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Arduino Technology an Effective Tool for GSM Based Prepaid Energy Metering Management System

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ABSTRACT
Management is an important aspect of life, so there is need to develop an effective management system that will aid the effective delivery of any kind of services to public. Most system fails as a result of poor management system, hence the reason for the research work which its main aim is to design and develop an energy metering with the use of arduino technology which will be managed by GSM Phone. The benefit of this system is that it save time, minimize the risks in terms of moving from one point to other to pay for Light bills and most importantly its provide more accurate reading compare to conventional electromechnical metering system. The system was implemented using C variant, Ardiuno based programming language and Arduino 1.6.5 IDE

KEYWORD: Ardiuno, GSM Based, management system,

I. INTRODUCTION

Conventional method of management 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. This can prove quite tedious as it involves various tasks like reading, then preparing the bill. 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 (political reasons). 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.

II. REVIEW OF RELATED LITERATURE

2.1 Management System for GSM Based Prepaid

Management system in terms GSM Based prepaid is a system that is design and develop using ardiuno technology in controlling the activities between the electricity provider and the consumers of electric via the consumers can charge his/her meter via mobile without any physical contact with the electricity provider.

2.2 Related literature review on Prepaid Energy Meter

Omijeh, [1] in his PhD thesis attempted to realize arduino based prepaid energy meter as in figure 1. In this project a circuit was designed that would work as electricity recharge station and an additional circuit was designed that could integrate with the regular household energy meters and capable of counting down energy usage and cut off the main supply once the energy usage countdown reaches zero. A memory stick was used as an alternative to smart card which stored the recharge information from the recharge station and could be plugged to the circuit integrated to energy meters for regulating main supplies. See the illustration in Figure 2.

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Figure 1: Prepaid Energy meter using Arduino

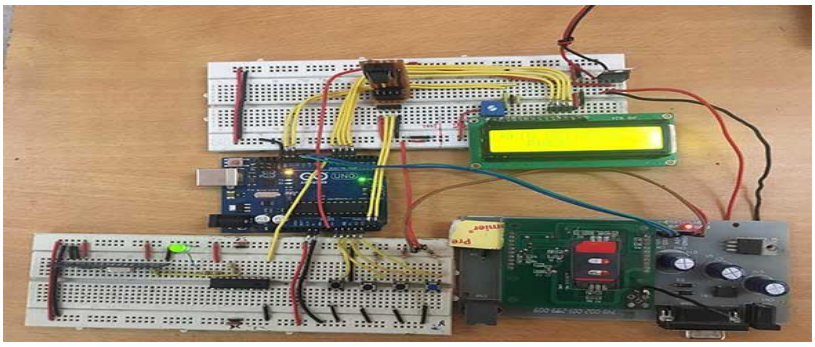

Figure 2: *Prototype of Arduino based Prepaid Electricity Recharge Station*
Source: Omijeh(2012)

The recharge station will also send a confirmation message to the registered mobile number of the consumer on every recharge. The recharge station and prepaid energy meter are shown connected to each via RF module in the project so that prepaid energy meter could send an alert of exhausting recharge amount to the recharge station and the recharge station could send an SMS to the consumer to make a recharge soon again.

Scaradozzi and Conte [2] viewed home-automation systems as Multiple Agent Systems (MAS). Home automation system was proposed where by home appliances and devices are controlled and maintained for home management. It is only a home management system and does not measure the amount of energy consumed by users

Amit and Mohnish [3] suggested in their paper, a prepaid energy meter behaving like a prepaid mobile phone. The meter contains a prepaid card analogous to mobile SIM card. The prepaid card communicates with the power utility using mobile communication infrastructure. Once the prepaid card is out of balance, the consumer load is disconnected from the utility supply by the contactor. The power utility can recharge the prepaid card remotely through mobile communication based on customer requests.

Koay et al [4] in their work, designed and implemented a Bluetooth energy meter where several meters are in close proximity, communicated wirelessly with a Master PC. Distance coverage is a major set-back for this kind of system because the Bluetooth technology works effectively at close range.

Kwan and Moghavvemi [5] paper suggested design of a system which can be used for data transmission between the personal computer and smart card. The device will transmit the data in half duplex mode. In this paper, an Intelligent Prepaid Energy Meter was designed, modeled and simulated using matlab/simulink tools.

III. METHODOLOGY

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In the realization for an effective management system we will implore Embedded System Development Methodology for the hardware design, while structured system analysis and design methodology will be adopted for the software component.

The proposed system mode of operation

In the management system in this Research is useful for billing purposes in Electricity board. Instead of going to every house and taking the readings or using a token, by just sending an SMS the readings of the house can be received and through the GSM phone the electric bill can be recharged. Every house will be assigned an identification number by the electricity board. The amount of consumption is stored in the arduino uno's memory and available to the authority as SMS. Using this software, SMS can be sent through the GSM Module to that particular number which is assigned by these authorities and wait for the response. In the office the GSM unit will receive the data and the total consumption information. After consumption of the entire balance on the meter, the power will be cut-off, and the consumer must send an SMS to recharge.

This energy meter calculates 1KWh for 3200 impulses, so rated as 3200imp/KWh, and there will be blinking of an LED for its every pulse. An Optocoupler has been connected to this LED so Optocoupler will be switched whenever LED blinks. We cannot directly connect energy meter's LED with Arduino because LED possesses analogue signals while we are feeding Arduino on the digital side. The pin number (D8) of Arduino is attached to the switching side of an Optocoupler for detecting pulses coming from energy meter. When a pulse occurs from energy meter, optocoupler is switched, pin D8 of Arduino detects a digital 0, otherwise it is not active and is in undefined state. There will be a count 1 to a data when there will be change on the state of the pin from digital 1 to 0. We have interfaced GSM module with Arduino UNO. The data communication pins are RX and TX, Arduino's RX pin is connected with GSM module's TX pin and vice-versa. Before connecting GSM module with Arduino, a valid SIM card must be installed in SIM card port of GSM module. All ground pins GND are connected together. For switching purpose (ON/OFF) to supply a relay is being used. We cannot connect Arduino directly with relay because as Arduino has ATMEGA328P processor and its pins can supply roughly 25mA, Processor pins have large effective resistance and a high voltage will "drop" as increasing current is drawn and a low voltage will rise as load increases. Pins may be specific with a maximum short circuit current but at that point a high pin will be pulled low and a low pin will be pulled high so short circuit current has limited applicability. So, relay is connected with Arduino through ULN2003 IC or relay driver, ON/OFF instructions are sent over to relay driver by Arduino and it can turn ON/OFF relay. LCD is also interfaced with Arduino digital pins (7, 6, 5, 4, 3, 2) on which we can see how much units are purchased, remaining units and balance.

The system gives the information of meter reading, power cut, total unit used, unit left, power disconnect, and tampering on request or regularly at a particular interval through SMS. Information is sent and received by the energy providing company such as PHCN (Power Holding Company of Nigeria) using the Global System for Mobile Communication (GSM) Network. A quad band GSM modems with a registered SIM (subscriber identification module) card with unique numbers is used. The communication process employed here is achieved by installing sets of AT (Attention) command strings in the GSM modems through HyperTerminal software which comes with Microsoft operating system. With the aid of the installed AT command strings, instructions and data are sent and received by the GSM modems respectively. Data received from the consumer unit are used to update the customer's database at the office of the power providing company. The EEPROM of the microcontroller is updated each time a customer pays his/her bills via SMS recharge by simply sending a secret pin from his mobile number to the developed system. Other information such as total energy consumed, total amount paid on consumption, User's interface consist of LCD (Liquid Crystal Display) which displays energy consumed, the (unit recharged) amount of bill paid and the amount left to be used. Information such as unit recharged, success of recharge, power disconnect/reconnect by the supply company, and when the unit left is critically low to avoid loss of power supply is communicated through the customer's mobile phone to the customer via SMS. With this new system, customers are confident that they are not being exploited, power pilfering is eliminated, rogue customers are shut off, prevention of bypass and the huge revenue loss which was inherent in the traditional metering system is completely avoided. For the programming and development of the controller part of the project at the energy meter end was made possible by the use of arduino development board. It is inexpensive, simple, cross platform and has other extensible properties. The microcontroller on the board has a flash memory of 32kB, making the processing speed

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fast enough for the single IC to cater to not just one but multiple microcontrollers in a residential building. The software section will contain the arduino C variant and java for serial communication and the interface.

When the system is powered up, the previous values stored in the EEPROM displays and immediate action will be taken depending on the balance. If the available balance is greater than N500 then the arduino turns on the electricity of the home or office depending on the context. If the balance is less than N500 then the arduino sends a message to the user regarding the low balance and instruct him to recharge as soon as possible. If the balance is less than N100, arduino turn off the light from the home or office and send a light cut off message to the user and request for a recharge or complete cut off. The proposed system block diagram is shown in figure 3

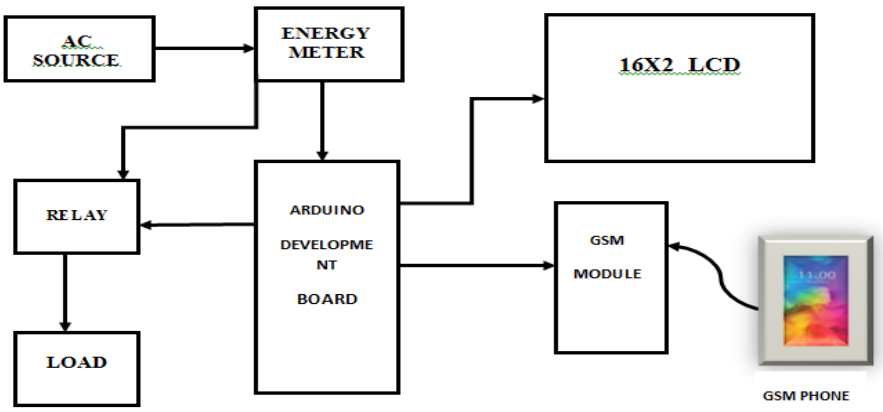

Figure 3: Block Diagram for Proposed System

IV. MATERIALS FOR DESIGN

i. Microcontroller on Arduino Development Board

An Arduino board consists of an Atmel 8-, 16- or 32-bit AVR microcontroller with complementary components that facilitate programming and incorporation into other circuits. An important aspect of the Arduino is its standard connectors, which let users connect the CPU board to a variety of interchangeable add-on modules termed *shields*. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an IC serial bus—so many shields can be stacked and used in parallel. Most boards include a 5V linear regulator and a 16 MHz crystal oscillator (or ceramic resonator in some variants), although some designs such as the LilyPad run at 8 MHz and dispense with the onboard voltage regulator due to specific form-factor restrictions. Figure 4 is an ardino board

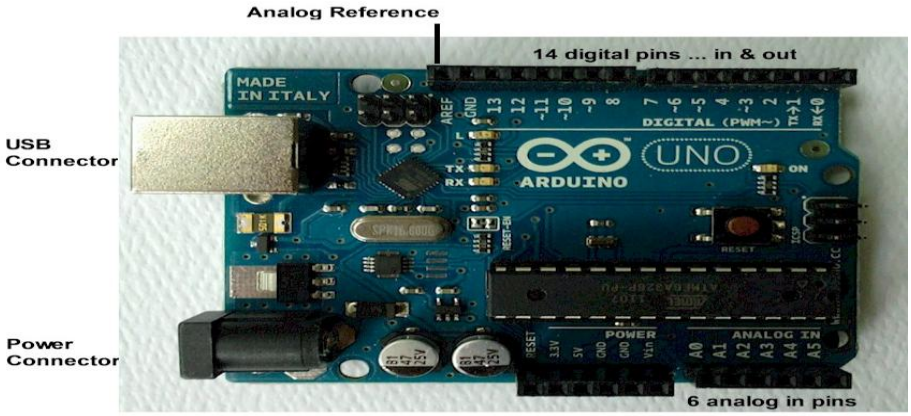

Figure 4: An Arduino's Board
Source: www.arduino.com/images

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Figure 4 is an Arduino's microcontroller is also pre-programmed with a boot loader that simplifies uploading of programs to the on-chip flash memory, compared with other devices that typically need an external chip programmer. At a conceptual level, when using the Arduino integrated development environment, all boards are programmed over a serial connection. Its implementation varies with the hardware version. Some serial Arduino boards contain a level shifter circuit to convert between RS-232 logic levels and transistor–transistor logic (TTL) level signals. Current Arduino boards are programmed via Universal Serial Bus (USB), implemented using USB-to-serial adapter chips such as the FTDI FT232.

Arduino project provides an integrated development environment (IDE) as shown in figure 13 based on a programming language named *Processing*, which also supports the languages C and C++ with several libraries to make things a bit easier. Figure 5 is arduino screenshot IDE

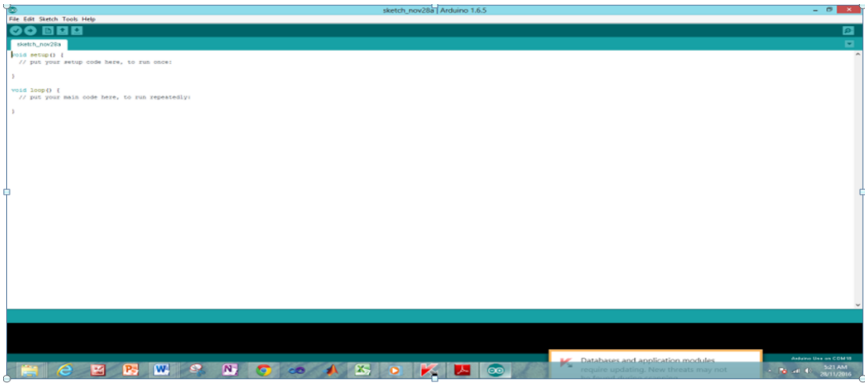

Figure 5: Screenshot of Arduino Integrated Development Environment (IDE)

4.1 The System Flowcharts

For the development of the application module, the first step we took was the design of the flowcharts. There are three major design flowcharts; the registration flow (figure 55), the units recharge flow (figure 56) and the overall recognition flow (figure 57). This system will interact with two categories of people namely;

i. The power IT personnel and
ii. The customers.

The power IT personnel interact with the system as the admin while the customers' data are handled by the system. The Admin needs to create his own username and password to login this system for the purpose of registering the customers in a situation where there is new meter or change of location by customer. If admin inputs the wrong username and password, the login program will not be successful and the admin pages will not display by the system. When admin enters the first part of the system [registration form], the customers' data, courses, customers' landlord data, customers' GSM details, capture images and their meter details. The information gathered at this point is stored in the database for future reference and authentication. The second flowchart is the unit recharge flow as in figure 56. This flow chart is for users' recharging process, at the initiation of the system if the unit is not greater than 0, it will tell the user to recharge your account. If it is greater than 0, it will instruct the user to chect the power unit and display the remaining unit. The third flow chart is the overall flow chart that handles all the processes going on in the system. It has the full communication in the GSM module of all the SMS to and from the customers. It connects to the meter through serial communication to the microcontroller in the arduino development board. It connects to the application for the power IT personnel monitoring. It disconnect the loads in the case of low unit balance. Figure 6 shows the overall system flowchart for the design

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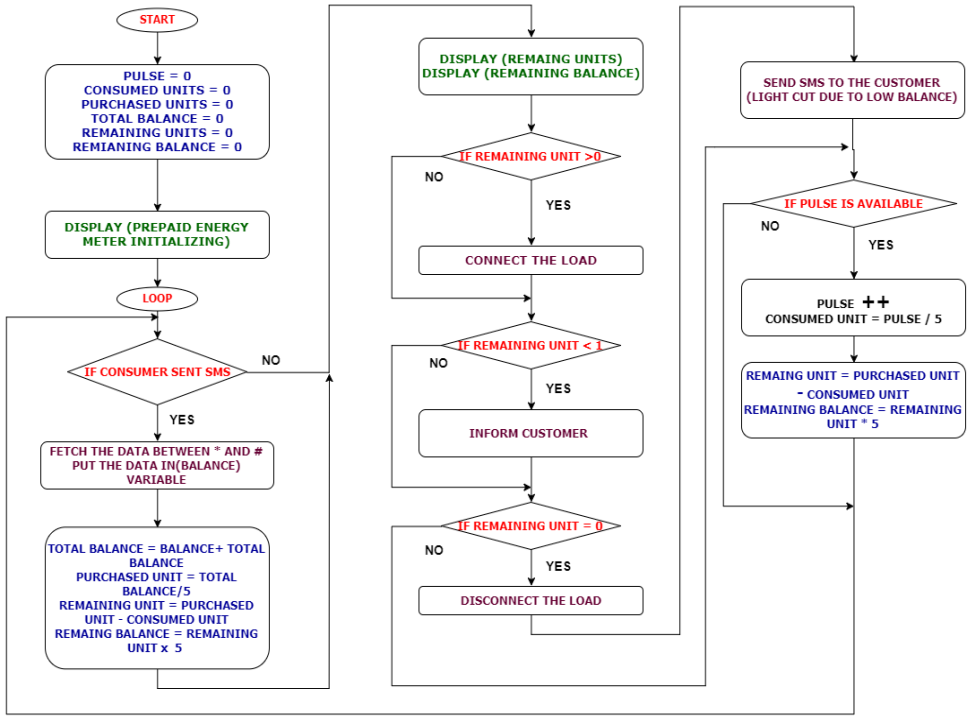

Figure 6: The Overall System Flowchart

V. TEST RESULT

The result from the test shows that the system achieved a great success due to the fact that it was difficulty for any customers to bypass the recharging of energy meter when they are out of credit unit Also the customer will be alerted at all-time about the energy usage and the issue of the customer having zero unit will be defeated. Table 1 and Table 2 shows detail summary of the various components expected and their actual results.

Table 1: Components, Expected and Actual Test Result

Components	Expected Result	Actual Result
Energy meter	This should be able to communicate to the controller and the GSM module for processing, energy units recharge, energy units monitoring, storage, validation and authentication.	It succeeded in communicating with the controller and the GSM module within its bandwidth with the free com port.
GSM module	To communicate with the GSM phones and controller for energy units recharge, energy units monitoring.	It succeeded in communicating with the GSM phones and the controller for the needful.
Microcontroller on arduino development board	This is the heart of the whole system where all the processes on the energy meter, computer system, serial communication establishment, building and burning of codes and GSM module activities are coordinated.	It succeeded in performing all these functions

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Table 2: Components, Expected and Actual Test Result continues

Components	Expected Result	Actual Result
Serial communication	Serial to USB communication (com port to USB converter) that port-powers the RS-232 to 422/485 converters, that changes TXD and RXD RS-232 lines to 422/485 signals. This is used to establish proper communication between the hardware and the personal computer.	The communication was established successfully through this medium.
Images objects	They have to be structured, indexed with the meter number and customers details for storage in the database.	This was successfully used to identify each customer
Storage	To store the meter number and customers details, images for easy retrieval, recognition and matching.	They were successfully stored and used for validation and authentication during customer monitoring.

VI. Conclusion

Conclusively, we were able to use arduino technology as a tool in the management of GSM Based Prepaid energy metering to ensure an effective services delivery to consumers of powers and also to monitor the activities of electric consumers with the view of curtailing bypass.

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