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Power Management in Home Area Network Using Zigbee Protocol

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Abstract: ***The power management scenario in India, is not efficient. To conserve energy, government applies power cuts, resulting in lot of inconvenience as even the essentials are cut off. Another way to save power is to train the staff to use power efficiently. This is again a method which is neither foolproof nor easy to monitor. This paper describes a proposed system which helps use the available energy efficiently. A Controller system has been designed that manages efficient utilization of power over an electrical network and helps conserve energy by making authorities keep a check on energy usage. To demonstrate this wireless sensor network is going to be developed which consists of number of nodes. ZigBee protocol will be used for the wireless communications. The main advantage of using ZigBee protocol is low power requirement which result in longer battery life. As a proof of concept PIC based prototype of proposed system is designed and going to be developed for small application.***

Keywords: PIC-16F877, Zigbee, power management

1. Introduction

Reducing energy use and waste is now widely seen as being good for the bottom line, as well as good for the environment. However, executives typically do not have the information they need to make informed, proactive decisions about their building portfolio's energy use. Today's business leaders are focused on just that: their business goals and strategies. While energy reduction and corporate social responsibility measures are important to executives, often the data and energy information is often not available in a simple, easy-to-comprehend format.

Energy initiatives too often are one-time upgrades that are not monitored and measured properly over time. As a result, the benefits of these improvements are soon lost. The key to reducing energy use and sustaining decreases over time is providing executives with the right information, to enable informed decisions that balance energy use with other objectives, such as building comfort and employee productivity. Remote energy monitoring is a proven solution that delivers a visible impact to the bottom line. Using web-based technology, remote energy monitoring delivers information, analysis, and guidance that allows business leaders to understand their organisation's energy use, take appropriate action, and continually improve energy efficiency building performance. Electric energy occupies the top grade in energy hierarchy. It finds innumerable uses in home, industry, agriculture and even in transport. The fact that electricity can be transported practically instantaneously, almost pollution-free, at the consumer level and that its use can be controlled very easily, makes it very attractive as compared to other form of energy. The per capita consumption of electricity in any country is; index of the standard of living of the people in that country.

The electric energy demand in India during the past 20 years was higher than the gross generation as a result of which there were massive power-cuts. It has been estimated that an investment of about Rs. 3, 00, 00 crore would be needed in India in the next decade to add new generating capacity for keeping a balance between supply and demand. Indian energy scenario today is dominated by feelings of discomfort and despair regarding the abysmally poor supply of power in most parts of the country

2. Proposed System

It is foreseen that service and personal care wireless sensor systems will become more and more ubiquitous at home in the near future and will be very useful in assistive healthcare particularly for the elderly and disabled people. Wireless sensor systems consist of numerous spatially distributed sensors with limited data collection and processing capability to monitor the environmental situation. Wireless sensor networks (WSNs) have become increasingly important because of their ability to monitor and manage situational information for various intelligent services. Due to those advantages, WSNs has been applied in many fields, such as the military, industry, environmental monitoring, and healthcare. The WSNs are increasingly being used in the home for energy controlling services. Regular household appliances are monitored and controlled by Wsns installed in the home. New technologies include cutting-edge advancements in information technology, sensors, metering, transmission, distribution, and electricity storage technology, as well as providing new information and flexibility to both consumers and providers of electricity. The ZigBee Alliance, wireless communication platform is presently examining Japan's new smart home wireless system implication by having a new initiative with Japan's Government that will evaluate use of the forthcoming ZigBee, Internet Protocol (IP) specification, and the IEEE 802.15.4g standard to help Japan to create smart homes that improve energy management and efficiency. It is expected that 65 million households will equip with smart meters by 2015 in the United States, and it is a realistic estimate of the

size of the home energy management market. There are several proposals to interconnect various domestic appliances by wireless networks to monitor and control such as provided. Also, smart meter systems like have been designed to specific usages particularly related to geographical usages and are limited to specific places. Different information and communication technologies integrating with smart meter devices have been proposed and tested at different flats in a residential area for optimal power utilization, but individual controlling of the devices are limited to specific houses.

There has been design and developments of smart meters predicting the usage of power consumption. However, a low-cost, flexible, and robust system to continuously monitor and control based on consumer requirements is at the early stages of development. In this study, we have designed and implemented a ZigBee-based intelligent home energy management and control service. We used the ZigBee (the IEEE 802.15.4 standard) technology for networking and communication, because it has low-power and low-cost characteristics, which enable it to be widely used in home and building environments. The system focuses on human-friendly technical solutions for monitoring and easy control of household appliances. The inhabitant's comfort will be increased and better assistance can be provided.

3. Block Diagram

The implementation of the proposed system is illustrated in Figure 1.As depicted, a ZigBee based home area network system is implemented for the monitoring and control of household devices. To cater for the household's high data rate needs, a zigbee network is implemented. A home gateway has been developed to provide interoperability between these networks. The home gateway presents a unified interface for users to locally and remotely access home networks.

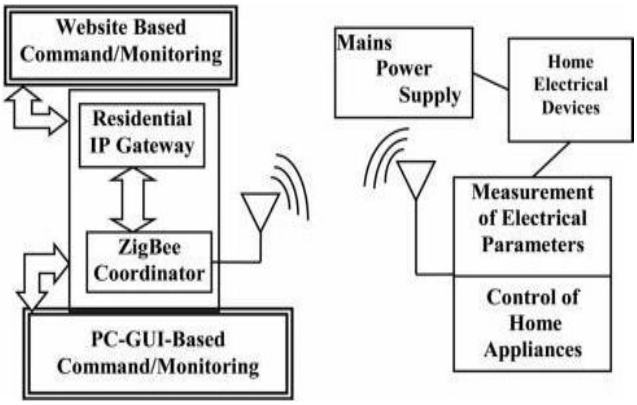

Figure 1: Block diagram of proposed system

The security and safety of the home area network is realised through the development of the labview based Home Gateway.

3.1 Individual Node Block Diagram

For each household device an individual node is created. Fig 2 shows the individual node block diagram.

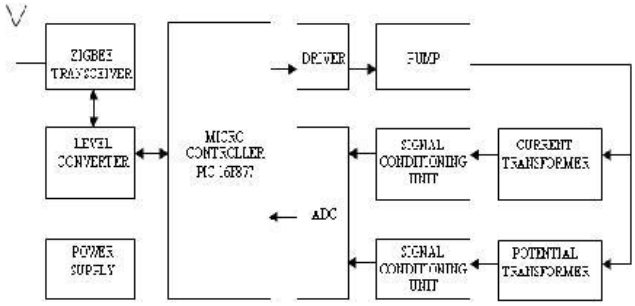

Figure 2: Individual node block diagram

The current and potential transformer are used to measure the current and voltage drawn by pump. The output of current and potential transformer is given to signal conditioning unit. The output of scu unit is given to PIC microcontroller. The output of PIC microcontroller is given to zigbee transceiver.

3.2 Local GUI & Remote monitoring unit

The below diagram shows local gui and remote monitoring unit. In local gui the zigbee coordinator is connected with the computer. The coordinator receives data from all nodes in the network. The local computer will show all the details of each node like ON,OFF status, power consumed and tariff.

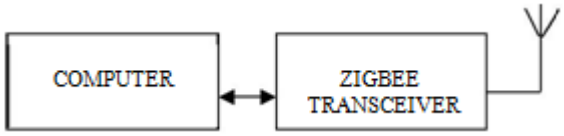

Figure 3: Local gui &remote monitoring unit

The local computer uses labview for monitoring and controlling the network.

4. System Description

The system has been designed for measurement of electrical parameters of household appliances. Important functions to the system are the ease of modeling, setup, and use. From the consumer point of view, electrical power consumption of various appliances in a house along with supply voltage and current is the key parameter. Fig.1 shows the functional description of the developed system to monitor electrical parameters and control appliances based on the consumer requirements. The measurement of electrical parameters of home appliances is done by interfacing with fabricated sensing modules .The output signals from the sensors are integrated and connected to XBee module for transmitting electrical parameters data wirelessly. The XBee modules are interfaced with various sensing devices and interconnected in the form of mesh topology to have reliable data reception at a centralized ZigBee coordinator. The maximum distance between the adjacent ZigBee nodes is less than 10 m, and through hopping technique of the mesh topology, reliable sensor fusion data has been performed.

The ZigBee coordinator has been connected through the USB cable of the host computer, which stores the data into a database of computer system. The collected sensor fusion

data have been sent to an internet residential gateway for remote monitoring and controlling the home environment. By analyzing the power from the system, energy consumption can be controlled. An electricity tariff plan has been set up to run various appliances at peak and off-peak tariff rates. The appliances are controlled either automatically or manually (local/remotely). The smart power metering circuit is connected to mains 240 V/50 Hz supply

5. Results and Discussion

SOFTWARE: MATlab
TOOL : simulink

The developed prototype can be used in home with various electrical appliances regularly used by an inhabitant.

For example the following appliances can be connected with the developed system: room heater and motor. In total, different electrical appliances can used in the experimental setup; however, any electrical appliance whose power consumption is less than 2000Wcan be used in developed system. The sampling rate for the fabricated sensing modules was setup with 50 Hz, so that electrical appliance usages within interval of time will be recorded correctly.

By monitoring consumption of power of the appliances, data are collected by a smart coordinator, which saves all data in the system for processing as well as for future use. The parameters will be entered in the data coordinator in software from appliances include voltage, current, and power. These parameters will be stored in a database and analyzed. Collected data will be displayed on the computer through graphic user interface (GUI) window so that appropriate action can be taken from the GUI.

The processed voltage, current, and power values are displayed on the graphical user interface running on a computer. The processed data are accurate and user friendly. The sensing system in the sensor node measures the parameters (voltage and current). The raw data (i.e., converted ADC values) are transmitted to the coordinator. The computer then collects the data from the coordinator and processes them. The computer then applies the necessary formulas to get the actual voltage, current, and power consumption of the electrical appliances.

5.1 End devices measuring unit

The developed measuring unit measures the voltage and current and sends these data to the coordinator unit through wirelessly by using zigbee protocol.

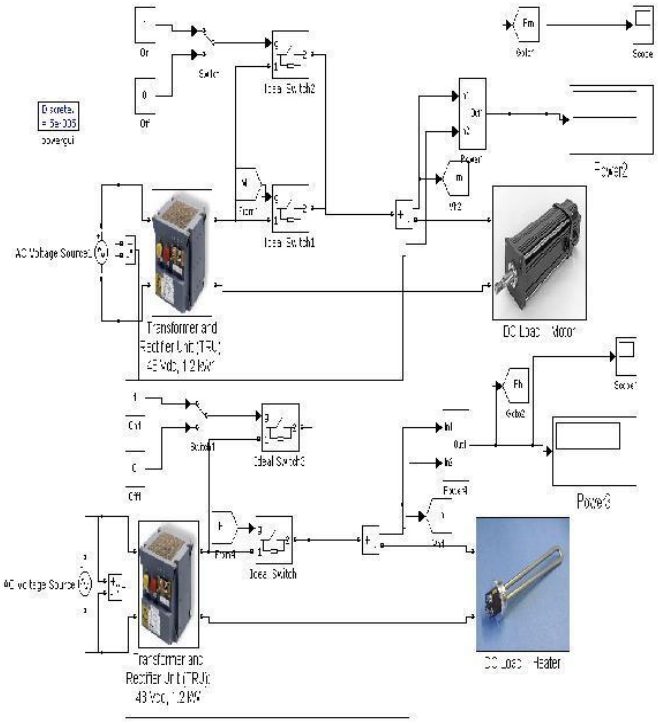

Figure 4: End device measuring unit

5.2 Coordinator and Local Control Unit

The coordinator will receive the data from the end devices and this coordinator is attached with the pc will save the data of the end devices.

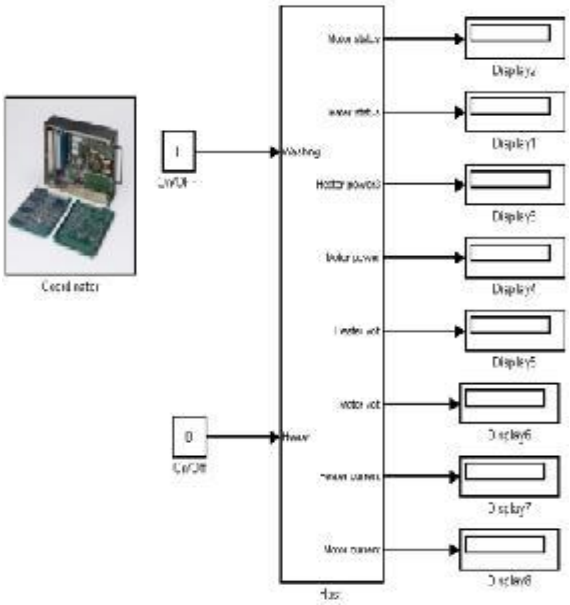

Figure 5: Coordinator and local control unit

5.3 EB unit

The EB unit will collect the power consumed by each customer through wirelessly with the help of zigbee device.

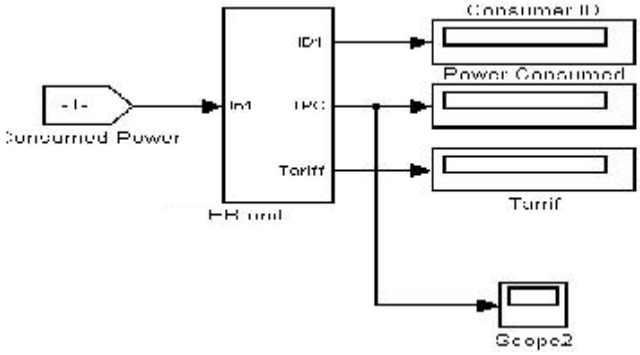

Figure 6: EB unit

The below diagram shows simulation model for the proposed system

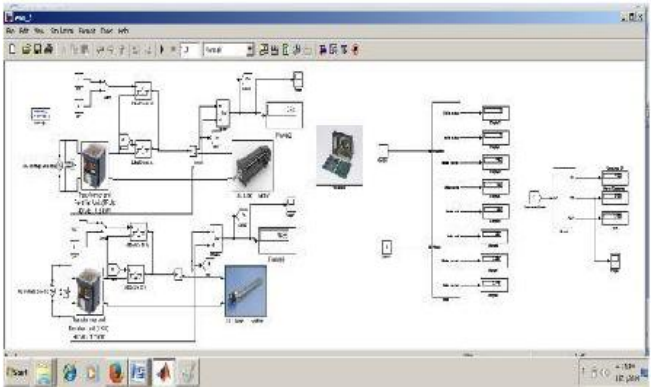

Figure 7: Simulation model of the proposed system

6. Simulation Results

The below graph shows the power consumption of the node 1 motor.We can controll the motor through internet.

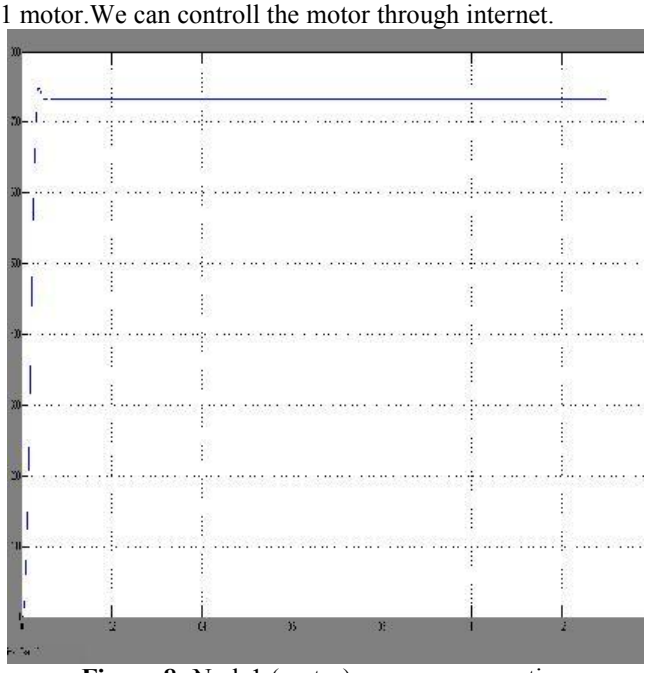

Figure 8: Node1 (motor) power consumption

The below graph shows the power consumption of the node2 heater. We can controll the heater through internet.

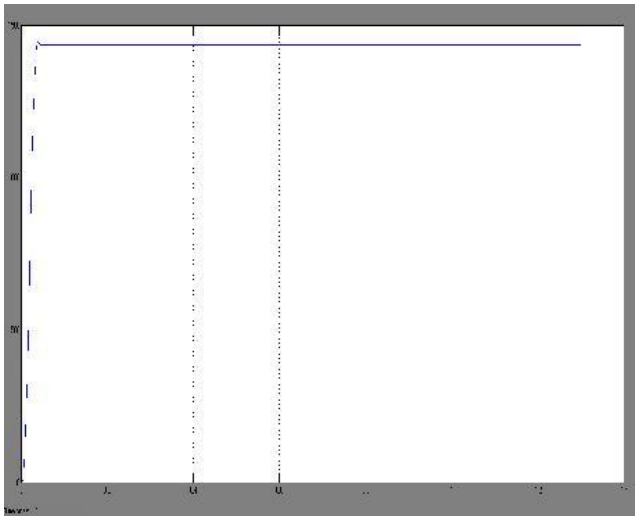

Figure 9: Node2 (heater) power consumption

The below graph shows the total power consumption of node1 motor and node2 heater.

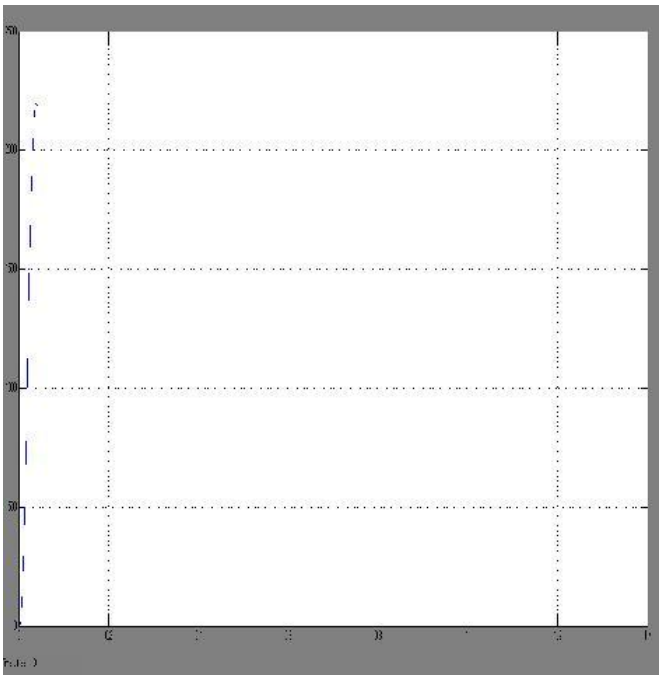

Figure 10: Total nodes power consumption

7. Conclusion

A Smart power monitoring and control system has been designed by using MATlab simulink. The designed system was able to perform the remote monitoring and control of appliances effectively. In future, the system will be integrated with co-systems like smart home inhabitant behavior recognitions systems to determine the wellness of the inhabitant in terms of energy consumption.

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