IOT Based Smart Energy Meter for Efficient Energy Utilization in Smart Grid

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***Abstract*— Efficient energy utilization plays a very vital role for the development of smart grid in power system. So, proper monitoring and controlling of energy consumption is a chief priority of the smart grid. The existing energy meter system has many problems associated to it and one of the key problem is there is no full duplex communication. To solve this problem, a smart energy meter is proposed based on Internet of Things (IoT). The proposed smart energy meter controls and calculates the energy consumption using ESP 8266 12E, a Wi-Fi module and uploads it to the cloud from where the consumer or producer can view the reading. Therefore, energy analyzation by the consumer becomes much easier and controllable. This system also helps in detecting power theft. Thus, this smart meter helps in home automation using IoT and enabling wireless communication which is a great step towards Digital India.**

***Index Terms*— IoT, ESP 8266 12E, smart energy meter.**

I. INTRODUCTION

The internet of things (IoT) is a network of connected smart devices enabling to transfer data. The 'thing' in IoT could be a person with a heart monitor or an automobile with built-in-sensors, i.e. objects that have been assigned an IP address and have the ability to collect and transfer data over a network without manual assistance or intervention. The embedded technology in the objects helps them to interact with internal states or the external environment, which in turn affects the decisions taken.

With rapid growth and development, energy crisis has become a very big issue. An applicable system has to be made in order to analyze and control power consumption. The existing system is error prone, labor and time consuming [1]. The values that we get from the existing system are not precise and accurate though it may be digital type but it is always necessary that a concern person from the power department should visit the consumer house in order to note down the data and error can get introduced at each and every step. Therefore, the remedy for this solution is smart energy meter.

The smart grid plays a great role in our present society. Tens of millions of the people's daily life will be degraded dramatically because of the unstable and unreliable power grid [2]. Smart meter is a reliable status real time monitoring, automatic collection of information, user interaction and power control device [3]. It provides a two way flow of information between consumers and suppliers providing better controllability and efficiency [4]. It provides real time consumption information providing energy consumption control [5]. Whenever the maximum load demand of customers crosses its peak value, the supply of electricity for the customers will be disconnected with the help of smart energy meter [6]. In ideal environment with normal work load condition, the life span of the smart meter is about 5 to 6 years [7- 8]. But in reality smart energy meter suffers environmental issues and decreases its life span with abnormal consumption of energy [9]. The factors affecting lifespan of a smart meter consists of life expectancy (LE), genetics (GE), environment factors (EF), change over time (CT) and limited longevity (LL) [10].

IoT based energy meter system mainly consists of three major parts i.e. Controller, Wi-Fi and Theft detection part. Whenever there is any fault or theft, the theft detection sensor senses the error and circuit response according to the information it receives. The controller plays a major role in the system making sure all the components are working fine.

Therefore, IoT can improve the performance and efficiency of the smart grid mostly in the three phases. Firstly, it increases the reliability and durability. Secondly, it focuses on enablement i.e. collection and analyzation of data to manage active devices within the smart grid. Lastly, controlling can be done by analyzing the result obtained from the second phase which helps the grid department to make fine decision for future upliftment.

The energy meter available till now can only control and monitor the energy consumption of customers. Smart energy meter developed using power line communication (PLC) helps in power loss [11]. Several system using Arduino as well as microcontroller have been developed though the efficiency to measure power consumption drastically increased but due to cost effective it may not be considered as the suitable one. The consumer cannot have a good and accurate track of the energy consumption on a more interval basis The conventional meter has some of the common errors like [12]

- Time consuming.
- Chance of theft.
- Error while taking the information and extra human involvement.
- Consumer cannot have daily update of his/her usage.

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Thus, we proposed a smart system which enables the consumer as well as producer to monitor and control the energy consumption on more immediate basis.

II. PROPOSED SYSTEM

The proposed system is cost effective and compact, so, installment becomes much easier. The result is uploaded at every interval into cloud space called "*Thinksspeak*" and monitoring can be done by consumer/customer as well as supplier/ producer.

In this proposed system, an energy meter is connected to ESP8266 12E via optocoupler. An OLED display is also connected to the system. In the driver circuit, ULN2003 is used to drive the relay in order to switch the loads. A current sensor is also equipped to determine the power theft. Fig. 1 shows the functional block diagram of the proposed smart monitoring system.

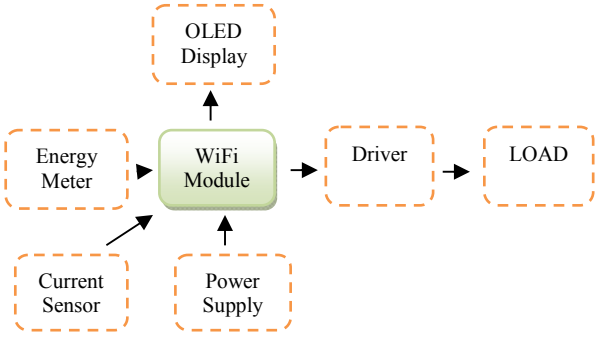

Fig. 1: Functional block diagram of smart meter.

The main functional unit of this system is discussed hereafter.

- WiFi module: - ESP 8266 12E is used here which is a programmable module with 80 MHz Microcontroller. As the module doesn't have separate USB port, we need to use an external USB to Serial adapter such as our FT232R Serial to UART Board to develop code using this module.
- OLED Display: - 0.96 inch OLED display is used here which doesn't need backlight. The display can self-illuminate high resolution.
- Energy meter: - The analog meter used here is of 3200imp/kwh. An optocoupler senses the led calibrated from the energy meter and sends its output to ESP 8266 12E.
- Optocoupler: It consists of an LED that produces infra-red light and a semiconductor photo-sensitive device that is used to detect the emitted infra-red beam. Optocoupler 4N35 is used here in order to sense the Cal impulse from the energy meter.
- Current Sensor: - ACS712 current sensor gives precise current measurement for both AC and DC signals. These are good sensors for metering and measuring overall power consumption of systems. The ACS712 current sensor measures up to 5A of DC or AC current. In this system it is used in order to measure the power theft.
- Driver: - A relay driver is used in order to switch the load connected to the system.ULN2003 is used here.
- Load: - A 100W bulbs are connected as loads to the system.
- Power supply: - A 230V ac power supply is given to the system in order to power the energy meter. Wi-Fi module power is supplied by 5 V DC.

The Wi-Fi module is programmed using Arduino IDE software in order to calculate the pulse from energy meter. It senses the pulse via optocoupler and sent the data obtained to the cloud using ESP 8266 12E.The LED blinks 3200 times for 1 unit. The blinking of LED is calculated for consumed power in units along with the cost of the units. The monitoring is done in every interval. The system also provides a power theft feature which is done using the current sensor connected to the system. Thus, the system doesn't involve human providing less human error.

III. PRACTICAL IMPLEMANTATION

To analysis the proposed energy monitoring system, the system is practically implement in the lab. The details practical implementations are explained below:

Initially the system is not connected to the main supply i.e the system is in OFF condition. Fig. 2 shows the hardware implementation without connecting the main supply. After verifying all the hardware connection, supply is given to that hardware system. Fig .3 illustrates that the system is in ON condition. As soon as the Wi-Fi module is connected to the server the relay trips and the load energies.

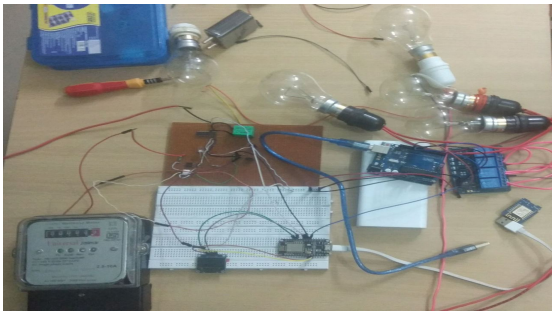

Fig.2: System in OFF condition.

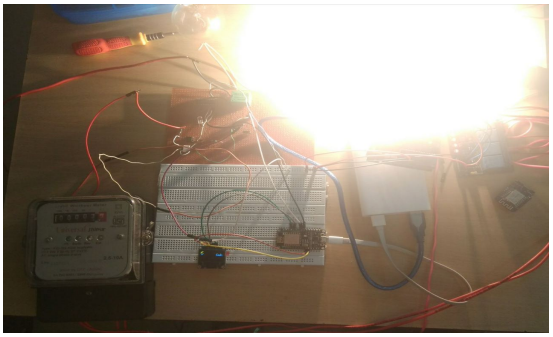

Fig.3: System in ON condition.

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Fig. 4 demonstrates that the Wi-Fi module is trying to connect to the available server. If there is any server available near to that system, it gets connected. Fig .5 here Wi-Fi module connects to the server and the system is now ready to take the information.

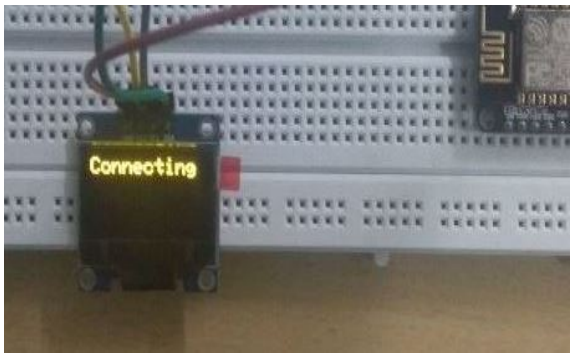

Fig. 4: WIFI module connecting to the server.

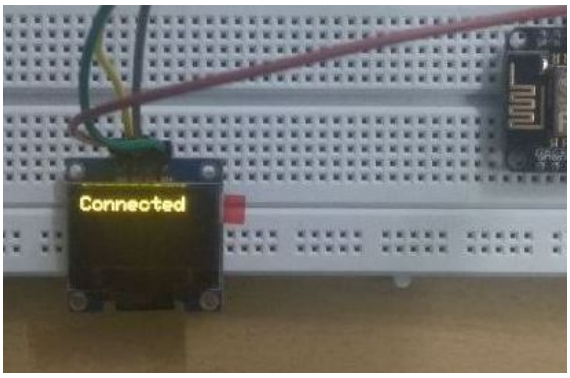

Fig. 5: WIFI module connected to the server.

After connecting the Wi-Fi with that system, system is ready to give the information regarding the load or energy consumption by the customers. Fig. 6 shows the initial information on the OLED display when the load is not energies i.e. there is no load connected to the system. As a result, OLED display is showing '0' reading. Fig. 7 shows the reading on the OLED display when the system starts taking pulses from the energy meter. Fig. 8 shows that when the system doesn't take any pulses, the system detects that there is a power Theft in the system and the OLED displays the same information. After there is a power theft, the system is completely turned off as shown in Fig. 9. At the same time the system contacts the Power Department to give the information about the power Theft and then the Theft data is uploaded in the cloud too.

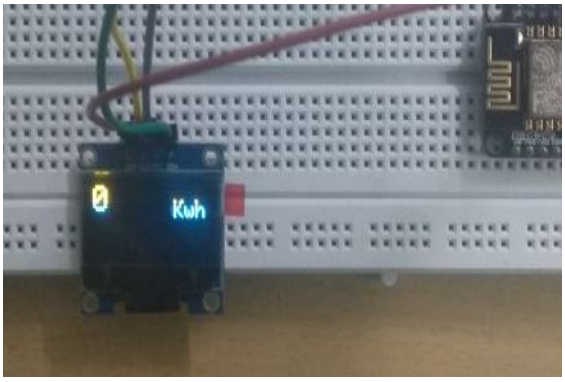

Fig.6: System is ON (Load not connected).

Fig.7: System is ON (Load connected).

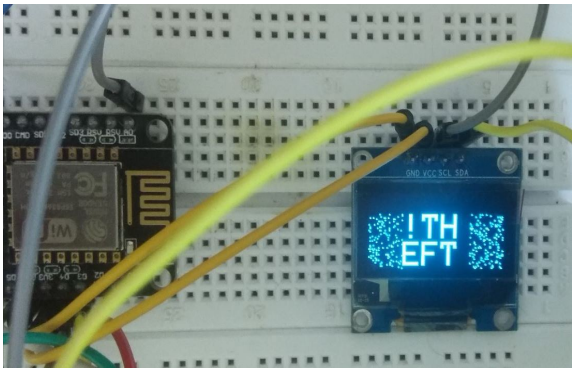

Fig. 8: Theft Detection.

Fig. 9: System is shut down and contact to Power Department

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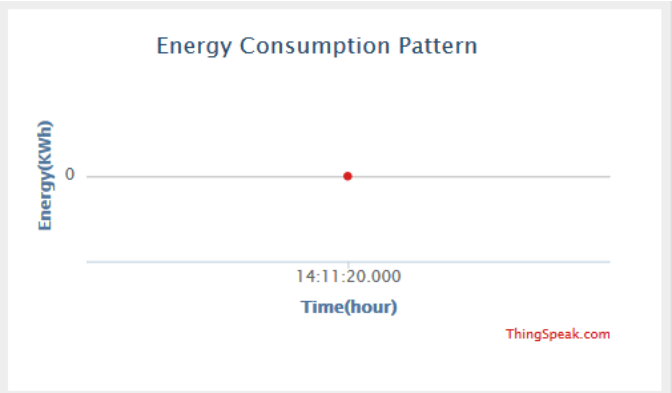
IV. Result and Discussion

The result obtained has been uploaded to an open IoT platform "ThingSpeak" which help us to store, collect, analyze data from arduino and other supporting hardware. Initially, no information is transferred to the cloud via ESP 8266 12E (Wi-Fi Module) as the load is not energies to the system. After connecting the load, information is transferred to the cloud using Wi-Fi module. Fig. 8 shows the initial data transferred to the cloud with connection of load



. Fig. 8: Energy consumption data

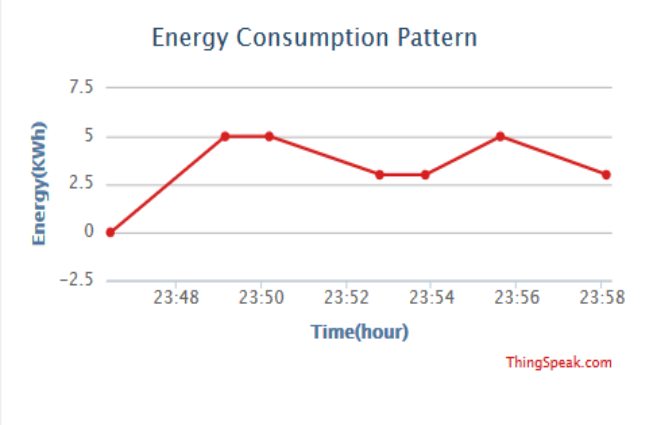


Fig. 9: Energy consumption pattern for first load set

To verify the system, experimental result is obtained for various load connection of the system at a particular time. Fig. 9 and fig. 10 respectively shows the energy reading for different loads connection of a system at a particular time. Here, we kept the system ON for a while in order to obtain the results. . Fig. 11 shows the theft data consumed by the system.

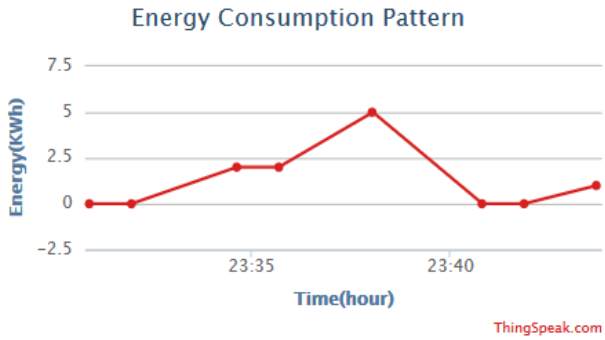


Fig. 10: Energy consumption for second load set

Fig. 11: Theft Data.

V. CONCLUSION

This paper provides wireless meter reading system that can monitor and analyze the data at every interval providing accurate results with less error. Some of the advantages of this smart system are: -

- Energy conservation.
- Lots of time and power saving from power department.
- Automatic control of energy meter.
- To make consumer keep the track of energy meter.
- Power theft detection.

Some of the disadvantages are:-

- Sometime the system takes time to upload the data depending on the Internet Speed and Module baud rate.

The IoT concept can also be implemented in various working environment such as home automation, automatic water level detector and traffic control system etc.

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