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Abstract—Nowadays technology is increasing day by day. So, by using these advanced technologies we can manage the wastage of power. This power wastage is mainly occurred by the power theft. In our India, power theft was very common. So, by implementing smart energy meters (SEM) we can detect those power thefts. And we can also control and monitor the home appliances by using this smart energy meter. For collecting the meter readings, we need human resource and sometimes it will make delay and there is a possibility of errors. So, by using these SEM, the bill was automatically recorded and it was available on database. Aim of this study is to measure electricity consumption in the household and generate its bill automatically using IOT and also aims to detect and control the energy theft.

Keywords— Internet of Things (IOT), Smart Energy Meter (SEM), Electricity theft.

INTRODUCTION

Internet of things (IOT) is simply a network of all the physical objects, in which all these objects are connected by the sensors and software applications for the purpose of connection and transferring of information between the object.

The demand for the power supply is very large and the losses will increase with high utilization. So, we have to use a smart energy meter which is used for controlling the losses and for continuous monitoring of the applications [1]. A smart energy meter will act as a controlling device that will give automatic correction of data. It is real monitoring data so that the customer will get clear information about power usage [2].

By using these smart meters, the information will transfer to both the customer and to the service Provider [3]. The interoperability between the devices and the efficiency of measuring the information of the power consumption can be increased by using a service-oriented architecture [4]. We can easily detect power thefts by using the new metering infrastructure [5]. The utilization of smart meters was increasing day by day but also the lifetime was decreasing based on environmental factors, changing over time [6]. Energy meters using IoT can be used for controlling and monitoring of the devices and the meters which are using Power Line Communication will reduce power loss [7]. The meters which are using Arduino can be used for increasing the efficiency of measuring the meter readings and also the power thefts will be identified very easily [8]. When the meter was running using a nodemcu the data will be transferred and secured for long ranges without any delay [9].

Electricity is one of the essential requirements of human being for their life. It is a non-renewable energy source therefore we must use it in better way for its sustainable utilization. With the help of wireless communication technologies, we can easily control the devices automatically and we can also reduce the human efforts. By using traditional meters, it was impossible to control the devices and also bill making takes much more time and also the information about the power consumption was announced after one month [10].

So that SEM's will reduce those problems. And by using this wireless communication information will be transferred very easily to the customer and provides greater reliability and it also gives the information about the amount of current utilized by using Automatic Meter Reading (AMR) [11].

Most of the loses in the electricity will occurs in two forms i.e., technical and non-technical. Technical losses were occurred due to the equipment failure and non-technical losses were occurred due to the human resource. Conventional energy meter will measure the instant voltage and current value to display the information about the usage in terms of joules and this conventional meter will display the information about electricity in Kilowatt-hour [13].

These SEM's will provide real time pricing and we can control our usage by comparing with the real time data. This will minimize the wastage of power supply [14]. With the help of there smart meters, we can

disconnect the load whenever the load demand increases suddenly and crosses its certain limit.[15].

There are some drawbacks from the conventional energy meter which we can overcome by using smart energy meter are:

1. It takes much time for updating the information
2. Difficult to detect the power theft.
3. Possibility of errors while recording the data from energy meter.
4. It was not possible to control and monitor of the home appliances.

So, for control, monitoring and for saving of power these smart energy meter must have to be installed. So that the customer can have clear idea on the utilisation of power supply.

TYPES OF SMART ENERGY METERS:

Smart energy meter is an electronic device which is used for recording the information about the utilisation of electricity, and also the voltage, current and power factor values. We can also check the tariff by using these meters. There are different to types of smart energy meters. They are:

1.ZIGBEE BASED SMART ENERGY METER:

ZigBee is a global wireless radio communication standard network which was designed for controlling and monitoring of connected devices. It was low-power, close-proximity solution suited for home automation. ZigBee is a personal area network (PAN). This technology is used for controlling and mostly used in home automation.

ZigBee network can be implemented in two ways, they are Star network and mesh network. When compared to both these network star network is simple because star network has only one parent node and child node, whereas mesh network has an extra router node. This node will transfer data from child to parent node and also it will increase the coverage area.

This ZigBee based smart energy meter consists of various components, they are

1. Current sensor module
2. Voltage transformer module
3. ZigBee module
4. Control unit
5. Management unit

This ZigBee based smart energy meter mainly depends on current sensors and voltage transformer. By connecting these components to main supply, the current sensor will give analog output voltage. Voltage transformer has an inbuilt multi-turn trim potentiometer which is used for adjusting output ADC values. For getting the required ADC output value the customer has to calibrate by using a trim potentiometer.

The control unit has two microcontrollers one microcontroller is used on smart meter and another one is used as a gateway. ZigBee module is used for transferring and receiving the signals by ZigBee TX and RX. Finally, management units are used for managing the power consumed data and also to upload the data on the cloud by using an ESP8266-01 Wi-F module. And also, we can use a SD card for saving the data [10].

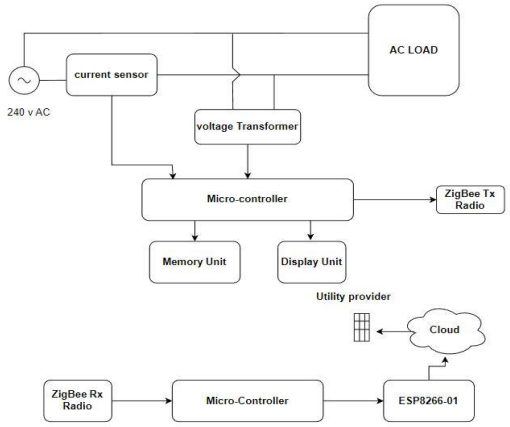

Fig-1 Block diagram for Zigbee based meter

2.ARDUINO BASED SMART ENERGY METER:

This energy meter is used for accurate billing and also for the advanced metering. This meter is used for total controlling and monitoring of the appliances. This smart energy meter has an energy meter, GSM modem, microcontroller and also a relay circuit. In this the microcontroller is nothing but an Arduino. These components were connected in between the smart energy meter and load.

This smart energy meter will provide metering and all billing services like recording the consumed power, and also it will send the generated bill by the short message service (SMS). This energy meter system contains of digital energy meter, Arduino and an GSM modem.

After switching on the Power to the Arduino and the GSM modem then turn on the relay. Then after connects the energy meter to load using relay. It will read the EEPROM data and display the power consumption data. The Arduino will identify or detects the Impulse from the meter. Then if any

impulse occurred then the data will be recorded increase the previous data and display's current data.

Global system for Mobile communication (GSM) modem will identify if any messages were found. Once GSM modem identifies any SMS then it will read and send the corresponding instructions to the meter and really acts according. For example, if the message was line cut then automatically the load will disconnects. Similarly, if the message lone ok then automatically load will gets connects to the meter. And the relays get turned on.

In this type of meter there is an optocoupler. The main purpose of the optocoupler is for protection purpose. It separates the electronic parts from the High voltage and current values. It takes and short and easy path for the transmission of signals between the elements.

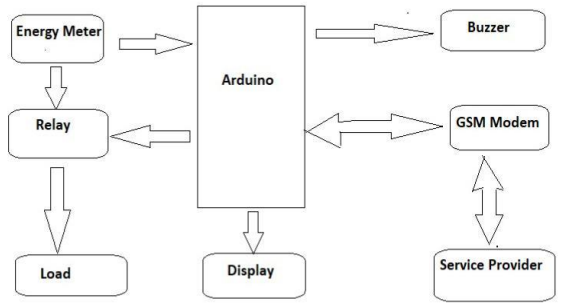

Fig-2 Block diagram for Arduino based meters.

The main working of this meter was it will depend on the microcontroller i.e., Arduino for the instructions. After connecting the meter with Arduino, the meter will get instructions whether to connect or disconnects the load. When the load gets connected to meter then Arduino will detect the impulse and it will record the power consumption. And it will display the information. If any fault or unwanted things occurs then automatically Arduino disconnects the Load from the meter [11].

3.Embedded energy meter:

The term embedded means which is used to fix something into an object. Embedded system is a combination of hardware and software of the computer which is designed for implementing of a certain function. When compared to other meters this embedded meter is different and it also has different methods for measuring and paying the bill. In this meter the customer has to place the card into this embedded energy meter. There are two types of cards they are bar code card and smart card.

(a)Bar code card:

This bar code card consists of two bar codes on two sides of the card.This bar codes will provide full security for the customers and it does not allow other to access their card.Two bar codes are named as code 1 and code 2.If the customer place that card into meter then code 1 will verified to know the identification of the card and display place code 2 then after inserting the code 2 it will check the status and displays about the balance, lifetime and Validity of the card.This card can not be reusable.

(b)Smart card:

Smart card is a costly card when compared to the bar code card. It is a reusable card. once the balance was completed in the card then the customer can recharge the card. function of this card is as similar to bar code card when we insert this card it will gets verified and displays the status of the card. After

WORKING:

When we insert the smart card into the meter, the code which was encrypted on the card will gets verified by the terminal reader in meter. If it was matched with the terminal reader then it will check the time of the card. It this card contains certain amount then the logic 1 value will send to J-K flip-flop and output of that flip flop has logic 1. And the relays get energised and the switches will gets closed so that the meter will gets connected to load. Then appliances will get the power supply and energy meter disc will gets rotate.

It contains an opto-electronic receiver it will transfer the frequency of the rotation to the frequency to voltage converter. Then converted voltage value will gets verified by the terminal reader and compares with the balance and time of the card.

If the time and balance of the card was completed then the terminal reader will send the logic 1 to J and k input of J/F flip-flop to change the output from logic 1 to logic 0. So that accordingly the relays will get deenergised. After that the meter will gets disconnects from the main supply.

After the completion of the balance then the customer will again recharge the card and the same process will go on. This is the main working of this embedded energy meter [12].

FLOW CHART:

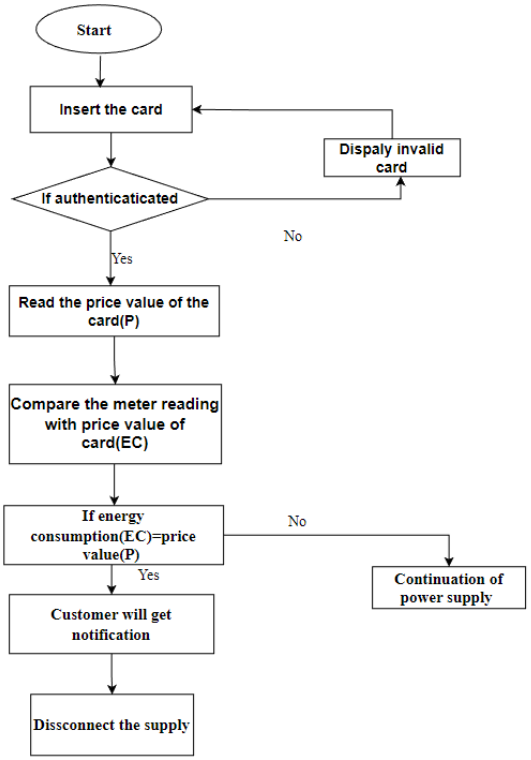

Fig-3 Flow chart for Embedded Energy Meter

4.GSM MODEM & ZIGBEE BASED SMART ENERGY METER:

This energy meter was mainly worked on the two components they are Global system for Mobile communication (GSM) and ZigBee modem boards. This ZigBee is used for power transmission purpose example Machine to machine network. This ZigBee is preferred more when compared with the Wi-Fi because Wi-Fi is used for short ranges only. But this ZigBee is used for longer ranges and also data will be transferred more conveniently. Here GSM modem is used for transferring and receiving the message over mobile networks. u This smart meter works in two methods. One is prepaid and another one is post-paid.

Prepaid method:

If the customer inserts the card into the meter, then it will display prepaid mode on display. And it will check the validity and information of the card and it will display on the meter. If the load gets the supply, then the meter will record the information about the power consumption and compare with the remaining balance in the card. If the power consumption values has crossed half of the limit of card, then it will generate buzzer sound. If the customer does not recharge their card, then the meter will automatically stop the power supply by using the relays.

Post-paid method:

In this method when customer inserts their card in meter then it displays post-paid mode and in this the meter will always displays the power consumption values of the load continuously and this information will be transferred to the base station from where the electricity supplied. If there is any power sent difference occurs then the power theft message was sent to the local operators. In this the mode power theft will be identified.

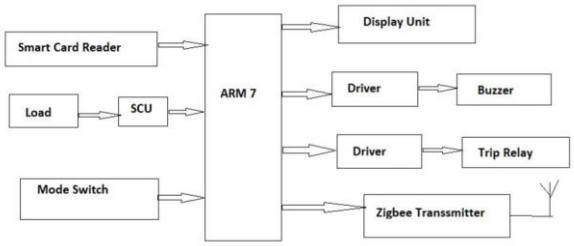

Fig-4 Block diagram for appliances by using ZigBee and GSM.

This paper will always monitor the data continuously and it provides continuous and accurate billing. It avoids human efforts and if customer fails lo recharge then automatically the power supply will gets disconnected [13].

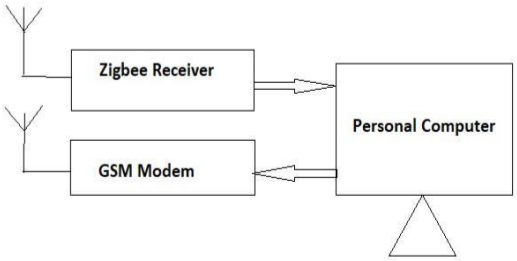

Fig-5 Block diagram for Data transferring

5. BLUETOOTH BASED SMART ENERGY METER:

This type of energy meter is worked based on blutooth network. Wireless technology will provide greater reliability for transferring the information and also it provides better meter readings. With this energy meter we get accurate meter reading with Automatic meter reading (AMR) and Automatic polling mechanism (APM). This energy meter is implemented on these two methods.

Automatic Meter Reading (AMR):

This AMR technology is used for collecting the data automatically and this collected data was transferred to the data base and also it is used for collecting the real time data. It will reduce the human labour. When the energy meter is connected wirelessly with the pc then pc will give commands whether to give the supply or not. Once the power

supply flows through the meter then automatically it will collect the power consumption data.

Automatic Polling Machine (APM):

APM will poll each and every Bluetooth meter automatically for gathering the power consumption data of the customer.

This Bluetooth based energy meter works in three phases. First one is interfacing the pc with the Bluetooth radio module. Second one is interfacing the Bluetooth radio module with the microcontroller. These two phases will support RS2322 protocol. And the third one is interfacing the energy meter and the microcontroller.

This meter consists of BlueEZ module and analog devices ADE7756 energy meter. And this energy again operates in three ways. And also, it has some possible commercial applications they are PDA (Personal digital assistant) this will explains that instead of using PC this PDA will record the data of power Consumption.

Second one is the data which was recorded by the meter about the power consumption data must be transfer to base station or cloud base through telephone network.

Third one is that the GSM modem acts as gateway. This GSM modem will gets connected by the energy meters so that the data information will be transferred to the service provider [14].

Communication Technologies for smart energy meter:

Communication Technologies plays a major role in the working of the smart energy meter. These smart energy meter will transfer large amount of information of the power supply and power consumption data. This data was so sensitive and it was not possible for everyone to access that data. Each customer has their own security. There are various communication networks they are Power Line Carrier (PLC), Broadband power line (BPL) communication. These communications are used for larger communications. Session Initiation Protocol (SIP), Voice over Internet Protocol (VoIP), User Datagram Protocol (UDP), or Stream Control Transmission Protocol (SCTP). SPI communication protocol will be used in place of UDP and SCTP.

Peer-to-Peer (P2P), ZigBee and Home area network and finally GPRS network. These are the main communication technologies. Here the peer-to-peer network is used for increasing the operational range of the appliances. Currently GPRS and PLC communication networks were commonly used because these networks were simple and very to use and also for maintenance.

Design issues, Maintenance and challenge for smart meters:

When we installed these Smart energy meter (SEM) we can face many issues like design issues, maintenance issues and also some challenges.

Design Issues:

Design issues are classified into four categories they are Technologies, Physical aspects, cost and communication. Here from technologies, we can say Billing method and meetering technology. And physical aspects will explain about the strength of the meter and has to be in safe place. Cost should be in one of the major issue and communication will explains about types of communication, range of communication, cost of device used for particular communication and quality of signal. These are the design issues.

Maintenance Issues: Maintenance issues were another major drawback for the working of the smart energy meter. This maintenance issues consists of Base server problems, smart meter, and Network failures.

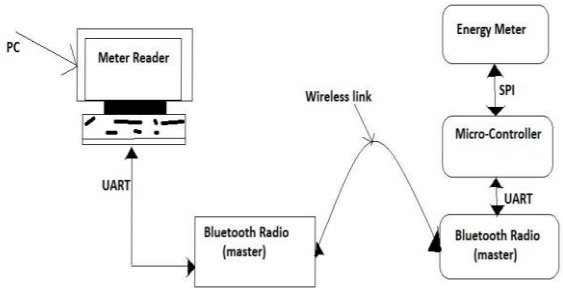

Fig-6 Bluetooth based energy meter.

Challenges for data transmission:

This consists of how much quantity can be transmitted and this data can't be accessed for all. It has to be secured. Every customer data must transfer and receive with the required modulations and has to be protected [15].

Advantages of smart energy meter:

1.It provides efficient power control

2. we can easily detect the power theft

3. These SEMs will continuously monitor the appliances.

4.The customer will get power consumption data continuously.

5.When compared to traditional meters, meter readings will be recorded automatically.

6.And also billing will be done accurately and it did not make any delay in billing.

7. With these SEM we can bill the data in real-time.

8. Customer will get information in real-time and with that information the customer will consume according to the balance.

9. It can produce high security for the data.
10. It will reduce human efforts. In traditional meters, human labor is required and the data will take at least with some error.

11.The customer can know the price values like on-peak time and off-peak time.

CONCLUSION:

This paper reviews about different types of smart energy meters and their detailed working process. This also includes about communication technologies which is used for the smart energy meter and also about the Issues like design, Maintenance and challenges for data transmission. This paper explains that Smart energy meter is used for continuous monitoring process and also, we can remotely control the power supply and also provides safety like whenever the load demand crossed its maximum value the fluctuations will occur in the supply, at that time the load will automatically disconnected. So that the power consumption will be minimised.

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