# Energy Efficient Smart Metering System Using IoT and GSM

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***Abstract-*** *This paper describes PIC16f877a Microcontroller based design and implementation of energy meter using IOT concept. The proposed system design eliminates the human involvement in Electricity maintenance. The Buyer needs to pay for the usage of electricity on schedule, in case that he couldn't pay, the electricity transmission can be turned off autonomously from the distant server. The user can monitor the energy consumption in units from a web page by providing device IP address. Theft detection unit connected to energy meter will notify company side when meter tampering occurs in energy meter and it will send theft detect information through GSM modem and theft detected will be displayed on the terminal window of the company side. Wi-Fi unit performs the IOT operation by sending energy meter data to web page which can be accessed through IP address. The Hardware interface circuit consists of PIC16f877a Microcontroller, MAX232, LCD display, Theft detection unit and ESP8266 WiFi module. Wi-Fi unit performs the IOT operation by sending energy meter data to web page which can be accessed through IP address.*

***Keywords:*** *PIC16F887A, Energy Meter, GSM Module, ESP8266, MAX232, LCD Display.*

## I. INTRODUCTION

This paper proposes smart, integrated power consumption monitoring system has been implemented with the use of open standard technology, commercial project & household items which actively monitors the voltage & current ration in remote system. Here a GSM based smart energy metering system using IOT which will replace traditional meter reading method. They can monitor the meter readings regularly without the person visiting each house. Microcontroller based power consumption monitoring system that senses parameters & shows on an LCD display. The meter readings are automatically send on Cloud generated using IOT. According to that reading we have to pay the bills. The main drawback of this system is that person has to go area by area and he has to read the meter of every house and handover the bills. Many times errors like extra bill amount, or notification from electric board even though the bills are paid are common errors. To overcome this drawback we have come up with an idea which will eliminate the third party between the consumer and service provider, even the errors will be overcome. In this paper the idea of smart energy meter using IOT have been introduced. In this method we are using microcontroller because it is energy efficient.

## II. RELATED WORKS

Energy is a very important resource for life and increasing social welfare, this means that a sufficient and reliable supply of energy is needed to ensure sustainable development, but the use and conversion of primary energy mostly produce emissions. The increasing level of environmental problems related to energy use has led to a growing interest in the problem of sustainable development. Therefore, to overcome these problems requires the use of resources, technology, appropriate incentives, and strategic policy planning. Energy management is the best solution for managing energy use. The definition of energy management has been suggested by several experts and researchers. According to Ates and Durakbasa [1], Energy Management is a combination of activities to carry out energy efficiency, engineering, and related process management to produce energy costs and lower $CO^2$ emissions. According to the German Federal Environment Agency [2], Energy Management is an action planned and implemented to ensure minimum energy input to achieve a predetermined/targeted performance. Based on research conducted by Bunse et al [3], energy management is defined as an activity of controlling, monitoring, and improving energy efficiency. prove sustainable energy performance . According to Segatto et al [4], EMS is an automation system that can collect energy measurement data from a place or building, and compile these data in a visualization form that can be understood by users. According to Shamseldein et al [5], the EMS is a computer system used by users to monitor, control, and carry out optimal energy management. According to Robin Kent [6], an EMS is needed to identify, plan and complete projects to produce energy savings, without a system the energy management activities will not be properly accommodated and eventually become damaged. EMS unites and handles the

main electricity and energy systems. EMS is the heart of smart green buildings that provide benefits for consumers and utilities. One of the developments of the EMS is the Energy Management Information System (EMIS).

## III. SYSTEM DESIGN

This paper is aimed to design a circuit which helps the consumer to monitor the electrical energy consumption and protect him/her from the extra charges incurred due to minor changes in slab categories, since even small changes can affect the bill at a high rate.

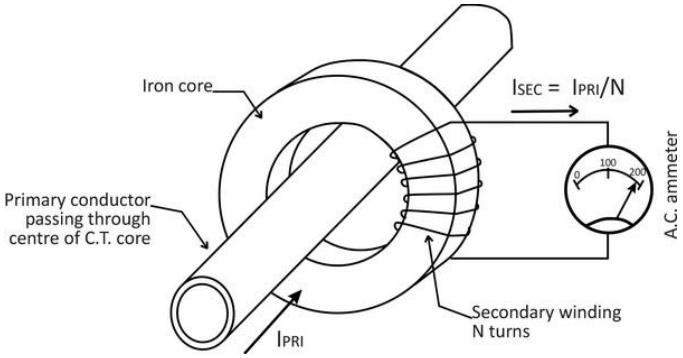


**Figure.1 Block Diagram**

In this paper, electricity usage is updated periodically that is read from the energy meter and then sent to PIC microcontroller. The energy values once taken from the energy meter are digitized and processed with the help of a microcontroller. The microcontroller that we use here is PIC microcontroller. The cost value for the corresponding energy value is determined and the threshold cost value is fixed for which the consumption level increase is notified to the user. Daily consumption cost will be updated to the user through SMS. The problem of overload can also be monitored. When the circuit is overloaded, the difference in consumption is also analyzed. This deviation from the normal value is notified to customer to prevent tripping of the breakers or blowing of fuses.

### 1. ENERGY METER

The energy is the total power consumed and utilised by the load at a particular interval of time. It is used in domestic and industrial AC circuit for measuring the power consumption. The meter is less expensive and accurate. The energy meter has the aluminium disc whose rotation determines the power consumption of the load. The disc is placed between the air gap of the series and shunt electromagnet. The shunt magnet has the pressure coil, and the series magnet has the current coil. The pressure coil creates the magnetic field because of the supply voltage, and the current coil produces it because of the current.

### 2. CURRENT TRANSFORMER

A current transformer (CT) is a type of transformer that is used to measure alternating current (AC) shown in the Fig 2 It produces a current in its secondary which is proportional to the current in its primary. Current transformers, along with voltage or potential transformers, are instrument transformers. Instrument transformers scale the large values of voltage or current to small, standardized values that are easy to handle for measuring instruments and protective relays.

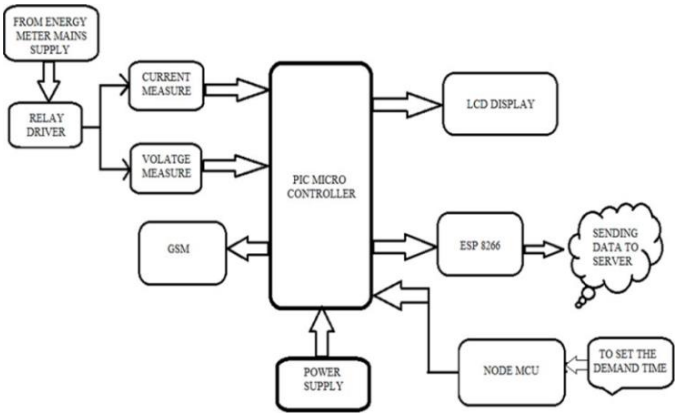


**Figure.2 Current Transformer**

The instrument transformers isolate measurement or protection circuits from the high voltage of the primary system. A current transformer provides a secondary current that is accurately proportional to the current flowing in its primary. The current transformer presents a negligible load to the primary circuit. Current transformers are the current-sensing units of the power system and are used at generating stations, electrical substations, and in industrial and commercial electric power distribution.

### 3. GSM (Global System for Mobile communication)

GSM (Global System for Mobile communication) is a digital mobile network that is widely used by mobile phone users in Europe and other parts of the world. The Fig 3 shows the GSM module. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies: TDMA, GSM and code-division multiple access (CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot.


**Figure.3 GSM Module**

It operates at either the 900 megahertz (MHz) or 1,800 MHz frequency band. GSM, together with other technologies, is part of the evolution of wireless mobile telecommunications that includes High-Speed Circuit-Switched Data (HSCSD), General Packet Radio Service (GPRS), Enhanced Data GSM Environment (EDGE) and Universal Mobile Telecommunications Service (UMTS).

## 4. LIQUID CRYSTAL DISPLAY

16×2 Character LCD is a very basic LCD module which is commonly used in electronics papers and products. It contains 2 rows that can display 16 characters as shown in the below Fig 4 Each character is displayed using 5×8 or 5×10 dot matrix. It can be easily interfaced with a microcontroller. In this tutorial we will see how to write data to an LCD with PIC Microcontroller using Hi-Tech C Compiler. Hi-Tech C has no built in LCD libraries so we require the hardware knowledge of LCD to control it. Commonly used LCD Displays uses HD44780 compliant controllers. This is the pin diagram of a 16×2 Character LCD display. As in all devices it also has two inputs to give power Vcc and GND. Voltage at VEE determines the Contrast of the display. A 10K potentiometer whose fixed ends are connected to Vcc, GND and variable end is connected to VEE can be used to adjust contrast. A microcontroller needs to send two information to operate this LCD module, Data and Commands. Data represents the ASCII value (8 bits) of the character to be displayed and Command determines the other operations of LCD such as position to be displayed. Data and Commands are sent through the same data lines, which are multiplexed using the RS (Register Select) input of LCD. When it is HIGH, LCD takes it as data to be displayed and when it is LOW, LCD takes it as a command. Data Strobe is given using E (Enable) input of the LCD.

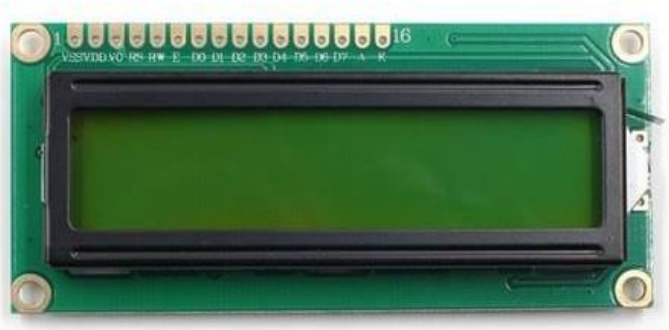

**Figure.4 LCD**

When the E (Enable) is HIGH, LCD takes it as valid data or command. The input signal R/W (Read or Write) determines whether data is written to or read from the LCD. In normal cases we need only writing hence it is tied to GROUND in circuits shown below. The interface between this LCD and Microcontroller can be 8 bit or 4 bit and the difference between them is in how the data or commands are send to LCD. In the 8bit mode, 8bit data and commands are send through the data lines DB0 – DB7 and data strobe is given through E input of the LCD. But 4bit mode uses only 4 data lines. In this 8bit data and commands are splitted into 2 parts (4 bits each) and are sent sequentially through data lines DB4 – DB7 with its own data strobe through E input. The idea of 4bit communication is introduced to save pins of a microcontroller. You may think that 4bit mode will be slower than 8bit. But the speed difference is only minimal. As LCDs are slow speed devices, the tiny speed difference between these modes is not significant. Just remember that microcontroller is operating at high speed in the range of MHz and we are viewing LCD with our eyes. Due to Persistence of Vision of our eyes we will not even feel the speed difference.

## 5. INTERFACING OF LCD WITH PIC MICROCONTROLLER

The LCD is interfaced with the PIC microcontroller as shown in Fig 5 The Liquid Crystal Display will also display the status of the units consumed and the cost for the units consumed.

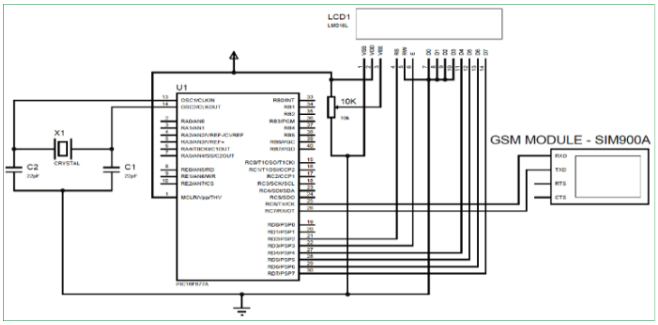


**Figure.5 LCD interface**

At the first day it displays "SMART ENERGY METER". Then at the end of each day it displays the status. After sixty days the system sends a SMS to the user's mobile and the service provider.

**6. POTENTIAL TRANSFORMER**

Potential transformers are also known as voltage transformers and they are basically step down transformers with extremely accurate turn's ratio. Potential transformers step down the voltage of high magnitude to a lower voltage which can be measured with standard measuring instrument. These transformers have large number of primary turns and smaller number of secondary turns. A potential transformer is typically expressed in primary to secondary voltage ratio. For example, a 600:120 PT would mean the voltage across secondary is 120 volts when primary voltage is 600 volts.

**7. RELAY DRIVER**

A relay driver circuit is a circuit which can drive, or operate, a relay so that it can function appropriately in a circuit. The driven relay can then operate as a switch in the circuit which can open or close, according to the needs of the circuit and its operation.

**Figure.6 Relay**

In this paper, we will build a relay driver for both DC and AC relays. Since DC and AC voltages operate differently, to build relay drivers for them requires slightly different setup. We will also go over a generic relay driver which can operate from either AC or DC voltage and operate both AC and DC relays. All the circuits are relatively simple to understand.

**8. PIC MICROCONTROLLER**

PIC belongs to a family of microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to Peripheral Interface Controller, then it was corrected as Programmable Intelligent Computer. Early models of PIC had read-only memory (ROM) or field-programmable EPROM for program storage, some with provision for erasing memory. All current models use flash memory for program storage, and newer models allow the PIC to reprogram itself. Program memory and data memory are separated. Data memory is 8-bit, 16-bit, and, in latest models, 32-bit wide. Program instructions vary in bit-count by family of PIC, and may be 12, 14, 16, or 24 bits long. The instruction set also varies by model, with more powerful chips adding instructions for digital signal processing functions. The hardware capabilities of PIC devices range from 6-pin SMD, 8-pin DIP chips up to 144-pin SMD chips, with discrete I/O pins, ADC and DAC modules, and communications ports such as UART, $I^2C$, CAN and even USB. Low-power and high-speed variations exist for many types. PIC devices are popular with both industrial developers and hobbyists due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, serial programming and re-programmable Flash-memory capability.

**9. PIC 16f877a**

The PIC microcontroller PIC16f877a is one of the most renowned microcontrollers in the industry. This controller is very convenient to use, the coding or programming of this controller is also easier.

**Figure.7 PIC microcontroller**

One of the main advantages is that it can be write-erase as many times as possible because it uses FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output as shown in the Figure 7 PIC16f877a finds its applications in a huge number of devices. It is used in remote sensors, security and safety devices, home automation and in many industrial instruments. An EEPROM is also featured in it which makes it possible to store some of the information permanently like transmitter codes and receiver frequencies and some other related data. The cost of this controller is low and its handling is also easy. Its flexible

and can be used in areas where microcontrollers have never been used before as in coprocessor applications and timer functions etc.

**10. NODE MCU**

Node MCU is an open source IOT platform. Which includes firmware which runs on the ESP8266 Wi-Fi Module from Espressif Systems, and hardware which is based on the ESP-12 module.


**Figure.8 Node MCU**

The term "Node MCU" by default refers to the firmware rather than the dev kits. Node MCU firmware was developed so that AT commands can be replaced with Lua scripting making the life of developers easier. So it would be redundant to use AT commands again in Node MCU.

**11. THINGSPEAK**

In this paper we describe the use of ThingSpeak, an "Application Programming Interface" (API) and web service for the "Internet of Things" (IOT). While the interpretation as to what should be understood under the term is changing over time, here we refer to enabling objects or simple devices to be identified and communicated with via the Internet. The ThingSpeak API is an open source interface which listens to incoming data, timestamps it, and outputs it for both human users (through visual graphs) and machines (through easily parse-able code). We look into practical examples using the Arduino micro-controller as well as communication with graphical interface operating systems through a Python script. Our report concludes that ThingSpeak is especially useful for smaller hardware projects where connectivity over the Internet is required but in which the maintenance of a dedicated communication server is not practical. Alternative IOT services exist but tend to require payment for some of their functionality and are consequently not open source.

**IV. CONCLUSION AND FUTURE SCOPE**

In this paper, we have automated the bill generation without using the manpower. This paper will help us to use the energy economically as it alerts the user with respect to the tariff table. The LCD will display the status and the GSM will send the SMS to the user's mobile and thus creates an awareness among the users about their energy usage. At the end of the sixty days it sends the bill to the users and the service provider. In future this paper can be integrated with the complete automation of home appliances. The power consumed by every appliance can be calculated and monitored. The device which consumes more power can be found and alternatives can be made. This can be incorporated with the prepaid meters as it is going to be implemented. The complete automation can be achieved and the user will also know everything about his energy usage which will help to save the energy.

**V. RESULT**

This paper is intended to present an overview of prepaid energy meter which can control the usage of electricity on consumer said to avoid wastage of power. Prepaid energy meter is a concept to minimise the electricity theft with a cost efficient manner. The users are not bound to pay excesses amount of money, users have to pay according to their requirement. Prepaid energy meter is more reliable and user friendly. This prepaid remote energy meter proves to be a boon in the power sector. It controls the usage of electricity on consumer said to avoid wastage of power. It helps to the country revenue by stopping current theft and punishing the dishonest customers. However their design has to meet certain prepaid standards and regulations. The only concern is the security and privacy of data as they are prone to cyber attack. However the use of GSM in this particular system provides numerous advantages over methods that have been previously used. Data transmission is charged at standards SMS rates, thus the charges are not based on the duration of data transmission. The cost efficient of readings. Developed system also gives information about daily, monthly and yearly power usage. Details regarding daily power consumption will help consumer to manage their power usage. This developed system is reliable and secure as only authorized person can access the system.

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## VI. RESULT COMPARISON

| Existing Method | Proposed work |
|---|---|
| ➢ Billing system fails if no GSM network coverage.<br>➢ Charges may be applicable for network use.<br>➢ Requires fixed GSM number. | ➢ Improved power quality.<br>➢ More efficiency.<br>➢ Secure power delivery.<br>➢ More accurate bills.<br>➢ This cost effective and easy to use. |

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