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Smart Energy Meter and Power Demand Controller using IoT

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***Abstract*: The effort of collecting electricity utility meter reading. Internets of Things (IoT) present an efficient and co-effective to transfer the information of energy consumer wirelessly as well as it provides to detect the usage of the electricity .The main intention of this project to design and implementation of an energy monitoring system by using the PIC16F877A micro controller and Global System for mobile communication (GSM) module in home appliances and generate it's bill automatically. The energy grid needs to be implemented in a distributed topology that can dynamically absorb different energy sources. IoT can be utilized for various applications of the smart grid with distributed energy plant meter, energy generation and energy consumption meter smart meter, energy demand side management and various area of energy production.**

Keywords— Smart Grid, GSM, Energy Meter, Internet of Things.

I .INTRODUCTION

Along with the advancement of technology development, research on wireless applications and remote control has become significant and popular today. An electricity meter, electric meter, or energy meter is a device that measures the amount of electric energy consumed by a residence, business, or an electrically powered device. A Smart Energy Meter is electric device having energy meter chip for electric energy consumed measurement, wireless protocol for data communication (such asGSM Modem) and peripheral devices for security purpose, data showing, meter controlling etc. Energy meter systems can be incorporated with embedded controllers such as GSM modem to transmit the data over the mobile network. Such data can be then fed and integrated into existing Energy Management Systems (EMS) located at power companies and organizations. The energy monitoring system is appropriate for Industries, manufacturing plants, commercial buildings or any situation where an electrical system is used. The system provides the centralized energy monitoring and control. The EMS leads to savings in the overall cost. These savings may be come from better utilization of manpower, servicing cost, savings in the energy consumption, and non-breakdowns in the system. The smart energy meter contains an energy meter, a GSM modemand microcontroller. 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 Short Message Service (SMS) over the GSM network. Factually at present, the metering and billing system of our country is totally conventional and it is very much slowed, faulty and corrupted so our proposed smart energy meter is highly deserved for national implementation. The IoT is used to turn on/off the household appliances using relay and Arduino interfacing. The objective of this system is to monitor the amount of electricity consumed. The distributer and the consumer both will be benefitted by eventually reducing the total power consumption.

II. LITERATURE SURVEY

Archelle B.Batiller et al., [3] described two implementations of prepaid metering systems for isolated micro grids. The first implementation uses GSM as its communication channel. The system is composed of smart meters with GSM capability and a utility server that handles all the accounting and reloading processes. The system allows communication among the supplier or micro grid owner, the consumers, and the retailers through SMS. The second implementation replaces the GSM module with a Zigbee module which allows communication on areas without cellular access. This system is composed of smart meters and a base station which communicate with each other up to a certain distance. The results show that the meter performs accurate energy measurements for linear and non- linear loads. The smart meter, utility server, and base station are also able to properly handle all incoming and outgoing messages in modest duration given a moderate GSM signal strength or a certain distance whether indoors or outdoors. The server is also able to reload, audit and disconnect the meters whenever necessary.

Labib Labib et al., [17] proposed, designed, and implement a low-cost universal smart energy meter with demand-side

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load management.The meter can be used in the postpaid and prepaid modes with flexible tariff plans such as time of use, block rate tariff, and their combination. The smart meter comprises of a potential transformer, current transformer, and microcontroller unit with an embedded communication module. The connectivity among the utility authority, the smart meter, and consumer is established by authority identification number, meter identification number, and user identification number using the cellular network. The load management option of the meter controls electrical loads and provides emergency power during the power shortage. The USEM can be configured and reconfigured remotely simply by short message service without changing hardware. Besides, energy consumption status, meter tampering, and fault at the distribution end can be monitored with the proposed metering system. Here, a prototype of the smart meter is presented, and its effectiveness, flexibility, and versatility are experimentally demonstrated.

Nazmat Toyin et al., [10] described the energy fuels the growth and development of any country, and as such effective monitoring, measurement, billing and access control is imperative. This paper presents a device that uses the evolving Internet of Things (IoT) technology in the design and implementation of an Internet based prepaid energy meter often referred to as smart meters. The energy measurement and billing system is automated. The system employs the ATMega328p and ESP8266 to operate a dual core microprocessor unit with one core dedicated to energy sensing and measurements, while the other handles the network connectivity, storage, computations and overall system performance. This work uses the HTML5 technology to develop a highly interactive mobile and web frontend graphic user interface application that allows for consumers to have access to monitor and control their consumption pattern while the utility companies can monitor and control customers and their billing systems.

Taleb Tariq et al., [13] discussed the demand for energy is increasing due the growth of the population and industrial development. To improve the energy efficiency, consumers should be well informed of their energy consumption. Throughout the past few years, the welfare services have begun to develop new electrical energy meters; which are known the smart meters, they are is a efficient and performed interactivity between supplier and consumer. This article presents an approach in the pervasive systems domain, The suppliers would control the energy consumption in given houses by cell phones based on data sent by sensors installed on different corners of houses from the Arduino card based upon Zigbee protocol which will store the information and communicate with consumer via SMS. For this, programmable Arduino card via Arduino software and programmable Zigbee module by X-CTU software is used.

Himshekhar Das et al., [6] described electrical utilities are suffering from huge losses due to power theft, inadequate usage of energy, unpaid bills, distorted power quality. Many viable solutions are proposed out of which smart energy metering, energy management system and smart home automation are some that seems to be potent enough. These technologies are presently used by developed countries. Under meter data acquisition system of restructured accelerated power development and reform program scheme in the year 2009-10, India plans to develop advanced metering infrastructure. But no effort has been made to develop an economic model for the customers which would play a key role in better acceptance of the scheme. In this paper, a smart energy system for the residential customers is developed and a smart switch board which can curtail the need to upgrade to smart appliances to make the system more economic. Further, a virtual instrumentation has been developed which can be operate in any computer to function as in-home display for energy management system.

Masudur Rahman et al., [8] described energy management system is trying to make automatic, portable and remote control. This work presents a novel smart energy meter for an automatic and superior metering and billing system. The integration of the Arduino and GSM short message service provide the meter reading system with some automatic functions that are predefined. Firstly, we have simulated the project in PROTEUS 8.0 then successfully implemented on the circuit board in laboratory. The proposed energy meter system can incorporate with embedded controller and GSM modem to transmit the data like consumed energy in kWh, generated bill, security services (line Cut/On) over GSM mobile network such as data can be then fed and integrated into existing energy management systems located at power companies or organizations to provide the services among the customers without man-power. Our implemented project is able to provide all required services remotely for metering and billing with high fidelity.

III PROPOSED METHOD

This project 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. 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 micro controller. 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.

Block Diagram of Proposed System

The block diagram shown in the Fig. 1 consists of energy meter, PIC microcontroller, LCD and GSM.

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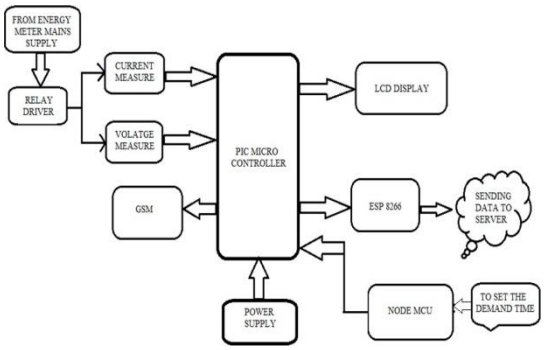

Fig. 1 Block Diagram

A. Energy Meter

The energy is the total power consumed and utilized 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 shuntmagnet 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.

B.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 too small, standardized values that are easy to handle for measuring instruments and protective relays. 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.

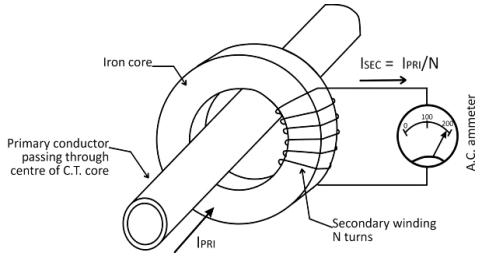

Fig. 2 Current Transformer

C.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.

Fig. 3 GSM Module

The Fig.3 shows the GSM module. GSM uses a variation of time division multiple access and is the most widely used of the three digital wireless telephony technologies, GSM and 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. 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, General Packet Radio Service (GPRS), Enhanced Data GSM Environment (EDGE) and universal mobile telecommunications service.

D.Liquid Crystal Display

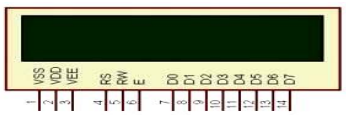

Fig.4 LCD

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 Figure 5.3.3. Each character is displayed using 5×8 or 5×10 dot matrix. It can be easily interfaced with a microcontroller. 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 spitted 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.

E.Interfacing of LCD with PIC Microcontroller

The LCD is interfaced with the PIC microcontroller as shown in Figure 5.5. The Liquid Crystal Display will also display the status of the units consumed and the cost for the units consumed. At the first day it displays “SMART

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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.

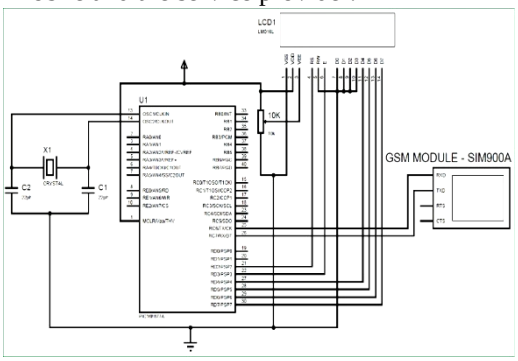
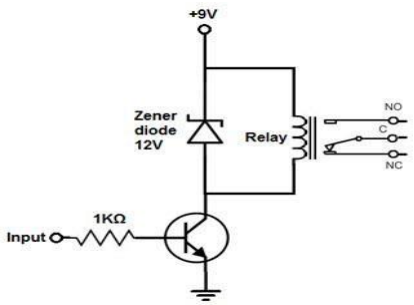


Fig.5 Interfacing of LCD with PIC

PIC is 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 and 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. 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.

F.Relay Driver

A relay driver circuit is a circuit which can drive, or operate, a relayso that it can function appropriately in a circuit. The driven relay can then operate as a switch in the circuit which



canopen or close, according to the needs of the circuit and its operation. In this project, 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.

G.Transformer

Selecting a suitable transformer is of great importance. The current rating and the secondary voltage of transformer is a keyfactor. The current rating of the Transformer depends on the current needed for the load to be driven. The input voltage to the 7805 IC should be at least 2 volt greater than the required 2 volt output; therefore it requires an input voltage at least close to 12V. So, a 12-0-12V transformer with current rating of 500mA i

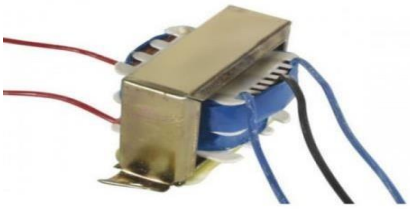


Fig. 6 Transformer

H.PIC Microcontroller

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.

One of the main advantages is that it can be write-erase

Fig.7 PIC Microcontroller

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 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.

IV RESULTS AND DISCUSSION

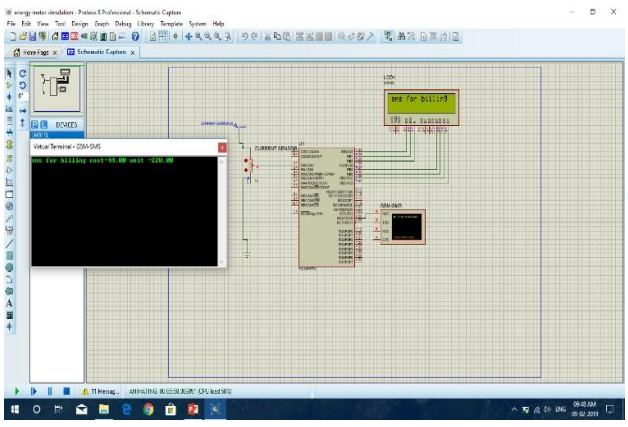


Fig.8 Simulation Result

First, we have designed the counter using the PIC microcontroller where pulse on the pin is given by signal generator then the data will be displayed in the LCD as

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shown in the fig.8. We have connected the GSM shield using a 'USB to Serial Converter' at USB port of the PC. The connection of the PIC microcontroller with GSM is established. We have also used 'Virtual Terminal' of PROTEUS to see the data exchanging between the GSM modem and PIC microcontroller.

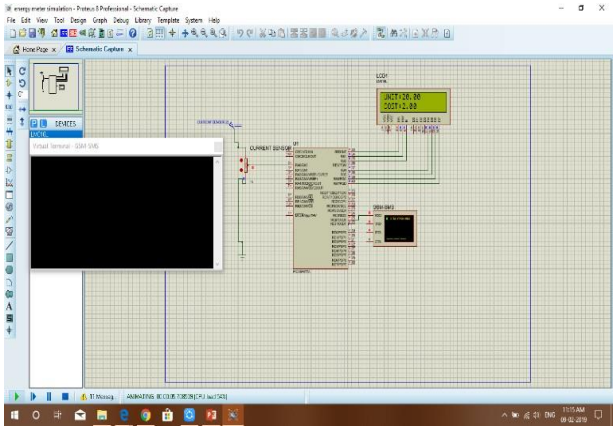

Fig.9 Simulation Result

One unit and cost the virtual terminal shows everything that occurring or exchanging in the GSM modem and PIC microcontroller. We have to set all BAUD rate of virtual terminal port to 9600 kbps because of GSM modem will communicate as shown in the fig.9.

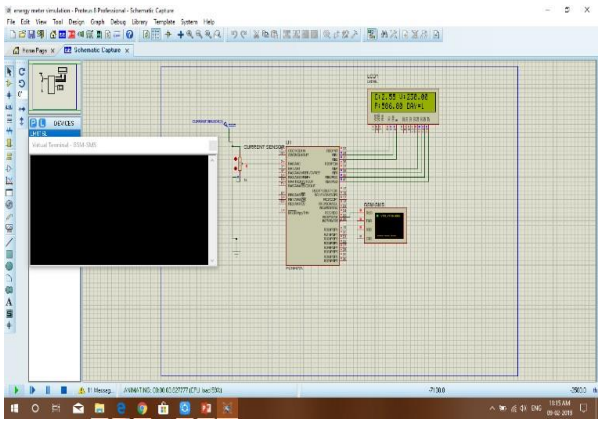

Fig.10 Simulation Result

Otherwise garbage value will show in the virtual terminal. Before RUN the software, the '.hex' file of the associated paper i.e. the program should be loaded to the PIC microcontroller otherwise it will show error. We have connected button for tampering attempt detect. Internal EEPROM will store data permanently. After stop the simulation if we start again data will not lost. To GSM mobile SIM number is used for demo operation over GSM network, where one as customer and another as service provider. At the first day the LCD will display smart energy meter. Then at the end of each day it displays the cost and the units consumed. After sixty days the cycle starts again as from the first day. This display will help us to see the status from the home and the SMS will help us to know the usage details even if we are not at the home.

At the end of day 1 it shows the consumption details and the day at the display as in fig.9. The SMS will be sent to the user through the GSM modem. In the simulation, the message sent is shown with help of virtual terminal as given in the fig.10. At the end of the sixty days the total bill is calculated and then it sends SMS to the user and the service provider.

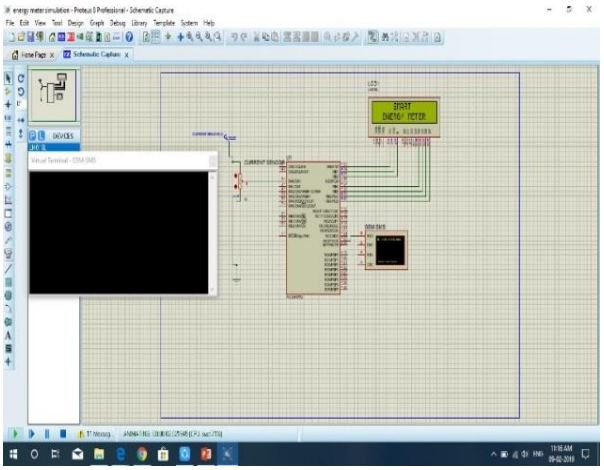

Fig.11 Simulation Result

The virtual terminal shows the content of the message to be sent and the LCD shows that the message is being sent to the user and the service provider as in the fig.11.

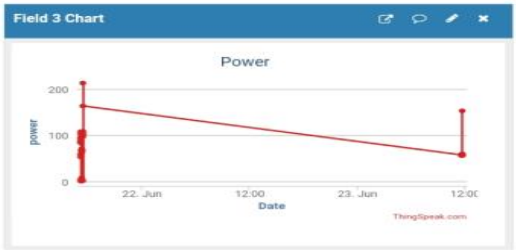

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Fig.12 Simulation Result

V.CONCLUSION

In this project, we have automated the bill generation without using the manpower. This project will help us to use the energy economically asit 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 createsawareness 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 project can be integrated with the complete automation of home appliances. The power consumed by every appliance can be calculated and monitored.

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