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DESIGN AND DEVELOPMENT OF SMART MONITORING AND CONTROLLING SYSTEM FOR POWER MANAGEMENT USING WSN

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***Abstract*— Wireless sensor networks have become indispensable to the realization of smart homes. The objective of this paper is to develop such a WSN that can be used to construct smart home systems and buildings. The project focuses on human-friendly technical solutions for monitoring and easy control of household appliances. The developing system is a low-cost and flexible in operation and thus can save electricity expense of the consumers. The novelty of this system is the implementation of the controlling mechanism of appliances in different ways. The developed system has the five different types of sensors which are processed and monitors the electrical parameters of household appliances such as intensity, temperature, voltage, current and gas leakage. The monitored values are sending to the computer through zigbee and controlled by using a LabVIEW for remote control and for automatic control all the sensors are processed and controlled by a single Arduino board, with the help of fabricated smart sensing unit consisting of Triac.**

***Index Terms*—Automatic control, LabVIEW, Remote control, Sensors.**

I.INTRODUCTION

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 [5].

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 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 [7]. There are several proposals to interconnect various domestic appliances by wireless networks to monitor and control such as provided in [8], [9]. But the prototypes are verified using test bed scenarios. 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.

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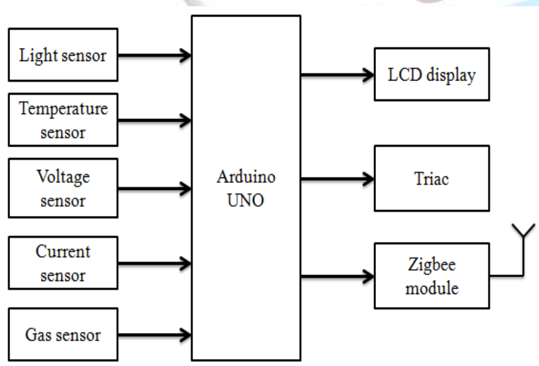
There has been design and developments of smart meters predicting the usage of power consumption [9]–[13]. However, a low-cost, flexible, and robust system to continuously monitor and control based on consumer requirements is at the early stages of development. In this study, we have designed and implemented a ZigBee-based intelligent home energy management and control service. We used the LabVIEW (Laboratory Virtual Instrument Engineering Workbench) for monitoring and controlling electrical parameters which is visual programming language and user friendly.

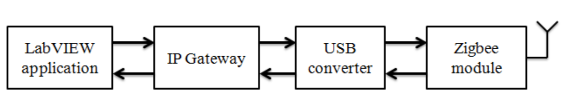
In this paper, a less hardware, low-cost, flexible, and real-time smart power management system, which can easily integrate and operate with the home monitoring systems is presented. Section II provides detailed implementation of the developed system; Section III presents the working methodology of the system; Section IV & V presents the results and the Conclusion of the work.

II 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.



a) Transmitting Section



b) Receiving section

Fig 1. Functional block diagram of the system

The measurement of electrical parameters of home appliances is done by interfacing with fabricated sensing modules. The details of the design and development of the sensing modules are provided in the following sections. The output signals from the sensors are integrated and connected to XBee module for transmitting electrical parameters data wirelessly.

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).

III WORKING METHODOLOGY

A. Measurements of Electrical Parameters

1) Intensity Measurement: The intensity of room is measured by using a LDR whose resistance decreases with increasing incident light intensity. The LDR works on the principle of photo conductivity. A photo resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

2) Temperature Measurement: The temperature of room is measured by using a LM35.It is an precision integrated circuit temperature sensor whose voltage is linearly proportional to the Celsius. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level.

The low-output impedance, linear output and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power

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supplies, or with plus and minus supplies. The processor can instruct the sensor to monitor temperature and take an output pin high (or low) if temperature exceeds the programmed limit

3) Voltage Measurement: The voltage transformer used in our paper step-down transformer. The step-down voltage transformer is used to convert input supply of 230–240 V to 10 VRMS ac signal. The secondary voltage is rectified and passed through the filter capacitor to get a dc voltage. The available dc voltage is reduced by a potential divider to bring it within the measured level of 3.3 V of the ZigBee.

This output signal is then fed to analog input channel of ZigBee end device. The acquired voltage signal is directly proportional to the input supply voltage. A voltage regulator is connected to the rectified output of voltage transformer to obtain the precise voltage supply of 3.3 V for the operation of ZigBee and operational amplifier. The scaling of the signal is obtained from the input versus output voltage graph as shown in Fig. 2. The actual voltage is thus obtained as follows:

Vact =m1 ×Vmeasured voltage (1)

Where m1 is the scaling factor obtained from Fig. 2, Vactis the actual voltage, and Vmeasured voltage is the measured.

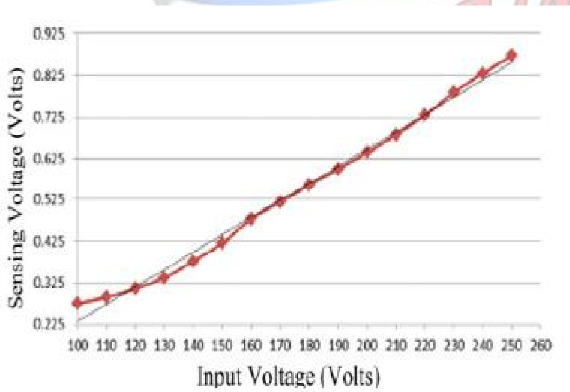

Fig.2. Scaling factor (m1) of voltage signal.

4) Current Measurement: For sensing current, we used current transformer. The main features of this sensor include fully encapsulated PCB mounting and compact. The circuit design layout for current measurement is shown in Fig. 3(a). In this current sensor, the voltage is measured across the burden resistor of 50Ω. The necessary filtering and amplification is required to bring the voltage with the necessary measurement level of ZigBee.

The scaling factors for current measurement for two different ranges of currents are shown in Fig. 3. Christo Ananth et al. [10] discussed about a system, In this proposal, a neural network approach is proposed for energy conservation routing in a wireless sensor network. Our designed neural network system has been successfully applied to our scheme of energy conservation. Neural network is applied to predict Most Significant Node and selecting the Group Head amongst the association of sensor nodes in the network. After having a precise prediction about Most Significant Node, we would like to expand our approach in future to different WSN power management techniques and observe the results. In this proposal, we used arbitrary data for our experiment purpose; it is also expected to generate a real time data for the experiment in future and also by using adhoc networks the energy level of the node can be maximized. The selection of Group Head is proposed using neural network with feed forward learning method. And the neural network found able to select a node amongst competing nodes as Group Head.

Iact=m2×Vmeasuredvoltage for current

Where m2 is the scaling factor obtained from Fig. 2, different values ofm2to be used for different current transformers. Iact is the actual current; Vmeasured voltage for current is the measured sensing voltage for current.

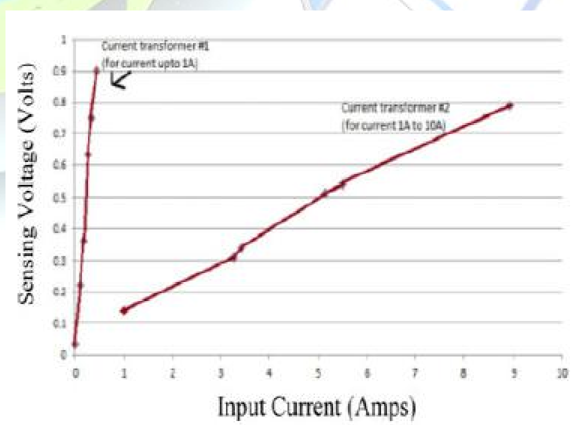

Fig 3. Scaling factor (m2) of current signal.

5) Gas Measurement: Gas sensor measures the concentration of gas in its vicinity. A sensor is a

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technological device that detects / senses a signal, physical condition and chemical compounds. It is also defined as any device that converts a signal from one form to another. Gas sensor interacts with a gas to measure its concentrationThe concentration of the gas can be determined by measuring the current discharge in the device.

B. Arduino UNO Controller

The Arduino Uno is a microcontroller board based on the ATmega328 it is Open source and extensible hardware. The output signals from the sensors are integrated to the control unit Arduino UNO controller. Arduino is a single-board microcontroller to make using electronics in multidisciplinary projects more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. The software consists of a standard programming language compiler and a boot loader that executes on the microcontroller.

It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less. Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less.

An Arduino board consists of an Atmel 8-bit AVR microcontroller with complementary components to facilitate programming and incorporation into other circuits. An important aspect of the Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable add-on modules known as shields. Some shields communicate with the Arduino board directly over various pins, but many shields are individually addressable via an I²C serial bus, allowing many shields to be stacked and used in parallel.

Arduino programs may be written in any programming language with a compiler that produces binary machine code. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio The Arduino IDE supports the C and C++ programming languages using special rules of code organization. The Arduino IDE supplies a software library called "Wiring" from the Wiring project, which provides many common input and output procedures. A typical Arduino C/C++ sketch consist of two functions that are compiled and linked with a program stub main() into an executable cyclic executive program

C. Control of Home Appliances

1) Automatic control: Based on the electricity tariff conditions, the appliance can be regulated with the help of smart software. This enables the user to have more cost saving by auto switch off the appliances during the electricity peak hours. The electricity tariff is procured from the website of the electricity supply company and is updated at regular intervals.

2) Manual control: An on/off switch is provided to directly intervene with the device. This feature enables the user to have more flexibility by having manual control on the appliance usage without following automatic control. Also, with the help of the software developed for monitoring and controlling user interface, user can control the device for its appropriate use. This feature has the higher priority to bypass the automatic control.

3) Remote control: The smart power monitoring and controlling software system has the feature of interacting with the appliances remotely through internet (website). This enables user to have flexible control mechanism remotely through a secured internet web connection. This sometimes is a huge help to the user who has the habit of keeping the appliances ON while away from house. The user can monitor the condition of all appliances and do the needful.

Thus, the user has the flexibility in controlling the electrical appliances through the developed prototype.

D. Storing and control of parameters

In the present system the monitored values are transmitted wirelessly through Zigbee to the system. The collected data's are controlled by various methods and the following parameters will be stored in a database and analyzed. Collected data will be displayed on the computer through LabVIEW

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window so that appropriate action can be taken from the visual programming language.

The LabVIEW includes extensive support for interfacing to devices, instruments, cameras, and other devices. Users interface to hardware by either writing direct bus commands (USB, GPIB, and Serial) or using high-level, device-specific, drivers that provide native LabVIEW function nodes for controlling the device.

Many libraries with a large number of functions for data acquisition, signal generation, mathematics, statistics, signal conditioning, analysis, etc., along with numerous graphical interface elements are provided in several LabVIEW package options.

IV RESULTS

Monitoring data's are collected by a controller, which saves all data in the system for processing as well as for future use. The parameters will be stored in the LabVIEW software include voltage, current, and power. These parameters will be stored in a database and analyzed. Collected data will be displayed on the computer through LabVIEW window so that appropriate action can be taken from the visual programming language.

The sensing system in the sensor node measures the parameters they processed voltage, current, temperature, light and concentration of gas values are displayed on the LabVIEW running on a computer for remote monitoring. and for automatic control all the sensors are processed and controlled by a single Arduino board, with the help of fabricated smart sensing unit consisting of Triac. The processed data are accurate and user friendly.

V CONCLUSION

An intelligent power monitoring and control system has been designed and developed toward the implementation of an smart building. The developed system effectively monitors and controls the electrical appliance usages at an elderly home. Thus, the real-time monitoring of the electrical appliances can be viewed through a website. The system can be extended for monitoring the whole smart building. The sensor networks are programmed with various user interfaces suitable for users of varying ability and for expert users such that the system can be maintained easily and interacted with very simply.

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