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# Review on Design and Implementation of Intelligent Energy Meter Using Arduino and GSM Modem

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**ABSTRACT:** Power theft is the biggest problem in our country which causes lots of loss of electrical energy. This is done using Smart Energy Meter (SEM). SEM is an electric device having energy meter chip for measuring the electric energy consumed and a wireless protocol for data communication. In this paper we are focusing on automatic billing and metering. Firstly, we have simulated the project in PROTEUS 8.0 then successfully implemented on the circuit board in laboratory. The integration of the Arduino and GSM (Global System for Mobile communications) Short Message Service (SMS) provide the meter reading system with some automatic functions that are predefined. The energy utilization or consumption and electricity bill will be conveyed through GSM module not only to the electricity department but also to the customer. An alert message will be sent to the customer when the consumption unit reaches beyond the threshold. In this paper, energy consumption details will be given in terms of power units. These power units will be displayed on the LCD and will be sent to the customer and customer will also be able to recharge with the help of PIC microcontroller and GSM module.

**KEYWORDS:** Arduino, LCD display, GSM modem.

### I. INTRODUCTION

An electricity meter, electric meter, or energy meter provides the amount of electric energy consumed by the user it may be a residence, business, or an electrically powered device. A smart energy meter (SEM) is electric device having energy meter chip for electric energy consumed measurement, wireless protocol for data communication (such as GSM Modem) and peripheral devices for security purpose, data showing, meter controlling etc [1]. Now days with emerging developments in all sectors and growing demands, electricity has become priority for each individual and also for organizations. The basic steps for power supply include power generation, power transmission and power distribution to the consumer. Naturally considering few technical faults, losses may occur due to power dissipation by some devices. These losses can be minimized using the modern technologies, but what about the other types of losses? These are the losses caused wilfully by human beings for the illegal access to the power distribution, is nothing but the power theft [4]. In this project, a new method of post-paid electronic energy metering is introduced in this paper which will automatically sense the used energy, records these reading continuously, then sends it to the billing point through the wifi module. Finally, after processing the collected data bill is generated using a web based system software and is send back to the customer as SMS (Short Messaging System) using GSM network.

The smart energy meter contains an energy meter, a GSM modem, a microcontroller (Arduino) and a relay circuit, which is connected between the energy meter and the load [8]. The proposed smart energy meter is able to provide all the metering and billing services like counting the consumed energy, sending the generated bill by the SMS (short message service) over the GSM network as well as the security services proposed smart energy meter is highly deserved for national implementation because of, at present the metering and billing system of our country is totally conventional and it is very much slowed, faulty and corrupted [8].

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## II. LITERATURE SURVEY

Mr. Paraskevakos was first AMR system inventor in the 1974 in USA, who used a advance technology developed on 1972 by Theodore George [3]. For communication to the server many options are available as wired or wireless such as, power lines, cable networks, RF modules, GSM modules, LCD Display , which are studied by different researchers. Abhinandan Jain et al. [8] represented the development of a fully Automated Energy Meter which has capacities such as remote monitoring and energy meter controlling. Here Automatic Meter Reading system (AMR) continuously monitors the energy meter and sends data on request of service provider through SMS. That system was allowed to the customers to pay online bill either by credit card, debit card or by net banking. At the end of each month a person from the electricity board goes to every house and takes the meter reading manually. These meter readings are used for electricity bill calculation and this bill sent to consumer house by post. Customer goes to electricity department for paying this bill amount. But in this technique we are required great number of persons for reading the meters. The procedures of sending the bills to customer are very laborious and cumbersome [9]. A Global System for Mobile communications (GSM) automatic power meter reading was built to demonstrate an automatic power meter reading. This system provides effective, reliable and efficient wireless automatic power meter reading, billing and notification through the use of GSM network [3]. Meter reading has too many errors in the recent methods because involvement of human. Person from the EB takes approximately 100 photos each then photos are checked by the server and if any home is closed then Person has to revisit that place and another way is take average of last 3-4 bill if door is closed for more than 2 months. If consumer gets defective bill then he has to visit the electricity office and stand in queue to get it corrected bill. All these problems are raised due to the human involvement. To avoid such problems in billing process, AMR is used [6]. In future we can also update the tariff within the energy meter by writing a program in the java and it must be connected to the energy meter using USB port which automatically updates the program in the micro controller. And we must also make easy to the customers for buying the watts using SMS request. This makes flexible for both user and the company [7]

## III. ENERGY METERING SYSTEM

### A. Conventional system

Electricity meters give energy used (joules, kilowatt-hours etc.) by continuously measuring the instantaneous voltage and current in volts and amperes respectively. There are two types of electricity meter i.e. electromechanical and electronic. Mostly or commonly used electricity meter is the electromechanical induction watt-hour meter. This meter operates by counting the revolutions of a non-magnetic metal disc. This metal disk is made to rotate at a speed proportional to the power passing through the meter. These numbers of revolutions are proportional to the energy used by the customer. Second type is Electronic meters, which display the energy used on an LCD or LED display [8]. These kinds of Electricity meters support time-of-day billing, for example, recording the amount of energy used during on-peak and off-peak hours.

There are many flaws and errors in conventional billing. Some human mistakes may also occur in manual billing [1]. Analyzing the conventional billing some of the common are:

- It's a time consuming procedure
- There is always a chance of human error while taking the manual meter reading.
- There is no check and balance and verification procedure of this meter reading.
- There is always a chance of theft and corruption.
- Extra human power is required
- Consumer is not updated of his usage.

### B) Proposed system

A smart meter works by communicating directly with wireless data protocol with your energy supplier, so the company will always have an accurate meter reading and there's no need for you to take a meter reading yourself. Smart meters

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can work in a variety of different ways, including using wireless mobile phone type technology to send data. There are many benefits of smart energy meter such as:

- Your smart energy monitor shows you how much energy you're using in money. So you can see what you're spending by the minute. Knowing more about how much energy things use, will help you choose the way you use them.
- Your smart meters send us accurate, regular information about your energy use. So your bills will be accurate and there will be an end to having to submit meter readings.
- If you want to get the most out of being a smart meter customer, let us know and we'll update your smart meters to record readings for every half-hour. Your smart meters will continue to only send one 'batch' of readings through to us each day but this will enable us to provide you with a Smart Energy Report a week after your bill.

The proposed system consists of digital energy meter, an Arduino (microcontroller) and GSM modem. After switching power on the Arduino and the GSM modem, turn on and connects the energy meter to load via relay. Then read the EEPROM and display the current data. Arduino checks the impulse from energy meter. If impulse occur increase the data and display current data. GSM modem checks the new SMS. If there is a new SMS and read it. If the SMS is "DATA", send data to the specific number. If the SMS is "LINE CUT", turn OFF the relay, so load will disconnect. Again the SMS is "LINE OK" and then turn ON the relay so load will connect. If there is any other SMS in any other formats, then delete the SMS. Any tampering attempt occurring the metering unit, Arduino turns OFF the relay, turns ON the buzzer and sends SMS to the service provider.

## IV. SYSTEM DEVELOPMENT OF SMART ENERGY METER

The system architecture of Arduino and GSM based smart energy meter is shown in the Fig. 1. The energy consumption is being calculated using the energy meter IC and Arduino(Uno 3). In order to prevent a tampering, detection program is present in the Arduino. Arduino and GSM based smart energy meter can be divided into several parts as Energy Meter IC, LCD, Arduino, GSM modem [11], Relay, Optocoupler, Control Unit, Display Unit and Power Supply Unit etc. The hardware description of different parts is separately introduced as follows:

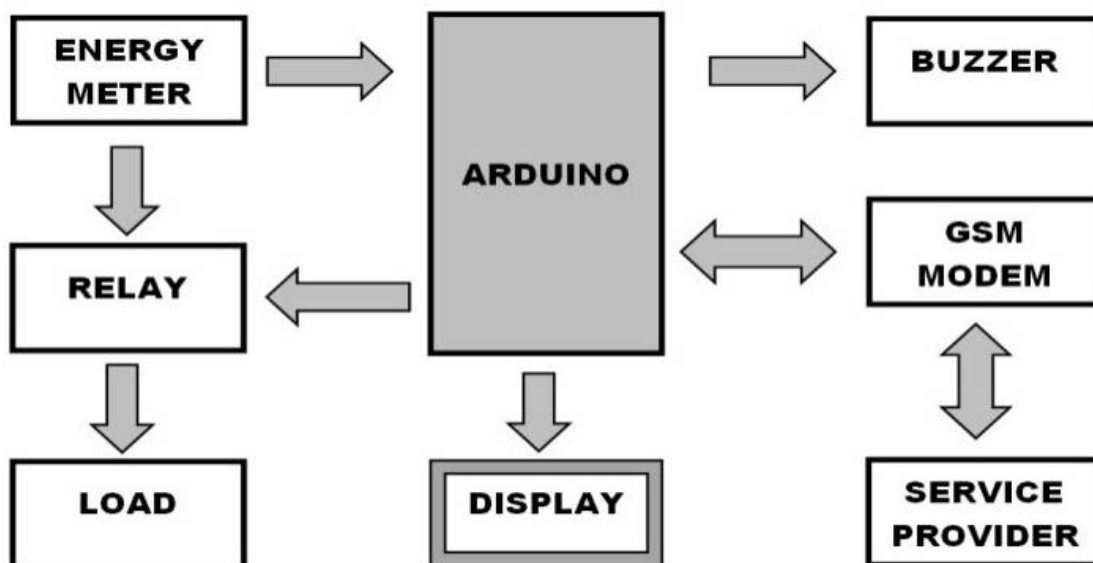


Fig. 1: Block diagram of the proposed smart energy metering system.

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## A. Energy Meter IC (BL6503)

In BL 6503, the two ADCs (ADCs are 16-bit second order sigma-delta with an oversampling rate of 900 kHz) digitize the voltage signals from the current and voltage transducers. This analog input structure greatly simplifies transducer interfacing by providing a wide dynamic range for direct connection to the transducer and also simplifying the anti-aliasing filter design. Easy transducer interfacing facility is provided by programmable gain stage in the current channel. 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 [1].

The ADE7756 IC is used for energy measurement. It is interfaced to a microcontroller through a serial interface (SPI). The SPI port allows the user to calibrate various components of the meter, including gain, offset, and phase errors. The purpose of the microcontroller is to send display data to the LCD and control the various functions of the meter. An EEPROM is not only used to store various calibration parameters of the meter but also to store the meter's data during a power-down. The GSM module provides the wireless communication and SMS-based facility for the design. Power connection/disconnection to the load is implemented using a Relay. The relay receives instructions from the microcontroller through its input signal pins. System working current time data is recorded by the RTC. The power supply unit provides the operational voltage of 5volts for the ADE7756 IC, Microcontroller and the LCD. The entire meter is calibrated through an external calibration routine by a PC through an external SPI interface [5].

## B. Arduino (Uno R3)

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on our computer, used to write and upload computer code to the physical board. The Arduino [12] platform has become quite popular with people just starting out with electronics, and for good reason. Unlike most previous programmable circuit boards, the Arduino does not need a separate piece of hardware (called a programmer) in order to load new code onto the board - you can simply use a USB cable. A simplified version of C++ is additionally used by the Arduino IDE for making it easier to learn to program. Finally, Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package. The Uno is a great choice for beginners or developer and one of the more popular boards in the Arduino family [1].

## C. Relay

A relay is an electrically operated switch that uses an electromagnet to mechanically operate a switch. At a low-power signal, relays are used to control a circuit, or where several circuits must be controlled by one signal.

## D. Power Supply Unit

A power supply is an electronic device that supplies electric energy to an electrical load. As all know, any invention of latest technology cannot be activated without the source of power. All the electronic components starting from diode to Intel IC's only work with a DC supply usually ranging from  $\pm 5V$  to  $\pm 12V$ . We are utilizing for the same, the cheapest and commonly available energy source of 230V-50Hz and stepping down, rectifying, filtering and regulating the voltage to convert it into suitable DC voltage. In our project, the required voltage is +5V & +6V to run Energy meter IC, Microcontroller and the display unit.

## V. CONCLUSION

To continuously monitor the meter reading, a wireless meter reading system is designed. Also, it provides the new feature to an electrician, i.e. to cut off or shut down the power supply remotely whenever the consumer is unable or fails to pay the bill. The proposed system displays the corresponding information on LCD for user notification. The customer can easily know his bill in his mobile phone at the month's end through mobile SMS.

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