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An IOT based smart metering development for energy management system

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Article Info	ABSTRACT
	The worldwide energy demand is increasing and hence necessity measures need to be taken to reduce the energy wastage with proper metering infrastructure in the buildings. A Smart meter can be used to monitor electricity consumption of customers in the smart grid technology. For allocating the available resources proper energy demand management is required. During the past years, various methods are being utilized for energy demand management to precisely calculate the requirements of energy that is yet to come. A large system presents a potential esteem to execute energy conservation as well as additional services linked to energy services, extended as a competent with end user is executed. The supervising system at the utilities determines the interface of devices with significant advantages, while the communication with the household is frequently proposing particular structures for appropriate buyer-oriented implementation of a smart meter network. Also, this paper concentrates on the estimation of vitality utilization. In this paper energy is measured in units and also product arrangement is given to create bill for energy consumption and implementing in LabVIEW software. An IOT based platform is created for remote monitoring of the metering infrastructure in the real time. The data visualization is also carried out in webpage and the data packet loss is investigated in the remote monitoring of the parameters.

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1. INTRODUCTION

Urbanization results in increase of residential and commercial loads at higher rate in growing nations, It will leads to a demand supply shortfall in numerous nations [1, 2]. In [3], the author predicts that the worldwide energy will get doubled by 2030.Increasing energy demand exponentially will have negative impacts on the surroundings. Naturally the focus is not as it were to produce more power through conventional and alternative resources also the demand can be limited for a better management. In [4, 5] the author proposed that reducing the energy consumption of the building with by means of direct real-time energy consumption feedback is compared with indirect feedback which is similar to month to month bills. In present days Smart meters [6] have been installed in most of the developed countries. In any case, the measuring energy utilization at household is not able to accurately realize the consumer energy utilization design. Motivated by this, a low cost interactive energy management system has been proposed that lets the people to know their electric power utilization design and alter their behavior to decrease their energy consumption.Further, such a scheme can also be associated with generation estimate and monitor to additional optimize the building level consumption [7-9]. From literature [10, 11] it is found that different designs of smart meters that predict power consumption should be noted. In any case, these solutions are

usually higher and hence not possible to develop an energy management system. In this work, an IoT based real time energy measurement and actuating framework is proposed and can be easily integrated with home monitoring systems. The cloud based home automation development is inspired by the necessity to monitor and control the home remotely in an affordable way. The direction of this work is intended towards a private cloud setup managed by the user. This will help the user from feeling an invasion of privacy unlike when a third party is monitoring their house for them. It can read inputs from multiple sensors in multiple rooms of the house via RF and has a base node that is able to connect to multiple relays for controlling major appliances of the home Since it is connected to the cloud, it can be accessed from anywhere in the world as long as internet is available in some form. Real time monitoring system has been developed under Smart Grid Environment, presents a low cost, monitoring system that can be used for quick and accurate smart grid is also able to monitor various power system parameters. It involves measuring the voltage and current waveforms in real time and the detection of the power system disturbances during operation [12]. It provides a dedicated utility communication in cellular network which guarantee high quality for low cost maintenance, reliability with reduced operational cost and strong security is studied in [13]. The combined natural surroundings of Industrial Wireless Sensor Networks (IWSNs) brings more than a few benefits over traditional wired industrial monitoring and control systems, as well as self-organization, quick sending, adaptability, and characteristic intelligent-processing ability. Here ISWN have important role in making a highly reliable and self-healing industrial system that quickly reacts to real-time actions with suitable activities [8]. To provide effective solutions for a variety of regions together with customer electronic device control, energy management and good organization, home and commercial building automation as well as managing industrial plant. For smart home and energy control production a design of a multi-sensing, heating and air-conditioning system and actuation application - the residential users and sensor based network smart light control system are needed [14, 15].

2.   PROPOSED SYSTEM

A smart meter is an electronic appliance to report utilization of electrical energy in interval of one period or less to communicate that data on a daily basis for monitoring and billing. Smart energy meter enables bi-directional communication between the meter and the monitoring system that is represented as Advanced Metering Infrastructure (AMI). Conservative Automatic Meter Reading (AMR) differs from Advanced Metering Infrastructure (AMI) and permits a two-way communications with in meter. The lab view based proposed system is shown in Figure 1. Price/unit will be increased or decreased according to general hours, peak hours and demand requirement given by electricity board. The electrical consumption power can be increased or decreased. An electric device consists of power rating for different loads and is given to second and hour calculation logic block through interfacing bus. On and off time period for each load will be displayed in Second and hour calculation logic block. The power consumed for all loads will be displayed in the total power consumption block.Electric bill for all loads will be displayed in the total electric bill calculation. By using debit card system we can access the information. Home appliances are shown in Figure 2. According to turn ON/OFF load of smart home individual load will be calculated. Depends upon load turn ON/OFF power will be increased or decreased and according to that total unit will be formulate. The total will be increased according to the load consumption.
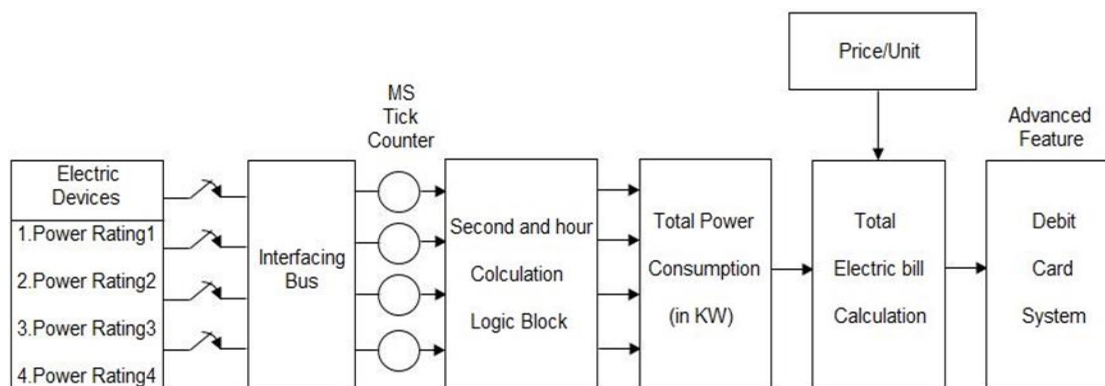

Figure 1. Smart energy meter in labview simulation

Figure 2. Energy monitoring system

AMI is an incorporated system of smart meter, communication network and management of data. Information administration in the AMI framework empowers the two-path correspondence among utilities and Customers.AMI gives continuous information to consumer to monitor consumption of energy. Smart energy meter screens and stores the information of utilization of energy. By using the AMI initiative, the vitality supervision can be acquired data from sensor for a specific building to specific location. Acquired data will be transmitted through the Wi-Fi module to the server. Individual load information will be communicated through smart meter by network protocol. All the information can be monitored in remotely and it can be utilized according to schedule pattern manner in smart building.

2.1. Web server

The Web server is move to a proposed system association to neighborhoods Personal Computers that works as a server and offers observing and control of energy practice to fascinated clients. It utilizes a basic PHP improvement condition and SQL as a database. This can be utilizes to store the power information in the database. A Wifi module can be used to convert the basic HTTP and is used for communication among server. The Graphical User Interface (GUI) of the network application enables clients to include or expel the device. Appliances can be turned ON/OFF by clients in remote manner. Controlling the client's energy usage by network applications is intended to screen. The client includes a device utilizing its MAC address which is put away in the database against client's ID and begins to speak with the server consequently. The output for table creation utilizing HTML is given in Figure 3. The site comprises of login page and a home page and data's are embedded to the database to each 10 Secs.
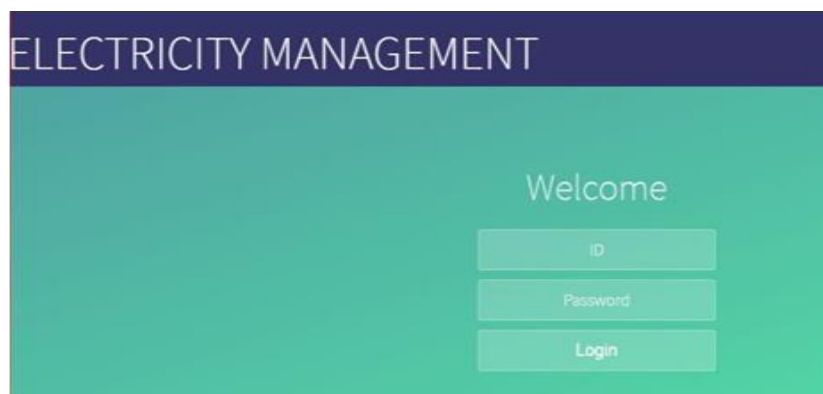

Figure 3. Login page

2.2. Data security

SSL (Secure Sockets Layer) is a regular precautions novelty for building up a programmed interface between a server and a client—typicaly a web server (site). A server can mail information to through server customer SSL grants delicate information, for instance MasterCard numbers, government handicap numbers, and login accreditation to transmit unharmed. The process flow and structure of data security system is

shown in Figure 4. The SSL tradition has dependably been used to encore and secure transmitted data. SSL endorsement has a key match with an open private key. The confirmation similarly contains what is known as the "subject" what is the activities of the endorsement/site proprietor.
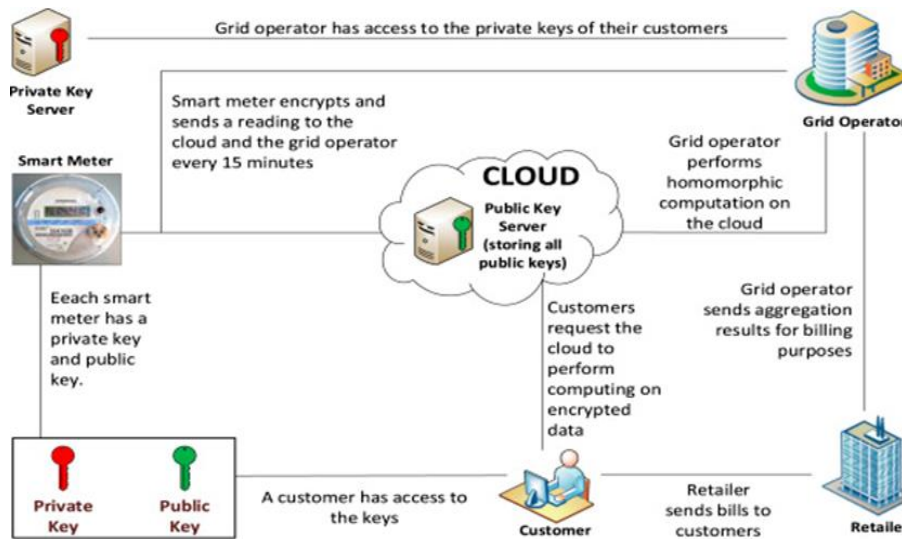

Figure 4. Data security system

3.   PROPOSED IOT BASED ENERGY MANAGEMENT SYSTEM

The system allows alertness to be set for consumption levels above and below "user set trigger levels" and to forecast future energy use. To measure bidirectional flow of energy to enable customers participate in energy management and to perform occupancy detection algorithm to automatically on/off the appliances when not in use. To categorize the loads into levels and perform load shedding in peak hours and hence loads to effective energy management and to allow the system operator to control the appliances remotely by accessing through IOT in case of peak load shaving and power quality issues. IOT plays a vital role in smart buildings energy optimization and next generation building management system. The system has to provide remote control and monitoring by means of few communication protocols. The loads in the building need to be categorized as low, medium and heavy loads. The structure of advance meter technology is represented in Figure 5.
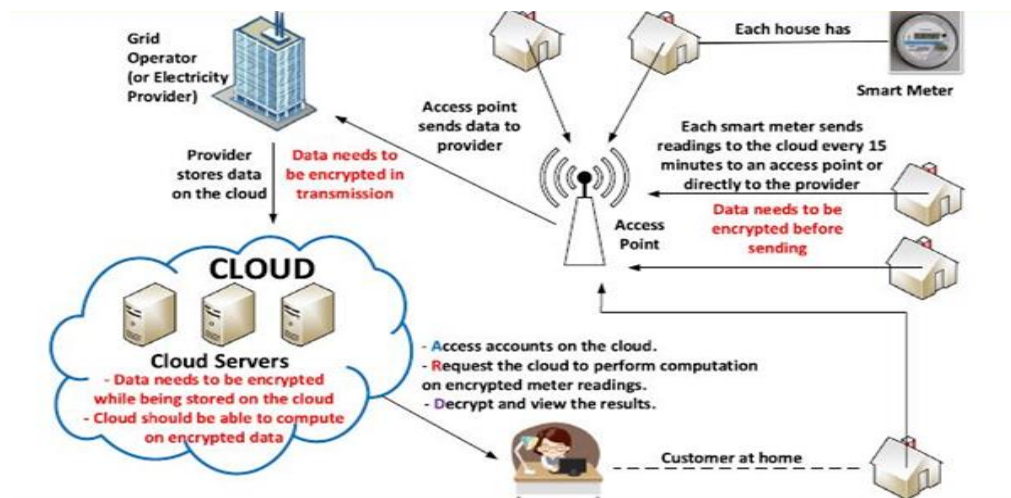

Figure 5. Advanced metering infrastructure

The smart meter developed will measure the electrical parameters in three streams providing separate information about the different types of loads. The data visualization and the data log carried out will provide information to the operator to take suitable actions in case of emergencies and power quality issues. Suitable occupancy prediction algorithm need to be performed based on intelligent methods for accurate prediction of occupants in room. The system operator is also provided remote control of appliances through IOT platform. The proposed hardware structure is shown in Figure 6. In this proposed system data can be communicated through wired or wireless communication technology. To using a raspberry pi processor a information from sensor will be stored according to the load will be Turn on/off developed in a program. By turn ON/OFF different methodology of various loads present in smart home to using IOT platform. Load data can be displayed in web page.
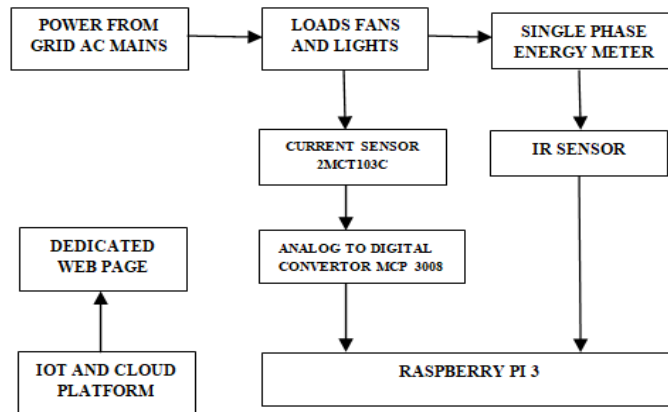
Figure 6. Hardware architecture

4. RESULTS AND DISCUSSIONS
4.1. Simulation platform

In this paper smart meter is developed in LabVIEW platform. Power and energy waveform is measured. Energy and power measurement is shown in Figure 7. Input current and/voltage three phase waveform is generated and it is fed to filter circuit section. In filter section noise will be removed from waveform generation. It will be fed to power and energy calculation for fundamental vector analysis and it is fed to power spectrum analysis. In this system output issampled according to load consumption. It will be given to star to delta or delta to star module for utilizations for single phase or three phase power fed to loads.
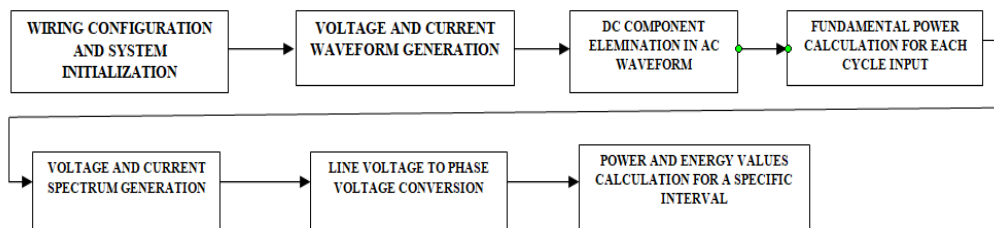
Figure 7. Advanced metering infrastructure

The simulation developed in Lab view is shown in Figure 8 performs power measurement, one-cycle power measurement, and signaling measurement. A power value calculates power value from voltage and current spectra.This simulation proceeds apparent power, active power, reactive power and power factor. Voltage and current waveform for Energy and power measurement in lab view is shown in Figure 9. Power values will be considered and formulated according to true power, apparent power, active power and reactive power. The calculated active and reactive power values will be fed to be considered for energy consumption values are shown in Figure 10.
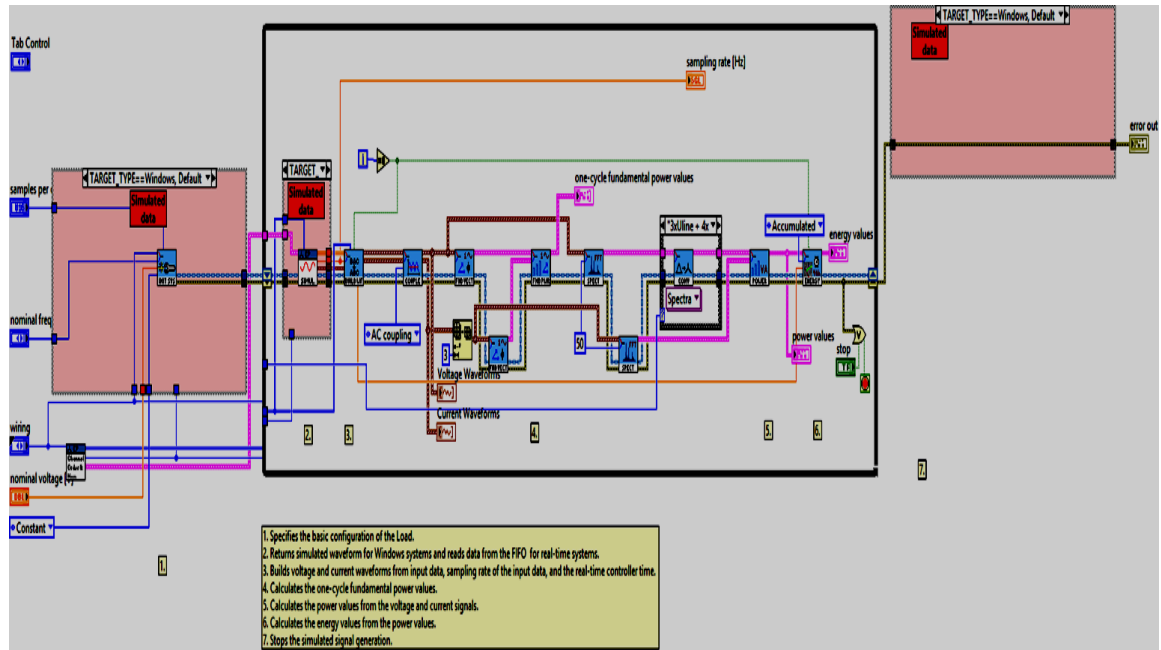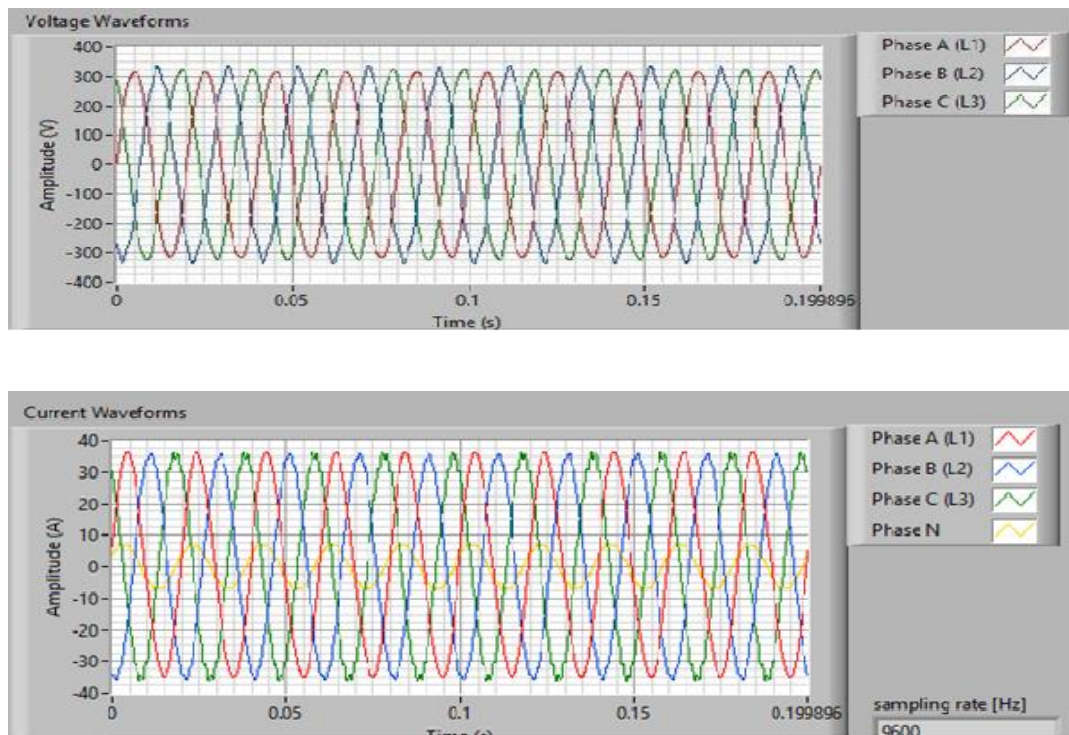
Figure 8. Labview simulation

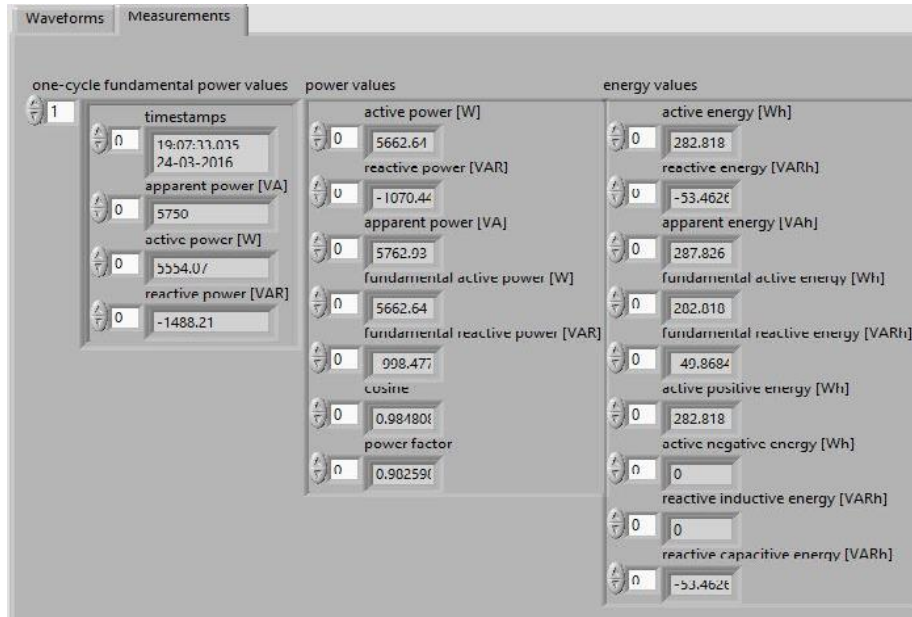Figure 9. Voltage and current waveform

Figure 10. Monitoring platform

4.2. Simulation platform

The different type of loads used for energy monitoring is given in table. Integrated system will communicate between the smart meter and Energy scheduling will be informed to the consumer according to the real time energy usage.Individual data will be measured and communicated through raspberry pi developed. Smart energy will be monitored in remotely and tracked continuously.Smart energy meter system is shown in Figure 11.
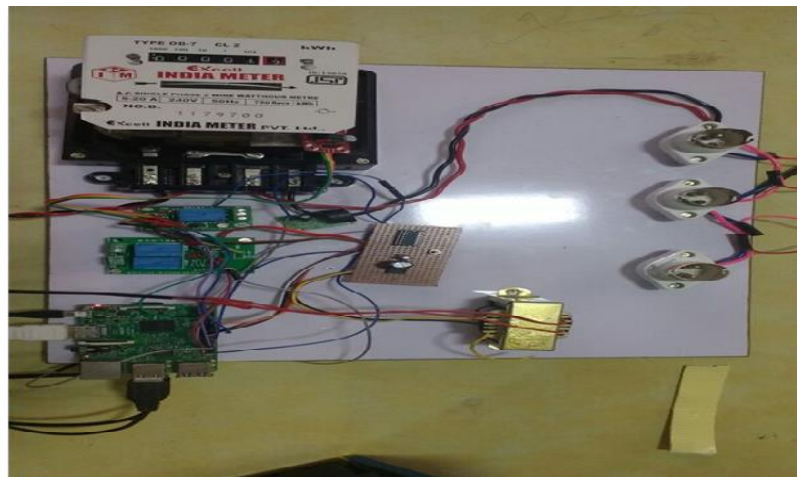

Figure 11. Smart energy meter

In this energy meter read data of loads. Current transformer is used to measure load current and Potential transformer is used to measure the voltage. Raspberry pi has a implicated wi-fi module, ADC and low power consumption.Data of load can be displayed in webpage. The flow chart for the working of smart metering is shown in figure 12. Individual IP address are created for loads. Circuit will be operated depending upon the increase or decrease in loads and corresponding voltage, current and power will be monitored in webpage as well as energy meter.
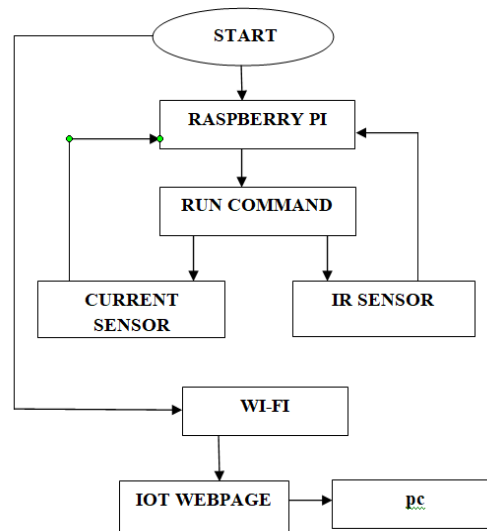
Figure 12. Flowchart for hardware Set up

The setup of Smart Energy Monitoring System is developed in a Lab in the Electrical and Electronics department. Power rating of loads is given in Table 1. For Experimental studies, loads are connected in different combinations as given in Table 2. The load for the different cases are represented in Table 3.

Table 1. Capacity of loads

LOAD	POWER RATING
Fan	50 Watts
Lamp-1	36 Watts
Lamp-2	18 Watts

Table 2. Types of loads

CASES	DESCRIPTION
1	Fan
2	Lamp type 1
3	Fan+Lamp Type 1+Lamp Type 2
4	3 Fan+2 Lamp Type 1
5	2 Fan+Lamp Type 2
6	Fan+Lamp Type 1+Lamp Type 2

Table 3. Load study

Case	Voltage	Current Actual	Display	Absolute	Power Actual	Display	Error
1	230	0.2	0.17	0.03	50	40	-10
2	230	0.15	0.14	0.01	36	33	-31
3	230	0.45	0.56	0.11	104	129	25
4	230	0.96	1.06	0.1	222	244	22
5	230	0.51	0.61	0.1	118	141	23
6	230	0.45	0.56	0.11	104	129	25
6+5	230	0.96	1.03	0.07	222	237	15
5+4	230	1.47	1.56	0.09	340	359	-1
5+4+6	230	1.33	1.96	0.03	444	450	6
5+4+3	230	1.93	2.08	0.15	444	479	33
5+4+3+2	230	2.08	2.11	0.03	480	480	6
5+3+2	230	1.12	1.35	0.23	258	302	-44
5+3+2+1	230	1.55	1.47	0.08	358	338	20
1+2+3+4+5	230	2.75	2.66	0.09	634	612	17

The load curve for the test case is shown in Figure 13. According to increase or decrease loads with different time interval are plotted in graph as shown in Figure 14 and Figure 15. According to all loads are increase or decrease plotted a graph for energy pattern.
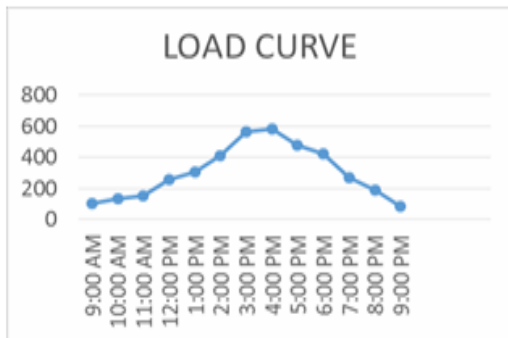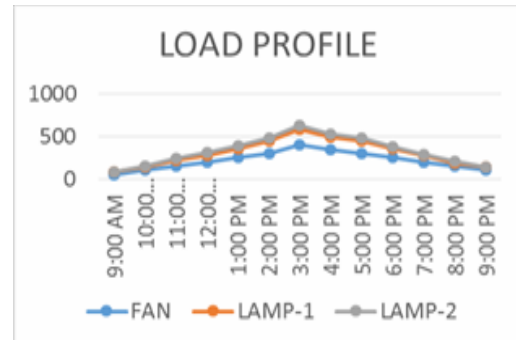

Figure 13. Load curve

Figure 14. Load profile

4.3. Data loss

Losses occur once in single or further package of information travelling crosswise a comparator system is unsuccessful to attain their target. The load data for the study is given in the Table 4. Packet loss is measured as a percentage of packets that are missed with esteem to send packets. Packet loss is detected through application protocols system administrator needs to detect and diagnose packet loss. For testing this ping command is used.

Figure 15. Data loss

Table 4. Data loss study

PARAMETER	RESULT
Size of data	32 Bytes
Packets sent	4
Packets received	4
Minimum round trip time	115 ms
Maximum round trip time	143 ms
Average round trip time	129 ms

5. CONCLUSION

Different types of loads are categorized as medium loads, heavy loads and light loads. Sense overcurrent and switch the medium loads like fans and lights to batteries powered by solar module (low rating enough).Wireless transmission of data between smart meter and server system, fast communication without any data packet loss. All data's are monitored in data logs and storage in the server. Graphical monitoring of the real power, reactive power, power factor, power quality, current, voltage and system states. Development of web page and load scheduling through IOT platform by remote monitoring.

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