

Post-paid Wireless Meter Reading System for Automatic Power Controlling and Consumption Billing Applications

T. Kamalesh, M. Veda Chary

Abstract- Traditional metering method for retrieving the energy data is not convenient and the cost of the data logging systems is high. So this paper presents of design and development of Automatic meter reading (AMR) system. AMR system is a boom for remote monitoring and control domestic energy meter. AMR system give the information of meter reading, power cut, total load used, power disconnect and tempering on request or regularly in particular interval through SMS. This information is being sent and received by concerned energy Provider Company with the help of Global system for mobile communication (GSM) network. This system not only reduces the labor cost but also increase meter reading accuracy and save hugs amount of time.

Index Terms- ARM7 (LPC2148) Microcontroller, Short message service (SMS), Automatic meter reading (AMR), GSM, Zig-bee, Tamper detection.

I. INTRODUCTION

An energy meter is a device which is used to measures the consumption of energy of any residence or other industrial establishment. In Conventional metering system to measure electricity consumption the energy provider company hire persons who visit each house and record the meter reading manually. This is only a sluggish and laborious. In Conventionally metering system people try to manipulate meter reading by adopting various corrupt practices such as current reversal or partial earth fault condition, bypass meter, magnetic interference etc. If any consumer did not pay the bill, the electricity worker needs to go to their houses to disconnect the power supply [1].

The ZigBee devices are extremely limited in resources including processing, memory and power, short operating range [2]. GSM based automatic meter reading system is a succor. In this system each and every meter is provided a particular ID number. This ID number is provided according to SIM card unique service number. This system continuously monitors every meter reading daily, weekly,

monthly or on request and sends to central server of energy Provider Company. The meter reading is stored in database server through SMS gateway. After billing calculation a bill is issued by energy Provider Company which can be sent through SMS. AMR also sends the information of power cut and power consumption through SMS. This SIM card service number is used to identify and retrieve customers detail for billing and identification purpose.

II. PROPOSED SYSTEM

The high level block diagram of the wireless meter reading system is shown in the Fig 1.

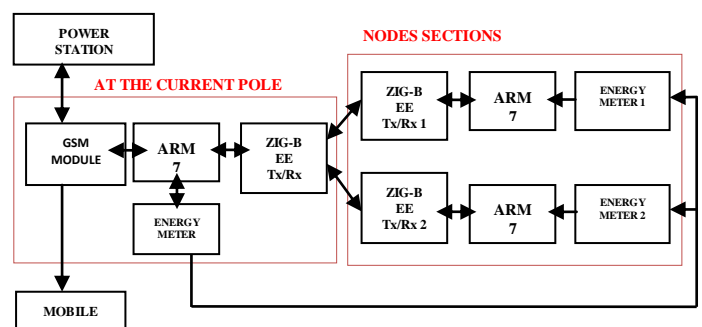


Fig 1: Overview of GSM & Zig-Bee based AMR system

The Power Supply section supplies all other components with required Power. At the slave meters/ Nodes the ARM7 LPC2148 microcontroller module takes the data from the energy meter, which consists of LED, which blinks according to the power consumption. If the consumption is more, then LED will blink with a faster rate but if consumption is less then LED will blink with slower rate. The LED is receiving train of pulses which is responsible for its blinking. This train of pulses is applied to one of the interrupt pin of ARM controller using a counter unit [3]. The counter is activated at the interrupt pin, which counts the number of pulses that ARM controller is receiving and thus controller measure the amount of energy consumed in the household and it also performs the necessary control operations like breaking the circuit through Relay control unit and the required information is given & taken by the master meter/ Power line meter via Zigbee.

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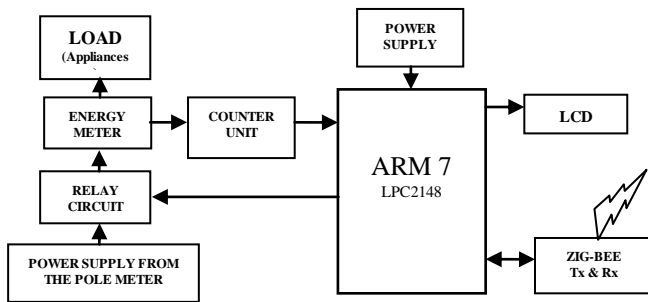


Fig 2: Node section

The overall information is taken from the master meter and forwards to the power station via communication module GSM with the use of corresponding commands. The MAX-232 which was inbuilt in the ARM7 is used as a serial communication interface for the GSM modem for transmitting the data from the controller to the mobile phone.

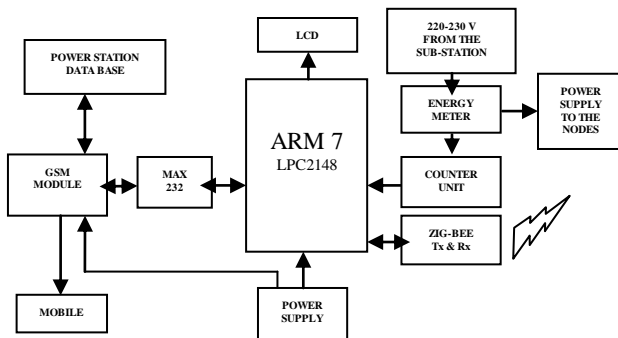


Fig 3: Monitoring & Controlling unit at Power Line Section

In the Load bank section a 60W incandescent bulb is used as a load for the purpose of energy consumption of the user. The user can obtain the status of the energy consumption and the billed amount by sending the corresponding commands as shown in the Table 1, from the mobile phone to the GSM modem. Then it sends the commands to the microcontroller section through Zigbee and the required information is sent to the user mobile through the GSM modem.

III. SYSTEM HARDWARE

The basic hardware components used in the Project are shown below in Fig 4, 5, 6.

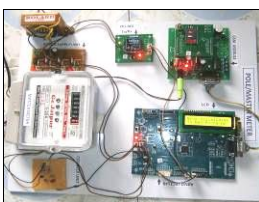


Fig 4: Power line /Master meter



Fig 5: Node1/House1 meter

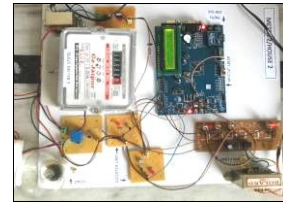


Fig 6: Node2/House2 meter

A. ARM7-LPC2148 Microcontroller

ARM stands for Advanced RISC Machines. It is a 32bit processor core used for high end applications. The LPC2148 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine the microcontroller with embedded high speed flash memory ranging from 32KB to 512KB. ARM (Advanced RISC Machine)



Fig 7: LPC2148 Microcontroller

T–The Thumb 16 bit instruction set. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate [4]. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. The LPC 2148 microcontroller is shown in figure.6. Due to their tiny size and low power consumption, various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

B. Energy measuring unit (EMU)

The energy measuring unit consists of a standard calibrated energy meter along with the tampering detection circuit. If any variations other than the rated voltage or specified values are obtained, the ARM -based embedded system (AES) generates the necessary signals required for further operations.

In many countries, it is seen that the consumers attempt to obtain electrical energy illegally. These incoming losses of stolen power for utility companies are very high. It's necessary for utility meter to have the capability of tamper detection. The following events are considered for tamper detection by the method.

- Missing potential event
- Current unbalance event
- Current reversal event

If any above event occurs, the AES will record the meter status in database and inform UCC about tamper warning on the instant.

C. ZigBee module:

ZigBee technology is emerging following the Bluetooth. It is short-range, low power, low cost and low complexity of wireless communications technology. The technology is applied in the home automation, building automation, industrial control and industrial areas of logistics. When using the 2.4GHz band, ZigBee technology can transmit 10 meters in the indoor, while in the outdoor transmission distance can reach 200 meters, in other uses spectrum, the indoor distance is 30 meters, while in the outdoor transmission distance can reach 1000meters. The actual distance will be based on the size of the transmission power.

D. GSM Module

To implement AMR system a GSM modem is connected to a microcontroller which would transmit data from a meter to cell phone and also receive command from cell phone to energy meter. AT commands set which stands for attention terminal are used by energy meter to communicate with the GSM Modem.



Fig 8: GSM module

1. Quad-Band 850/ 900/ 1800/ 1900 MHz
2. GPRS multi-slot class 10/8
3. Compliant to GSM phase 2/2+
 - Class 4 (2 W @ 850/ 900 MHz)
 - Class 1 (1 W @ 1800/1900MHz)
4. Dimensions: 24* 24 * 3 mm
5. Weight: 3.4g
6. Supply voltage range 3.4 ... 4.5 V
7. Low power Consumption
8. Operation temperature: -30 °C to +80 °C

E. Relay Control Unit:

Relay control unit is used to shutting off the electric power supply when the due date is over. Whenever the user pays the bill the electric power supply is resumed by the relay module. The relay is driven by the LPC2148 controller. Depending on the information received from the remote station, the LPC2148 can control the Relay module to shut off or resume the electric power supply.

F. Liquid crystal display

A Liquid crystal display are interfaced to microcontroller unit that are used to display the meter reading, date time, power factor, power status, total load used etc.

G. Temper detection unit

Today energy theft is a serious problem due to energy theft heavy revenue losses are incurred by country. A tempering unit used for stop of this energy theft that sent the alert to energy Provider Company when tempering occurs. If any person tries to tempering (such as current reversal or CT reverse tampers, partial earth fault condition, bypassing meter, magnetic interference, phase or neutral wire swapped, external tempers etc.) with energy meter the tempering unit will be activated and as SMS alert send central server of the energy provider company.

IV. SYSTEM SOFTWARE

The system software is implemented by Embedded C language in the Keil micro Vision software along with flash magic. All software development tasks including editing, compiling and debugging can be accomplished using the above mentioned software's.

4.1. Meter Reading Terminal Software Design

According to the hardware circuit design features, meter reading terminal software design flow is shown in below algorithm. First, the system initializes each module, and then reads the meter readings regularly, and stores them. In case of uncertain events such as reverse voltage, tampering, etc the AMRS will generate error signals by enabling pre-programmed flags. The system is usually in standby mode. The controller may read the contents of the status register to monitor data transfer status.

4.2. Server End Terminal Software Design

In accordance to the function of the hardware circuit design, the software programming idea of server end terminal is as follows: first, the system completes initialization, and then sends commands to the meter reading terminal through the GSM modem. When the host AMRS receives the signal, it will select the data and update the database at the same time, send the consumption to the consumer via SMS.

4.3. Technical Specification

Table 1 shows the complete operation of the GSM based energy meter using the specific commands as shown below

S.No	COMMANDS	DESCRIPTION
1	EMx/pwr/on	Used to ON the supply
2	EMx/pwr/off	Used to OFF the supply
3	EMx/c/power	Used to know the consumed units instantaneously
4	EMx/b/genrt	Used to generate the bill
5	EMx/b/paid	Used once the bill payment is done
6	EMx/ck/Tmpr	Used to check for the tamper

TABLE 1: Here x=Energy meter 1, 2, 3...

The algorithm is as follows

- Step 1.** Initialization of devices.
- Step 2.** Give a missed call to the authenticated mobile number at the end of power line GSM based module.
- Step 3.** Once the number gets registered, conformation message is sent to the authenticated mobile number.
- Step 4.** If the authorized person number is authenticated, initially system checks for the outstanding dues.
- Step 5.** Simultaneously counts of the units are initiated & it is displayed on the LCD at the Power line GSM based module as well at the node sections also.
- Step 6.** At a specified time bill is generated through SMS, which consists of consumed units & total bill amount.
- Step 7.** If the person fails to pay the bill in time power will be disconnected using corresponding commands given to the GSM by the energy provider company.
- Step 8.** Else, if the payment is done, power will be re-connected using corresponding commands.
- Step 9.** For tamper checking, tampering unit compares the units reading at both Power line section & nodes section,
- Step 10.** If the provided units & consumed are not equal then tampering unit will be activated and as a SMS alert is send to the energy provider company.
- Step 11.** If the tamper doesn't exist then it shows as No tamper detected.
- Step 12.** Stop the process.

V. SYSTEM IMPLEMENTATION AND RESULTS

The proposed system is tested in the place of conventional power meter and achieved good results. Fig 9(a) to 9(b) shows the actual photographs of the proposed system. LPC2148 is interfaced with GSM module, Energy meter Module, the Relay Control Unit. For demonstration purpose, 60Watt bulb is used as load to examine our system. The bulb is connected to load and the Energy meter which is used to measure the average real power information.

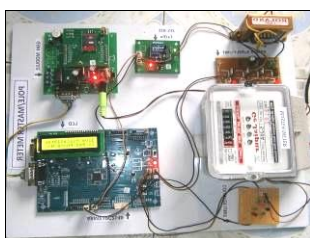


Fig 9(a)



Fig 9(b)

Fig 9: (a) GSM based energy meter at power line end
 (b) When the load is ON with the interfacing of Energy meter, ARM7 microcontroller modules

The test is performed and power consumption [9] is observed. During this period the bulb glows continuously which is shown in Fig 9(b). After the due date, the LPC2148 controller turned off the bulb through the relay, which proves

the accuracy of our system in terms of the power and calculation remote controlling.



Fig 10: Initialization of GSM

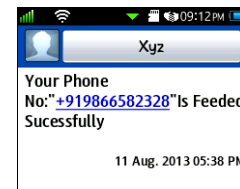


Fig 11: Conformation message is received after giving a miss cal to the GSM based energy meter

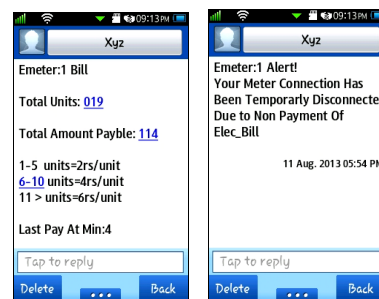


Fig 12(a)

Fig 12(b)

Fig 12: (a) Bill generates using a command EM1/b/genrt
 (b) Power will be disconnected automatically when the payment is not done as on date

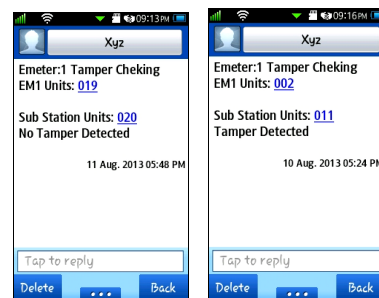


Fig 13(a)

Fig 13(b)

Fig 13: Checking for the tamper using a command EM1/ck/Tmpr

VI. CONCLUSION AND FUTURE SCOPE

GSM based energy meter is easy to installation and beneficial for both energy provider and consumer. AMR is not only solve the problem of manual meter reading but also provide additional feature such as power disconnect due to outstanding dues, power reconnect after pay dues, power cut alert, tempering alert. AMR also gives the information of total load used in a house on request at any time. It sends a SMS alert to energy provider company whether a person using more than specify limit of load. The statistical load used and profile can help customer manage their energy consumption. This system is secure and reliable because it can be accessed only by an authorized person. If any

unauthorized person tries to access the system this system send an alert to energy provider and also give warning of that unauthorized person. Further we can concentrate on the bill payment through online automatically using E-Billing. But the proposed system has a drawback that embedded system is purely dependent on the GSM module.

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Bibliography:



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