Embedded System based Prepaid Electricity Metering & Billing

Mrs. Akanksha Shukla, Shobhit Saxena, Siddhant Singh and Sohil Jain

Abstract— **Electricity theft is common in India. This leads to monetary loss to the supply company and energy wastage due to misuse of electricity. Just like we recharge our mobiles with some amount and are entitled to talk until we run out of balance in our account. The balance is deducted as per the time usage according to pulse rate. Similar concept is now applied to electricity billing, where we can recharge our accounts with some amount and this amount is burned as per the usage in accordance with the current energy tariff.**

***Keywords*— Prepaid Energy Meter, Atmega32, Sim 900, LCD, Embedded System**

I. INTRODUCTION

Indian Government had planned a mission of "power for all". For achieving this, expansion of the regional transmission network and inter-regional capacity to transmit power would be essential. Power communities around the world have realized that the capacity addition alone is not a solution to bridge the ever-widening gap between demand and supply. But reduction in demand by the end user can achieve this goal at a fraction of cost incurred in adding capacity. Distribution companies are still struggling to overcome power shortages and poor power quality in spite of growth in supply. Because of demand exceeding supply, severe peak and energy shortages continue to clutch the sector. Inefficiencies in power generation, distribution and end-user systems worsen the shortages. The other problems faced by the utilities are poor finances and poor revenue collection. Inefficient collection is root cause of poor financial condition of the state electricity boards. Indian distribution companies since past many years have been facing problems mentioned underneath:

1) Poor revenue
2) Very large overheads
3) Unpredicted peak Load / Demand
4) Poor billing resulting in large commercial losses

Another problem faced by the utilities is the huge overhead of meter reading and billing, delays in payment collection, warning to defaulters, disconnections and handling consumer grievances. These activities consume considerable amount of time and effort, adding up to the already high overheads. Implementation of prepaid metering can play a significant role in resolving the problems.

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II. PREPAID ENERGY METER-A SOLUTION TO THE PROBLEM

Prepayment metering is simple and user friendly. Prepayment or "pay as you go" has been accepted by the utilities worldwide as a means to improve customer service, cash flow and their revenue cycle. It is totally a new area in India and is likely to improve revenue collection and energy management. This will benefit the State Electricity Boards private utilities and the electricity consumers The consumer has to get a new kind of meter installed in his/her house along with an in-built display device as a consumer interface unit which helps them in monitoring their consumption, current load and balance amount.

To recharge the meter, consumer needs to buy electricity in advance according to his/her requirement. The consumer can buy electricity through various vending options. This will be in form of a scratch card with a code printed on it. The consumer punches the code into the meter either directly or through an in-home display using a key pad. The meter is credited with the amount of recharge bought and supply is switched on automatically at load side.

As the consumer's balance reaches the below the emergency limit provided by the utility, meter issues an alarm. The consumer needs to recharge the meter at this point. If recharged in time then the load is not disconnected. However, if even after warning, a consumer does not recharge their meter and all available balance is exhausted (as per the prevailing tariff defined in the meter) then meter automatically disconnects the supply at load side. The system provides real time consumption information in terms of money and connected load which attracts the consumer's attention and leads to their involvement with the system. This also helps consumer in identifying their connected load at any given point of time and their consumption in terms of rupees.

III. EXISTING AND ONGOING WORKS AND RESEARCHES

Prepaid Meters in Electricity. A Cost-Benefit Analysis

The prepayment technology was initially developed in South Africa in the late 1980s with the objective of supplying energy to a large number of low-income and geographically dispersed users.

Major Economic Indicators CELCA Various Years					
Type Of Consumer	**1992**	**1996**	**2003**	**Annual Average 1992-1996 (%)**	**Annual Average 1996-2003 (%)**
Conventional Users					
Residential	3197	3563	2360	2.7	-5.7
Industrial	50	110	84	21.8	-3.8
Other	1197	980	931	-4.9	-0.7
Prepayment Users					
Residential	0	184	1974	268.3	40.4
Industrial	0	3	11	31.6	20.4
Other	0	48	302	163.2	30.0
Total	4444	4888	5662	2.4	2.1
Average Annual Consumption (kW)					
Conventional Users					
Residential	1214	1458	1322	4.7	-1.4
Industrial	22213	54605	56723	25.2	0.5
Other	5374	5040	4887	-1.6	-0.4
Prepayment Users					
Residential	0	795	1407	431.0	8.5
Industrial	0	25343	62595	1161.7	13.8
Others	0	2671	4324	618.9	7.1
Average Tariff	0.10	0.14	0.13	8.2	-0.8
Revenue	1814343	2392419	2871011	7.2	2.6
Assets	2192814	3615308	3689411	13.3	8.7
Cash & Equivalents	29987	21580	85662	-7.4	21.8
Investments	20123	14040	118712	-8.6	35.7
Accounts Receivable	602681	1235519	813840	19.7	-5.8
Fixed Assets	1183528	2034615	2201509	14.5	1.1
Inventories	245012	248463	414948	0.3	7.6
Other Assets	111484	61090	54769	-13.9	-1.5
Equity	863761	2303861	2974780	28.2	3.7

The table shows that liquid assets and investments notably increased since adoption of the prepayment, reversing the deteriorating trend that prevailed before from CELCA's Annual Report and Balance Sheet.

The fact that payment is made prior to consumption implies both a significant improvement in the collection of revenues and a reduction of working capital. Moreover, prepaid systems may constitute a way to provide more flexible payment options to users with minimal or unreliable income streams without increasing transactional costs to the firm. From the consumer's perspective, prepayment systems may result in a better understanding of how much energy is being consumed, inducing more control of energy use and budget management.

"Building A Prototype Prepaid Electricity Metering System Based On RFID"- RFID stands for radio frequency identification. Works in the manner that a signal is sent to a transponder, which wakes up and either reflects back a modified signal (passive RFID) or broadcasts a signal (active RFID).The project was divided into two parts: clients and server. The client consisted of a digital meter based on a microcontroller and an RFID reader and the server consisted of a PC with MySQL database server. The client was to be installed in each house and the server installed in local sub-station. RFID reader was used to read the credit ID in meter charging, the ID was sent to the server to check the ID's information in the database and sent them back to the client where the microcontroller took action based on that information.

"A Smart Card Based Prepaid Electricity System"- This project focused on web enabled smart card based solution for controlling consumption of electricity. It uses IP based controller TINY & WATTNODE type power meter which interrupts the controller at regular intervals (around 0.75 watts/hrs). Based on the consumption of electricity the balance is updated as per certain tariff structure. Unique feature is that electricity meters at homes can be accessed by electricity supplier, without PC thus reducing cost. Smart card is mainly used here for

-Authenticating user log in.

-Updating balance in card as per tariff and consumption stored in it.

IV. SUGGESTION BASED UPON ANALYSIS OF EXISTING RESEARCHES

A. Pre-paid Energy Meter based on AVR Microcontroller

Advantage of the prepaid system is that the human errors made reading meters and processing bills can be reduced to a large extent. Many works in the field of prepaid meter have already been done but they have used 8051 controller for their operation. In this paper, the idea of pre-paid energy meter using AVR controller have been introduced. In this method 8051 has been replaced by AVR controller because, it is energy efficient i.e. it consume less power, it is fastest among all the microcontroller families, it has inbuilt ADC and have advanced RISC architecture. In this paper, energy meters have not been replaced which is already installed at our houses, but a small modification on the already installed meters can change the existing meters into prepaid meters, so this meters are very cheaper. The use of GSM module provides a feature of pre-paid through SMS. One can recharge meter with the help of mobile through SMS, on the basis of recharge amount, AVR controller count the amount of energy consumed and display the remaining amount of energy on the LCD. If the amount falls below certain minimum amount, then it will be indicated by the controller through buzzer

B. Building Blocks of GSM Based Prepaid Energy Meter

The design includes an energy meter interfaced to the microcontroller. The energy meter will measure the energy used and send it to the microcontroller's ADC port. The

measured quantity will give the power consumption value at that instance after be calibration using any standard device.

The controller multiplies the instantaneous value of measured power with internal timer value to get the energy consumption. The energy consumption is multiplied with the existing tariff rate and the account balance is burned as per usage and current tariff rate. When account balance burns out controller instructs the relay to disconnect load. For user alert an LCD and buzzer is also attached to the controller to alert the user about low balance.

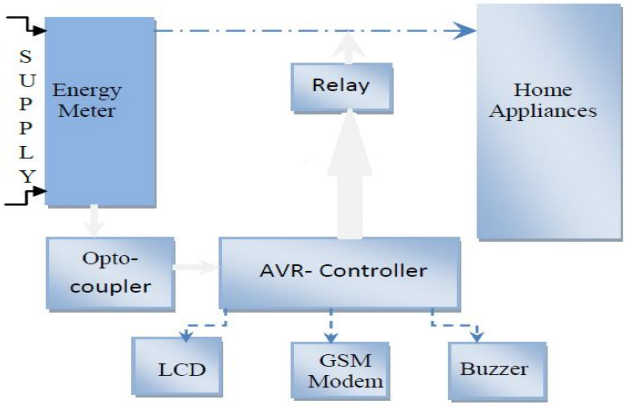

Fig. 1 Building Blocks of GSM Based Prepaid Energy Meter

C. Microcontroller- ATMEGA 32

A Microcontroller is a programmable digital processor with necessary peripherals. Both microcontrollers and microprocessors are complex sequential digital circuits meant to carry out job according to the program / instructions. Sometimes analog input/output interface makes a part of microcontroller circuit of mixed mode (both analog and digital nature). A microcontroller can be compared to a Swiss knife with multiple functions incorporated in the same IC.

The ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

Features of ATMEGA 32

- 32K Bytes of In-System Self-programmable Flash program memory
- 2K Byte Internal SRAM
- Programming Lock for Software Security
- 1024 Bytes EEPROM
- Real Time Counter with Separate Oscillator
- Programmable Serial USART
- On-chip Analog Comparator
- 32 Programmable I/O Lines
- 4.5 - 5.5V for ATmega32

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D. GSM Module – SIM 900

GSM module transmits user's account information from power meter to utility company and also receives data from utility company. The SIM900 is a complete Quad-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications.

Features of SIM900

- SIM900 is designed with a powerful single-chip processor integrating AMR926EJ-S core.
- Quad-band GSM/GPRS module with a size of 24mm X 24mm X 3mm.
- SMT type suit for customer application.
- An embedded powerful TCP/IP protocol stack.

CONCLUSIONS

There are clear results from many countries, where prepaid system has reduced the usage (wastage) by a large amount. Another advantage of the prepaid system is that the human errors made reading meters and processing bills can be reduced by a large extent.

The system provides many features few of them are listed below:

- Any time any where recharge facility: This becomes possible as the system works on keypad based technology, hence the token can be got by vend through phone, SMS or web at any time and at any place.
- Friendly days / hours: For the ease of the consumer as well as of the utility, the system is designed in such a manner that it will not disconnect the supply or will not give any alarms on predefined day or hours. These days or hours are called friendly days or hours.
- Emergency credit limit: To make the consumer aware that their credit will be exhausted within a specified time interval, the system has a provision of emergency credit limit. This is an optional feature, which depends upon the utility, they may choose to configure it or not.
- Alarms visual / buzzer: To attract the consumer's attention the meter gives an alarm to consumer regarding the actions it will be taking. This is a buzzing alarm as well as a visual display on meter/CIU. This enables consumer to take necessary action.
- Supports a variety of tariffs: The Indian tariff structure is complex and there are a variety of tariffs like slab rate, TOD / TOU, fixed charge, monthly minimum charge, etc. All tariffs are supported by the system.
- The system is equally beneficial both for consumers and the utilities.

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