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Rechargeable Prepaid Energy Meter Based On SMS Technology

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Abstract*— In this paper a method is proposed to develop and design of Prepaid Energy Meter based on SMS (Short Messaging Service) technology. A microcontroller is used as heart of the system. Energy Meter IC is giving output pulse to microcontroller, proportional to the energy consumed which is calculated by using counter and timer of microcontroller. A relay is used to make connection of load. If sufficient Energy unit is not available relay acts as open circuit. A LCD is used to display the how much energy unit left. A single phase prepaid energy meter is design to measure up to 40A and 220 V line to neutral line. To get the power signal, voltage signal and current signal of supply is multiplied. The amount of balance is stored on EEPROM of microcontroller. When balance is zero GSM modem will send SMS to customer for further recharge of energy units and power cut off until recharge is done. To make it more user friendly a warning massage is coded so that when fifty unit energy left customer will get an warning SMS. Two water heater of ratting 500Watt each (equivalent to total 1kW load) are used as load.

***Index Terms*—microcontroller, gsm modem, energy meter, relay, sms.**

I. INTRODUCTION

The present electric energy billing system in Westbengal (India) is time consuming and tedious. An electric board (EB) staff came to each home and note down current and previous reading of digital energy meter, then calculate unit of energy consumed and prepare bill. So the house owners have to wait for EB staff when they will come. In this billing system user and supplier both have to give time, also after that user have to go to billing station to paid energy bill. Rechargeable Prepaid meter based on sms technology improve the billing system, where consumer have to buy energy unit advance and the number of unit is depend on consumer. EB staff will recharge the energy unit by just sending a SMS. When the no. Of energy unit tends to finish, customer will get a warning SMS "You Have Left XX unit energy only. Keep Recharge for Uninterrupted Service" (XX is the no. of energy unit left). New electronic meter are developed replacing electromechanical meter. Still Indian power sector face a difficult task to collect revenue. Conventional billing system which is not accurate, flexible and very slow is main reason for that as described in [1]. Theft detection was also a challenge. Recent development in implementing energy efficient metering technology for accurate, precise, error free as described in [2]. Due to low cost microcontroller, prepaid energy meter has been developed by Microchip Technology Inc [3]. Digital energy meter as an alternative of electromechanical meter developed by using PIC as describe in [4]. Polyphase prepaid energy meter has been developed based on local prepayment and card reader [5]. In this paper the design of a prepaid energy meter is proposed based on SMS technology. A GSM modem is used for two way communication between distributor and customer by means of SMS. C language is used to develop software programming. the applicable criteria that follow.

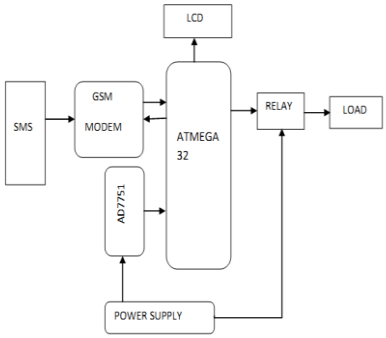

Fig. 1. Block diagram of the system

II. ANALYSIS OF HARDWARE COMPONENTS

A. Power Supply

The microcontroller and associated circuitry requires 5V supply while the relay requires a 12 V supply. A single 12V adapter connected to the mains produce DC 12V output usable for the relay and this voltage is further passed through a positive fixed voltage regulator IC 7805 resulting in a 5V DC output usable for the microcontroller and other logic circuitry. The adapter performs the functions of rectification and filtering. Load is connected across 220V ac supply.

B. Microcontroller

Microcontroller is a programmable device which contains a microprocessor, memory, input-output ports etc which can be compared with the microcomputer. Microcontroller is a single chip computer. As microcontroller is a low cost programmable device. It is used in the automatic control application. Now the pulses produced at the pin CF is directly applied to the counter pin of the microcontroller. The microcontroller counts the pulses that appear at pin 1 of Microcontroller (ATmega32) within every 20 seconds. The number of pulses per second appeared at pin 22 of Energy Meter IC is directly proportional to the instantaneous real power information for a particular load. Information such as

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power, energy, and maximum demand are stored at the EEPROM of the Microcontroller (ATmega32).

C. GSM Modem

We have used GPRS modem SIM300 from SIMCOM limited designed for global market, SIM300 is a Tri-band GSM/GPRS engine that works on frequencies EGSM 900 MHz, DCS 1800 MHz and PCS1900 MHz SIM300 provides GPRS multi-slot class 10 capabilities and support the GPRS coding schemes CS-1, CS-2, S-3 and CS-4. With a tiny configuration of 40 mm x 33mm x 2.85 mm , SIM300 can fit almost all the pace. Requirements are in application, such as smart phone, PDA phone and other mobile device. The physical interface to the mobile application is made through a 60 pins board-to-board connector, which provides all hardware interfaces between the module and customers' boards except the RF antenna interface.

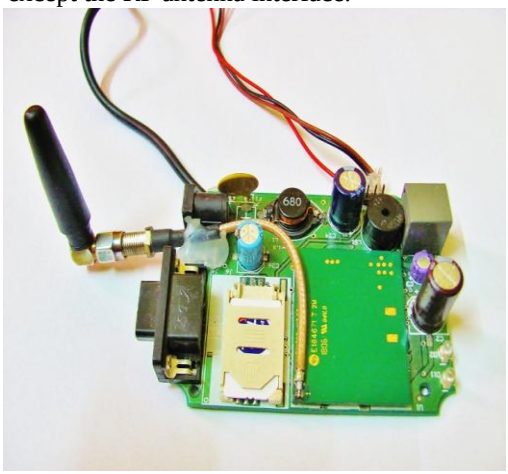

Fig. 2. Real view of GSM modem

D. Energy Meter IC

Energy meter IC has two ADCs that digitize the voltage and current signals from the supply main. These ADCs are 16-bit second order sigma-delta converters with an over sampling rate of 900 kHz. A high-pass filter in the current channel removes any dc component from the current signal. This eliminates any inaccuracies in the real-power calculation due to offsets in the voltage or current signals. The real-power calculation is derived from the instantaneous power signal. The instantaneous power signal is generated by a direct multiplication of the current and voltage signals. In order to extract the real-power component, the instantaneous power signal is low-pass filtered. The low frequency output of the energy meter IC is generated by accumulating this real-power information. The output frequency is therefore proportional to the average real-power. This average real-power information can in turn be accumulated by a counter to generate real-energy information.

E. Liquid Crystal Display

LCDs are preferred as display devices compared to LED because of lower power consumption, flexibility in display content and compact structure suitable for embedding in the hardware unit. LCDs work on the principle of change in orientation of the liquid crystals due to incident light. Polarized liquid crystals allows light to pass through indicating light shades and disoriented liquid crystals block passage of light, thereby making those regions look dark. LCD displays come in different type like Numeric LCDs, Alphanumeric LCD and Graphic LCD etc. Here we use 20X4 Alphanumeric LCD, which means we can display up to 4 lines with 20 Characters in a line.

F. Relay

Relay board consists of three SPDT relay and a relay driver ULN 2803. ULN 2803 is a unipolar relay driver IC with maximum output voltage 50V and output current 500mA. It contains eight Darlington pair transistors, each having a peak rating of 600mA and can withstand 50V in off-state. Outputs may be paralleled for higher current capability.

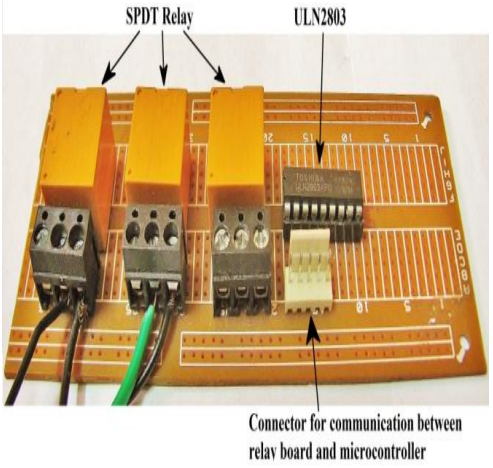

Fig. 3 SPDT relay board along with ULN 2803

III. ENERGY CALCULATIONS

The Energy Meter IC(AD7751) produces an output frequency that is proportional to the time average value of the product of two voltage signals. The input voltage signals are applied across current channel (pin 4, 6) and voltage channel (pin 8, 7) of Energy Meter IC. The Energy Meter IC also provides an output frequency at pin 22 of Energy meter IC equal to the output power. During calibration the frequency (F=0.5Hz) we got against load=1kW.Then power (P) will be (for any value of frequency say F)

$$P = \frac{\text{Load} \times X}{0.5} \quad (1)$$

$$P = 2000 \times X(\text{as Load} = 1000\text{watt}) \quad (2)$$

$$1\text{WattSec} = \frac{1\text{kWh}}{1000 \times 3600} \quad (3)$$

$$\text{Energy} = \frac{P \times \text{Sec}}{1000 \times 3600} \quad (4)$$

$$\text{Energy} = \frac{2000 \times X \times \text{Sec}}{3600000}\ \text{Units} \quad (5)$$

Fig. 4 Energy calculation process Units

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IV. CIRCUIT LAYOUT

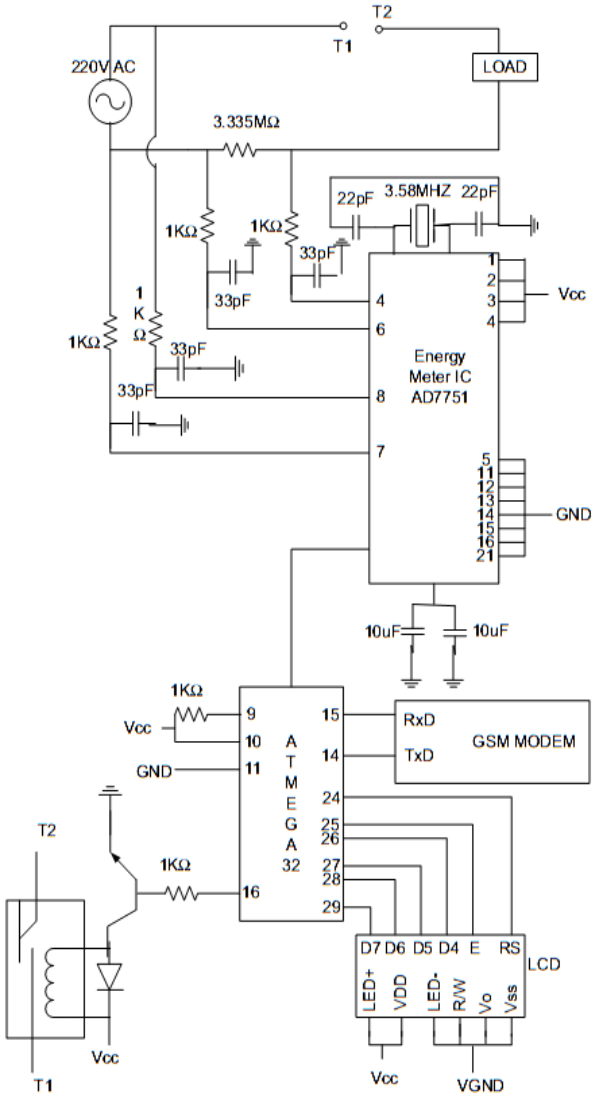

Fig. 5 Circuit layout of the energy meter

V. ALGORITHM

Step 1. Initialize display
Step 2. Check balance (B) stored in EEPROM. If B=0, go to Step15.
Step 3. Count no. Of pulse initiated from IC AD7751 with the help of counter and time by timer.
Step 4. Calculate power (P) and Energy (E) units.
Step 5. Perform B=B-E and stored B in EEPROM.
Step 6. If B=50, go to step11, otherwise go to step2.
Step 7. If SMS received check the no. From which SMS came.
Step 8. If SMS coming from unknown number go to step12.
Step 9. If SMS from known number with valid command, form B=B+R and stored B in EEPROM, where R= recharge amount.
Step 10. Sent SMS to Customer "Recharge Successful" and go to step12.
Step 11. Sent SMS to customer "Keep Sufficient balance to avail uninterrupted service".
Step 12. Delete SMS. Go to step2.
Step 13. Stop relay. Sent SMS to customer"Power off due to zero balance".

VI. RESULT

A smart system like this can help sustain energy and also plausibly suppress the foul techniques of steeling power from the power lines. The generation and linkage of electric power can be switched ON or OFF using simple techniques of recharge. It shows a much more convenient way to develop the power system and it is consumer friendly. This system is user friendly and cost effective and can produce a large interest for the electricity supply departments for its advantages. Developments such as these provide faster payments and also reliability towards the service.

VII. ACKNOWLEDGMENT

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