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IoT BASED SMART ENERGY METER FOR EFFICIENT UTILIZATION IN SMART GRID

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ABSTRACT

In the recent digital era, technology starts to find new ways of improving and enhancing human lives. So all the devices are getting smarter for efficient energy utilization that we could expect it would be. In the same way, we have an idea of making the energy meters of electricity board highly smarter using the technology "Internet of Things"(IoT). The smart energy meter is connected with electricity board, household appliances and the user through IoT and mobile application. The existing energy meter 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) for automation. The proposed energy meter controls and calculates the energy consumption using ESP826612E, a Wi-Fi module and uploads it to the cloud from where the consumer or producer can view the reading.

Keywords: Automation, Wi-fi module, Internet-of-Things (IoT), 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 tending to make or cause errors, 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. 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].

IoT based energy meter system mainly consists of three major parts i.e., Controller, Wi-Fi and theft detection part. The controller plays a major role in the system making sure all the components are working fine. It provides real time consumption information providing energy consumption control [5]. Whenever the maximum load demand of consumers crosses its peak value, the supply of electricity

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for customers will be disconnected with the help of smart 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 meter suffers environmental issues and decreases its life span with abnormal consumption of energy [9]. The factors effecting lifespan o of a smart meter consists of Life Expectancy, Genetics, Environmental Factors, Change over Time and limited Longevity [10]. The energy meter available till now can only monitor and control 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 increases 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.

II. CONVENTIONAL TYPE ENERGY METERS

In existing system, conventional energy meters or watt-hour meters displays kilowatt hour by continuously measuring the instantaneous voltage (volts) and current (amperes) to give energy used in joules [12]. Watt-hour meter is in fact a measuring device which can evaluate and records the electrical power passing through a circuit in a certain time. By implementing the Watt-hour meter, we can know how much amount of electrical energy is used by a consumer or a residence or an electrically powered device or a business [5]. Electrical utilities install these meters at their consumer's place to evaluate the electrical usage for the purpose of billing. The reading is taken in each one billing period. Usually, the billing unit is Kilowatt-hour (kWh). The primary type of electricity meter is the electromechanical induction meter and an electronic meter. In electromechanical induction meter, the total number of rotation of the aluminum disc is directly proportional to the power consumed is shown in Fig. 1.

Electronic meters shows the power consumed, power factor, the reactive power used digitally displayed on LCD or LED display [12], and also able to send the energy consumed readings to remote places through some communication network. It is a single way communication. In addition to energy used, electronic meters measuring can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used etc.

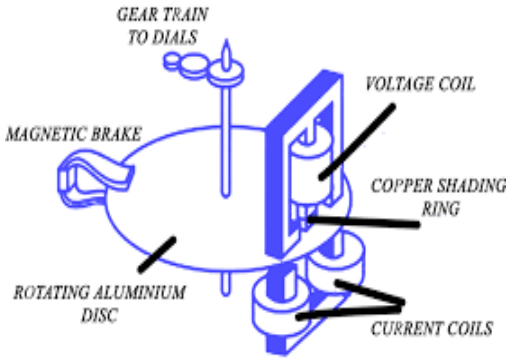

Fig. 1: Watt hour meter

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Disadvantages

i. The conventional meter has some of the common errors like time consuming, chance of theft, error while taking the information and extra human involvement.
ii. Consumer may not get the bill slip within due date [12].
iii. The consumer will not receive updates of his regular usage of energy.
iv. Whenever energy meter installed inside the house, which may lead to non-checking of reading due to lock.
v. Always there is no cross checking of human readers for energy utilization.

III. IoT BASED SMART ENERGY METER

It is proposing that IoT based smart energy meter is cost effective and compact. So, the installation becomes much easier. Smart energy meter is an electronic device that measures the most accurate amount of electricity consumed by a residence, business or any electrically-powered device. A smart meter is reliable source for most accurate information of consumed energy that reduces the chance of error in the existing billing system to minimal [8]. Smart meters work in a variety of different ways, including using wireless mobile phone type technology to send data [12]. The result is uploaded at every interval into cloud space called “Thinks speak” and monitoring can be done by consumer/customer as well as supplier/producer. Four key processes are inherent to smart metering schemes: measuring, data transfer, processing and analysis and feedback of use data[9].

In general, smart meter includes (i). a meter, which is used to measure the flow of electric power from input to the output terminal. (ii). LCD Display, which is used for displaying readings of the parameters that are being metered. (iii). Communication, which is present in modern electricity meters, which is used for one-way or two-way communication of information with the billing utility. In this proposed system, an energy meter is connected to ESP826612E via opt coupler. 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. Fig. 2 shows the functional block diagram of the proposed smart monitoring system.

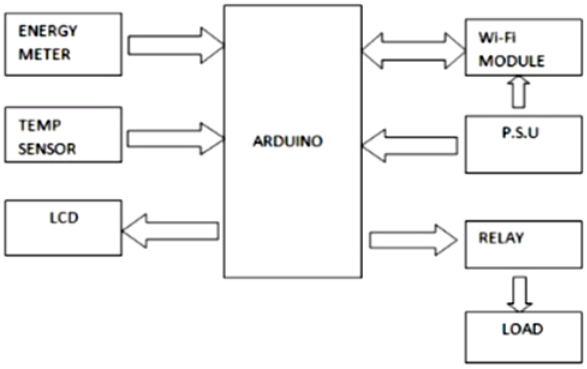

Fig. 2: Functional Block Diagram

IV. IMPLEMENTATION OF HARDWARE SYSTEM

In this project, we require an Energy Meter, a Wi-Fi module of ESP8266 interface, Arduino IDE, LCD, LDR, Temperature sensor, Relay and Load.

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4.1. Arduino

The Arduino microcontroller is prototype platform (open source) based on an easy to use hardware and software. It consists of a circuit board, which can be programmed (referred to as a microcontroller) and readymade software called Arduino IDE (Integrated Development Environment) is shown in Fig. 3, which is used to write and upload the computer code to the physical board [12].

The key features are,

i. Arduino IDE board has 20 pins i.e., 14 Digital pins and 6 Analogue pins.
ii. Arduino boards are able to read analogue or digital input signals from different sensors and turn it into an output such as activating a motor, turning LED on/off, connect to the cloud and many other actions.
iii. You can control your board functions by sending a set of instructions to the microcontroller on the board via Arduino IDE.
iv. Unlike most previous programmable circuit boards, Arduino does not need an extra piece of hardware in order to load a new code onto the board. You can simply use a USB cable.
v. Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program [12].
vi. Arduino voltage range is 5V DC.

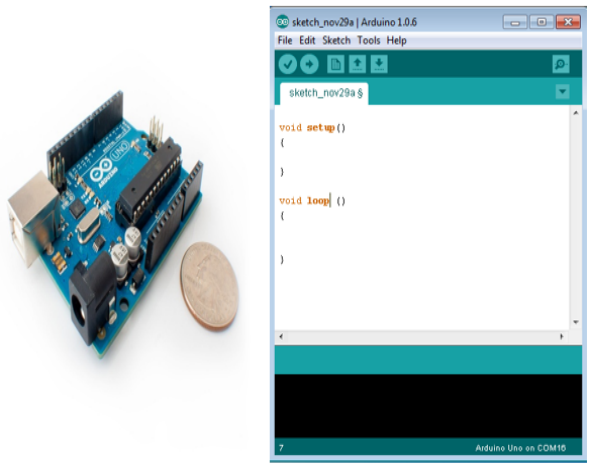

Fig. 3: Arduino IDE

4.2. Liquid Crystal Display (LCD)

LCD screen is an electronic display module and find a wide range of applications. Electronic meters display the energy used on an LCD or LED display, and some can also transmit readings to remote places and also support time of day billing [10]. A 16*2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LED's. A 16*2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5*7 pixel matrix. This LCD has two registers, namely, Command, and Data. The command register stores the command instructions given to the LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc.

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The details the ACSII value of the character to be displayed on the LCD as shown in Fig. 4.

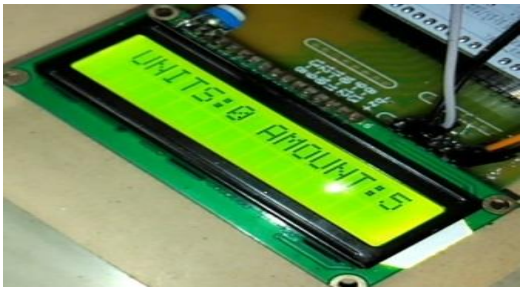

Fig. 4: LCD display

4.3. Relay

A relay is an electrically operated switch. Many relays use an electro magnet to mechanically operate a switch shown in Fig. 5, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations [11].

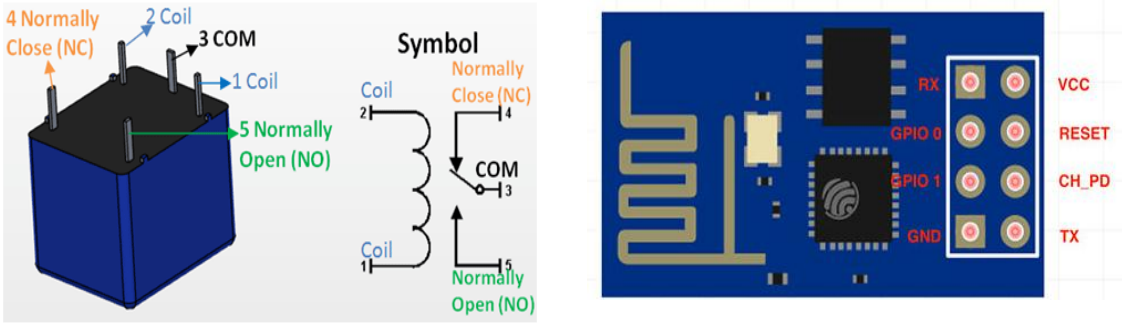

Fig. 5: 5V Relay pin diagram

4.4. Wi-Fi MODULE

The ESP8266 is a low cost Wi-Fi module that can be integrated easily into IoT devices. Energy systems offer effective solution to aforementioned challenges, as they enable end users to satisfy their needs with distributed energy generation and storage technologies[10]. The ESP8266 is a small Wi-Fi module built around the ESP8266 chip that can connect your microcontroller to the internet wirelessly for a very small cost. Smart meters are programmed to maintain a schedule for operation of the home appliances and control operation of other devices accordingly [5]. It can be a great option for Internet of Things (IoT) projects, but can be difficult to work with for beginners who don't have prior experience with the module. The module has 8 pins that serve different functions, but they are packed in a 4*2 arrangement. The ESP8266's pins are follows and module is shown in Fig. 6.

i. RX: UART serial communication receive pin
ii. GPIO 0: GPIO pin
iii. GPIO 1: GPIO pin
iv. GND: Connection to Ground

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v. VCC: Connection to 3.3V VCC
vi. RESET: Reset pin
vii. CH-PD: Chip enable and power down pin
viii. TX: UART serial communication transmit pin

Fig. 6: ESP8266 Pin out

To connect the ESP8266 to a computer and configure its settings, we'll need a USB to serial adapter with 3.3V logic, along with a serial terminal program. Fortunately for us, we have the Arduino and Arduino IDE's serial monitor. This means that we'll just have to connect the ESP8266 module to the Arduino and upload a custom sketch to the Arduino.

4.5. Voltage Regulator

A Voltage regulator is a device which converts varying input voltage into a constant regulated output voltage is shown in Fig. 7. Voltage regulator can be of two types:

i. Linear Voltage Regulator
ii. Switching Regulators

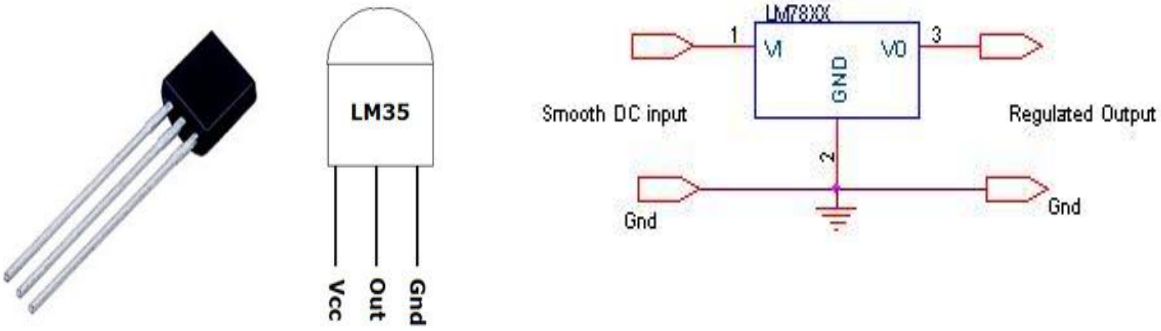

Fig. 7: Voltage Regulator

4.6. Temperature Sensor

A temperature sensor is a device, typically a thermocouple that provides for temperature measurement through an electrical signal. Temperature sensor measure the amount of heat energy or even coldness that is generated by an object or system, allowing us to sense any physical change to that temperature producing either an analogue or digital output. A smart meter system employs several control devices, various sensors to identify parameters and devices to transfer the data and command signals [6]. As it is used in home automation then the sensor will sense the temperature of the room and switch on the fan automatically. And we can get the intimation to our mobile by the technology IoT as shown in Fig. 8.

Fig. 8: Temperature sensor pin diagram

4.7. Light Dependent Resistor (LDR)

A photo resistor or light dependent resistor or cadmium sulphide cell is a resistor whose resistance decreases with increasing incident light intensity is shown in

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Fig. 9. It can also be referred to as a photo conductor. A photo resistor is made of high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron conducts electricity, thereby lowering resistance. A photo electric device can be either intrinsic or extrinsic. Smart meters can be used to control light, heat, air conditioning and other appliances [5].

Fig. 9: Light Dependent Resistor

4.9. Hardware Kit Description

In this hardware kit first the Wi-Fi module gets the input supply i.e.,5V DC using the adopter and this Wi-Fi module has a receiver and transmitter pins for serial communication. The transmitter pin (Tx) is connected to the receiver pin (Rx) of microcontroller and receiver pin (Rx) is connected vice versa. Additionally it has a pin that is connected to the Arduino for the power supply through a cable. In the Arduino IDE the code has dumped in C language for our convenience. In this code we can prefix the amount of money as well as no of units. After connecting the Wi-Fi to our mobile and then only we can get the intimation to our mobile as well as to the LCD display. The sensors are connected to the Arduino as analogue inputs. The relay is connected to the load as well as to the Arduino for the triggering purpose if the limit gets exceeded. The energy meter is connected to the load and to the relay also. Now when the Wi-Fi module is on then the Arduino gets on. The load is switched on then the energy meter is also on condition. In the mobile the Wi-Fi is connected using the IP address in the Mobile Telnet application. Whenever the energy starts consuming we can get the intimation to our mobile application as well as to the LCD that how much energy we are consuming and how much remains and also how much amount has completed by our energy utilization. If it exceeds the limits the load will automatically stops consuming energy and that alert also we can get to our mobile application. This intimation is getting to us by the technology IoT.

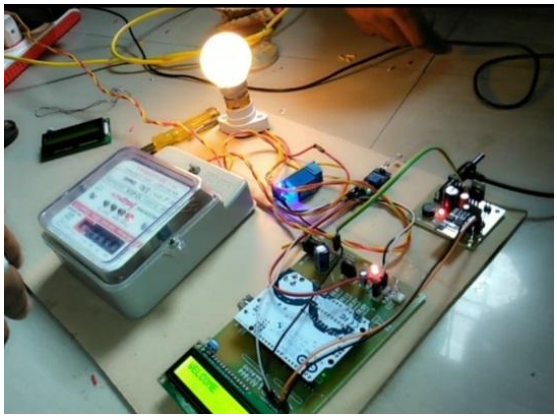

Fig. 10: Proto type IoT based Smart Energy meter

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V. RESULT

Unlike the conventional energy meters, this smart energy meter analyze the data at every interval providing accurate results with less error. Here the Arduino IDE has dumped with code by our requirement in C language i.e., to a high value or low value. According to that the Wi-Fi module sends messages to our mobile using IoT that how much of energy we have utilised and how much of amount is consumed and available till. Beyond the limit the meter stops consuming energy until we recharge that meter. So by using the technology IoT we can monitor the amount of energy consumed in an efficient way. Since there is need to utilize energy in better and efficient way this pre-paid meter proves to be a boon in the power sector. In this system to save time of consumer, the consumed energy corresponding price is displayed for the consumer benefits. By the implementation of this system overall efficiency in operations of the electric board will improve.

VI. CONCLUSION AND FUTURE SCOPE

In the present situation all customers are using manual communication. To reduce the manual efforts and human errors, we need to have some kind of automated system monitoring all the parameters and functioning of the connections between the customer and electricity board. Also by implementing this system we can control the usage of electricity on consumer side to avoid wastage of power. An attempt is made in this work to develop a system, which when interfaced with static electronic energy meter is voided where in complexity of the circuit is reduced and cost also gets reduced of the meter.

As per as market study Techsci Research is forecasted the growth and development of Smart Electric Meter market is projected to reach USD 11.51 Billion by 2023, at a CAGR of over 4%, from 2018 to 2023 owing to increasing investment in smart grid projects, increasing need for efficient data monitoring systems. Government also going to be implemented this type of project by using the technology IoT for efficient utilization and consumption of electricity.

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