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Energy Management Unit for Building Automation Using LPC2148 (ARM-7)

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Abstract
A building energy management system plays a vital role in managing the demand response of electric power consumption in smart grid technologies. This integrates many new technologies such as home network, smart home controller, monitoring systems etc. This paper presents the remote monitoring and control of the load in three modes such as manual mode, SCADA control mode and user control mode using GSM. To validate the performance of this proposed scheme a virtual environment has been created in Protous-7.8.

Keywords
Building automation, SACDA, ARM-7, HEM

I. INTRODUCTION

Recently, optimum utilization of electrical energy has attracted the attention of many researchers because the demand to supply ratio growing rapidly. Generally, 10-20% of electrical energy gets waste due mis usage of appliances. Mostly, the electrical appliances or loads are plugged-in but it is not in use [1]. In big building like hospitals, educational Institutions, hotels, residential and commercial places frequently electrical loads are forgotten unplugged for no reason [2]. On the other hand, if they go out with forgetting to unplug any electrical appliances, they must go work place to pull the plug out to avoid the misuse of power and dangerous situations so it is a waste of so much time and money [3]. In order to solve these problems, smart home technologies are required. In this context many researchers have developed smart home management systems in order to facilitate and improve the living standards of human beings. In paper [4] (alphy, 2014) author has implemented ZigBee based Home Management System that senses the presence of human using passive infrared sensor and switches the electrical loads such as lights and fans.

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The network architecture of Power Line Carrier Communication (PLCC) based home management system was proposed by [5] (Masahiro, 2003). In this paper two controllers have been used one for monitoring and managing home energy requirement and other for adapter for each home appliance. In [6] (Jinsoo, 2009) author presented a scheme to control and save the energy consumption using ZigBee protocol.

In this paper we have proposed efficient monitoring and controlling mechanism that controls the power consumption of building and simultaneously keeps the track of power consumption.

II. DESCRIPTION OF THE PROPOSED EMU SYSTEM

The concept of proposed scheme is shown in Fig.1. The overall system comprises a building energy management system that provides monitoring and controlling facility in three modes: (a) Manual mode (b) SCADA control mode and (c) user control through mobile/ GSM. In this scheme a controller is provided which ensures that total load plugged at any time instant should not cross maximum demand limit. The Energy Management Unit (EMU) connected to SCADA and GSM transmitter through RS-232 / USB protocol.

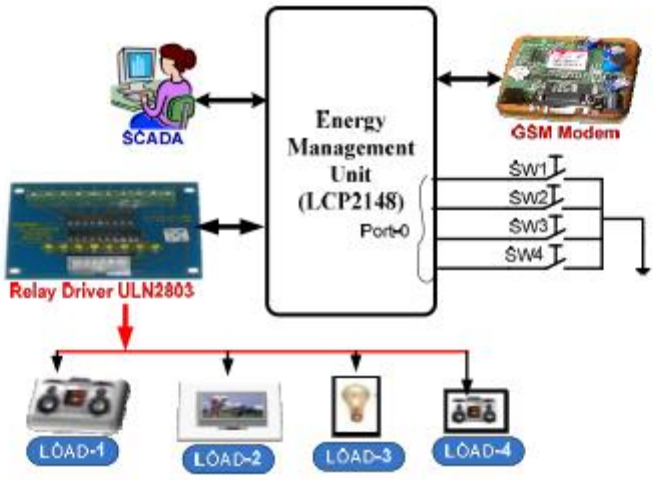

Figure 1. Schematics of Energy Management System

Architecture of Emu

The details of each block of the Energy management system as follows:

1. Universal Serial Bus

The USB is one the most upcoming and recent interfaces available on the PCs. It is being used to connect all sorts of peripheral devices to the PC. In this work ARM (LPC2418) Controller is connected to the USB to get a fast interface to the PC.

2. ARM LPC2418 Controller

The LPC2148 is a low-power Complementary metal-oxide-semiconductor (CMOS) 32-bit microcontroller used the enhanced RISC architecture which is used as the main part of this paper. Through executing powerful instructions in a single clock cycle, the LPC2148 achieves throughputs approaching 17 MIPS sustained 25 MHz permit the system designer, to optimize power consumption versus processing speed, operating Voltage range for this microcontroller is -4.5V to - 5.5V. It has one 32 bit port and one half duplex 16 bit port. In this controller we are having two serial port, where port-A is connected to GSM modem and port-B connected to SCADA computer through USB. The LSB of port-1 pins are connected to hardware switches and Port-0 has been considered as output which is connected to load through driver IC ULN2803.

3. Diver IC ULN2803

The ULN2803 consists of 8-bit TTL-input NPN Darlington sink drivers. Each Darlington driver can handle a maximum of 500mA continuous (when using a single channel only) and can withstand a maximum 50V in its off state. This makes the ULN2803 well suited to provide an interface between the low logic level interfaces and higher current/voltage devices such as relays, solenoids, motors and lamps.

4. GSM Modem

SIM-900 is used in most parts of the world. SIM-900 uses 890–915 MHz to send information from the mobile cell to the BTS (Base Transceiver Station) it is known as up-link and 935–960 MHz for the other direction (i.e. BTS to Mobile device) and this is known as down-link (shown in Fig.2). So to provide the high frequency for up-link and down-link we have to use an oscillator. Since all mobile communications are based on RF (Radio Frequency) so RF amplifier is used. Where, RF amplifier is the combination of RF Signal generator (Usually Voltage Controlled Oscillator) and RF power amplifier with proper matched (in terms of output and input stage of amplifier and antenna respectively) antenna.

In SIM 900 there are two UART (Universal Asynchronous Receiver Transmitter) ports one is used for serial communication (for AT Commands from MCU) and another one is for debug purpose. Debug port is used to firmware updating and real time emulation DTR and RI pins are connected to the processor because DTR are is used to wake up the module from sleep mode and RI is used for the detection for call or SMS. Output of SIM 900 not compatible with MCU so a level converter is required (Such as MAX 232) and another important thing TX pin of MCU is connected to the RX pin of SIM 900 while RX pin of MCU is connected to the TX pin of MCU. It means they are cross connected for data communication. This serial port can be used for CSD FAX, GPRS service and AT Commands. It can support variable baud rates such as 1200, 2400, 4800, 9600, 19200, 38400 and 115200. Auto bauding also support all baud rates as specified in above line except for the last baud rate i.e.,115200.

Figure 2. SIM900A Module with minimum peripheral for connection

5. EMU Communication Module

In this paper two type of communications are used one to communicate between EMU and SCADA and other between EMU and GSM modem. The communication module affects the performance of overall system.

The Demonstration of the Emu System

The proposed EMU system is shown in Figure 3 with commercial loads. The EMU Graphical User Interface (GUI) has been developed using WinTr open source SCADA software. The scripts of SCADA are written in C-sharp.net software. The refresh script, load script and button scripts are providing functionality to SCADA so that it updates the status of the field data (in this case ON / OFF status of the switches) as shown in the figure 3. The GUI provides a dashboard for main operator to monitor the status of the load, total power consumption at any given time. The data is regularly updated in SCADA and operator can also change his / her load priority and preference setting from the EMU screen. These updated data also sent to the user registered mobile through GSM modem.

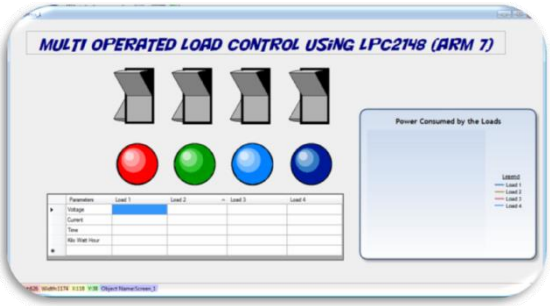

Figure 3. GUI of SCADA

III. OPERATION OF EMU

The EMU is designed using ARM-7 controller. Here, EMU works in Interrupt request mode to communicate with SACDA and GSM modem at 9600 baud-rate, 8-bit data protocol where its parity is none. The hardware switches are connected to port-1 of ARM-7 and they are continuously refereed in polling mode. The user can send the command signal any one of the following mode: (a) manual mode (b) SCADA mode (c) user control through GSM mode. In manual mode switches are continuously monitored, if user presses any switch the corresponding logic level will be changed. During this time EMU capture the present status and compares with past status of the switches. If any change occurs then it takes corresponding action (will change ON/OFF status of the load) as well as simultaneously data is updated in SCADA at 9600 baud-rate.

Here, we have used bidirectional SCADA is designed. If SCADA sends the signal to EMU it invokes the corresponding interrupt at serial port-A. Meanwhile, the controller stops the current operation and gives the services to the interrupts. The SCADA sends the data in form of alphanumeric string “A” i.e. Load-1 changed status is sent to EMU. If the new and old switching statuses of loads are same it complements the previous status. Further, LPC2418 controller sends the feedback to SCADA in “1A” (i.e. load is plugged) or “0A” (i.e. load is unplugged) In order to control the appliances in work place from distance GSM modem can be used. In this mode firstly, the user send the status query “CURRENT STATUS” to the GSM module which is connected to main controller (EMU). The EMU connected GSM module fetch the data from the SCADA and sends the SMS back to the registered mobile number of the user. If the user wants the change the plugging status of the load he/she will send the message by typing “1A to 0A” to the SCADA unit through EMU connected GSM module. The simulation of above proposed system is carried out in Protus software and its screen shot is given in Fig.4.

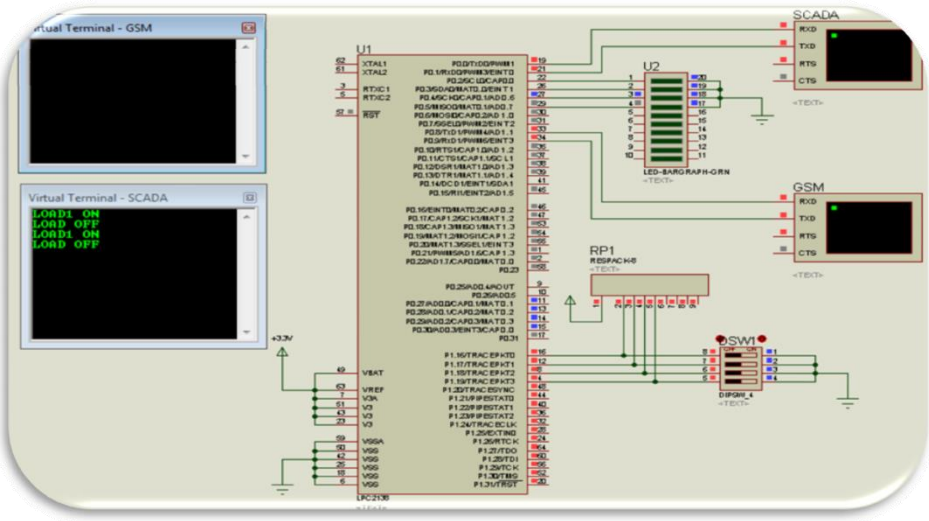

Figure 4. Protus-7.8 Simulation of EMU with SCADA and GSM virtual terminals

IV. CONCLUSION

In this paper ARM-7 (LCP2148) controller has been used to design Energy Management Unit. The proposed EMU system is simulated in virtual environment and designed in Protus-7.8. A separate computer is used to provide Human Machine Interface (HMI) using GUI dashboard. A bidirectional SCADA system has been design using WinTr open source software. In order to check and control the switches from remote location GSM module SIM-900 is incorporated in the system. The proposed system ensures the efficient utilization of resources which saves the money and time of users.

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