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Home Energy Management System for Appliance Scheduling using Markov Chain Algorithm

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ABSTRACT

Recent trends in electric meter is based on Global System for Mobile Communication(GSM), Radio Frequency Identification(RFID), Remote wireless energy measurement from meter. But none have turned to solve the problems related to power demand. In this paper, we propose a solution to solve the problems associated with power demand by designing an electric meter that efficiently handles the power consumed by the users with the power available at that time. So in order for efficient scheduling of appliances a Markov chain algorithm is used. It provides maximum use of the available power, hierarchy based scheduling, information to consumers about power shutdown. Thus the power consumed can be distributed to other places to compensate for the demand.

Keywords: GSM modem, Power demand meter, Home energy Management, Advanced metering infrastructures, RFID, Markov chain algorithm**.**

1. INTRODUCTION

With the latest research in science and technology, electric energy has become the basic needs to carry out our daily life. Power demand is the main crisis that our country is facing. Mostly industries are greatly affected due to insufficient power supply. Energy is one of the important means for the growth of the financial status and important factor for the increased growth of a state or country . Demand side management is one of the key components of future smart grid to accomplish more efficient and dependable grid operation. The primary goal of demand side response is reducing the peak load which in turn reduces the generation cost of electricity . Since 2008, SGCC (State Grid Corporation of China) has carried out an overall construction work of the power user electricity meters which widely used in this system had been undividedly designed according to the new smart electricity meter technical specification.

In order to protect the economic interests of the power company and the power consumers, SGCC demand these new designed smart electricity meters must past all the function detection, including measuring accuracy function detection, communication function detection, safety protection function detection were used before this system. The Energy Consumption Scheduling (ECS) devices are developed as a part of smart meters which is connected not only to the smart grid but also to the local area network in order to handle a two way communication in smart grid infrastructure. The controlling of various devices at home is based on certain priority levels. So the total consumption of electric energy will always remain below a certain range. The smart electricity meter detection device which has the communication detecting capability, IC card reader, Detection software to successfully detect smart

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electricity meter functions automatically. So, in this work development of a smart electricity meter that will operate the devices based on the load available at that time along with providing an information to consumers about maximum power demand by means of Markov Chain Algorithm. So the advanced metering infrastructures provide a time based controlling that makes the consumers reduce the peak consumption.

2. LITERATURE REVIEW

In this paper [1] author describes the smart metering infrastructure at scale where the demand-response (DR) programs may be tailored based on user's consumption patterns as obtained from sensed data. For issuing DR events it is important in understanding the materialistic consumption dynamics as to duly segment the user population. The occupancy states can be inferred from hidden Markov model framework. Occupancy is characterized by magnitude, duration, variability. The users can be grouped based on their consumption patterns into groups that denotesqualitatively different fluctuations that may be abused for the program enrollementpurposes.In this paper [2] author describes the boosting of power scheduling for energy management in particular to smart homes. A lot ofpower scheduling methods for energy management in smart homes has been done. The concept mainly focuses on fuzzy logic, neural networks, heuristic methods and evolutionary algorithms.In this paper [3] author describes the optimal and autonomous incentive-based energy consumption scheduling algorithm for smart grid. The Energy Consumption Scheduling (ECS) devices in smart meter for autonomous demand side management within a neighbourhood, in which a large number of buildings share a common energy source. The ECS devices are assumed to be built inside smart meters and to be integrated not only the power grid, but also to an local area network which is important for handling a bi-way communication within a smart grid infrastructure. They interact automatically by running a distributed algorithm to find the minimal energy consumption scheme for each subscriber, with an aim at decreasing the maximum energy cost in addition to the peak-to-average-ratio (PAR) in load demand of the system.In this paper [4] author describes the advanced demand side management for the future smart grid using working design. The user is equipped with an Energy Consumption Controller (ECC) as a part of its smart meter. All smart meters are connected to not only the power grid but also a communication framework. This allows bi-way communication among smart meters and the utility company. The Vickrey-Clarke-Groves (VCG) aims to maximize the social welfare that is the aggregate utility functions of all users minus the total energy cost. The energy provider determines each user's electricity bill payment. Finally some important parameters such as efficiency, user's truthfulness, and non negative transfer are verified. In this paper [5] author describes a distributed algorithm of appliances organizing for home energy management system. Each user in the system will find an optimal start time and operating mode for appliances in response to varying electricity prices. An appropriate Greedy algorithm is used to schedule the appliances. Each user requires only the knowledge of the price of the electricity which depends on the collective load of other users, instead of load profiles of characteristic users. A penalty term in the cost function, which put at disadvantage of large changes in the scheduling between repeated iterations, is used.

In this paper [6] author describes smart power scheduling for demand response on the smart grid. A power scheduling based transmission protocol for home devices integrated with the home area network and receiving real-time electricity prices via a smart meter is proposed. A joint media access and appliance scheduling approach is developed to allow appliances to equalize power usage so that total demand for the home is kept below a target value. Two types of appliances are considered real-time which exhaust power as they desire and schedulable which can be turned on at a later time. In this paper [7] author describes an optimal power scheduling method for demand response in home energy management system.The homegateway (HG) receives the demand response (DR)information indicating the real-time electricity

price, which is then relocated to an energy management controller(EMC). Referring to the DR, the EMC achieves an optimal power scheduling scheme, which is being supplied to each electric appliance by the HomeGateway. Proportionately, all appliances within the home will operate unquestionably in the most cost-effective way possible. To avoid the high peak-to-average ratio (PAR) of power, the real-time pricing model with the acclivity block rate model is utilized. By adopting this combined pricing model, the power scheduling method effectively reduces both the electricity cost and the PAR, conclusively improving the stability of the entire electricity system. In this paper [8] author describes a home energy management system for high power intensified loads. A home energy management system (HEM) is mainly used to increase the work of smart grid with the inclusion of demand response triggered application for residential customer preference. Demand shifting technique depends on demand shifting algorithm where the HEM system is developed in order to monitor the time requirement and power consumption for operation of various equipment and tries to alter the operation of certain unnecessary and supervise the power consumption of individual equipment. It acts as a modern home energy meter. The main purpose of the system is low the peak power demand and tries to keep the load curve smooth without disturbing the customers comfort zone. In this paper [9] author describes a Markov chain analysis of genetic algorithms (GA) with a state dependent fitness function. The fitness function is determined depending on the state of the whole function. For minute alteration in the probabilities, the limit distribution will put almost all the weight to the homogenous states. describing the state sub-ordinate fitness function as an monetary system will be asymptotically permanent with respect to intended working of the GA. In this paper [10] author describes development of a smart power meter for AMI based on Zigbee communication. An outage recording system is designed and embedded into smart meter. A zigbee based system is designed and integrated into power meter and used to transfer the in-depth power consumption data and outage event data to rear end processing system. The smart power meter can not only be used for power consumption data collection but for outage event data recording.

3. PROPOSED SYSTEM

The proposed system is designed in such a way that it solves the entire problem in the existing system and providing an efficient energy management system. It targets on power saving, preventing electricity theft, power demand, flexibility to consumers to operate desired loads. After initializing, the power demand meter circuit it should synchronize the microcontroller with the Global System for Mobile communication . By forwarding MASTER & SLAVE command, set one person as master and other person as slave the master unit will the Tamil Nadu electricity board and slave will be the consumer. From the Master mode send a command to the SIM in the GSM circuit to set the power meter to custom mode or unlimited mode. By means of setting the command, the power will be scheduling among all the appliances. However, the main goal of the demand response is to reduce electricity demand. The power demand meters reduce the use of inverter and save electricity for future use. By using the power demand meter, many things can be monitored and controlled continuously. The simulation is achieved by means of Proteus software. Proteus combines the schematic and layout diagrams to provide a powerful and integrated results. Proteus design suite is completely different in contributing the ability to co-simulate the high level and low level microcontroller code.

The proposed system will operate in three modes custom mode, limited mode, full power mode. When the generated power is about 200Mw then the message will be passed to the consumers by means of GSM about the low supply and automatically the Watt HrMeter will switch over to the custom mode where devices operating in a supply less than 200 Mw will be operated.When the generated power is about 200M to 300Mw then the supply will be provided to particular load lines where devices greater than 200Mw and less than 300Mw will be operated.When the generated power is more than required or in excess then the normal mode operation where all the devices will be operating.

4. SYSTEM MODEL

The main objective of deploying energy management system in the home is to minimize the expense of electricity and reduce the peak to average ratio by scheduling the pattern of electricity usage based on priority to ensure power system stability and security.

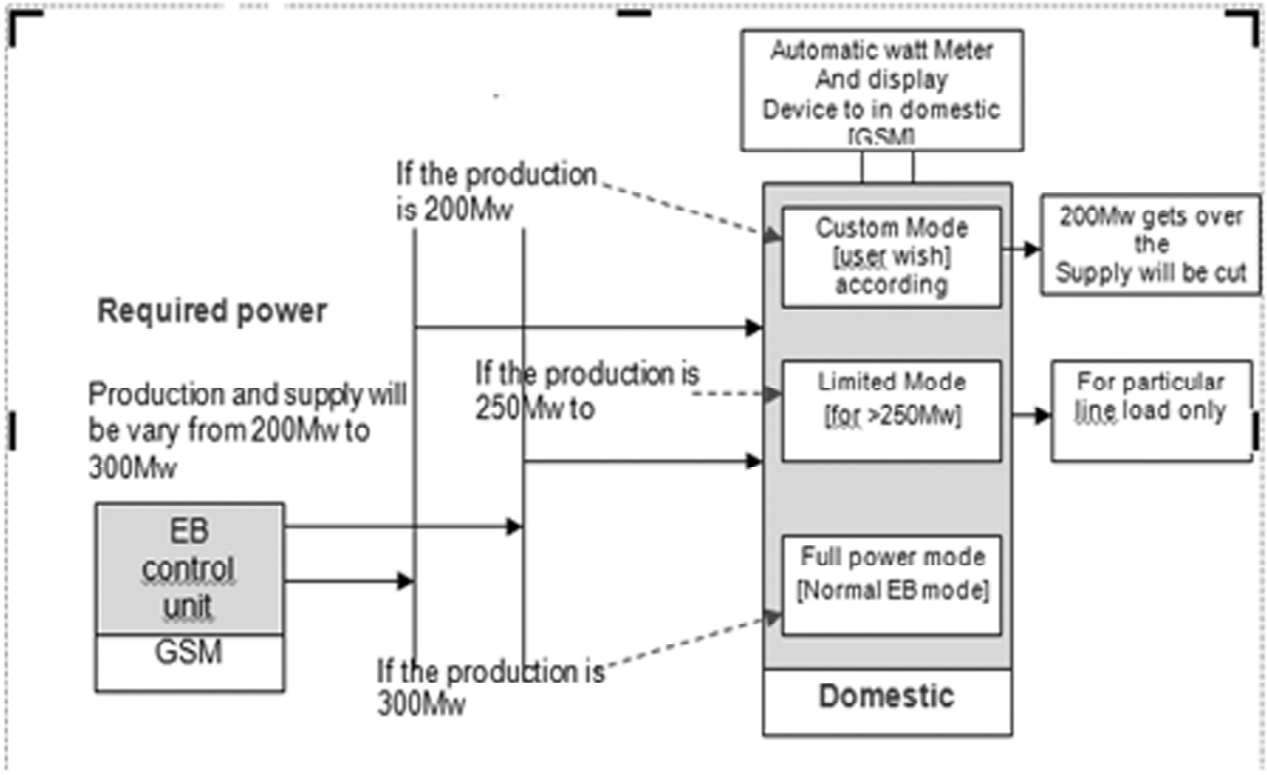

Figure 1: Diagram of proposed system

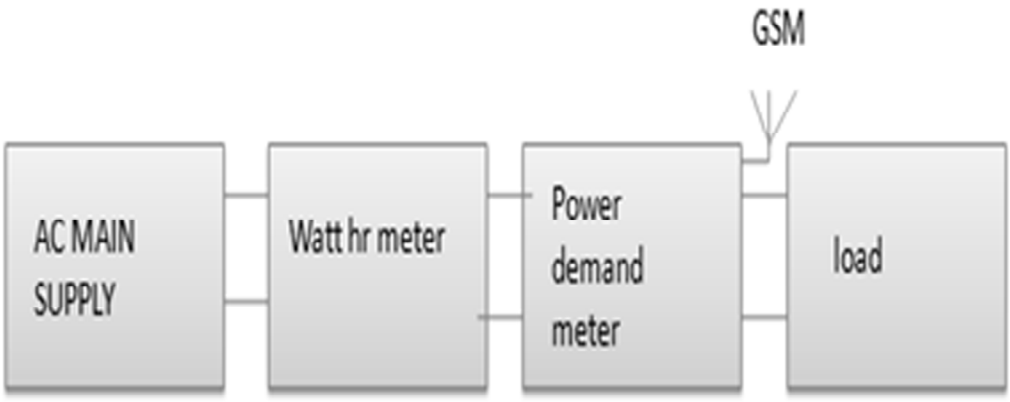

Figure 2: Block diagram at consumer premises

Figure 3: Block diagram in TNEB

4.1. AC Main Supply

A voltage of 230V with a frequency of 50Hz is the most commonly used AC supply. The AC power unit will have a step down transformer on every electric poles, which will step down the AC voltage from the transmission lines to a normal AC voltage of about240V for home supply purposes. The 240V supply has three wires, where two wires carrying 120V each having 180 degrees phase difference and third wire is neutral or ground. The formula to calculate the phase voltage is given by,

$$\text{Phase voltage} = \text{line voltage/root 3} \quad (1)$$

4.2. Watt Hr Meter

Watt-Hr Meter is a device that measures and records the electric power flowing through a circuit. The typical electric meter consists of a counter and a motor. An indefinitely a very small amount of the current passing through that circuit is diverted to make the motor run. The speed at which the motor rotates is proportional to the current flowing in the circuit. The most commonly used Watt Hr Meter is the electromechanical induction meter. The number of revolutions that the disc completes is given by the following formula

$$P = ((3600.Kh)/t) \quad (2)$$

4.3. Power Demand Meter

A demand meter has two pointers, red denotes the actual or the real time consumption and the black pointer indicates the last peak value being read. Even if the loads are reduced and the power consumption is decreased the black pointer in the maximum power demand meter points to the last peak value being measured. The red pointer points to the present electricity being consumed. This is the most important device in restricting the maximum power consumption.

4.4. GSM Modem

A GSM modem is a special type of modem that has a SIM card and provides subscription to mobile user. Communication unit establishes connection between home energy management unit and the load controller. GSM helps the Home Energy Management unit to send signals that act as a command signals based on the power available and the load priority. Using this modem the information is intimated to consumers easily. The blocks within a GSM are:

- Base station subsystem
- Network and switching
- GPRS core network
- Operation support system

The reason for selecting GSM modem is that it supports wide range of frequencies, Supports integration with RS232 cable, input voltage varies from 5v to 30v, Can be interfaced to system using USB cables, very less weight in few grams, provided with SIM holder and SMA antenna connector, programmable with AT commands.

4.5. Load

An electrical load is a electrical component or a portion of circuit that consumes electric power .Electrical load generally converts the electrical energy into light, heat or mechanical motion. The load can be either resistive, capacitive, inductive or a combination of all. The load can be any devices such as lights, fan, coolers, TV’s at home or machines in industries. The formula to calculate load is given by,

$$\text{Watts} = \text{Amps} \times \text{volts} \times \text{powerfactor} \quad (3)$$

$$\text{Kilowatts} = (\text{Amps} \times \text{volts} \times \text{powerfactor})/1000 \quad (4)$$

$$\text{Megawatts} = (\text{Amps} \times \text{volts} \times \text{powerfactor})/10\text{^}6 \quad (5)$$

4.6. PIC Microcontroller

PIC 16F877A is used for programming in Proteus. It has a 40 pin Dual –in-line package. It has many inbuilt peripherals. Every pin is only used between two or three functions so it makes easier to decide which function the pin is performing. It has a Liquid Crystal Display, 8 channels, a 256 bytes of data memory in EEPROM, 2 comparators of analog-to-digital converter, synchronous serial port.PIC mainly uses improved Harvard architecture and RISC architecture. The code is written entirely in embedded C language and converted into HEX file. This HEX file is then dumped into the PIC microcontroller and the simulation is obtained.

5. SIMULATION RESULTS

Figure 4 denotes the simulation diagram using Proteus software. The software version used is ISIS professional version 7. The program is usually written in CCS compiler in Embedded C language. The developed program is implemented in Proteus software. The coding is dumped in the PIC microcontroller and all the components

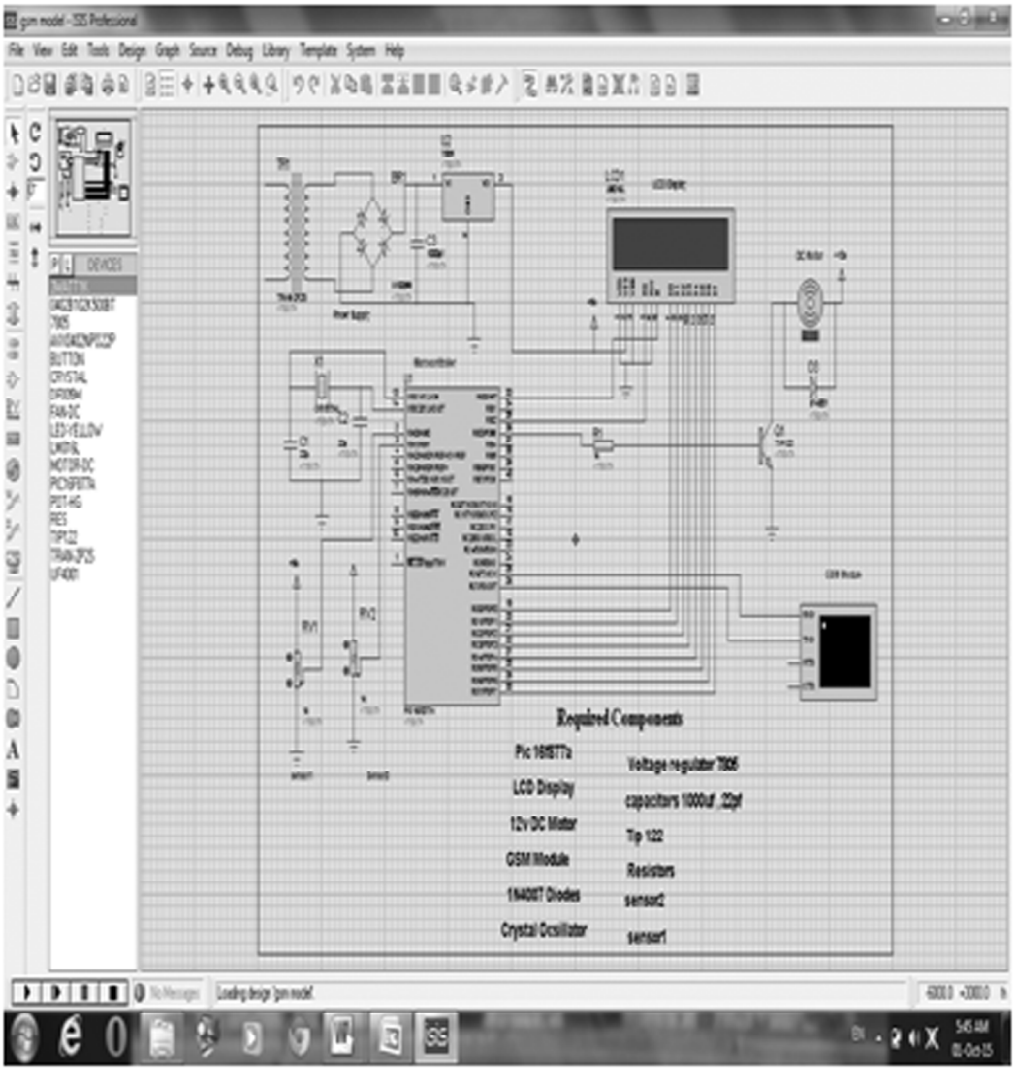

Figure 4: Block diagram in Proteus

are placed and the simulation is obtained. The simulation is obtained for three modes. The highly efficient Markov chain algorithm is implemented for the proper switching from one mode to another mode. The shutdown information is known to consumers by means of the newspapers. But this project strives to intimate the consumers about the shutdown information by means of a message through GSM to their corresponding mobiles. So this will help them to do the basic needs to run their life without electricity.

In industries, the maximum power demand indicator can be implemented along with the three modes of operation. The maximum power demand indicator will make the largest peak value ever recorded.So if the particular value is reached in order for prevention from over-usage the consumers are intimated by means of message through GSM. This makes them free from penalty. If decision is made according to the available power then there will be less chance for power shortage. This reduces the risk of power shutdown on a periodic basis.

Figure 5 shows the simulation results in virtual terminal. If the current in the load lines show a value for example from 200Mw to 300Mw then this will switch to limited mode and the message will be intimated to consumer via GSM.

Figure 6 shows the simulation results in virtual terminal. If the current in the load lines show a value for example less than 200Mw then this will switch to custom mode and the message will be intimated to consumer via GSM.

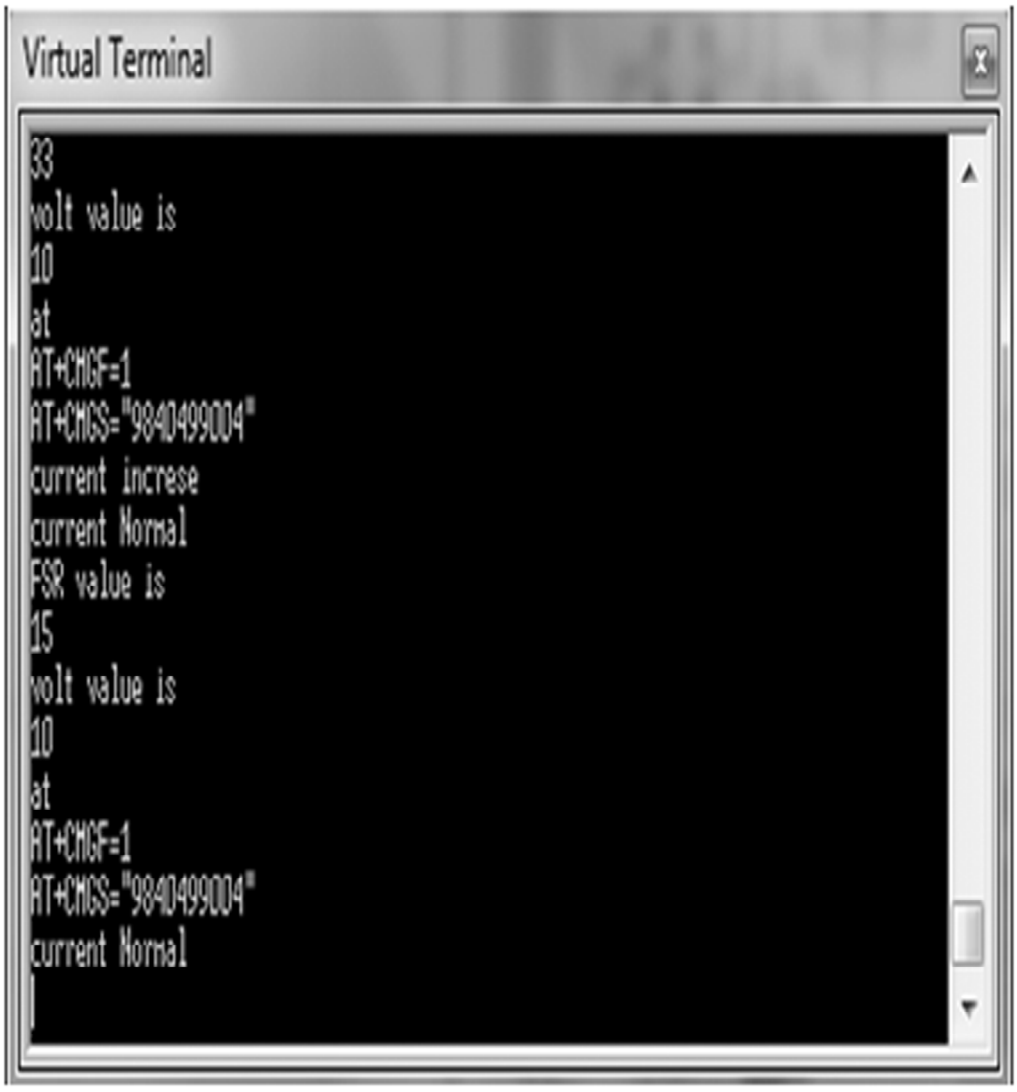

Figure 5: Simulation output of virtual terminal for current normal

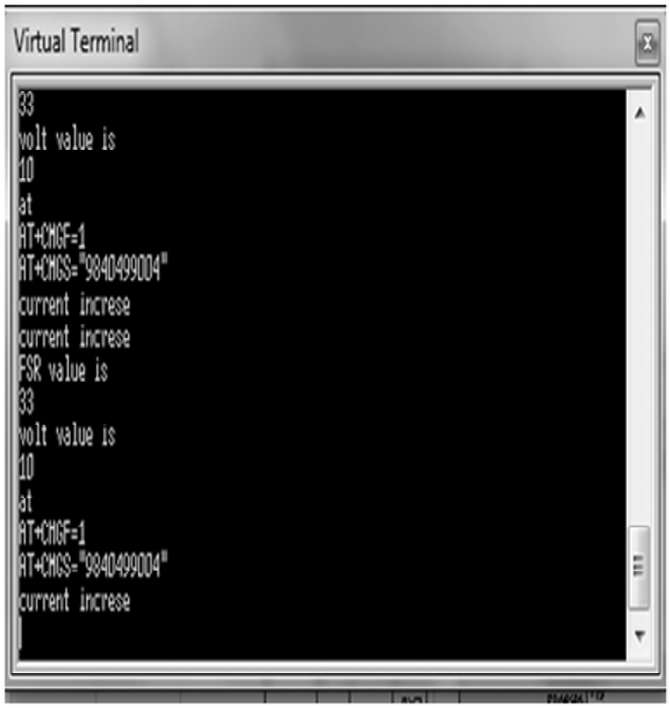

Figure 6: Simulation output of virtual terminal for current increase

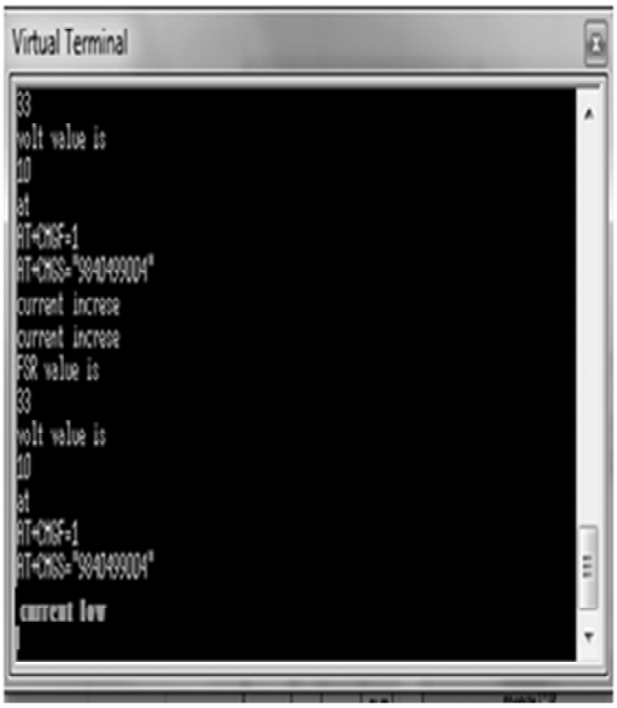

Figure 7: Simulation output of virtual terminal for current low

Figure 7 shows the simulation results in virtual terminal. If the current in the load lines show a value for example greater than or equal to 300Mw then this will switch to full power mode and the message will be intimated to consumer via GSM.

6. CONCLUSION

In this paper we have proposed a Markov chain algorithm of appliance scheduling for home energy management system. It provides an efficient distribution of the power to devices based on the available power at that time. As the basis for efficient energy management the demand response information will be provided to every home energy management system. With the help of energy management system being installed at every home the consumers can make use of this information via a home energy management controller. The consumers are provided information about the shut down by means of GSM modem .Simulation is demonstrated by means of Proteus software .The same can be developed to control the high power consuming devices in industries, etc. The power demand meter can be installed and the maximum power consumption can be controlled in prior. Prepaid meters can also be used to control the consumption and reduce the electricity prices.

The simulation can be implemented in hardware and is used for real time implementations. The same can be developed to control the high power consuming devices in industries, etc. The power demand meter can be installed and the maximum power consumption can be controlled in prior. Prepaid meters can also be used to control the power consumption and reduce the electricity prices. Some complex algorithms can be used to achieve improved results.

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