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Smart Energy Meter and Monitoring System using Internet of Things (IoT)

Dr.M.Karpagam
Department of ECE
Sri Krishna College of Engineering and Technology
Coimbatore, India
karpagam@skcet.ac.in

Sahana S S
Department of ECE
Sri Krishna College of Engineering and Technology
Coimbatore, India
20euec125@skcet.ac.in

Sivadharini S
Department of ECE
Sri Krishna College of Engineering and Technology
Coimbatore, India
20euec145@skcet.ac.in

Soundhariyasri S
Department of ECE
Sri Krishna College of Engineering and Technology
Coimbatore, India
20euec149@skcet.ac.in

***Abstract* --- In recent times, the energy calibration methods are universally expanding with the goal of effectuating, reliably operating, and managing the utility system. The growing demand for power in the current environment has necessitated the mandatory installation of energy meters, as well as the development of new methods for calibrating meter readings and governing the effective use of energy resources. AMR (Automatic Meter Reading system) is one such modernization. This employs analogue or digital energy meters with the assistance of smart meters. Currently, energy scaling is done by hand, which is a time-consuming process in the world of day-to-day networking demand and also requires skilled labour. The concept of AMR Systems is to overcome complexities in the rapidly growing field of energy management. This article proposes a smart energy meter based on IoT to detect the power theft. The proposed model consists of Arduino UNO, ESP8266, AC713 current sensors, and so on. The AC713 senses current usage with the help of the ESP32, which is then passed to the IoT platform. Though AMR is a very effective method, it costs the proxy of existing energy meters by SEM (Smart energy meters), which is highly inefficient. As a result, the proposed method focuses on detecting the power theft caused by public tampering. The proposed model is programmed by using a BLYNK software and simulated in PROTEUS software. The proposed system is then validated by using the simulated results.**

Keywords -- Internet of Things (IoT), Arduino UNO, energy meter, LCD, current sensor

I. INTRODUCTION

People are currently exposed to a medium that provides extreme ultimatums. The major crisis in today's society is the energy crisis. The proposed solution provides an appropriate solution to control this issue. To deal with this, various methods are now available. One of these methods is to reduce domestic or household power consumption. The traditional method of meter reading requires a large number of hired hands to visit the habitat in person and take readings offline from the meter by checking each one individually. This procedure necessitates two-way cooperation as it is necessary for an authority to take readings in a house only when an individual is present in the house in order to avoid insecurities. This causes a lag in the private working lives of ordinary people because they must be present in person during this procedure. Furthermore, it is a laborious procedure that leads to chaos when a hired-hand is mistaken for any criminal activities. "Monitoring of Energy Tampering using IoT" is a novel application that has been developed to control power tampering from anywhere in the world. This system has been modernized so that the data is updated every 10 to 12 seconds. This system is fundamentally designed to reduce power theft, which contributes to the reduction of commercial losses; direct tampering can be reduced by using this system. The proposed solution is cost-effective and provides significant assistance to the electricity authority. It is also a time-saving procedure for both authorities and general public.

II. LITERATURE SURVEY

Various solutions have been proposed to address the issue of electricity theft and automatic reading of power consumed. As a result of a lack of adequate energy supply, measures for energy conservation to satisfy the energy needs have initiated. To measure household readings, majority of the system relied on Arduino, current sensors, a GSM module, and an AMR unit.

According to the literature, there are no tamper detectors; thus, taking into account all of the factors, a novel design is proposed with a tamper detection unit that locates the fault. The self-regulated meter readings reduce the man power. The transparency demand has emerged as there is no need to perform manual verification.

A. ARM-based Energy management system using smart meter and Web server

Advanced RISC machine-based energy management system uses web server and SEM. Collection of the demographics of energy utility, power integrity and integration of devices for load displacement are done with the help of a consolidated Web Server. It is possible to govern the intake of power system as the device is used to see through the information that leads to the high consumption of power.

B. Smart Power Monitoring Using IoT

Smart Power Monitoring using IoT that expend energy is considered as the appreciably essential and demanding crisis. Large electric energy distribution system uses the automatic electrical energy meter. The smart power monitoring system integrates Arduino, Wi-Fi and SMS. Data to upgrade and lessen the power intake is provided by the smart energy meter. Monitoring sensor is also included in this system to turn OFF the power supply if there is no human presence.

C. Arduino based Smart Energy Meter

It is illustrated that energy meter on the basis of Arduino eliminated the living soul interruption thereby reducing the flaws caused often.

The system facilitates SMS service for user updating on energy consumption along with generation of final electricity bill and also reloading via SMS is added up. The relay is more helpful to implement the detachment of power supply on pending dues. The GSM is employed by the grid for a bi-directional communication.

After analyzing all these papers smart energy meter consisting of Arduino and current sensors operating based on IoT has given better results we also add up a theft detection unit for energy conservation.

III. PROPOSED SYSTEM

In this design we propose the idea on elimination of energy theft and showcase the authority about consumption of energy and parallelly updates in cloud using IoT. But the implementation of this was a bit challenging as it was not compatible for the system to connect to the Arduino UNO and the cloud using Wi-Fi Module. As a result of this complication, it was tricky to implement the proposed design. To overthrow this complication and to bridge electronic energy meter to Arduino UNO we used an Opto-coupler (a relay) for establishing connections and also to firewall our system from damage by excess power. The proposed design uses current sensors to detect and LED display to showcase the meter readings. The energy consumed are compared and theft by customer is exposed. This shaping of our system is derived from a Smart Energy Meter(SEM) with the help of WSN. This SEM effectuates by establishing communication with WSN (Wireless sensor networks) accompanied by microcontroller to form a self-propelling system.

A. Problem Statement

Electricity theft have become a common issue in the developing countries. It forms the major chunk of non-technical losses. There is a huge loss of energy due to illegal energy theft in the existing world with a immense energy needs. To avoid this Smart Energy Meter (SEM) with theft detection unit has come into use.

B. *Block Diagram and Circuit Diagram.*

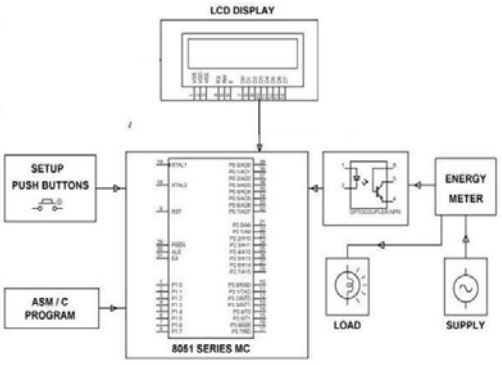

Fig 1 (a) : Block diagram

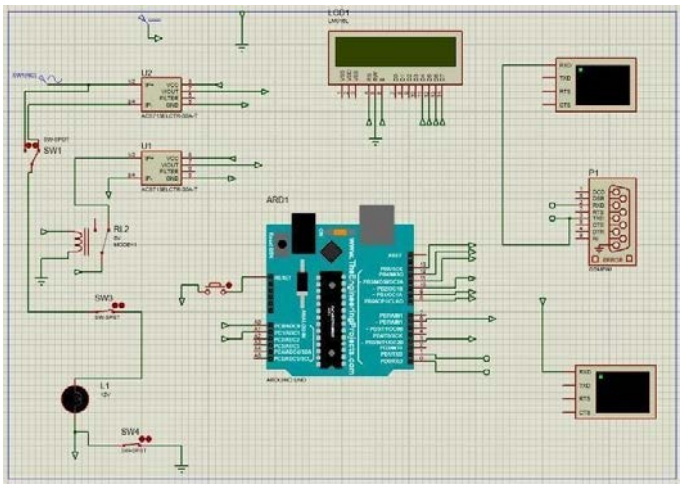

Fig 1 (b): Circuit Diagram

C. *Methodology of SEM with Theft Detection Unit*

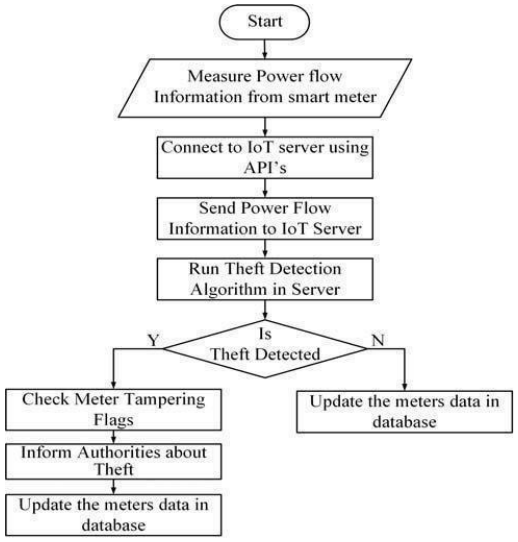

Fig 2: Workflow of a SEM

A Smart Energy Meter is a mechanistic device that accounts briefing such as electricity burning up, level of voltage, current and power. Smart energy meters pass on the data to the end-user for a greater exactness of their utilization behavior and electricity retailers for governing and managing customer billing. Arduino is inclusive in this meter with a WI-FI module for IoT connection. As we have executed our project in simulation format using proteus platform, we have used a Blynk server and Blynk app in the place of SMS services for intimation of energy consumed by a particular habitation. The components used to implement this project are Arduino, Current sensor, LCD Display and Relay. The Current transformer reduces or multiplies an alternating current. There is proportionality of current produced in primary to the current in secondary. This design engrosses on connectivity and networking criteria of IoT. In this proposed solution, Arduino ATMEGA 328P is made used to calculate the calibration counting pulses. ATMEGA328P is a Microcontroller in embedded system domain. This SEM is being implemented on the basis of this design. The whole methodology is developed on Arduino. Using IoT the cyberspace interaction of physical devices allows the stuff to ex data in our design above is connected to internet. As the Arduino could not be able to connect to the energy meter we make use of a opto-coupler circuit that forms a bridge connection for expected outcomes. The internal configuration of Single Pole Double Throw SPDT relay makes it more functional in many applications.

Arduino.Hex file used :

```
led2.off();
Blynk.virtualWrite(V6," ");
led3.off();
}
void loop();                    //main function
{
 Blynk.run();
 SENSOR();                      //calls sensor function
}
void BasicDisplay(void)
{
 float kw=0;
 kw=0.001*wattl;
 lcd.clear();
 lcd.setCursor(0,0);
 lcd.print(Amp5RMS);
 lcd.setCursor(5,0);
```

Shown above is the Arduino hex file used to program the Arduino. There is a need for a Hex file to program your Arduino when you use separate programmer to program your micro controller. It uses the programming language C++ to code. These tools work together to achieve a single goal converting your code into something that the Arduino board can understand. At the same time, a software called the bootloader works with the AVRDUDE to transmit that file through the USB cable and onto the flash memory of the Arduino. The Arduino works as programmed. A low resistance current and high voltage isolation are accompanied by a fully integrated half-linear base effect current sensor. The potential difference, ampere and real power consumed, power factor and energy is displayed on the LCD. The Arduino is connected to the LCD. Multiplying the real power consumed by the load with time gives the energy. A Blynk application and server is used. There is no need to code as the Arduino or ESP32 pins can be directly co-ordinated from your phone using Blynk library. The sending and receiving of data to or from a serial port is done by a virtual terminal. Serial port is a 9-pin port found mostly on computers and data communication in embedded system utilizes this port. The major use of a virtual terminal tool is viewing data coming from Serial port (DB9) and also conveyance of data to serial port. The simulated results are displayed in the virtual terminal command box. All the components discussed above combinedly contributes to the expected outcomes.

IV. RESULTS AND DISCUSSION

The circuit is simulated in Proteus platform and the outcomes are displayed in Blynk mobile app (Fig 4 & Fig 3) and Virtual terminal (Fig 8, Fig 7, Fig 5 & Fig 6). The amount of power sent from the grid and the amount of power estimated is compared.

The code file is given as input to the Arduino in proteus and circuit is run. The electricity, voltage and the power used by the firm is measured.

Fig 3: Meter taking readings and representing in graph

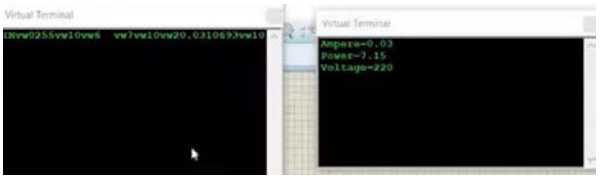

Fig 4: Estimated power to consumed

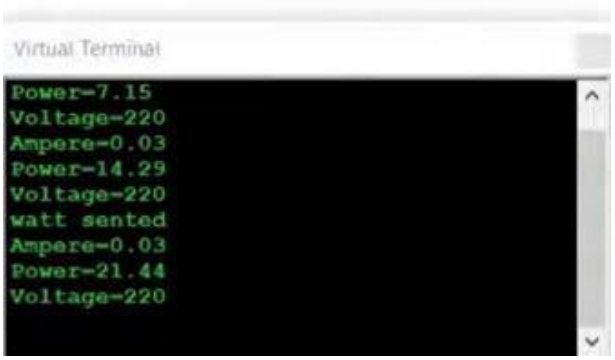

Fig 5: Amount of power sent is shown

The estimated power to be used and the amount of power used is measured and compared. If there are any discrepancies then itis confirmed as theft.

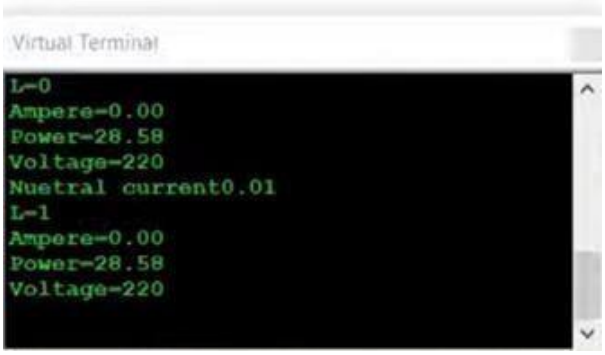

Fig 6: Amount of power, electricity consumed across different powerlines

Fig 7: Theft detected is indicated in Blynk mobile app

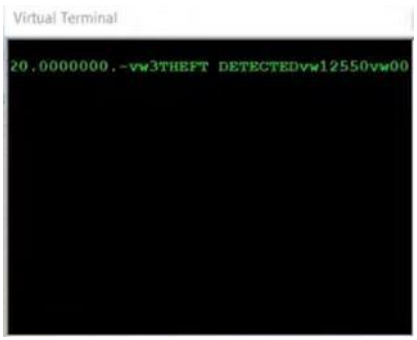

Fig 8: Theft is detected across the power lines and isshown

The advantages of this project are precise meter reading, Security is improvised, energy use is controlled successfully, Avoids energy wastage, accessibility of meter readings from the nook and corners of the world, Monthly bill payment by consumers, figure out the theft detection. This design deduces the involvement of hire hands in management of energy. This design eliminates the billing fault made by employees unintentionally and effectuates the energy reading process. An automated system is formed with the micro-controller together with the wireless sensor networks. The data is sent from the smart meter to the wireless sensor. And the utility company is also informed about the status of the meter. The smart energy monitor calculates the amount of energy used.

V. FUTURE SCOPE

The main problem that existing populations face is a lack of energy. The best measure is not to increase energy production, but rather to improve energy management in human habitats. Energy crisis can be reduced to a certain extent by properly governing the energy utilization and neglecting the effluent energy. If consumers work is simplified by allowing them to inquire into their energy utilization with the help of their own digital-hands replacing manual checks, they will be able to save time and plan their private working lives without lag. This is a boon to the existing digital society because consumers can now check their own energy consumption online from anywhere in the world. In the future, a design that continuously monitors meter readings without lag and automatically shuts down the power supply if the customer does not show up to pay his/her bills. This design will be beneficial to the digital age.

VI. CONCLUSION

In the digital age, the proposed solution focuses on the IoT's connection and associating factor. In this proposed design, an IoT and Microcontroller-based meter reading system is framed to continuously govern the scale of power and detect electricity tampering and notify the appropriate authority. The design's goals were met when the customer could access the energy meter from anywhere. The display of energy consumption units is shown in LCD displays. The benefits of SEM are that it saves time and eliminates the need to wait for customers to pay their bills. This enables energy providers to engage in activities against lawbreakers. In the future, the proposed system will be improved so that even jammers cannot disrupt the signa

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