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IoT BASED POWER CONSUMPTION MONITORING AND CONTROLLING SYSTEM

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Abstract: *Despite many efforts, Energy crisis is the present day problem and it is getting worse day by day. To overcome this situation people are finding various energy efficient resources. Among them, power is the main concern which needs to be monitored and controlled. With the rise in power consumption in every part of the world there is a subsequent rise in power theft and over usage of power. This is a serious problem which is being faced by the power utilities. In this paper, a model is designed which aims to control and monitor power consumption of a particular area or sector. The designed model monitors the power consumption of the end users and cut off the power supply when it exceeds the set limit. The device sends the power consumption data to the supplier's blynk server using Internet of Things (IoT) technology. The designed model can be placed before the transmission of the load in each house of that particular area. It consists a meter that generates a continuous unit pulse which can communicate with network through an Internet gateway WI-FI. With the help of internet accessibility, communication will be possible between end-user and the supplier. The supplier can monitor and control the power consumption of the end user from a remote place. Along with that the device sends notification to the supplier about status of power consumed and data sheet will generate using LabVIEW.*

Key words: Energy crisis, IoT, WI-FI, monitor and Control, Power consumption.

1. INTRODUCTION

Due to fraud of electricity consumers power utilities lose large amount of money every year. Electricity fraud can be define as a dishonest or illegal use of electricity equipment or service with the intention to avoid billing charge. It is difficult to distinguish between honest and fraudulent customers. Realistically, electric utilities will never be able to eliminate fraud. It is possible, however to take measures to detect, prevent and reduce fraud [5]. Investigations are undertaken by electric utility companies to assess the impact of technical losses in generation, transmission and distribution networks, and the overall performance of power networks. The installed capacity of the electricity sector in India is 344.00 Giga Watts as on 30 June 2018, which includes renewable and non renewable sources. The per capita electricity consumption in India in 2016-2017 was 1,122 kWh [15]. Every year 20-30 % average line loses according to WAPDA Company's loss more than RS.125 billion [23]. India's T&D losses are almost 20% of generation, more than twice the world average and nearly three times large as T&D losses in the United States. Electricity losses are the result of technical inefficiency and theft, but in places with good technical efficiency and low theft, T&D losses generally range between 6% and 8% [14].

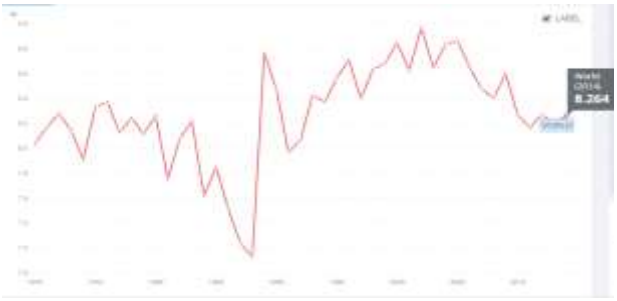

Fig. 1- Electric power Transmission & distribution losses (% of output) [12]

The work in [4] finds the solution for monitoring the power theft happening in and around a particular locality. In [20] analyses the current situation of Chinese building ceramics production lines and the development of the Internet of Things (IoT). The new research has been done for which concern about power consumption and smart prepaid energy meter are discussed [19]. In [21] author proposed the real-time monitoring system for residential energy meter is done using IOT. The significance of the research is to reduce manpower requirements. In [10] author analyzed the solutions currently available for the implementation of urban IoT.

At the time of purchasing the meter according to the requirement of customer the limit of meter will be set; in the same way the limit of transformer is also set according to the consumer requirement of the particular area. If the consumer uses the power beyond the limit of the meter in that case they have to pay the penalty. As many of the consumer's uses the high amount of power which crosses the limit of the transformer at that time the probability of busting of transformer increases. So in this paper we proposed a method to overcome above problem this paper mainly focusing on monitoring and controlling of power in the range of limit of the meter. The IoT has recently become universal to highlight the vision of a global structure of interconnected physical objects. As more

number of electricity-consuming products coming into daily lives, such as electrical vehicles (EVs) and advanced heating, ventilation, and air conditioning systems, load demand increases dramatically and power required at high amount.

1.1 Techniques used for estimation of power monitoring

In this project proposed a power consumption and monitoring system of the area that continuously monitor the consumption of consumer. If this consumption is beyond the limit of the meter in that case it cut off the power supply of the whole area.

The whole process is based on the Ohm's law which states that," the electric power in watts associated with a complete electric circuit or a circuit component represents the rate at which energy is converted from the electrical energy of the moving charges to some other form, e.g., heat, mechanical energy, or energy stored in electric fields or magnetic fields".
For a resistor in a D C Circuit the power is given by the product of applied voltage and the electric current".

P = V I

POWER= VOLTAGE X CURRENT

Here taking a voltage as a predefined data and on the calibration of current the power will be calculated.

At this point of technological development the problem of illegal usage of electricity can be solved electronically without any human control along with that meters are connected to the internet using IoT concept.

IoT concepts are used so that the information regarding meter status will be send wirelessly from the place where the meter is placed to the server from there it sends the information to the main station or substation. This method eliminates the need of human power during disconnection and reconnection of the load.

2. METHODOLOGY

2.1 Block Diagram

The AC load is given to the main system. This system contains the meter which receives the signal in continuous form. The controller is the heart or the brain of the system; it coordinates the functionality of other parts of the system. It can be any of the microcontrollers; for this research an Arduino microcontroller was used for easy prototyping, implementation and emulation of embedded systems.

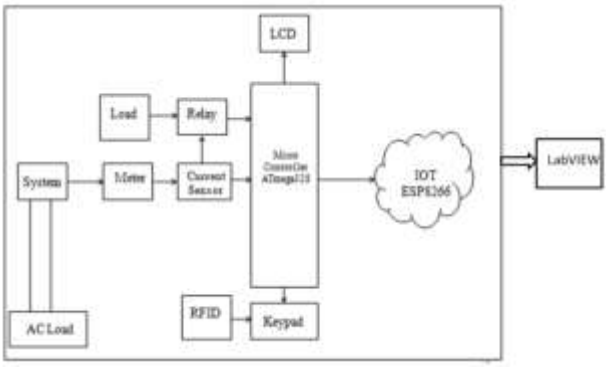

Fig.2- Block Diagram of the Circuit.

The power fluctuations are monitored using the current sensor which is fed to the microcontroller. Relay is an electromagnetic switch which operates on small electric current that turn on or off a much larger electric current. The live reading of meter is displayed on LCD. For transferring the data wirelessly IOT ESP8266 Wi-Fi module is used. The authorized person continuously receives the notification regarding consumption of power on the smart app that power is on the limit. If the power of the area is beyond the limit at that time the system cutout the power supply of the whole area and the notification is also generated that power is beyond the limit.

For making changes on the limit of meter is possible by RF-ID reader and keypad. Here RF-ID reader reads the ID card of authorized person and Keypad is attached which can be used for enter the security password. For simulation the whole process will be given to the LabVIEW. Here the calculation of total power supplied will be monitored and the permanent record will be stored in excel data sheet.

2.3 Hardware Module-Wise Description

2.3.1 ATmega328 Microcontroller

The Microcontroller that is used in this system is ATmega328 a single chip microcontroller manufactured by Atmel in the megaAVR family. Here microcontroller used for storing the predefined value of voltage in EEPROM memory along with it helps for proper monitoring of power consumed by the meter.

Fig.3- Atmega328 microcontroller

2.3.2 Current Sensor

ACS712 current sensor is used in power monitoring system. It provides precise solutions for AC or DC current sensing which is suitable in industrial, commercial, and communications systems.

2.3.3 Internet of Things (IoT)

IoT is an ecosystem of connected physical objects that are accessible through the internet. To transfer information wirelessly for power consumption monitoring and controlling NodeMCU Wi-Fi module is used. The NodeMCU development board is a powerful solution to program microcontrollers and be part of the Internet of Things (IoT).

Here for monitoring power the IoT ESP8266 modules take the calibration pulse from meter and perform necessary operations afterward it sends the required information like no. of units or power is on limit or not etc. in blynk server from there it continuously notified to the authorized person about the detail of consumption of power.

2.3.3 RFID Reader

EM-18 reader modules are those RFID reader modules that can read 125 KHz tags. It provides security as this is only accessible by the authorized person of electricity board section as the predefined value of the meter is only set by the electricity board so that they can control the power consumption of the whole area. If consumer required more power so as per their requirement the predefined values is change using these EM-18 RFID readers. On showing the ID cards of authorized person along that entering confidential passkey, RFID reader allows them to make changes on the predefined values if the ID cards of unauthorized person is shown at that time the system doesn't allow them to make changes in the predefined value.

2.3.4 USB to TTL convertor

CP2102 chip from SilicionLabs (siLabs) is a single chip USB to UART bridge IC. It requires minimal external components. CP2102 is a powerful tool to make all kinds of PC interfaced projects. This module helps to interface the system with LabVIEW.

2.4 Software Design

2.4.1 Flowchart

The flowchart in fig.4 has clearly defining the actual design steps for power consumption monitoring and controlling system. Here, once the device is power ON all components will initialized. The system will check the connectivity interface is in proper working condition. If the connectivity interface is working properly, then the IoT ESP8266 WI-FI module continuously checks the availability of internet connection for transferring meter status wirelessly to the Blynk server. When the internet connection available matches to the default connection at that time the WI-FI module is ready for receiving the meter reading from the system and transferring meter status to the Blynk server. If internet connection does not match it retry again. After WI-FI module connected the continuous notification will generate on the Blynk application which is installed on the authorized person cell phone or in their PC .It helps to check meter status at any time.

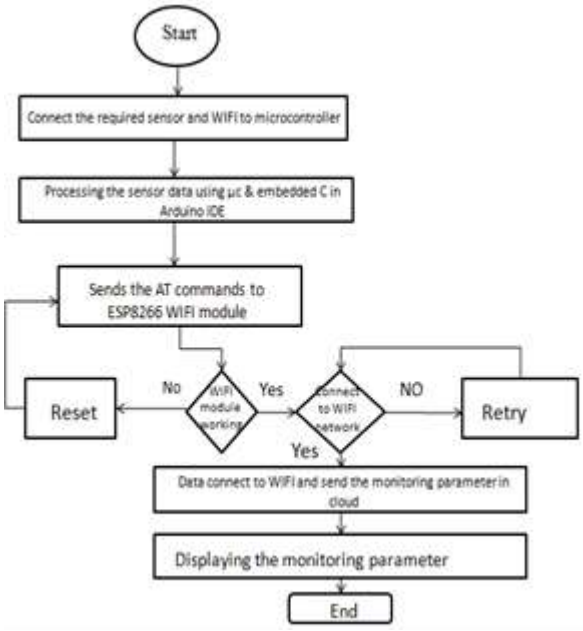

Fig.4-Process flow for sending meter status

The system constantly check if the power consumption occurred is on the limit of meter or not. As shown in fig.5.

If the power is beyond the limit of meter, the sensor will send a signal to the processor which in turn triggers the connectivity interface to send notification on the Blynk application to the authorized person of electricity board section that meter has been using high amount of power. At the same time it cut out the power supply of the whole

colony. In this way the power monitoring of the whole area will be monitored.

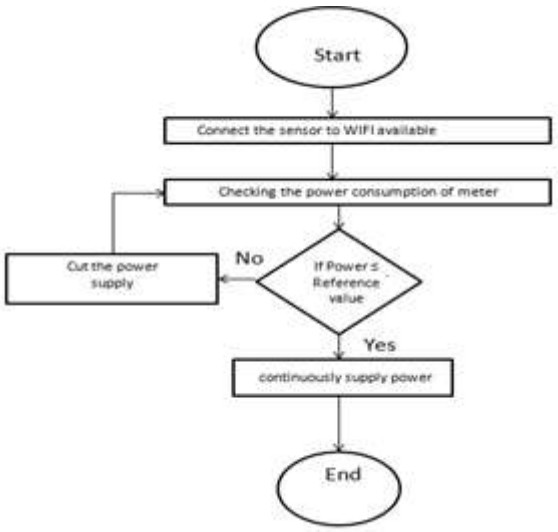

Fig.5-Flowchart for Disconnection and reconnection

3. RESULTS AND DISCUSSIONS

3.1Hardware developed

The figure.6 shows developed system for monitoring power.

Fig.6- Developed experimental setup

3.2 System integration with application

The below figures shows way for information is received and display on LCD, Blynk application and on the front panel of the LabVIEW.

1. At normal condition

Suppose here supplier sets the reference value of system which was placed after the transformer as 230W. Hence power consumption of that particular area will be in the range of 0-230KW but not more than the final limit. On placing the 3 bulbs means power consumption of 3 houses will be calculate. The bulbs are placed in a single board.

Case. I As per below fig.7, 3 bulbs of 100W placed on the bulb board. As power supply of the system turns on then current starts flowing. When bulbs of load1 and load2 are switch on then,

Predefined value = 230W

Total consumption of load = 200W

Fig. 7- System adjustment as per 200W loads at normal condition

The information regarding meter status was received and displayed on LCD and Blynk as shown in fig.8

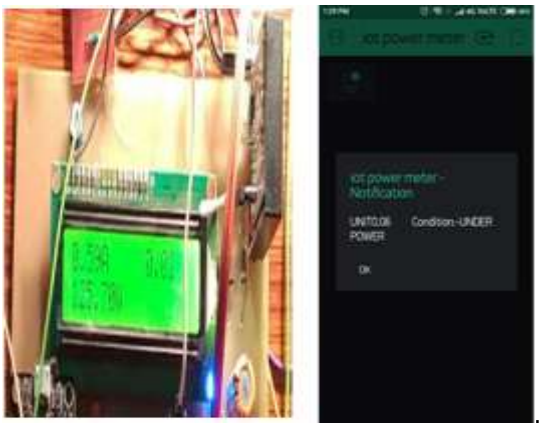

Fig. 8- Meter status on LCD (left) and Blynk at normal condition (Right)

At 200W power consumption the numerical values and graphical values of both current and power w.r.t time shown in fig.9 obtained on LabVIEW.

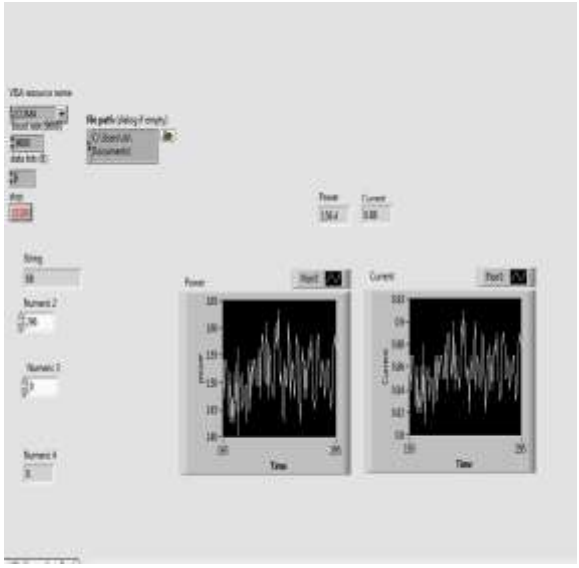

Fig.9- Meter status at normal condition LabVIEW
Overload condition

Case.II As per below fig.10, 3 bulbs of 100W placed on the bulb board in series connection each bulb refers the load of each house. When power supply is turn on current starts flowing in the circuit. When bulbs of load1, load2 and load3 are switch on then,

Predefined value= 230W

Total consumption of load= 300W

Fig. 10- System adjustment as per 300W loads at

The information regarding meter status was received and displayed on LCD and Blynk as shown in fig. 11. Here the power consumes according to the limit of meter so the live reading of meter was shown on LCD. In Blynk application notification regarding meter status is continuously receiving. The Blynk application only gets notification after connecting to internet. The internet that is available when matches to the system programming then only WI-FI is connected. After that the ESP8266 is ready for transferring meter status. Due to this a notification received to authorized person that the power is UNDER POWER. Along that it also notified per unit consumption of whole area. Using this supplier will able to monitor the whole area power consumption from remote place.

Fig.11- Meter status on LCD (Left) and Blynk at overload condition (Right)

At 300W power consumption the numerical values and graphical values of both current and power w.r.t time shown in fig.12 is obtained.

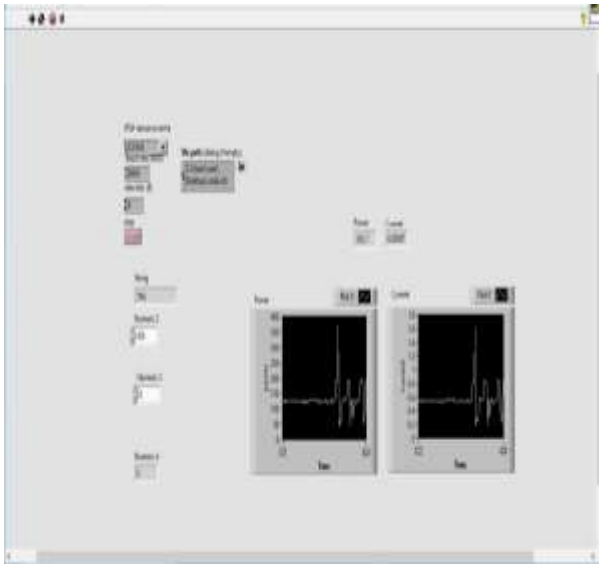

Fig.12- Meter status at over load condition on LabVIEW

3.3 Recorded data

A permanent data is recorded in the excel sheet in the form of date, time and power consumption of the particular area. From this data the authorized person exactly determined the power consumption from the remote place and to analyze the power consumption of the whole area.

Following are the some readings

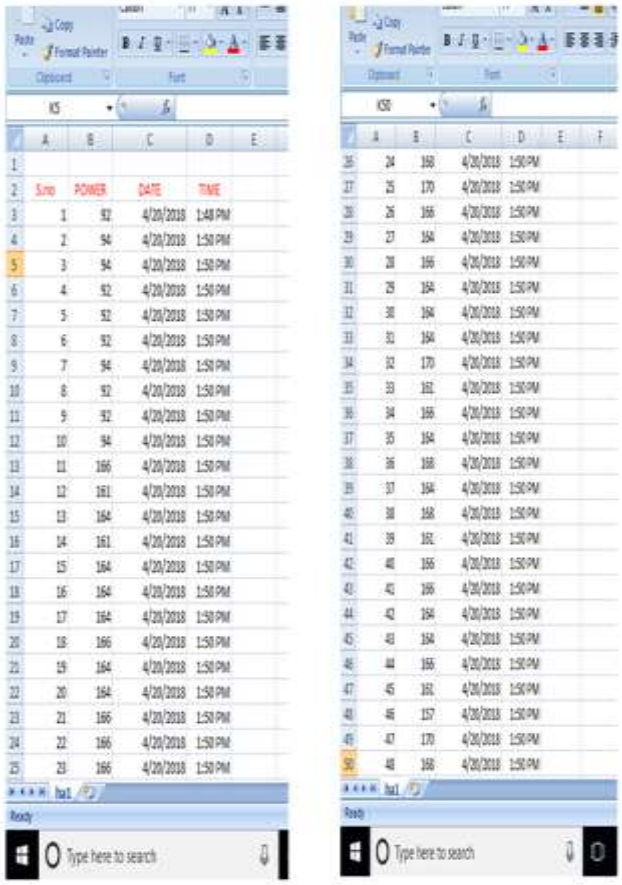

Fig. 13- Calculated Power using LabVIEW

As per fig.13 the variations of current is in milliseconds so on interval of 1minute more amount of reading in terms of power, date and time is stored on excel sheet.

3.4 Graph obtained on consumption of power and current

As the utilization of current increases the power consumed is also increased. In LabVIEW the current will be calculated as

Current = Reference Voltage/ Power Consumed

So the graph is obtained in between power and current. The unit of current which is calculated is in mA and power unit in watt. The fig. 15 shows the graph of power consumed by the whole system.

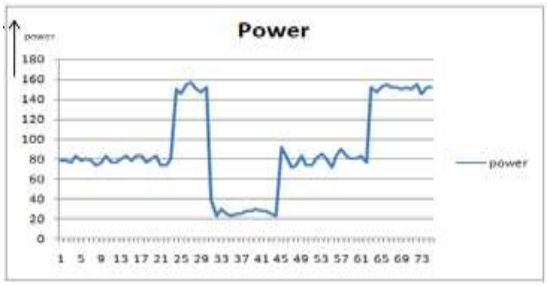

Fig.14-Graph obtained as per consumed

The fig.15 shows the graph of current consumed. The graph of power and current obtained is same. But it differs only on their parameter.

Fig.15- Graph obtained as per current consumed

4. CONCLUSION

With the help of designed model power consumption of a customer is monitored. When the user exceeds his limit of power consumption the supply of power will cut off automatically. The usage of every consumer in the region or sector is sent to the blynk server. Supplier will be notified about the power consumption of the entire region or sector. The supplier can monitor and control the power usage of the user as well as the entire region. The power consumption data sheet of the entire region is generated and analyzed using LabVIEW. If the generated data is provided to the customers, they can compare their usage with the data sheet. So this will help to identify the fraudulent user who is stealing the user's power by direct hooking method.

As the Indian Government has also proposed formation of Smart Cities which will have an effective energy management, transportation, waste disposal and resource conservation strategy using primarily Internet of Things. This wireless IoT based technique is much useful to detect the stealing of the electricity worldwide. So in this work variable voltage and variable power will set according to electricity board section as well as it provide safety as the limit of meter will change by the authorized person.

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