor and control their loads efficiently, which reduces the power consumption and their electricity bill easily. Implementation of this technique also postpones the blackouts. In this technique some threshold is set as per consumer requirement. The load priority is designed in such a manner loads are operated always below this point. Hence, by keeping the power consumption automatically below the threshold point. The power demand will be less than designed supply. This proposed technique prevents the blackout and also increases consumer satisfaction service [9].

III. PROPOSED TECHNIQUE

An RFID system consists of three components, such as tag, reader and application (use of data). In general, the reader reads the tag. The tag consists of an antenna and silicon chip encapsulated in glass or plastic. The tag contains a very small amount of information. RFID readers or receivers are composed of a radio frequency module, a control unit and an interrogate electronic tags via radio frequency (RF) communication. Many also include an interface that communicates with an application (such as the library's circulation system). Once the reader reads the tag, the information is passed on to "application" that makes the use of information.
The block diagram of model is depicted in Fig.1. Two microcontrollers are used in this system. One is the 16F87 PIC microcontroller and the other is 89C51 microcontroller. The programming is done for these microcontrollers using "assembly C" language. The PIC 16F877 has 8K and 14 bit words of Flash program memory, 368 bytes of data RAM, 256 bytes of data EEPROM and an 8 level and 13 bit wide hardware stack. The AT89C51 is a low power, high performance CMOS 8- bit microcomputer with 4 K bytes of Flash programmable with erasable read only memory (PEROM).
The RFID means radio frequency identification, it mainly consists of 3 components i) tag ii) reader iii) application that makes the use of data.

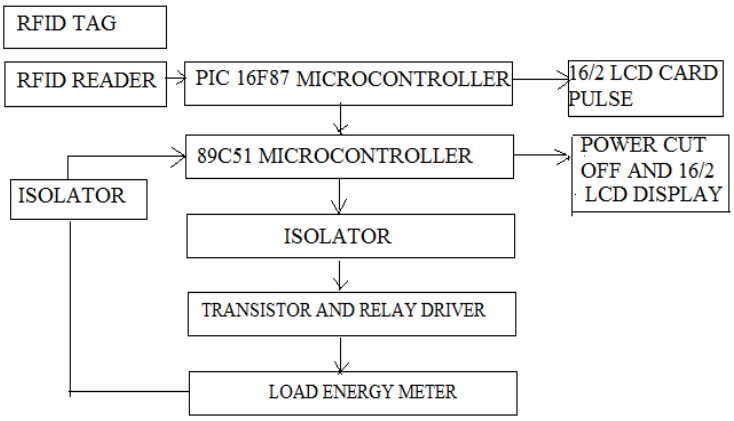

Fig 1. Block diagram of model

The tag consists of an antenna and silicon chip encapsulated in a glass or plastic. RFID readers are receivers, which composed of radio frequency module, a control unit and an antenna to interrogate electronic tags via RF communication. Many also include an interface that communicates with an application. Once the reader reads the tag, the information passed on to an "application" that makes the use of information.

When an RFID card is swapped over the RFID card reader. It senses the type of the card and code of card (each card processes certain amount of pulses and card have a particulate code). The reader senses particular amount of pulses of the card and sends the BCD signal to PIC microcontroller 16f877. The PIC microcontroller displays the number of pulses present in the swapped card, and it is displayed on 16/2 LCD display. The PIC microcontroller sends the digital signal to the 89c51 microcontroller. This microcontroller supplies the power to the load. So, it turns ON the load. At the same instant, timer starts count down and counts the number of pulses consumed by the load. These signals from energy meter comes to the 89c51 microcontroller through optocoupler. The 89c51 microcontroller keep the track of how much pulses had got consumed. After the consumption of each pulse, the buzzer turns ON (provides a sound).When the pulses in 89c51 becomes zero, then microcontroller sends a trip signal to the relay. So that respective load can disconnected. At the same time a continuous alarm will be get started to alert the user for further recharge.

Once the card is used, it cannot be used again. If consumer uses the same card again, then PIC microcontroller displays as "USED CARD" and pulses are not considered. If any unknown card is swapped on the RFID card reader, then the microcontroller display as "INVALID CARD". The flowcharts of both the microcontrollers are depicted in Fig 2 and 3 respectively.

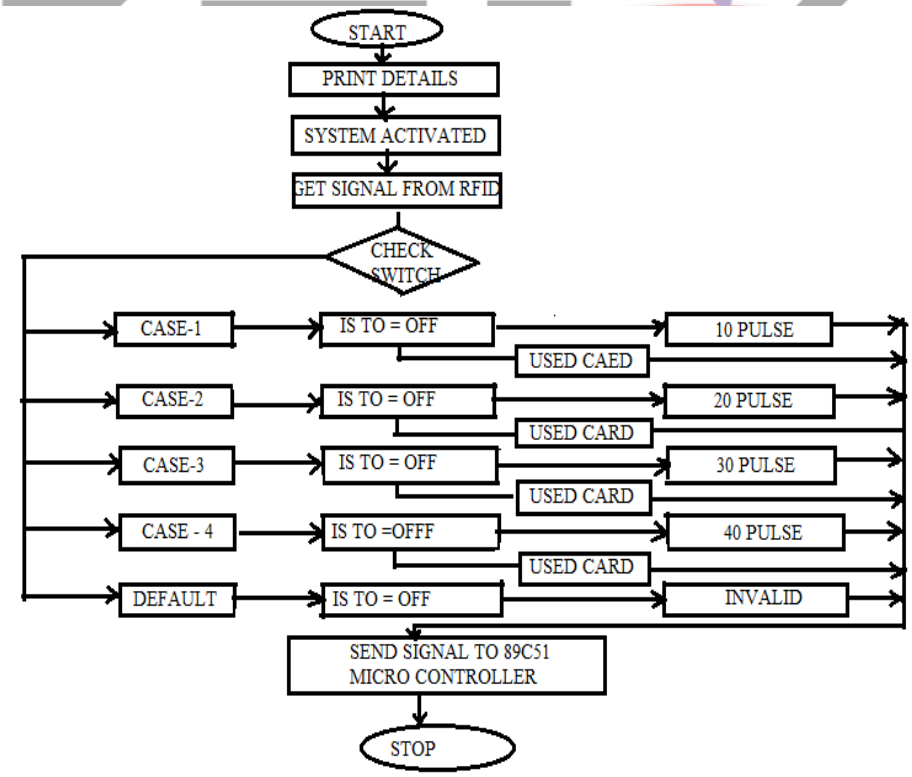

Fig 2. Flow chart for 16f877 microcontroller

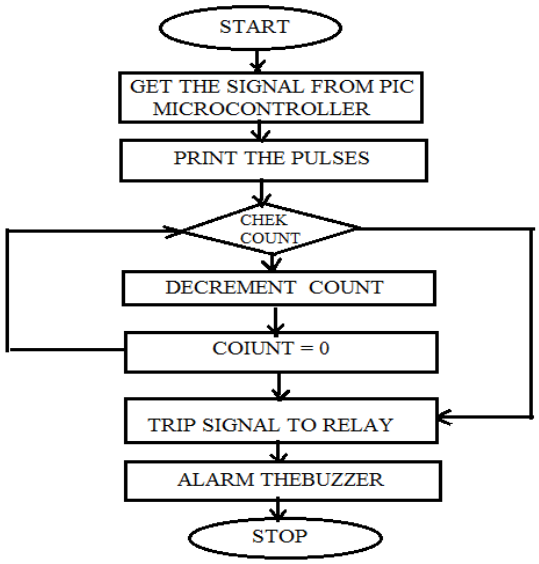

Fig 3. Flow chart for 89c51 microcontroller

1. RFID Technology:

The RFID mainly consists of 3 particulars namely i) An antenna or coil ii) transceiver iii) transponder

The antenna emits radio signals to activate the tag and read and write the data to it. Antennas are the conduits between the tag and the transceiver, which controls the system's data acquisition and communication. Antennas are available in a variety of shapes and sizes. They can be built in to a door frame to receive tag data from persons or things passing through the door, or mounted on an interstate tollbooth to monitor traffic passing by on a freeway. The electromagnetic field produced by an antenna can be constantly present, when multiple tags are expected continually. If constant interrogation is not required, a sensor device can activate the field.

The antenna is packaged with the transceiver and decoder to become a reader, which can be configured either as a handheld or a fixed mount device. The reader emits radio wave in ranges of anywhere from one inch to 100 feet or more, depending upon its power output and the radio frequency. When an RFID tag passes through the electromagnetic zone, it detects the reader's activation signal. The reader decodes the data encoded in the tag's integrated circuit (silicon chip) and the data is passed to the host computer for processing.

- TAGS:

An RFID tag is comprised of a microchip containing identifying information and an antenna that transmits this data to a reader. The chip consists a serialized identifier, or license plate number, that uniquely identifies that item which is similar to the way many bar codes are used. The RFID tags have a higher data capacity than their barcode counter parts. This increases the options for the type of information that can be encoded on the tag, including manufacturer, batch or lot number, weight, ownership, destination and history. In fact an unlimited list of other types of information can be stored on RFID tags.

i)The read only tag contain data such as serialized tracking number, which is pre written on to them by the tag manufacturer or distributor. These are generally the least expensive tags because they cannot have any additional information included as they move throughout the supply chain. Any updates to that information would have to be maintained in the application software that tracks SKU movement and activity.

ii) "Write once" tags enable a user to write the data to tag one time in production or distribution processes. It may include a serial number and other data like lot or batch number.

iii) Full "read - write" tag allow the new data to be written to the tag as needed and even written over the original data. Examples for the latter capability might include the time and date of ownership transfer or updating the repair history of a fixed asset. While these are most costly of the three type of tags.

- RF Transceiver:

The RF transceiver is the source of the RF energy used to activate and power the passive RFID tags. The RF transceiver may be enclosed in the same cabinet as the reader or it may be separate piece of equipment. When provided as a separate piece of equipment, the transceiver is commonly referred as an RF module. The RF transceiver controls and modulates the radio frequencies that the antenna transmits and receives. The transceiver filters and amplifies the backscatter signal from a passive RFID tag.

CIRCUIT DETAILS:

1. Controller circuit: A 230V supply is given to the step down transformer, voltage is reduced to 12V. This 12V supply is given to bridge rectifier consisting of four diodes, which rectifies the voltage. The output is given to 1000µF capacitor, which reduces the voltage fluctuations. This 12V supply is given to voltage regulator. So, it again reduces the 12V to 5V. A 100 µF capacitor is connected across this. A 0.1 µF capacitor is connected across the circuit to avoid electromagnetic and radio frequency interferences.

The optocouplers are connected to supply through 1K resistances the output from these optocouplers is given to port p1 of the 89c51 microcontroller. The pin 40 and 31 of the 89c51 Microcontroller connected to positive supply and pin 20 is connected to ground.

The port p2 is connected to LCD display. The pins 18 and 19 are connected to crystal oscillator, which generates a frequency of 11.0592 MHZ. Two 33pF start up capacitors are connected to crystal oscillator. The manual switch is connected to pin 9. The port p0 is connected to two optocouplers and the signal from the optocouplers is given to BC548 npn transistor. The collecting terminal is given to the buzzer and emitter terminal is connected to LCD display.

2. Receiver circuit: The 230V is given to the step down transformer that reduces the voltage to 12V. This 12V is given to bridge rectifier consisting of four diodes, which rectifies the voltage. The output is given to 1000µF capacitor, which reduces the voltage fluctuations. The 12V supply is given to voltage regulator, which reduces the voltage again from 12V to 5 V.

3. Driver circuit: A supply voltage of 230V is given to step down transformer (230/12). This voltage is rectified by the bridge rectifier circuit. The rectified voltage is filtered by a capacitor of 10µF, which is given to LED through 1K resistor for the indication of the presence of supply. The voltage is passed through the optocoupler, which is working at 5V, which consisting of a diode and photo transistor (Q1) through voltage divider circuit, the collector of (Q1) is connected to the base of transistor (Q2) through 1K resistor (to limit the current to a safer value). The function of transistor (Q2) is to drive the relay circuit.

IV. PROPOSED TECHNIQUE

Three different lamps are considered for result analysis. The lamps considered are i) Incandescent lamp (normal lamp) ii) CFL. The different wattage lamps have been considered for the analysis of time consumption for one pulse. In normal lamp category 60W, 100W and 200W are considered for practical consideration. In CFL category 15W, 18W and 23W are considered for practical consideration. It is observed from following experimental results that, more power occurs with use of normal lamp. At the same instant power saving is possible with use of CFL. It encourages the consumers to utilize the CFL as energy efficient lamp. It also promotes the national energy saving scheme. Table 1 indicates the comparison timing analysis for different CFL lamps.

Table 1: Rating and Timing analysis of Normal lamp

Wattage of lamp	Time for consumption of one pulse
60 Watts	18 Seconds
100 Watts	11.2 Seconds
200 Watts	1.8 Seconds

The below Fig. 4 shows the output of the timing analysis for different rating normal lamps. Here 60W lamp takes 18 seconds of time for consumption of one pulse. 100W lamp takes 11.2 seconds for consumption of one pulse and 200W lamp takes 1.8 seconds for consumption of one pulse.

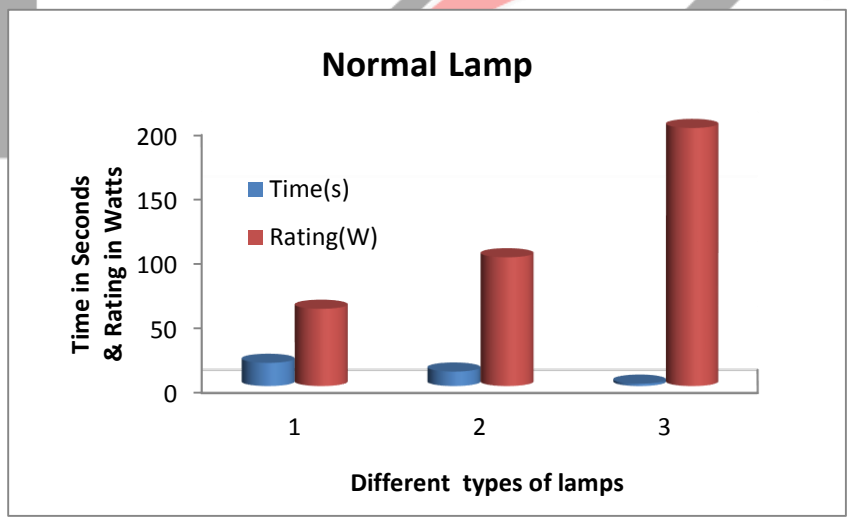

Fig.4: Plot showing the rating and timing of Normal Lamp

Table 2: Timing and Rating Analysis of CFL

Wattage of lamp	Time for consumption of one pulse
15 Watts	1 minute, 23 Seconds
18 Watts	56 Minutes
23 Watts	48 Minutes

Table 2 indicates the comparison timing analysis for different CFL lamps. It is clearly shown that the time consumption is decreased in all three CFL lamps as compared to conventional adder. The below Fig.5 shows the output of the timing analysis for different rating normal lamps. Here 60W lamp takes 18 seconds of time for consumption of one pulse. 100W lamp takes 11.2 seconds for consumption of one pulse and 200W lamp takes 1.8 seconds for consumption of one pulse.

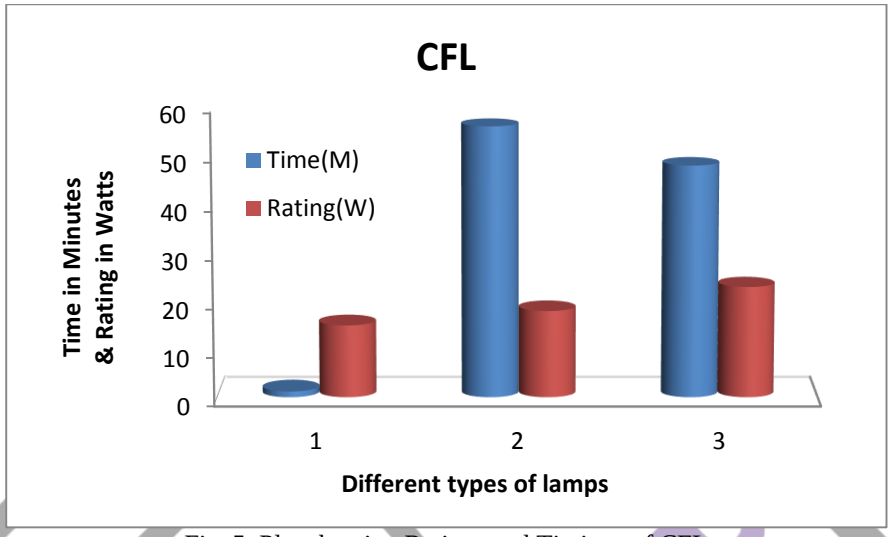

Fig. 5: Plot showing Ratings and Timings of CFL

CONCLUSION

The proposed RFID based prepaid electricity billing system has benefit of using a secure RFID card to use the distribution of the electricity. The initially collected amount from consumers can be utilized for electricity consumption based on user profile stored on the card. The utility comes to know about requirement of demand very early, encourages the efficient distribution of electricity. It also encourages the unique feature of using the RFID tags at a distance from few millimeters to several meters. It is more essential for developing countries like India to reduce the gap between electricity generation and demand. The initially collected huge fund can be utilized for modernization and up gradation of existing power system. The consumers are benefited with reduction in their electricity bills and uninterrupted power supply. The utility can be benefited by i) energy saving implementation ii) invest large fund in national development programmers iii) increase in generation plant load factor iv) postponement of installation of new generation and transmission systems.

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