A GSM Based Energy Management System using Automatic Prepaid Energy Meter

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---ABSTRACT---

The notion of electronic energy meters has been hosted the power sector to effectively record the energy consumed for billing purposes and also to curtail losses that occurs due to conventional electromechanical energy meters. Although the machinery of e-metering has gone through rapid technological expansions, still there is a demand for an efficient energy management system. This paper presents an efficient energy management system for household purposes using GSM based Automatic Energy meter. This system provides the necessary measurement of power consumption and payment with prepaid billing. It automatically provides prior notification to the consumers, once the recharge amount approaches zero. It also efficiently manages the energy consumption by periodic intimation of consumed power to the customers.
Keywords: Global System for Mobile communication (GSM); Prepaid Meter; Energy Management

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I.   INTRODUCTION

Since few decades, electrical power has become an inevitable resource in everybody's life. As with the increasing demand for electricity, automation in the energy distribution and management systems has also becoming a necessity. So, advanced smart meters are being developed to handle the measurement of power consumption, billing, customer notification etc.

In many developing countries like India traditional electro-mechanical meters are still widely used, which tend to drift over temperature and time due to the analogue and mechanical nature of the components in these meters. Due to the post-paid billing method, collection of meter readings is also inefficient, because a meter reader must physically be on-site to take the readings. This method of collecting meter readings becomes more problematic and costly when readings are collected from vast, and often scattered rural areas. Meter readers are reluctant to make the effort to travel to such areas which paves the way for incorrect estimations of the amount of electricity consumed. Even in some places these traditional meters are replaced with electronic meters but due to post-paid billing the problems still persist. So, instead of post-paid billing if prepaid billing is done the dependency of collecting bills will not be there.

In this paper, we are proposing an efficient automatic prepaid metering system which deduces the amount from the recharge balance without requiring the human intervention. This system also provides prior periodic notification to the customers in order to manage the power usage effectively.

II.   RELATED WORK

In existing systems, either an electronic energy meter or an electro-mechanical meter is fixed in the premise for measuring the energy usage. This method of electricity billing involves a person from the distribution unit reading the number of units of electricity consumed in the energy meter, conveying this information to the distribution unit and then preparing the bill according to the units consumed for a fixed amount of time. Still accuracy cannot be guaranteed as there can be errors in human reading. Even though digital meters are being replacing conventional electromechanical meters and provide much accurate readings, still the problem of deliberately making a false reading can exist. Despite this, the task of billing for every consumer is a time consuming job for the distribution grid. Also the consumer can deliberately consume more amount of power than required and still refrain from paying the bill and nothing can be done to severe the electric power supply. To eliminate all these problems, the most convenient method is making the whole system prepaid similar to a mobile phone recharge or a DTH recharge.

Many systems built on various platforms have been proposed by different research groups all over the world for

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Prepaid Energy Meter. In [1], the Atmega32 micro- controller was used and ATtiny13 was used as a smart card, both involve the requirement of a complex backend server. In [2] they used the GSM module connected to the energy meter unit and all the readings were sent to the energy provider. The energy provider used the E-mails and web portals to send notifications to the customers. In [3] Raspberry pi board was used, which is efficient but at the same time, it is costlier than the other systems.

III. SYSTEM METHODOLOGY

The functional block diagram for the proposed prepaid energy management system is shown in   Fig 1. This system is built using the 8051 microcontroller, single phase electronic meter, a LCD display and a GSM modem. A LDR is used to capture the blinking LED pulses from the meter to count the number of units consumed. A set of buttons are used for setting the cost and hence recharge the system. A relay is used for switching the supply on/off automatically.

The E-Meter is connected with the load, the LED present in the meter blinks according to the energy usage. The blinking of LED will be detected by the LDR placed over it. The output of LDR will serve as an input to the Micro-controller. With the blinking of LED, the blinking count will increase in the Micro-controller and thus the amount in the recharge balance will get deducted. The remaining amount will be continuously displayed on the LCD module. Once the amount approaches zero, the user will get a notification on the registered mobile number asking the customer to recharge for continuous availing of the services.
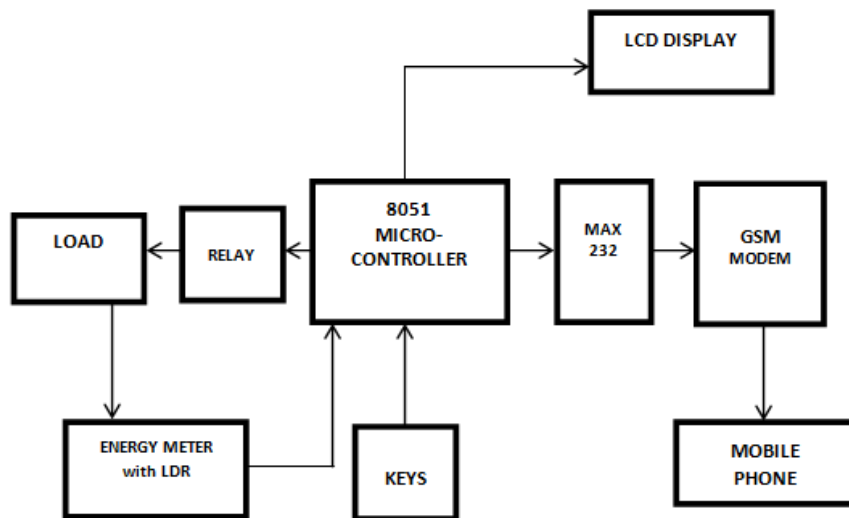

Fig 1. Functional Block diagram of Prepaid Energy Management System

If the balance becomes zero, the power will be cut off through the relay. The user also manages the system to get on-demand / periodic notification about the energy usage which in turn helps for efficient energy management.

The detailed block diagram of the system is given in Fig 2. The proposed system uses standard power supply comprising of a step-down transformer from 230V to 12V and 4 diodes forming a bridge rectifier that delivers pulsating dc which is then filtered by an electrolytic capacitor of about 470µF to 1000µF. The filtered dc being unregulated, IC LM7805 is used to get 5V DC constant at its pin no.3 irrespective of input DC varying from 7V to 15V. The input dc shall be varying in the event of input ac at 230V section varies from 160V to 270V in the ratio of the transformer primary voltage V1 to secondary voltage V2 governed by the formula V1/V2=N1/N2. As N1/N2 i.e. no. of turns in the primary to the no. of turns in the secondary remains unchanged V2 is directly proportional to V1. Thus, if the transformer delivers 12V at 220V input it will
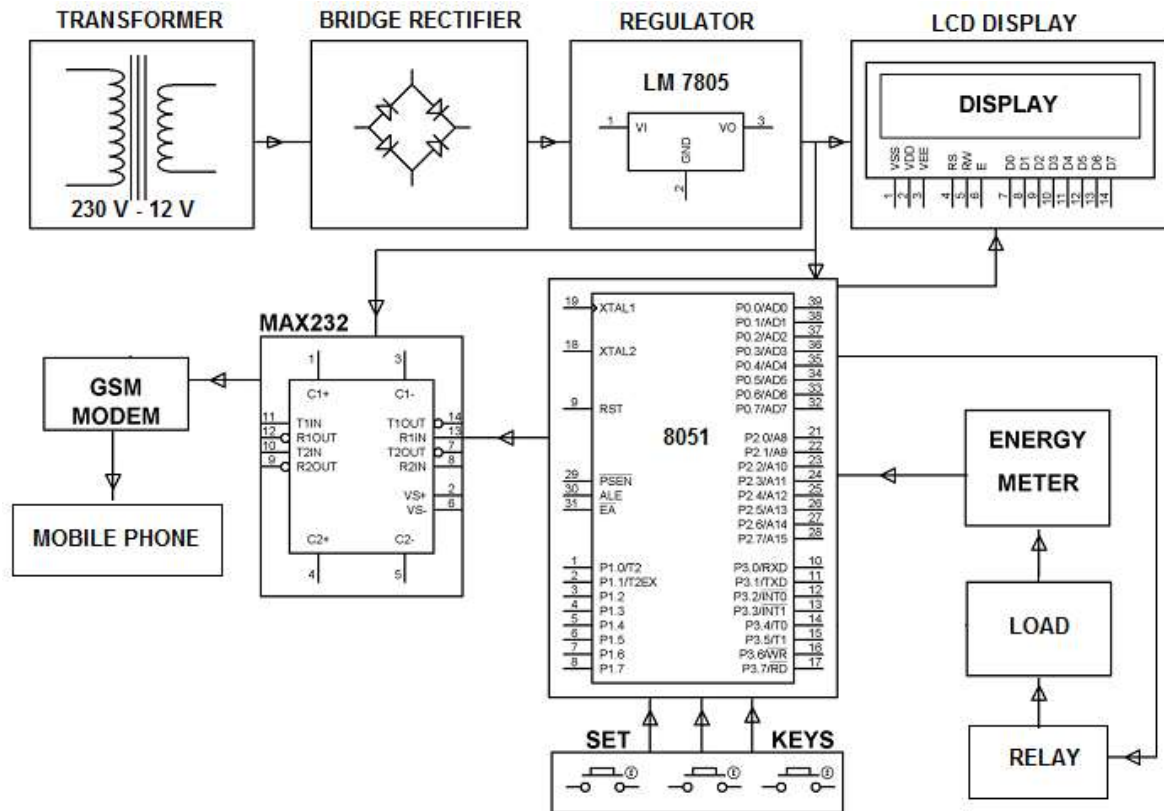
Fig 2. Detailed Block Diagram

give 8.72V at 160V. Similarly at 270V it will give 14.72V. Thus, the dc voltage at the input of the regulator changes from about 8V to 15V because of AC voltage variation from 160V to 270V the regulator output will remain constant at 5V.

The ATMEL series of 8051 family of micro controllers need certain standard connections. Every microcontroller requires a timing reference for its internal program execution therefore an oscillator needs to be functional with a desired frequency to obtain the timing reference as t =1/f. Pin no. 9 is provided with a re-set arrangement by a combination of an electrolytic capacitor and a register forming RC time constant. At the time of switch on, the capacitor gets charged, and it behaves as a full short circuit from the positive to the pin no. 9. After the capacitor gets fully charged the current stops flowing and pin no. 9 goes low which is pulled down by a 10k resistor to the ground. This arrangement of reset at pin 9 going high initially and then to logic 0 i.e., low helps the program execution to start from the beginning.

In absence of this, the program execution could have taken place arbitrarily anywhere from the program cycle. The pin termed as EA in 8051 microcontroller is required to be connected to 5V for accessing the program form the on-chip program memory. If it is connected to ground then the controller accesses the program from external memory. However, as we are using the internal memory it is always connected to +5V. RS232 is a widely used standard for serial communication in embedded systems. It is used to transfer signals between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE). In this case, AT89C52 is a DTE while GSM modem is a DCE.

IV. PROPOSED ALGORITHM

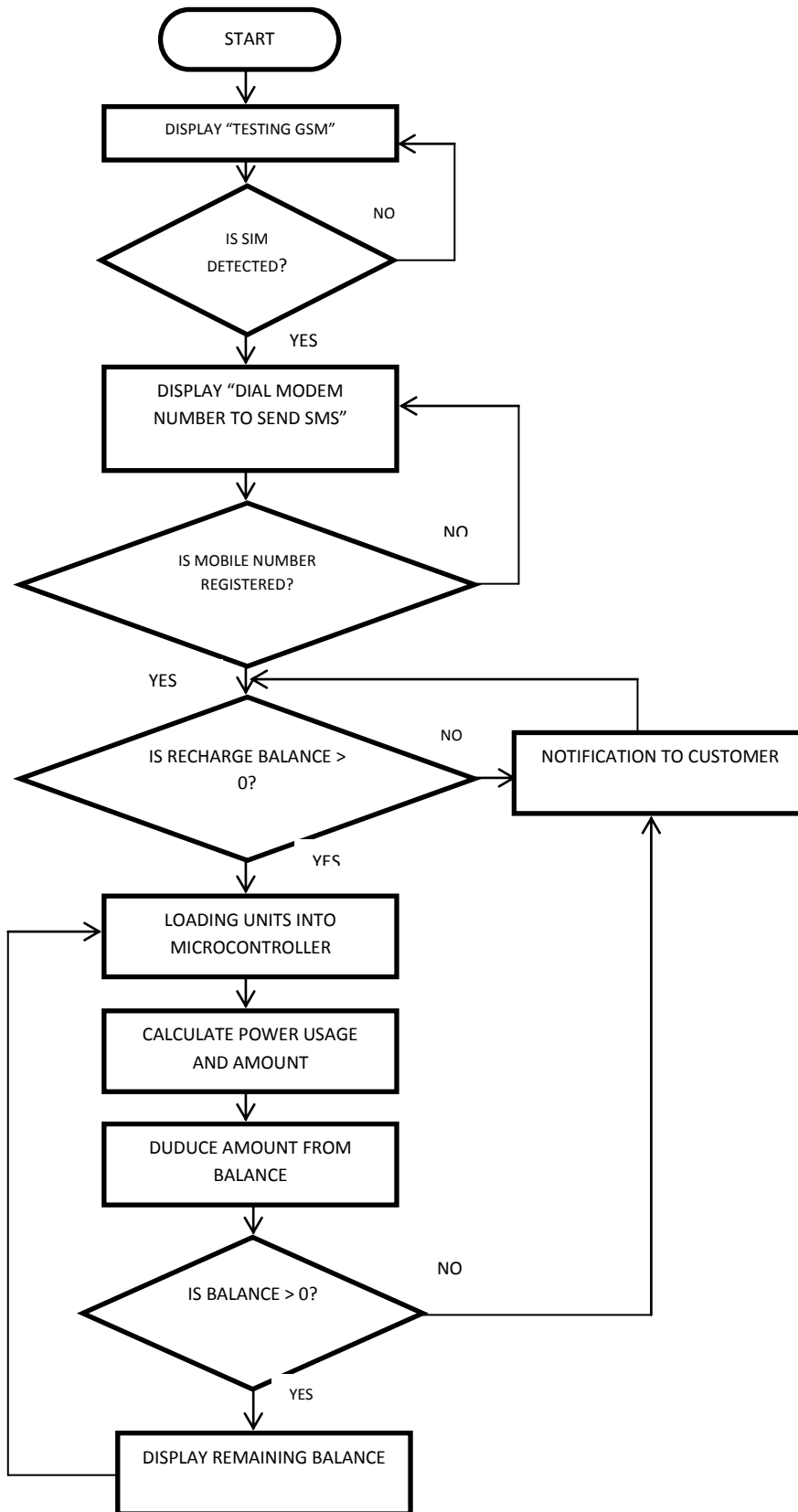The flow chart of the automatic metering based energy management system is depicted in Fig 3.

Fig 3. Flowchart of the proposed system

V.   RESULTS AND DISCUSSION

5.1 Testing the GSM module

Initially, when the supply is turned on, the system tests the GSM nodule which is shown in Fig 4. A message called "*Testing GSM*" will be displayed until the GSM module works properly i.e., until the SIM is detected.
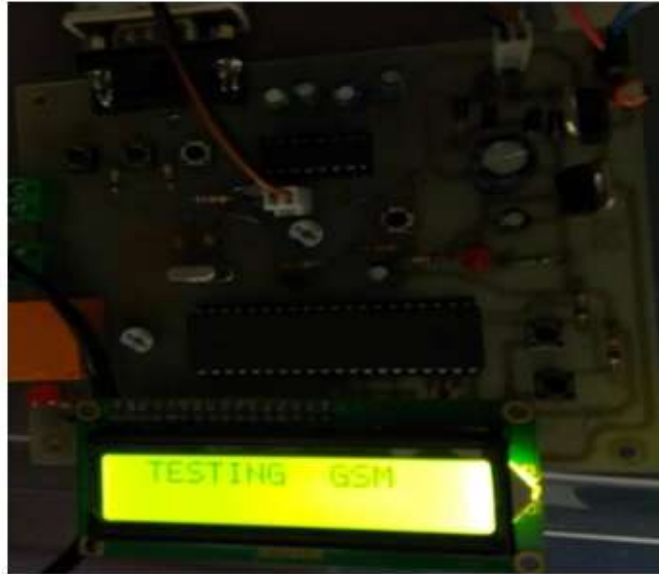

Fig 4. Testing the GSM Module

5.2 Registering mobile number

If the GSM module is working perfectly, then the system will ask for the user to call to the GSM module to register the phone number of the user. When the user calls to the GSM module, the system registers the phone number into the memory. The registration process is shown in Fig 5.

Fig 5. Registering Mobile Number

5.3 Setting up the system

After the phone number is registered the system asks the user to recharge. The recharge can be done using the RECHARGE button. When the RECHARGE button is pushed a pulse is sent to the relay and the load gets the power from the source and the LED in the meter starts blinking. Typically, when the LED blinks 3200 times 1 unit of the power will be consumed. So, for every blink of the LED in the energy meter some amount of the recharge will be deducted. The system is shown in Fig 6.
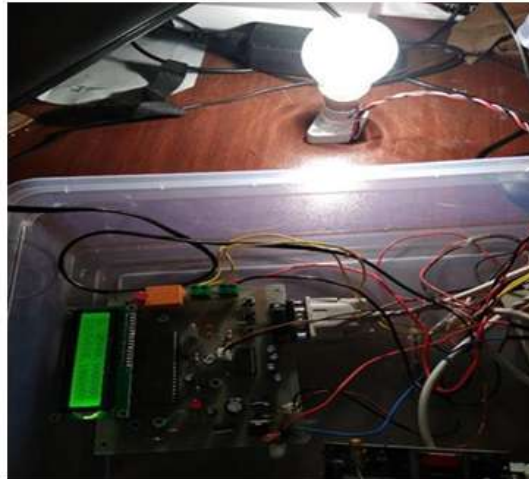
Fig 6. Setting the System

5.4 Cutting off the power and sending the notification

When the amount approaches zero, a notification is sent to the registered mobile number asking the customer to recharge. If the balance turns out to nil, a pulse is sent to the relay so that the power will be cut off at the load and the system will ask the user for recharge again. The cut off is shown in Fig 7. So, when the user recharges the system using RECHARGE button immediately a pulse is sent to the relay and the power will be consumed by the load.

Fig 7. Power cut off

After the balance is exhausted, the system sends notification message to customer's mobile as shown in Fig 8.
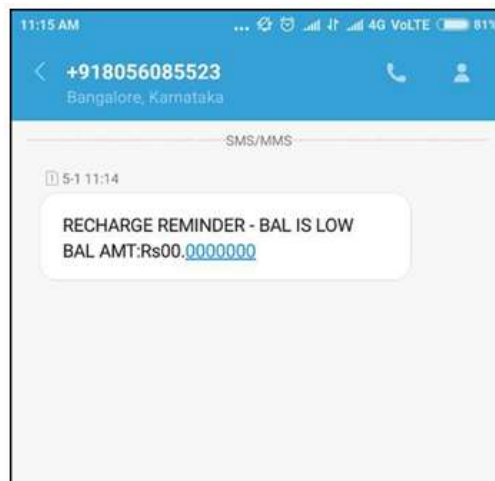

Fig 8. Notification sent via SMS

VI. CONCLUSION

The prepaid automatic metering based energy management system is beneficial for both the customers and service providers. This system eases revenue cost and gives a solution for the man made errors and problems like over running of the meter, over load, etc. This device acts like an add-on for the meters that are currently used in India. But, currently more researches on going on to design the meter entirely which integrates GSM module, with microchips for memory and processing so that they can incorporate all features in a single package.

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