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An Improved Prepaid Meter Billing Approach using Mobile Phone

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ABSTRACT

The automated prepaid electricity meter is used to measure the voltage, current, power and finally number of units consumed by the customer. The consumption of power varies from customer to customer; the variation of power consumption is monitored and controlled by automated electricity billing system. Besides checking of home purposes 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 billing system. The existing system of energy billing does not give the warning about amount of bill and remaining amount to user via SMS to user's mobile phone. In our proposed system prepaid electricity energy meter in which we can recharge its balance, like we do in our mobile phones. In this paper, we are building an automated system by using Arduino based hardware requirements with some development tools. In this system money is inserted by keypad and show on the LCD display. This system will count electricity bill and automatically send some updates to users mobile phone. The user can get the amount of bill of the energy meter via SMS.

Keywords: *GSM, Microcontroller, Transformer, Current sensor, SIM card, SMS, Mobile phone, LCD display, Energy meter.*

1. INTRODUCTION

For human survival and progress, electrical power has become essential. To make people's life standard it is necessary to enhance growing demand, automation in the energy distribution. The kilowatt hour is the most common unit of measurement on the electricity meter which is equal to the volume of energy used by a load of one kilowatt over a period of one hour. On the other hand consumers are also not satisfied with the services of power companies, most of the time they have complaints regarding statistical errors in their monthly bills. Presently prepaid billing system has been introduced which is a two way communication based on smart card technology that allows the customer to charge their advance electricity bill through vending station in the smart card. But the present system of energy billing does not give the warning to user via SMS to users mobile phone [2].

It is inefficient to meet the future residential development needs using traditional meter reading by human hand. So industrial, commercial and utility environment, there is an improved demand for automatic meter reading systems which collects meter readings automatically. A system which will offer the bill in users mobile will be more suitable in the current situation. At this point a new technique of prepaid electronic meter billing system is introduced in this project which will automatically sense the used bill, records these reading continuously, then sends it to the user through the existing GSM network. Here the inserted money is shown on the LCD display. Finally after processing the collected data bill is generated and is send back to the customer as SMS (Short Messaging System) [1].

The main purpose of the project is to develop a GSM based user warning system for pre-paid electricity billing system and load control through SMS. At past, electricity department sends employees to take meter reading every month, which is an expensive and time consuming job. The present prepaid system of energy billing does not give the warning to user via SMS to user's mobile phone. The proposed project provides a convenient and efficient method to avoid these problems.

The paper is organized as follows: proposed method is described in Section II, the general description of hardware's and software are presented in Section III, experimental setup in Section IV and finally Section V contains the result discussion and concluding remarks of this work.

2. PROPOSED METHOD

Fig. 1 shows the block diagram of the proposed SMS- based prepaid electricity billing system using GSM and Arduino which is implemented in this paper.

Design of the System

This system has been designed with keeping in mind the following key requirements-

- The server network should be accessible from anywhere for sending SMS to mobile phone.
- Clients should be able to quickly and seamlessly connect to and disconnect from the system.
- A SIM card of user should be registered.
- A periodic time should be set up by user for warning via SMS.
- Hardware's should be compatible with each other.

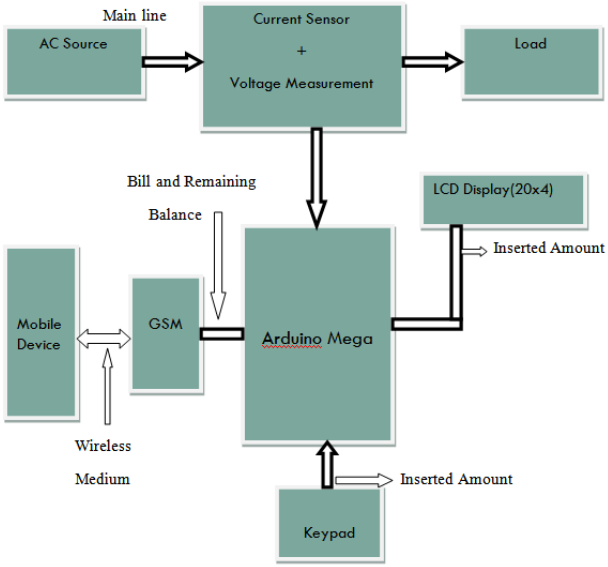

Fig. 1. Block diagram of the SMS- based prepaid electricity billing system using GSM and Arduino.

Analysis of the System

Our proposed system is implemented with Arduino based hardware requirements with some development tools.
Hardware requirements are-

- Arduino Mega 2560
- IOT-GA6 GPRS GSM module
- ACS712-05 current sensor module
- LCD display
- Step down transformer
- Bread board
- 100k resistor
- Keypad
- Male-male jumper wire
- Female-male jumper wire

3. GENERAL DESCRIPTION OF THE HARDWARE AND SOFTWARE

Hard ware Description:

3.1 GSM Network

GSM was originally known as Group Special Mobile but nowadays it is commonly referred as Global System for Mobile Communication. One of the key features of GSM is the SIM (Subscriber Identity Module) [1]. GSM is used by

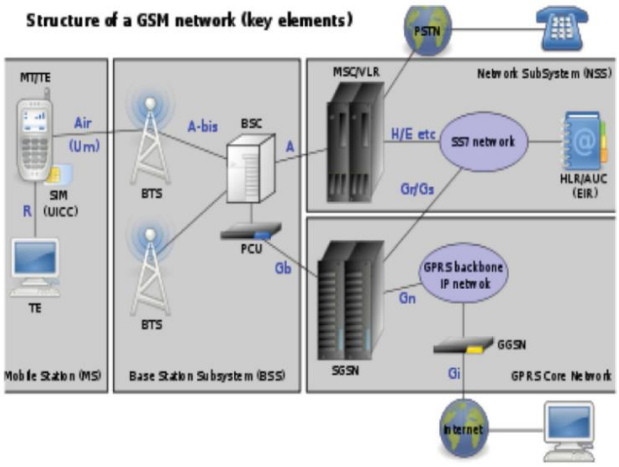

Fig. 2. GSM network structure

Over 1.5 billion people all over the world. GSM also pioneered the low cost implementation of the SMS which allows gatherings to conversation delay accepting short text messages. The popularity and coverage of cellular networks allows the use of SMS service [1]. Fig. 2 shows the block diagram of the GSM network structure and Fig. 3 represents the IC diagram that is used in the proposed method. The GSM module is mainly a GSM modem (A6 GSM module) linked to a PCB with different types of output taken from the board. This type of requirements varies with different modules [1] [3].

Fig. 3. IOT-GA6 GPRS GSM module [6].

3.2 Arduino Mega

Fig. 4 represents the IC diagram of *ArduinoMega 2560* that is used in the proposed method.

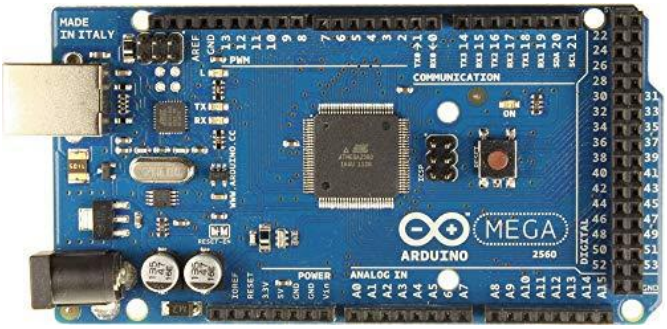

Fig.4. ArduinoMega2560 [5].

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs),16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on wiring) and the Arduino development environment (based on processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP). Arduino is a cross-platform program. The Arduino Mega 2560 is programmed using the Arduino Software (IDE), our Integrated Development Environment common to all our boards and running both online and offline.

3.3 Current Sensor

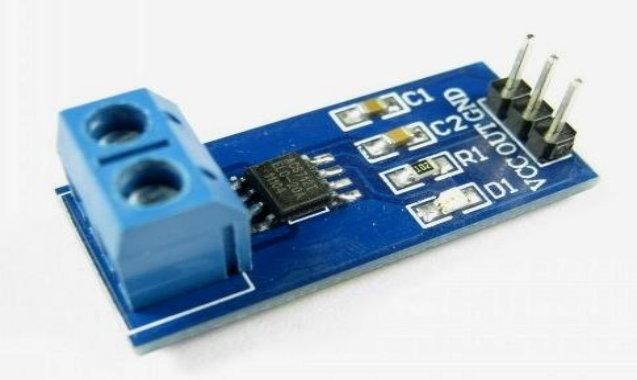

Fig. 5. ACS712-05 current sensor module [7].

We are using Hall Effect based current sensor in this project. This can be used to measure DC current, AC current, and even pulsed current waveforms. Applications for sensor include battery management circuits, battery chargers, arc welders, uninterruptible power supplies (UPS), and inverters. Attributes which are important in selecting the right Hall Effect Current sensor for our application include: rated current (A); supply voltage (VDC); mounting style (PCB or panel); Technology (open loop or closed loop); Primary connection and output (can be either an output voltage level or an output current level that is proportional to the primary current – as measured [1 [3]. Fig. 5 shows the IC diagram of ACS712-05 current sensor module that is used in the proposed method. For this project current sensor is one of the important hardware requirements. Since we are unable to manage/purchase a digital meter we need a current sensor for measuring current. Arduino power supply voltage (+5v) is connected to current sensor voltage (+Vcc). Ground is connected to ground pin of sensor. Output pin (A1) is connected to output pin of sensor.

3.4 Transformer

For metering function we need not only current sensor for measuring current but we also need voltage. We know arduino's maximum voltage access capacity is +5v. So we need a step down transformer that acts as a voltage divider.

3.5 Keypad

Keypad is used in this project for user input. The amount the user recharged in the meter, it has to be insert manually in Arduino via the keypad. So knowing how to connect a keypad to an Arduino is very important for building the system. At the end, when all equipment is connected properly and programmed, then a key is pressed, it shows up at the serial monitor on computer. But when the LCD display is connected, we prefer to give output of the key press in the LCD, because user must have known that which amount he or she entered and is that the right amount or not. In this

project, the type of keypad we will use is a matrix keypad. This is a keypad that follows an encoding scheme that allows it to have much less output pins than there are keys. For example, the matrix keypad we are using has 16 keys (0-9, A-D, *, #), however only 8 output pins. With a linear keypad, there would have to be 17 output pins (one for each key and a ground pin) in order to work. The matrix programming system allows for less output pins and thus much less connections that have to be made for the keypad to work. In this way, they are more efficient than linear keypads, being that they have less wiring.

The setup for key pad is following

```
keys [ROWS][COLS] = {
        {'1','2','3','A'},
        {'4','5','6','B'},
        {'7','8','9','C'}
        {'*','0','#','D'}
```

And pin number connected with Arduino board is;

Row pins [ROWS] = {45, 43, 41, 39}
Column Pins [COLS] = {37, 35, 33, 31}

3.6 LCD Display

LCD display is used for showing 'Insert Money' and when enter amount by keypad then show 'Inserted:…..'. LCD display is closely related with keypad.

Software Requirements:

A number of different programming tools and languages were used for the development of the various software components of the prepaid metering warning system. Since the system involves components that run on different platforms such as a mobile phone, desktop PC etc. the most appropriate language for each stage was selected.

3.7 C/C++

The development of the server application for this system has been coded using one of the most popular programing languages which is C/C++. This is a general purpose programming language. It has commanding, object-oriented and universal programming structures, while also providing the abilities for low-level memory handling [4].

3.8 Arduino IDE 1.6.8

This is open-source Arduino software (IDE) and this makes it easy to write code and upload it to the board. It uses c++ compiler to compile code written using the IDE [4].

4. EXPERIENTAL SETUP

A single task is easy to implement in comparison with implementing the overall system together. And that's why we need to divide the whole system into many segments or modules. In this system, there are many modules to implement the full system. These modules are described step by step on next-

The proposed model has the ATmega2560 microcontroller as central processing unit. The whole system is interfaced with ATmega2560 microcontroller. The GSM modem is serially connected with the controller which is the major communication module between user and provider. The GSM uses its own network for the transfer of information. Special coding in embedded c is used for programming the microcontroller using programmer hardware along with IDE software. The programming makes use of messaging features of GSM command. The power circuitry converts 230v AC to 12v DC with the use of step-down transformer and rectifier which is shown in Fig. 6 [8].

The LCD is interfaced to microcontroller using parallel port connection. In this project the microcontroller based system continuously records the readings and the live meter reading can be sent to the user. A dedicated GSM modem with SIM card is required for each energy meter. The microcontroller pulls the SMS received by phone, decodes it, recognizes the mobile no. and then switches on the current sensors attached to its port to control the appliances. After successful operation, controller sends back the acknowledgement to the user's mobile through SMS. The coding emphasis the fact that it reduces human labor but increases the efficiency in calculation of bills for used electricity and also will get displayed in LCD module. The LCD display will displays the used amount and balance amount that can be used. The screen shot of the entire hardware design work of prepaid billing system is illustrated in Fig. 7. And the result of the experimental setup is shown in Figures 8, 9, 10, 11and 12.

System Testing:

If the testing is done successfully then the system will be considered as an effective and efficient system. The system has been tested using both the black box testing and the white box testing. The black box testing ensures the correctness of the outputs of the system with the given inputs. While the white box testing involves providing calculated inputs so that the internal structure of the system can be verified to be error free. It determines all the possible ways of the code paths with the given inputs. For testing, at first the keyad is tested when light is on which is shown in Fig. 8. Similarly LCD display is tested in Fig. 9. Fig. 11. shows the testing for inserted money from keypad. And Fig. 12. is visualized the screen shot of the sms from GSM module for low balance and testing for sending SMS to mobile phone.

4. RESULTS DISCUSSION AND CONCLUSIONS

The GSM based user warning system for prepaid electricity billing system project as stated proffers solution to the deficiencies of traditional metering system. With the implementation of the GSM network system which is readily available. As this project is prepaid system for electricity billing so it is easy to add credit to the meter through keypad by users. It shows the inserted money on LCD display. Given warning about amount of spending and remaining balance via SMS to customer after a period of time. Thus it avoids human intervention, provides efficient meter reading, avoid the billing error and reduce the maintenance cost. In future we will be trying to work with real digital meter and trying to setup all devices in printed circuit board (PCB).

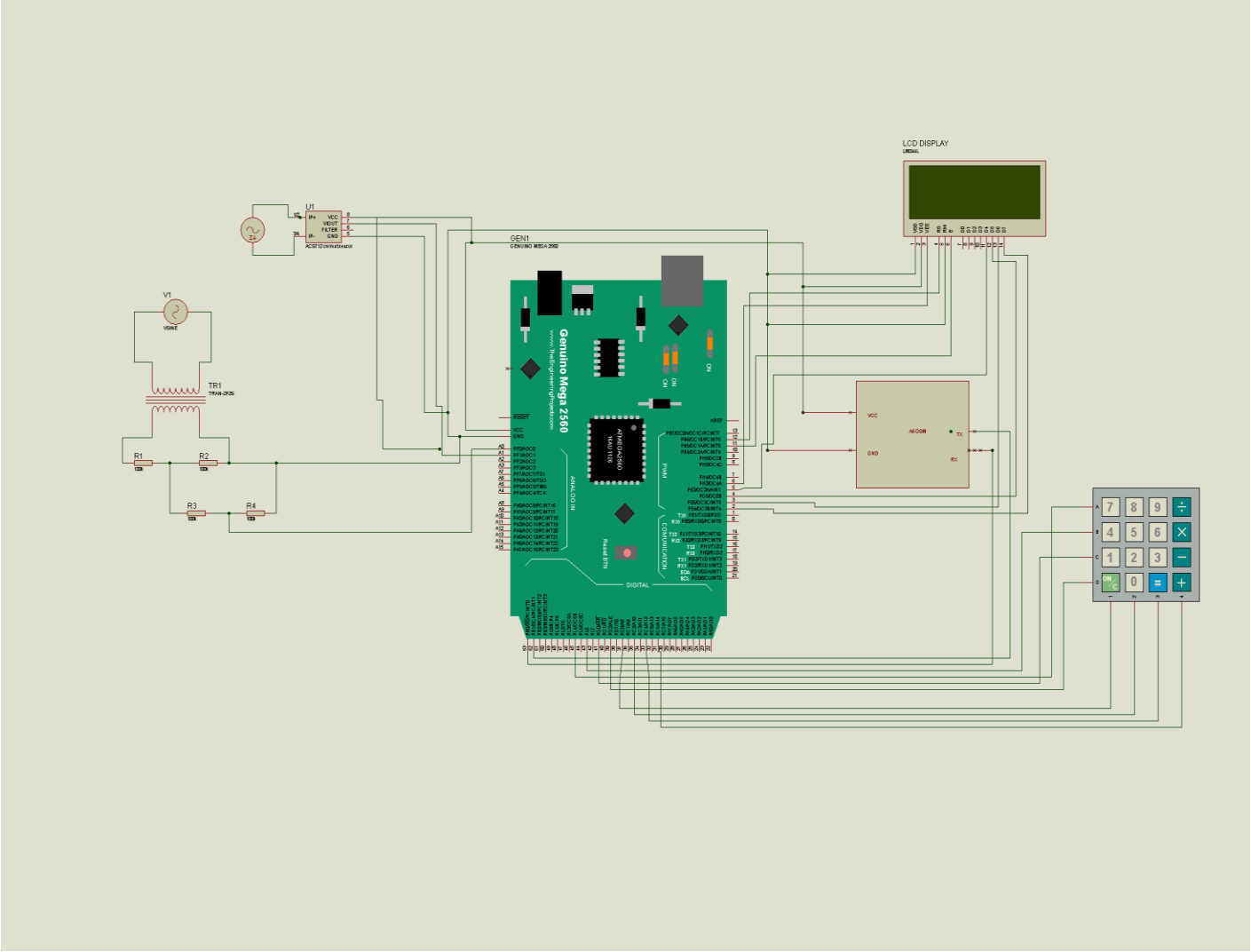

Fig. 6. Circuit diagram of the billing system.

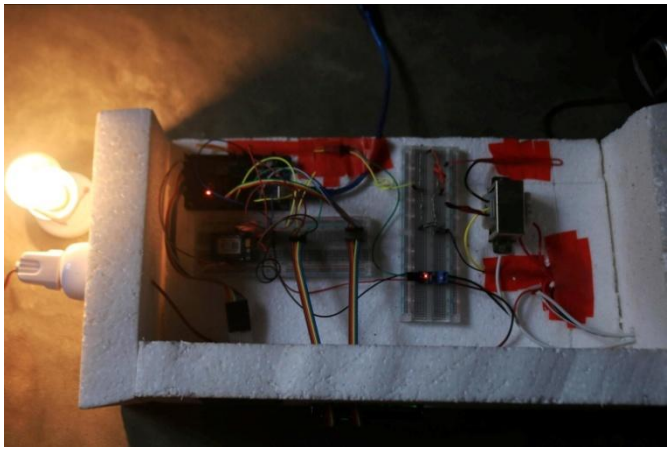

Fig. 7. Screen shot of the entire hardware design work of prepaid billing system.

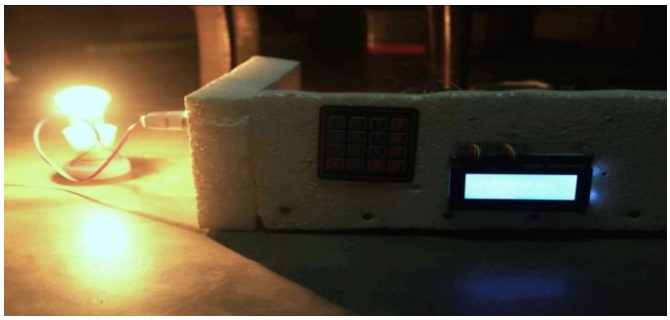

Fig. 8. Testing of keypad when light is on.

Fig. 9. Testing for LCD display.

Fig. 10. Testing for insert money from keypad by enter A.

Fig. 11. Testing for inserted money from keypad.

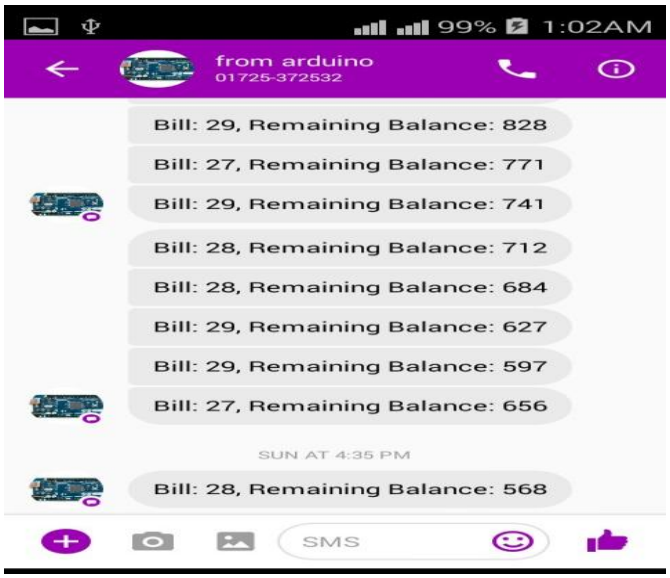

Fig. 12. Screen shot of the sms from GSM module for low balance and testing for sending SMS to mobile phone.

Thus the GSM based user warning system for pre-paid electricity billing is an efficient system that load control through SMS. The present prepaid system of energy billing does not give the warning to user via SMS to user's mobile phone. So the warning system about billing via SMS is a great feature in this work. 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 hourly update the power consumption by means of SMS. Power stealing 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.

5. CONFLICTS OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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