Ethernet Shield based Electricty Billing Framework

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Abstract—
Smart electricity billing system is an invaluable technological advancement that can lead to higher standard of living. It acts as an aid to solve many issues of the traditional meter reading system like need for manpower, accuracy, delayed work, unavailability of customer during metering visit by electricity board employee ,etc. This work presents a novel method for the design of a smart electricity billing framework. This framework involves the integration of Arduino and Ethernet Shield along with a pulse detector circuit carrying out the automatic functions that are predefined. The Ethernet Shield provides an interface with the server located at the electricity board for documentation purposes and for future references. A GSM modem acts as a gateway in each entity to have remote access over the usage of electricity.

Keywords— *Arduino (microcontroller), Ethernet Shield, Global System for Mobile (GSM), Short Message Service (SMS)*

I. INTRODUCTION

Electricity has become indispensable to human survival and progress. Now days, electricity demands are rapidly increasing. Demand for electricity is greater than its generation. Traditional meter reading by manual methods is inefficient to meet the future residential development needs. So the need for automated electricity reading and billing systems is expanding over industrial, commercial and utility environment. It has become a trend to integrate automatic systems via wireless applications over network. Along with the advancement of technology development, research on wireless applications and remote control has become significant and popular today.

An energy meter is a device that measures the amount of power consumed by a residence, business, or an electrically powered device. Energy meters operate continuously by measuring instantaneous voltage (volts) and current (amperes) to give the energy consumed (in joules, kilowatt-hours etc.). The meters fall into two basic categories, electromechanical and electronic. At present, the electromechanical meters have been replaced with electronic meters.

A. Drawbacks of Conventional Metering Sytem:

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

- Time consuming procedure.
- Chance of human error while taking the manual reading.
- Extra man power required.
- Non-availability of consumer at the time of metering.

Our proposed system consists of an energy meter, a GSM modem , a microcontroller (Arduino), a Ethernet shield, pulse detector circuit and the load. In our proposed framework, the power consumed is automatically sensed, the readings are recorded continuously and sent to the billing point through the Ethernet Shield. Finally after processing the collected data, bill is sent to the consumers through the existing GSM network.

II. LITERATURE SURVEY

For this work existing meter reading techniques in India are analyzed and conducted an extensive study on different energy measuring instruments available. The meters currently in use are only capable of recording kWh units. The kWh units used then still have to be recorded by electricity board employee monthly on foot. The recorded data need to be processed by the electricity board. For generating the bill, the electricity board needs to link each recorded power usage to an account holder and then determine the amount by means of the specific tariff in use.

Many systems built on various platforms have been proposed by different research groups all over the world for Automated Electricity Billing. Many e-metering systems have been proposed based on Bluetooth, GPRS, GSM as explained in [2], [3]. Design of an electric energy meter for long-distance data transfers is proposed in [4]. These systems cannot be implemented so easily due to difficulties in GPRS. A GSM Energy meter with instant billing facility is introduced in [1], but does have a server to store the data for future references. A more reliable and user friendly system with a server and a database

is created in this project which would manage the data efficiently even if there is a loss of SMS.

For our design framework, energy meter specifications and tariff structure followed by the Tamilnadu Electricity Board is adopted.

III. SYSTEM ARCHITECTURE

The system architecture of Smart electricity billing framework is shown in fig 1. The framework consists of the following components: Energy meter, Pulse detector circuit, Arduino UNO, RTC, Ethernet shield, GSM modem and a Server.

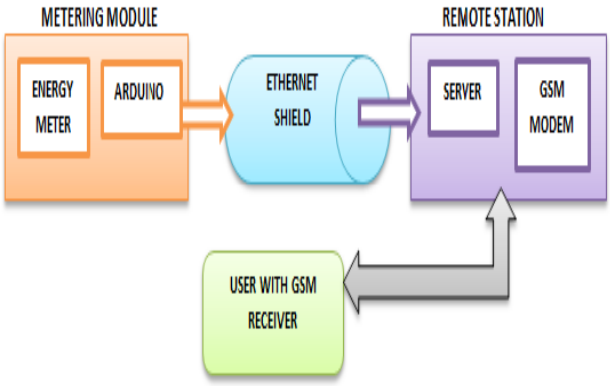

Fig 1: Overview of Proposed System

A. *Energy Meter:*

An Energy meter or Watt hour meter is an instrument which measures the amount of electrical energy used up by the consumer. These instruments are installed at both domestic and industrial locations to charge for the electricity consumption by loads such as lights, fans and other electrical appliances. There are two types of meters namely Electromechanical meters and Electronic (Digital) meters. Electromechanical meters are currently being replaced with Electronic meters as it can be tampered. Electronic meters are highly accurate and is available with digital displays.

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 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 inorder to load new code onto the board- you can simply use a USB cable. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program. Finally, the Arduino provides a standard form factor that breaks out the functions of the micro-controller into a more accessible package. The UNO is one of the more popular boards in the Arduino family and a great choice for beginners.

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C. *Arduino Ethernet Shield:*

The Arduino Ethernet Shield allows the users to connect the Arduino to the internet using the Ethernet library and to read and write an SD card using the SD library. This shield enables the Arduino to send and receive data from anywhere in the world with an internet connection. It is based on the Wiznet W5500 Ethernet chip. The Wiznet W5500 provides a network (IP) stack capable of both TCP and UDP. It supports upto eight simultaneous socket connections. The most recent version of the board exposes the 1.0 pinout on rev 3 of the Arduino UNO board.

D. *Arduino GSM Shield (SIM 900):*

The GPRS Shield is based on SIM900 module from SIMCOM and compatible with Arduino and its clones. The GPRS Shield provides you a way to communicate using the GSM cell phone network. The shield allows you to achieve SMS, MMS and GPRS and Audio via UART by sending AT commands (GSM 07.07, 07.05 and SIMCOM enhanced AT commands). The shield also has the 12 GPIOs, 2 PWMs and an ADC of the SIM900 module present onboard. The Arduino GSM Shield connects the Arduino to the internet using the GPRS wireless network. The Arduino GSM Shield also make/receive voice calls and send/receive SMS messages.

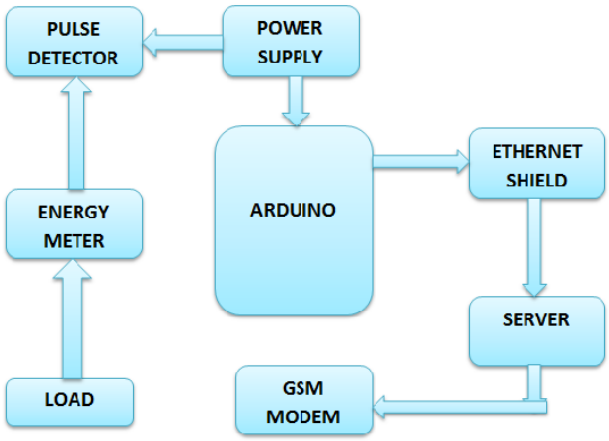


Fig 2: Block Diagram of the Proposed Framework

E. *Pulse Detector Circuit:*

The pulse detector module is shown in Fig 3. The main component of this circuit is LDR. LDRs are made from semiconductor materials to enable them to have their light sensitive properties. These LDRs work on the principle of "photo conductivity". Whenever light falls on the surface of the LDR, the conductance of the element increases resulting in increase in voltage. This in turn triggers the RESET pin IC555 which in turn triggers the relay. The voltage developed across the relay will be sufficient

to drive the IO pins of the Arduino thereby indicating the blink of the LED in the energy meter.

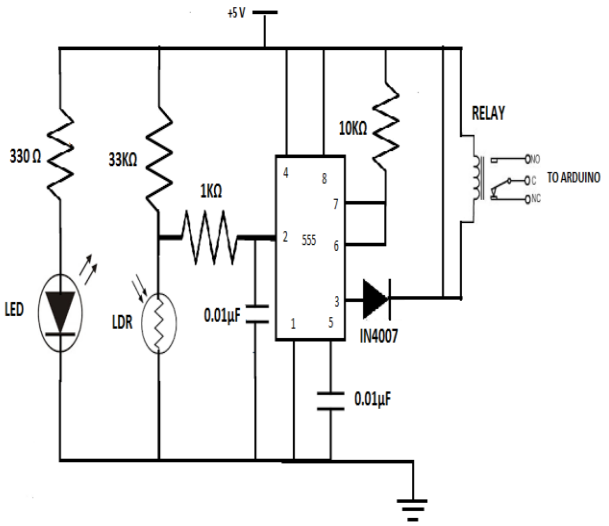


Fig 3: Pulse Detector Circuit

F. Power Supply Unit:

A power supply is an electronic devise that supplies electric energy to an electrical load. Any invention of the 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 ±5v to ±12v. In our project the required voltage is +5v to power the pulse detector circuit and the Arduino board.

IV. CIRCUIT CONNECTIONS AND POWER CALCULATION

The Energy meter which we have used is single phase 240v electronic meter. Blinking of the LED in the energy meter represents the amount of power consumed. Following is the calculations of the power consumed that id determined from the no. of pulses.

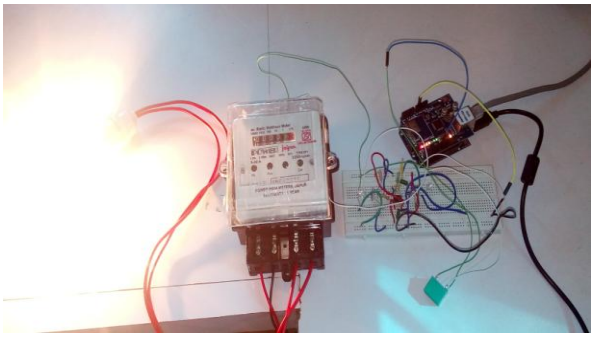
1 unit of energy (kWh) consumption = 3200 pulses in LED

Energy per count = $(I_{max} * V_{rms})/3200$.

where I_{max} is the maximum load current and V_{rms} is the RMS voltage.

Energy per LED pulse = 1000 * 3600/Mpr.

where Mpr is the pulse rate of the energy meter in impulse/kWh.



We have connected and positioned the pulse detector circuit in front of the LED in the energy meter. The pulse detector circuit gets triggered for every blink of the LED. The output the relay (5V) is connected to pin 8 of the Arduino to detect the impulse of the energy meter. The Arduino counts the no. of pulses by detecting a high input at pin 8. From the no. of pulses counted, the units consumed is calculated by the formula,

Units consumed = No. of pulses/3600

From the units consumed, the bill amount is calculated based on the tariff specifications for the consumer. Once the bill is calculated, the Arduino will send the current data via GSM modem to the specific number i.e. service provider as

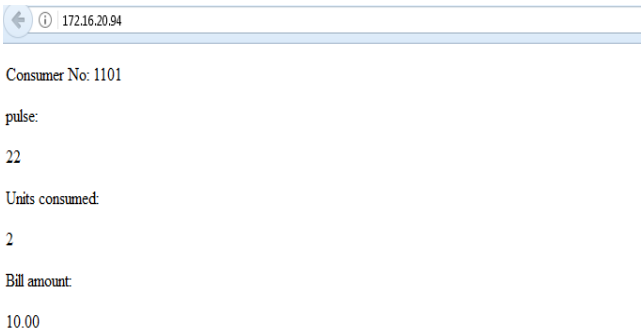
'Consumer ID : .....

Energy Consumed (Units) : .....kWh

Amount to be paid : Rs...... '

The data which is processed in the Arduino is sent to the server via Ethernet Shield. The Ethernet shield acts as a gateway for communication between the Arduino and the server. The IP address of the server to which the data is sent should be specified in the program. On specifying the IP address of the system, the units consumed and its corresponding tariff can be viewed in the server.

User interface is created using HTML. The user can log in to his account and have access to his account and can pay the bill online.



V. CONCLUSION AND FUTURE WORK

Various electronic meters have been developed and are still developed. The use of Ethernet Shield as a communication gateway has

paved way for the evolution of IoT. Previously, GSM used as a gateway has a drawback that incase of poor network coverage, the transmission becomes a problem. The proposed work eliminates the need for manpower in electricity billing system. Not only does it eliminate the need for manpower but it serves to be a more accurate method as there is no human intervention. Employing laborers to manipulate the readings from each household stands as an overhead . This framework eliminates the above overhead. This system can be further improved by devising a system to detect electricity theft in the power lines. This framework if implemented can be a part of Digital India scheme.

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