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Design and Prototype Implementation of Prepaid Energy Meter

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Abstract: In this paper, the idea of prepaid energy meter using an AT89S52 microcontroller and GSM module has been introduced. The aim of the project is to make a reliable and user friendly technology to purchase credit electricity in advance of power consumption. This provides a cost efficient manner of electricity billing. The present energy billing systems are discrete, time consuming, inaccurate, costly and slow. The major drawback of traditional billing system is power and energy theft. This drawbacks are reduced by the concept of credit power before consumption. The advent of microprocessor based devices and meters has greatly improved the ease of operation, making the system user friendly. The GSM technology is used so that the consumer would receive messages about the consumption of power and automatically alert the consumer to recharge when the recharge reaches minimum amount. The automated billing system will keep track of the real time consumption.

Keywords*:* Microcontroller, Energy meter, GSM module, Opto-coupler, Relay.

I. INTRODUCTION

IN recent years many attempts have been made to design the energy meter with instant billing technique but till now the designed energy meters are not efficient and do not provide replacement. Now-a-days the numbers of Electricity consumers are increasing in great extent. It is hard to handle and maintain the power due to growing requirements. Maintenance of the power is an important task as the human operator goes to consumer's house and produces the bill as per the meter reading.

The billing process takes much time if the consumers is not in the house while taking readings on energy consumption. It requires a lot of time and more labour to analyse energy consumption and generating the bill. If the consumer did not pay the bill, the Foreman needs to go to their houses to disconnect the power supply. These consumes time and difficult to handle. The manual operator cannot find the Un-authorized connections or malpractices carried out by the consumer to reduce or stop the meter reading/power supply. Some of the energy meters which had been implemented are prepaid but it needs Smart card to recharge it. The major disadvantage of that method is that it needs internet and the computer interface. In this paper we propose a method which uses GSM Network which eliminates the need of internet.

"A Prepaid Energy Meter for Efficient Power Management" system consists of Energy Meter and the GSM network. The system provides efficient power meter reading, usage notification and consumer's maximum demand using GSM network. GSM modem utilizes the GSM network to send equivalent unit for the recharged amount to the Microcontroller and send message to the consumers end. The message consists of details like recharged amount and power consumption. In the energy provider side this system is used to update the consumer account and the database. [1]

II. SYSTEM ANALYSIS

2.1 *Problem definition*

In the present billing system the power usage reading is made manually at the consumer location by the power provider. This requires large number of labor and working hours to accomplish the task.

Manual billing is sometimes restricted and delayed by bad weather conditions and at isolated areas. There is also a tendency of printed bill getting lost. If the consumer does not make the payment before the desired time the utility must take further actions such as disconnection of the supply, which is also time and labor consuming. The manual billing system is error pron. In the present system the chances of overbilling; loss for the consumer, under billing; loss for the utility or power provider, due to energy meter faults are high. One of the main drawback of the traditional billing system is the energy theft. The proposed system addresses the above mentioned drawbacks.

2.2 *Proposed System*

The proposed system is based on the concept of prepaid energy or pay before use. In this, a separate module is installed along with the existing energy meter.

The proposed system works on principle similar to the prepaid mobile recharging. In prepaid energy metering system the user recharges for the amount of energy he/she require. Here the user is issued with a unique number code. User sends a message to the utility server along with the code number and his/her consumer id in the prescribed format like in mobile recharge system.

The utility send a trigger signal to the energy meter at the consumer point through GSM module which switch on the power to the consumer. When the power consumption for the recharge amount is reached the microcontroller triggers the relay and the meter is cut out from the supply.

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2.3 *Components*

2.3.1 *AT89S52 Microcontroller*

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8Kbytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. The Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, axis-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes.

The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.
The microcontroller acts as the brain of the system. It acts as a master to communicate. It monitors the energy meter reading. It is programmed to switch on the power supply to the consumer when a recharge is done. When the consumption reaches the recharge amount the microcontroller triggers the relay and the power is cut out.

2.3.2 *GSM Module (900A/1800MHz)*

Semen's GSM smart modem is multifunctional, ready to use, rugged unit that can be embedded or plugged into any application. The Smart Modem can be controlled and customized to various levels by using the standard AT commands. The modem is fully type-approved, it can speed up the operational time with full range of Voice, Data, Fax and Short Messages (Point to Point and Cell Broadcast), and the modem also supports GPRS for spontaneous data transfer. (Fig.2.1)

The modem comprises several interfacing features like:

- LED function including operating status
- External antenna
- Serial and control link
- Power supply.
- SIM card holder
- LED status indicator

Fig.2.1 GSM Module

The GSM module uses SIM technology to exchange data, and signaling between the user and the utility. The GSM module acts as the communication link between the prepaid unit and the server at the utility. The GSM module will transmit the consumption amount to the server.

2.3.3 Relay (SPST 12V, 5A)

Relay is an electromagnetic device which is used to isolate two circuits electrically and connect them magnetically. They are very useful devices and allow one circuit to switch another one while they are completely separate. They are often used to interface an electronic circuit (working at a low voltage) to an electrical circuit which works at very high voltage. For example, a relay can make a 5V DC battery circuit to switch a 230V AC mains circuit. Thus a small sensor circuit can drive, say, a fan or an electric bulb.

A relay can be divided into two parts: input and output. The input section has a coil which generates magnetic field when a small voltage from an electronic circuit is applied to it. This voltage is called the operating voltage. Commonly used relays are available in different configuration of operating voltages like 6V, 9V, 12V, 24V etc. The output section consists of contactors which connect or disconnect mechanically. In a basic relay there are three contactors: normally open (NO), normally closed (NC) and common (COM). At no input state, the COM is connected to NC. When the operating voltage is applied the relay coil gets energized and the COM changes contact to NO. Different relay configurations are available like SPST, SPDT, DPDT, etc., which have different number of changeover contacts. By using proper combination of contactors, the electrical circuit can be switched on and off.

2.3.4 *LCD Display*

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16×2 LCD display is very basic module and is very commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5×7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

LCD displays the status of the microcontroller, power consumption, recharge amount etc.

2.3.5 *Opto-coupler*

The opto-isolator or opto-coupler is a component that transfers electrical signals between two isolated circuits by using light. Opto-coupler prevent high voltage from affecting the system receiving the signal. Commonly available opto-couplers withstand voltages up to10kV An opto-isolator contains a source (emitter) of light, almost

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always a near infrared light-emitting diode (LED), that converts electrical input signal into light, a closed optical channel (also called dielectric channel), and a photo sensor, which detects incoming light and either generates electric energy directly, or modulates electric current flowing from an external power supply.(Fig.2.2)

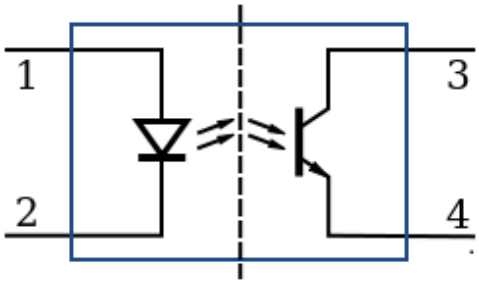

Fig.2.2 Opto-coupler

The sensor can be a photo resistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR) or a triac. Because LEDs can sense light in addition to emitting it, construction of symmetrical, bidirectional opto-isolators is possible. An opto-coupled solid state relay contains a photodiode opto-isolator which drives a power switch, usually a complementary pair of MOSFETs. A slotted optical switch contains a source of light and a sensor, but its optical channel is open, allowing modulation of light by external objects obstructing the path of light or reflecting light into the sensor.The energy meter output is tapped using the opto-coupler.

2.3.6 *IC MAX232*

The MAX232 is an integrated circuit first created in 1987 by Maxim Integrated Products that converts signals from a TIA-232(RS-232) serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

The drivers provide TIA-232 voltage level outputs (approx. ± 7.5 V) from a single five volt supply via on-chip charge pumps and external capacitors. This makes it useful for implementing TIA-232 in devices that otherwise do not need any other voltages.

The receivers reduce TIA-232 inputs, which may be as high as ± 25 volts, to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 volts and a typical hysteresis of 0.5 V. This is used to enable the serial communication between the microcontroller and the LCD display.

2.3.7 *Current Driver IC ULN2003*

The ULN2002A, ULN2003A, ULN2003AI, ULN2004A, ULQ2003A, and ULQ2004A are high-voltage high-current Darlington transistor arrays. Each consists of seven npn Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. For 100 V (otherwise interchangeable) versions of the ULN2003A and ULN2004A, see the SN75468 and SN75469, respectively. The ULN2001A is a general-purpose array and can be used with TTL and CMOS technologies. This is used to drive the relay unit

2.3.8 *DC Supply*

The available power supply at the mains is 230V AC. The microcontroller and the subunits works under low voltage and current. The supply required for microcontroller is 5V DC. In order to power the module we convert the available supply to low voltage DC.

The DC supply consists of a transformer, rectifier and regulator. The transformer is of step down type. 230/9V transformer is used. It steps down the voltage to a value suitable for the working of electronic devices. The step down AC voltage is converted to DC by the rectifier. The rectified output is then regulated at the regulator unit and given to the microcontroller and LCD display.

2.3.9 *Energy Meter*

An electric meter or energy meter is a device that measures the amount of electrical energy supplied to or produced by a residence, business or machine. The most common type is a kilowatt hour meter. When used in electricity retailing, the utilities record the values measured by these meters to generate an invoice for the electricity. They may also record other variables including the time when the electricity was used. Modern electricity meters operate by continuously measuring the instantaneous voltage (volts) and current (amperes) and finding the product of these to give instantaneous electrical power (watts) which is then integrated against time to give energy used (joules, kilowatt-hours etc.). The meters fall into two basic categories, electromechanical and electronic.

Here a digital energy meter is used for measuring purpose. Digital signal processor or high performance microprocessors are used in digital electric meters. Similar to the analog meters, voltage and current transducers are connected to a high resolution ADC. Once it converts analog signals to digital samples, voltage and current samples are multiplied and integrated by digital circuits to measure the energy consumed. Microprocessor also calculates phase angle between voltage and current, so that it also measures and indicates reactive power. It is programmed in such a way that it calculates energy according to the tariff and other parameters like power factor, maximum demand, etc. and stores all these values in a non-volatile memory EEPROM. It contains Real Time Clock (RTC) for calculating time for power integration, maximum demand calculations and also date and time stamps for particular parameters. Furthermore it interacts with Liquid Crystal Display (LCD), communication devices and other meter outputs. Battery is provided for RTC and other significant peripherals for backup power.

2.4 Features

- User friendly

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- Pay before use
- No billing production and distribution
- No billing errors
- No need to chase payments
- Social acceptability
- Load and demand side management
- Helps to limit load
- Daily weekly monthly budgeting for the consumer
- Reduce energy theft
- Reduce waste and conserves energy
- No unexpected disconnections for the consumer[2]

III. BLOCK DIAGRAM AND WORKING

The microcontroller AT89S52 acts as the primary controller. It collects the information about power consumption from the energy meter and recharge information from the utility server. When an energy recharge is made a trigger signal is sent to the microcontroller. In this system the recharge is made by sending message to the GSM module. The microcontroller is program to monitor the consumption depending upon the current tariff. The microcontroller continuously records the reading and is transferred to the utility in prescribed intervals.

When the power equivalent to the recharge amount is consumed the microcontroller automatically cutoff the supply from the utility with the help of relay unit. The block diagram is given below. Fig (3.1).

The LCD display displays the consumption, status of the meter, recharge remaining etc. When the recharge amount is low the user is informed by a message from the microcontroller. The communication is established with the help of GSM module. The GSM uses its own network for communication.[3]

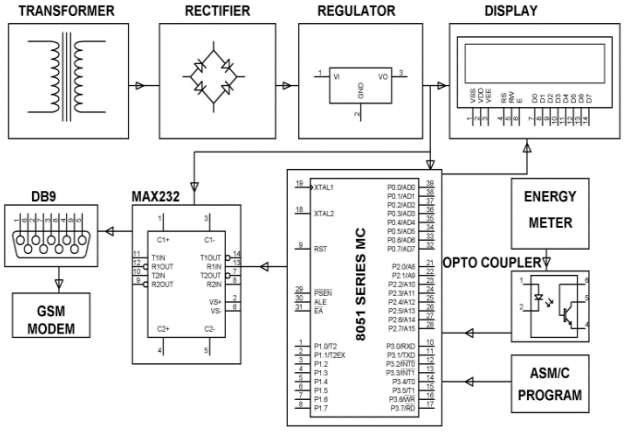

Fig.3.1 Block Diagram

IV. CONCLUSION

The design of Smart Energy meter using GSM technology can make the users to pay for the electricity before its consumption. In this way, consumers hold credit and then use the electricity until the credit is exhausted. If the available credit is exhausted then the electricity supply is cut off by a relay. An arrangement is also made to intimate the user with the help of GSM communication module when their credit in their balance goes low. This system has been proposed as an innovative solution to the problem of affordability in utilities system. Since a microcontroller based system is being designed, the readings can be continuously recorded. This reduces human labour and at the same time increases the efficiency in calculation of bills for used electricity. Smart energy meters will bring a solution of creating awareness on unnecessary wastage of power and will tend to reduce wastage of power. This module will reduce the burden of energy providing by establishing the connection easily and no theft of power will take place.

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