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21st Century Modern Technology of Reliable Billing System by Using Smart Card Based Energy Meter

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Abstract: The main objective of writing this abstract is to give precise information about the project and the various procedures involved in the project. This presents a single phase digital prepaid energy meter based on two microcontrollers and a single phase energy meter IC. This digital prepaid energy meter does not have any rotating parts. The energy consumption is calculated using the output pulses of the energy meter chip and the internal counter of microcontroller (A Tmega32). A microcontroller (A Ttiny13) is used as a smart card and the numbers of units recharged by the consumers are written in it. A relay system has been used which either isolates or establishes the connection between the electrical load and energy meter through the supply mains depending upon the units present in the smart card. Energy consumption (kWh), maximum demand (kW), total unit recharged(kWh) and rest of the units (kWh) are stored in the ATmega32 to ensure the accurate measurement even in the event of an electrical power outage that can be easily read from a 16*2 LCD. As soon as the supply is restored, energy meter restarts with the stored values. A single phase prepaid energy meter prototype has been implemented to provide measurement up to 40A load current and 230V line to neutral voltage.

Keywords: SCBEM, Energy Meter, Power Theft.

I. INTRODUCTION

One of the prime reasons is the traditional billing system which is inaccurate many times, slow, costly, and lack in flexibility as well as reliability [1]. Meters, in the past and today in a few countries, were electromechanical devices with poor accuracy and lack of configurability. Theft detection was also a challenge. Recent developments in this direction seem to provide opportunities in implementing energy efficient metering technologies that are more precise, accurate, error free, etc.[2]. A Prepaid Energy Meter enables power utilities to collect electricity bills from the consumers prior to its consumption. The prepaid meter is not only limited to Automated Meter Reading but is also attributed with prepaid recharging ability and information exchange with the utilities pertaining to customer's consumption details. The use of electronic token prepayment metering has been widely used in UK for customers with poor record of payment [3]. A paper suggests a design of a system which can be used for data transmission between the personal computer and smart card [4]Another paper suggests making use of state of art technologies like Imax in Prepaid Energy Meter owing to the idea of centralized accounting, monitoring and charging [5]. Polyphone prepaid energy metering systems have also been proposed and developed based on local prepayment and a card reader [6]. Wireless prepaid energy metering system has been proposed which incorporate RF based system [7]. Digital energy metering system as an alternative for the electromechanical system has been proposed and developed with the Peripheral Interface Controller (PIC) and necessary software [8]. Due to the low cost of microcontrollers, Prepaid Energy Meter has been developed using a microcontroller from the Microchip Technology Inc. PIC family [9].

A. Why Do We Need Smart Card Based Energy Meter?

Energy meter are typically calibrated in billing units, the most common one being the kilowatt hour. Periodic reading of electric meters establishes billing cycles & energy used during a cycle .In settings, when energy savings during certain periods are desired, meters may measure demand, the maximum use of power in some interval. In some areas electric rates are higher during certain times of day, reflecting the higher cost of power resources during peak demand time periods. There are some following associated problems. This are:-

- If there is an error on billing, the error will not be detected easily.
- There is a problem of energy thief by person to person and no one can catch the thief.

- On billing time, there is a huge line for paying. People were stands for many hours and facing problems.
- Power distribution system is not efficient.
- Illiterate people do not understand billing system.

III. WORKING OF SMART CARD BASED ENERGY METER

A card of known value say Rs/- 500 will be entered in card reader. It will then send command to energy meter. It will allow the power to user through solid state relay. As long as power is consumed by the user the reading on energy-meter will start increasing till it reaches the limit value of card. Whenever the power is put off, energy-meter will stop the reading. Whenever the card is removed from card reader, the command will go to energy-meter to cut-off the power and stop the energy-meter. Whenever power is increased by second load, then energy-meter will increment faster. As the energy-meter reaches the limiting value of card, the power is cut-off to user and indicated with display that, recharge the card. The second card which is issued is provided with password. As soon as second card is entered, the password is asked to enter and on checking the valid password by the energy-meter. The power is allowed to pass through solid state relay as shown in fig 1. The process will

IV. BASIC STRUCTURE OF SMART CARD BASED ENERGY METER

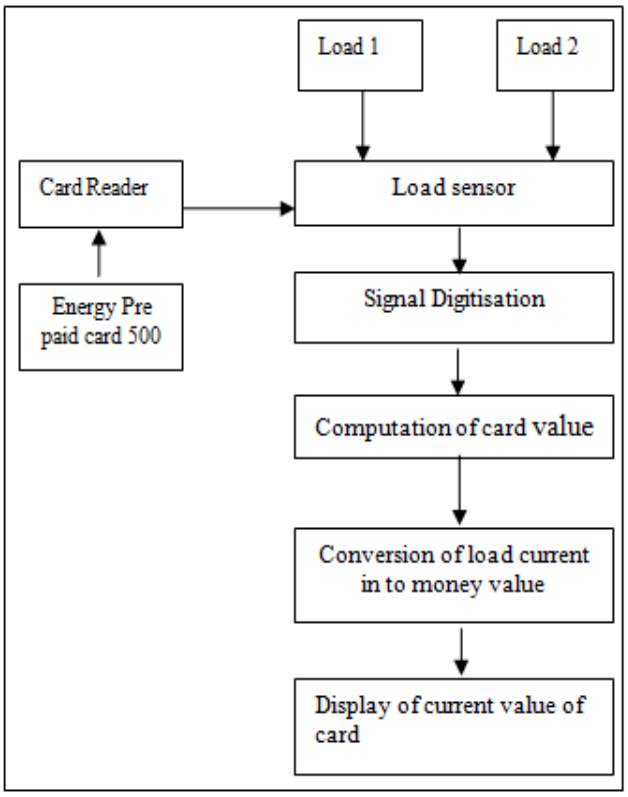

Fig.1. Block diagram of SCBEM.

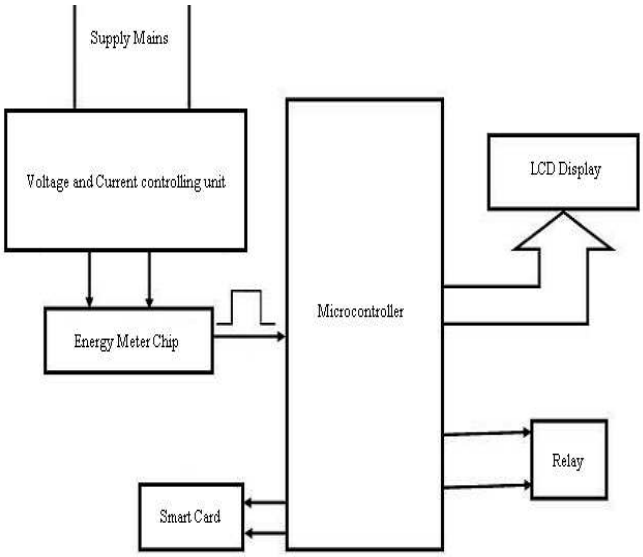

Fig.2. Energy meeting system.

continue. This energy-meter also gives the message on startup that one should save power. The energy metering system (fig.2&3) consists of Energy Meter chip, Microcontroller, Voltage and Current controlling unit, Smart cart, Relay and Liquid Crystal Display.

- Energy Meter IC generally produces electrical pulses proportional to the power consumed by the consumer and the power supply of microcontroller.
- Microcontroller calculates the energy consumed by the consumer utilizing the output of Energy Meter Chip and programs loaded on the microcontroller.
- Voltage and Current controlling unit feeds the actual current and voltage of load connected to consumer side to the energy meter chip.
- Smart Card interfaces with the microcontroller unit in which the number of units recharged by the consumer are written.

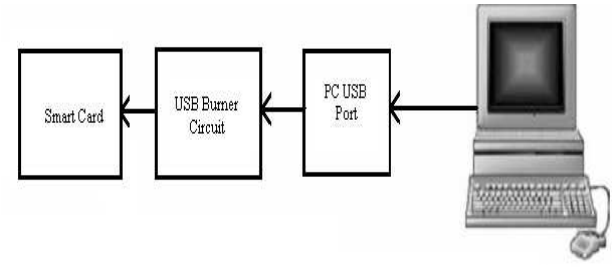

Fig.3. Prepaid energy billing system.

- Relay mainly performs the opening and closing of a connection between energy meter and load through supply mains depending upon the number of units present in the smart card at a moment.
- Liquid Crystal Display shows the energy consumption, number of unit recharged by the consumer, rest of the unit and maximum demand.

V. MAIN COMPONENTS

1. Transformer
2. Relay
3. Resistor
4. Bridge rectifier
5. Transistor
6. Capacitor
7. Diode
8. ICS
9. Power supply
10. Energy meter
11. LCD
12. Analog to digital converter
13. Microcontroller
14. Regulator
15. Led
16. Temperature sensor
17. PCB

A. Hardware Design Specification Steps taken while preparing circuit

1. PCB Designing

The main purpose of printed circuit is in the routing of electric currents and signal through a thin copper layer that is bounded firmly to an insulating base material sometimes called the substrate. This base is manufactured with an integrally bounded layer of thin copper foil which has to be partly etched or removed to arrive at a pre-designed pattern to suit the circuit connections or other applications as required. The term printed circuit board is derived from the original method where a printed pattern is used as the mask over wanted areas of copper. The PCB provides an ideal baseboard upon which to assemble and hold firmly most of the small components.

2. Layout design

When designing the layout one should observe the minimum size (component body length and weight). Before starting to design the layout we need all the required components in hand so that an accurate assessment of space can be made. Other space considerations might also be included from case to case of mounted components over the printed circuit board or to access path of present components. It might be necessary to turn some components around to a different angular position so that terminals are closer to the connections of the components. The scale can be checked by positioning the components on the squared paper. If any connection crosses, then one can reroute to avoid such condition. All common or earth lines should ideally be connected to a common line routed around the perimeter of the layout. This will act as the ground plane. If possible try to route the outer supply line to the ground plane. If possible try to route the other supply lines around the opposite edge of the layout through the centre. The first set is tearing the circuit to eliminate the crossover without altering the circuit detail in any way.

3. Etching Process

Etching process requires the use of chemicals. Acid resistant dishes and running water supply. Ferric chloride is mostly used solution but other etching materials such as ammonium per sulphate can be used. Nitric acid can be used but in general it is not used due to poisonous fumes. The pattern prepared is glued to the copper surface of the board using a latex type of adhesive that can be cubed after use. The pattern is laid firmly on the copper using a very sharp knife to cut round the pattern carefully to remove the paper corresponding to the required copper pattern areas. Then apply the resistant solution, which can be a kind of ink solution for the purpose of maintaining smooth clean outlines as far as possible. While the board is drying, test all the components. Before going to next stage, check the whole pattern and cross check with the circuit diagram. Check for any free metal on the copper. The etching bath should be in a glass or enamel disc. If using crystal of ferric-chloride these should be thoroughly dissolved in water to the proportion suggested. There should be 0.5 it. Of water for 125 gm of crystal. To prevent particles of copper hindering further etching, agitate the solutions carefully by Gently twisting or rocking the tray.

4. Component Assembly

From the greatest variety of electronic components available, which runs into thousands of different types it is often a perplexing task to know which is right for a given job. There could be damage such as hairline crack on PCB. If there are, then they can be repaired by soldering a short link of bare copper wire over the affected part. The most popular method of holding all the items is to bring the wires far apart after they have been inserted in the appropriate holes. This will hold the component in position ready for soldering. Some components will be considerably larger .So it is best to start mounting the smallest first and progressing through to the largest. Before starting, be certain that no further drilling is likely to be necessary because access may be impossible later.

5. Soldering

This is the operation of joining the components with PCB after this operation the circuit will be read to use to avoid any damage or fault during this operation following care must be taken.

- A longer duration contact between soldering iron bit & components lead can exceed the temperature rating of device & cause partial or total damage of the device. Hence before soldering we must carefully read the maximum soldering temperature & soldering time for device.
- The wattage of soldering iron should be selected as minimum as permissible for that soldering place.
- To protect the devices by leakage current of iron its bit should be earthed properly.

- We should select the soldering wire with proper ratio of Pb & Tn to provide the suitable melting temperature.

VI. SOFTWARE DEVELOPMENT FOR PREPAID ENERGY METER

The system software is implemented by C language and the developed code is edited, compiled and debugging by Win-AVR software.

A. Algorithm for Energy Metering system at consumer's end

1. Start.
2. Initialize the display.
3. Decide whether the number of units in Microcontroller is sufficient or not. If the balance is insufficient then disconnect the load from supply otherwise connect to the load to supply.
4. Count the number of pulses initiated from Energy Meter IC AD7751 with the help of counter0 when the load consumes power.
5. Measure time with the help of timer1.
6. Calculate power, $P = 3000 \times X$ using this equation, where X denotes the frequency of pulses that is produced by the Energy Meter IC.

B. Advantages

1. Cost saving of energy-meter reading.
2. Prevention of manipulation of reading both by technician & consumer.
3. Advance collection of revenue.
4. Power distribution management is efficient.
5. Analysis of load consumption is easy.
6. User who does not know unit of energy (in KWH) cannot understand billing methodology.

C. Disadvantages of Project

1. Such systems are costlier compare to bill that consumer pays per month.
2. Such system payback period is more than 3 years.

D. Application of Smart Card Based Energy Meter:

1. It is used in residential areas like homes, hotels, apartments, complex etc.
2. In large & big factories, it is used for saving the power.
3. In big textile industries, it is also used for saving the power.
4. In field areas like farms, there are large power motors are used, so for their power saving purpose, we use smart card based energy meter.
5. With the help of smart card based energy meter, we can prevent to commit a theft of electricity.

VII. RESULTS AND ANALYSIS

The Energy Meter was tested in the Measurement Laboratories of Rajshahi University of Engineering & Technology, Bangladesh. An Electric Heater of 1.2 Kw rating was used as a load that draw currents of up to 5.5 A. The supply voltage was between 210 Vand 230V.Energy measurement process is described step by step. At first, A.

VIII. CONCLUSION

This paper has demonstrated for measuring the electrical energy consumption of an electrical load for two wire distribution systems with the proposed energy meter as an alternative to the conventional electromechanical meters. This microcontroller based energy meter prototype has been implemented to provide measurement up to 40 A load current from a 230 V line to neutral voltage. The proposed energy meter is capable of measuring energy consumption for all loads conditions i.e. power factor and non-sinusoidal voltage and current waveforms. It does not possess any rotating parts that help in the prevention of meter tempering, which is an attractive feature for the utilities. The proposed energy meter includes a "no load threshold" feature that will eliminate any creeping effects in the meter. In addition, the process of reading the energy consumption is facilitated by the LCD display that is simpler than that for the analog meters which reduces human errors while noting down the meter reading. This energy meter has the potential to change the future of the energy billing system in Bangladesh. The energy billing system may help the energy distribution companies to reduce costs and increase profits, to improve metering and billing accuracy and efficiency, and to contribute the energy in a sustainable way. To recharge the microcontroller chip, it must be taken to the server terminal or unit. The energy billing system provides employment for nearly 2-3 people in every server terminal for jobs like recharging smart card and processing the distribution of power in a convenient way. In future, mode of recharging the smart card can be improved by wireless communication between the server terminal and energy meter unit.

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