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Implementation of WSN based Smart Sensor and Actuator for Power Management in Intelligent Buildings

ABHISHEK R. MAHAJAN[1], PROF. S.M.PATIL[2]

[1]PG STUDENT, Electronics & Telecommunication Department
Datta Meghe College of Engineering, Mumbai University
Airoli, Navi Mumbai, Maharashtra, India
[2]ASSISTANT PROFESSOR, Electronics Engineering Department
Datta Meghe College of Engineering, Mumbai University
Airoli, Navi Mumbai, Maharashtra, India

Abstract - *The implementation of a smart monitoring and controlling system for household electrical appliances in real time is proposed in this paper. The system monitors electrical parameters of household appliances such as voltage and current and calculates the power consumption. A Visual Basic application is included in the system which will be controlling all the activities of the system in user controlled mode [manual mode] or system controlled mode[Intelligent mode]. This is improvise the savings of the energy which will provide better efficiency and power management in the buildings.*

***Key Words*: Maximum demand Controller, Load priority, Power Management , Consumption, Radio/RF link, Wireless Communication**

1.INTRODUCTION

This system is designed as a solution for a major issue related to the demand and supply problem related to the electricity distribution or usage in the domestic area or in some of the areas of the industries. Whereas the unit consumed per unit time by the utility is considered to be demand by the system. In particular time period at which maximum power is demanded that is called as peak duration or maximum demand period. We are suppose to control consumption by the end user load by assigning the priorities to the load and suppose to control it using priority algorithm. There are various demand management algorithms are available to control the demand ratio. The first step to an effective energy load management is to calculate the consumption of each appliances . Calculate monthly energy consumption and demand for load and then finding the rate charges available in the system to determine the most effective low cost with user defined comfort conditions. In order to reduce peak demand system will automatically turn off the large load in particular peak time. but at the same time system will also determine the priorities of the load in order to sustain the comfort zone of user.

All the load equipments connected in the system are continuously monitored using current and voltage sensor in order to calculate the power getting consumed by the load. also a switching section is provided in the system at sensor node for turning off the devices in case of over load condition occurred. For communication between all nodes and master software a 2.4GHz radio link is implemented among the sensor nodes so that Visual Basic application can query particular node for current energy consumption.

2. RELATED WORK

Now a day's systems are arising for home environment which aim to integrate renewable sources, lighting control or by implementing some time based mechanism for household appliances in order to make advanced auto operation modes. The impulse given by the newest technologies for communication networks have also become a big step in this field, where the high cost of wired infrastructures plus the limits in the existing ones have been solved by means of the wireless networks like Wi-Fi, Bluetooth or ZigBee Our main goal is the creation of an application to control the power consumption, which will be supported by ZigBee Technology. This network will follow the philosophy of the WSN (Wireless Sensor Network), where a central coordinator is responsible for carrying out the task control algorithm, while the nodes simply provide parameters for the decision and are responsible for acting on the loads. Currently, ZigBee is the leader in monitoring and control products to manage energy and water. The ZigBee Smart Energy profile is one of the main areas in development in recent years for energy efficiency. Furthermore, this profile is complemented with other profiles such as Building Automation, Home Automation or Light Link. As previously mentioned the term Smart Energy involves both home and business users of energy, and for suppliers, so is intended a constant communication by means of which is possible to reduce individual consumption and efficiently manage the connection and production of energy from facilities., Subhash Chandra Mukhopadhyay, Nagendra Kumar Suryadevara[1] had partially implemented the real time monitoring and controlling system for household appliances. The low power RF based system reduces the ideal mode power. The sensors monitor & calculate the electrical parameters such as voltage, current the calculated sensor output is then sent to the radio module. The data is wirelessly sent to the main mode at computer which is used further for control application.

3. STATEMENT OF PROBLEM

It has been observed that a lot of energy is wasted due to unnecessary use of electrical appliances. Also, it is very difficult to track this wastage of energy resources on human level. The system will ease these extra efforts which will simplify our lifestyles and lead towards progressive methods of energy utilization. A brief overview of related electrical usage by several electrical appliances is provided in this report. Although a large number of methods for power management systems have been proposed over the past years, it is hard to find the best state-of-the-art method because of non-availability of standard datasets, ground truth, and common evaluation measures. However, there is still a lack of performance for power management systems. The objective is to develop a comprehensive performance algorithm for energy management. Since numerous efforts concerned with energy resource management are made on trial and error basis it is crucial to implement a substantial system which will surely make an impact on this performance.

4. BLOCK DIAGRAM

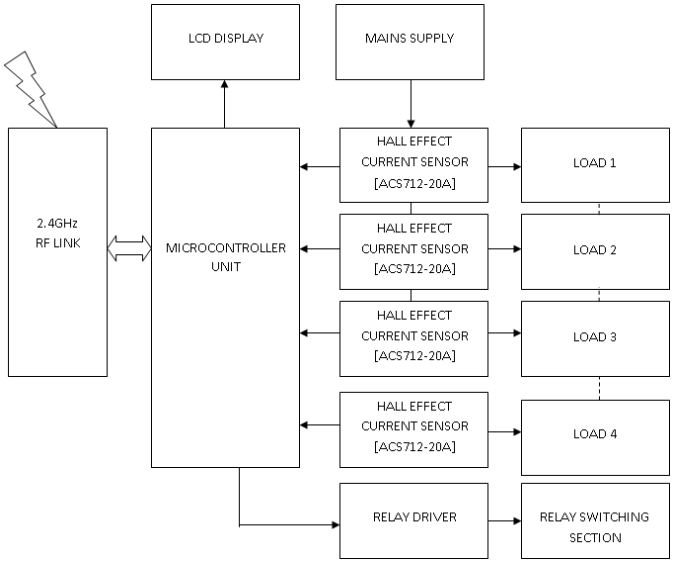

Fig -1: Sensing Unit Block Diagram

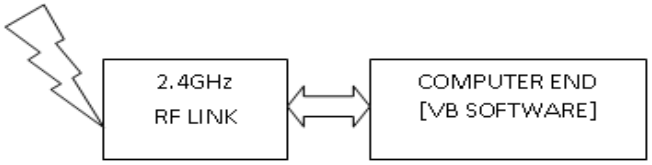

Fig -2: Control Unit Block Diagram

5. IMPLEMENTATION & WORKING OF THE SYSTEM

As system block show, power sensor i.e. voltage and current sensor are used. Whole operation of the circuit is controlled with the AVR microcontroller. ACS712 based current sensor are used which are having linear relationship with input AC/DC current. RMS value of the current is calculated using the controller. All the parameters from each load is combined in one packet frame and combined with network address to be send by the wireless transmitter.

At receiver end wireless receiver, receives the packet and decode it for extraction of the required data for processing at computer end. Depends up on the data received from the sensing node, visual basic software distinguish between power consumption values of each load and assigned them to corresponding fields. Then system will check for the user assigned load priorities and maximum demand limit, if current demand value fall of the limit window then system will turn off the load according to priority to maintain the limit. For switching of the loads computer software will send relay switching commands on reverse channel to the sensor node. For time limit or peak time selection control option is included to enable automatic demand control on time basis for auto start functionality. Manual mode is also provided in the software to manually turn OFF & ON remotely.

6. PROTOTYPE HARDWARE

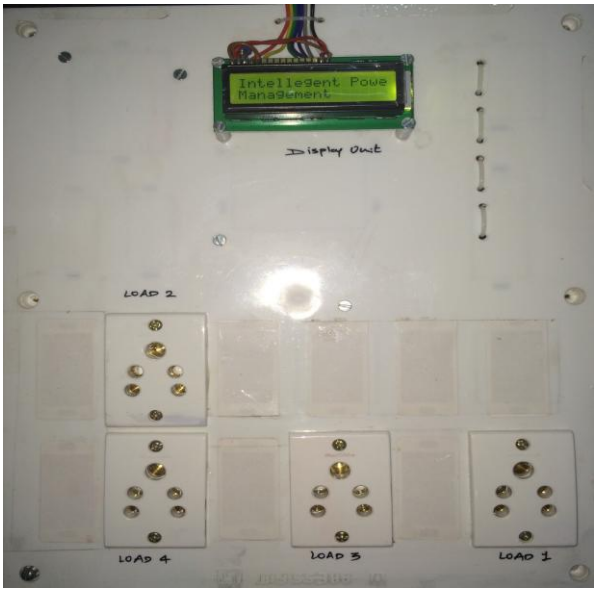

Fig -3: System Prototype Hardware

For real time implementation of the system, whole hardware is incorporated into the common power outlet box as shown in fig.3 which can be easily installed in homes to measure the consumption & to control the switching. At now each socket is capable of delivering maximum 5Amp of current to the load.

Fig -4: Parameter status Display

As shown in fig.4, a display is provided which shows the current and power getting consumed by each load connected to the power outlet. For demonstration an indecent lamp load is connected at power outlet no. 2 which is consuming 0.53A of current results in total power consumption of 127.67 Watts.

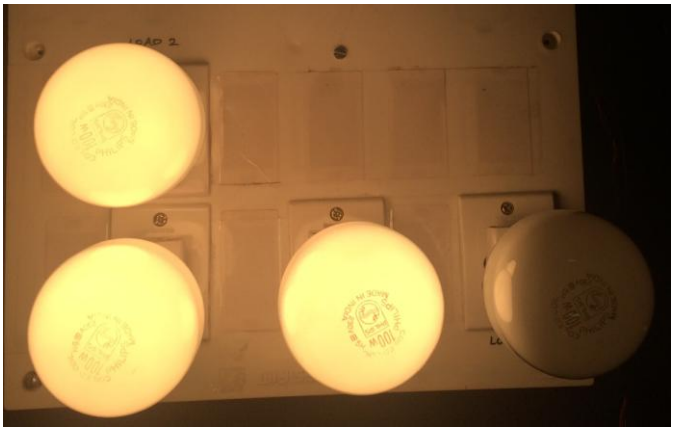

Fig -5: Auto Switching OFF of the load

Fig.5 shows the automated switching condition of the system in which, at First iteration to maintain the demand limit level lowest priority load 1 is automatically turned OFF where as rest of the loads are still in ON state. Whereas in second iteration if the total consumption is still above the limit another comparatively low priority load will get OFF automatically.

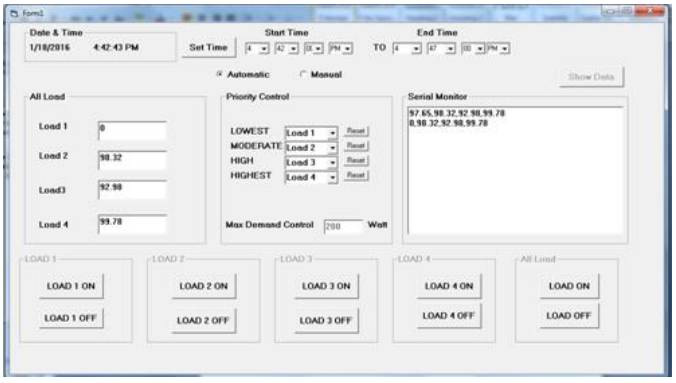

Fig -6: System Automatic mode with load 1 OFF

Fig.6 shows the control software screen in which, demand is set on 200W and priorities of the loads are assigned to load 1 to load 4. Thus at first iteration system has turned OFF the lowest priority load (i.e. load 1) and second iteration is still in the execution.

7. RESULT ANALYSIS

By considering above system, we can compare the results based on switching time, maximum allowed load in peak time and static model analysis.

MATLAB MODEL ANALYSIS:

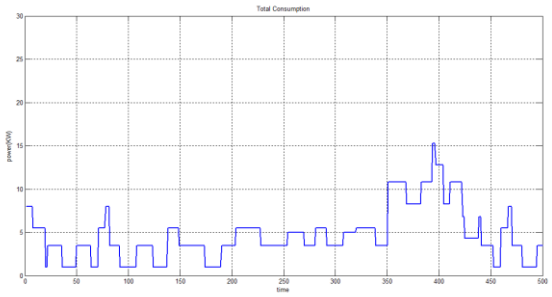

Fig -7: Matlab simulation with static electrical appliances models with respect to the time.

In this MATLAB model analysis is the primary testing of the system algorithm in which a particular time duration and maximum demand is set so that during control time period system keeps the load below the threshold limit by switching the loads.

GRAPHICAL REPRENTAION OF LOAD VALUES:

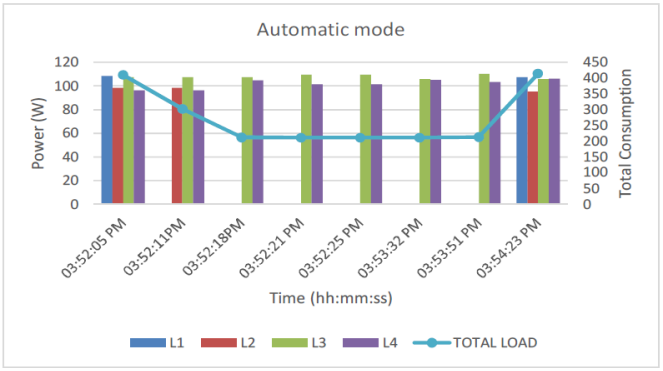

Fig -8: Automatic Switching Control of the loads

As shown in fig.8, the load is kept under the control of threshold value for the peak time defined by the user with the help of auto switching of the loads where as for non control i.e. manual mode no demand limit is incorporated so that more power is getting consumed unnecessarily.

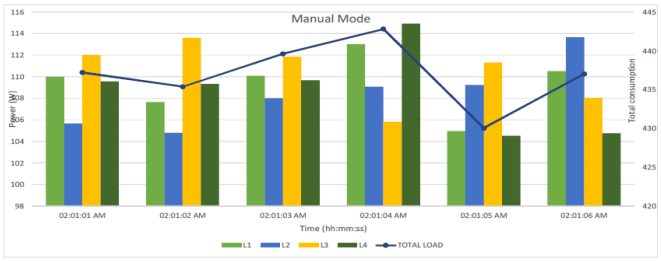

Fig -9: Manual Mode Switching Control of the loads

Fig.9 shows the power consumption by the loads without maximum demand limit defined in non automated mode of operation.

8. CONCLUSIONS

In this work, we can conclude that by monitoring the power consumption by each device in normal running hours and peak hours we can implement a better algorithm to control the power demand or wastage of money and energy. By observing at the consumption graph for demand control and without demand control we can conclude that system will help to control load ON timing according to the priority so that overall consumption will held below the threshold limit. With the help if this kind of system we can effectively control the customer unnecessary expenditure on electricity charges in peak tariff duration by eliminating the heavy appliances.

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