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HOME ENERGY MANAGEMENT SYSTEM BASED ON POWER LINE COMMUNICATION

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Abstract - *Home Energy Management can be achieved by implementing a power line based home energy management system. It can provide easy access to information on home energy consumption in real time, intelligent planning for controlling appliances and optimization of power consumption at home. This is an alternative to load shedding by load scheduling. The HEMS consist of three modules. An advanced power control planning engine, a device control module, a power resource management server. A slave microcontroller is to be kept at each house for constant power monitoring and control of relays connected to the appliances and a master microcontroller that receives the signals from the slave microcontroller. One of the easiest solution for this is by using power line communication. PLCC is the communication technology that enables sending data over existing power cables. This means that with just power cables running to an electric device, one can power it up and at the same time control the device in full manner. The major advantage of PLCC is that it does not need extra cables, it uses existing wires. In this paper we control load consumption, managing home appliances and also providing a check to energy theft by consumers. Further communication of important information is also enabled in this system via power line.*

Key Words: **PLCC, Home Energy Management, Microcontroller, Relays.**

1. INTRODUCTION

Energy saving is an important issue in the times of increasing energy prices. In the current scenario of increasing prices, there is a high need for controlling and monitoring the energy that we are utilizing in our day to day life. The remedy for such a situation is in our own hands, if we could control these appliances by transmitting signals just like transmitting electrical signals to our home. This project is mainly implemented for the purpose of managing home energy utilization. The aim of the project is to measure and monitor consumption of allocated energy for a month to a consumer by the electricity board, and manage it for optimal use using electronic devices allocated to each house. The system can monitor the power usage and can warn the users when power usage is getting close to the prescribed energy usage level. It also possesses the capability to automatically turn off the low priority devices when the usage of power crosses a prescribed threshold level. The system also possesses a part which checks power theft by the consumer and automatically cuts off this supply and re permits only when user stops stealing energy. This activity is also reported to the energy company to take necessary action.

The conventional method of electricity billing is discrete, inaccurate, costly, slow and lack flexibility as well as reliability. It involves a person from the distribution unit reading the number of units of electricity consumed in the energy meter, conveying this information to the distribution unit and then preparing the bill according to the units consumed for a fixed amount of time. This can prove quite tedious as it involves various tasks like reading, then preparing the bill. Still accuracy cannot be guaranteed as there can be human errors in the reading. Despite this, the task of billing for every consumer is a time consuming job for the distribution grid. To eliminate all these problems, the most convenient method is making the whole system prepaid using power line communication. The concept of power line communication is used for the transfer of data between consumer and utility. Power line communication uses high power line for the communication. The data is transmitted at a higher frequency than that of the transmission frequency. The main advantage of this is that no additional transmission line is required for the transmission of data. A power line communication module is provided at the consumer as well as the utility side. A microcontroller is provided at each consumer to manage the different functions to be performed like keeping track of energy consumption by checking the calibrate LED of the energy meter.

When the allocated energy for the month reaches 75%, a buzzer rings to warn the consumer to use energy carefully. On reaching 90% of the monthly allocation, the low priority loads like A/C, Refrigerators etc. are cut off from supply. On completing total allocation, the energy supply to house is terminated. User can once again regain connection by paying

again for more units. It also acts as a suitable system to control energy usage. Load shedding, power cuts etc. helps to rearrange the available power but they cannot be used to prevent unwanted usage of energy. Also the system gives the user real time information about the units he consumed and units he has left.

Thus by using power line communication we can monitor and control the usage of devices by providing a control over the usage of devices by providing a control circuit at the consumer end. Hence in this project we are encapsulate the process of control, monitoring, messaging through power line communication and control the load from a centralized control. Thus load management can be achieved.

2. BLOCK DIAGRAM REPRESENTATION

The block diagram consists of 2 sections.

ENERGY BOARD SECTION

- An Atmega32 microcontroller
- A 16X2 LCD module
- A 4X4 Hex Keypad
- A PLC modem is employed as the communication module
- Regulated supply source to the microcontroller

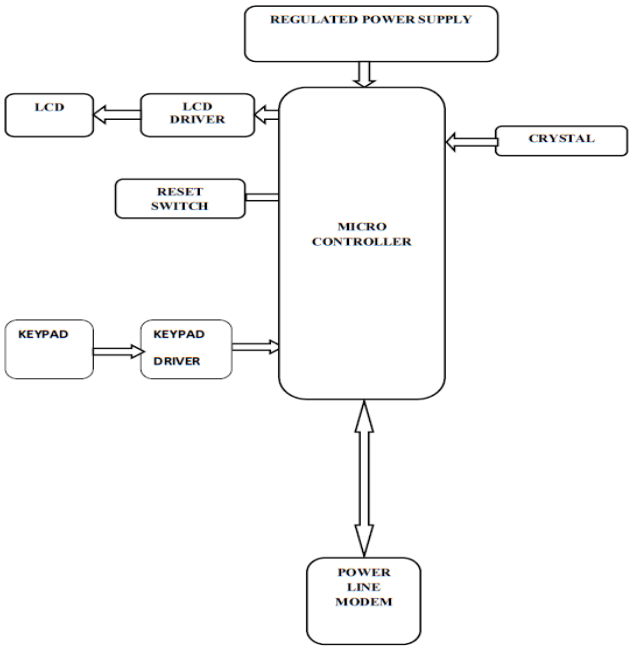

Fig -1: EB Block Diagram

The energy billing is done in a pre-paid manner as shown in the above figure. The user goes to the energy company office and remits the amount corresponding to the units required by him for that month. The officer types in this amount on the 4X4 keypad connected to the microcontroller. The MCU converts the amount into corresponding units and transmits this data to the home section through the power cables.

HOME SECTION

- An Atmega32 microcontroller
- An energy measuring unit consisting of an energy meter and a light dependent
- resistor
- A switching unit that is working with the help of relays
- A control unit used to control the processes taking place. An Atmega32 micro-
- controller is used
- A LCD module to display various statistics
- A PLC modem is employed as the communication module
- Current transformers are employed to check energy theft
- Buzzer to alert the consumer
- Regulated supply source to the microcontroller

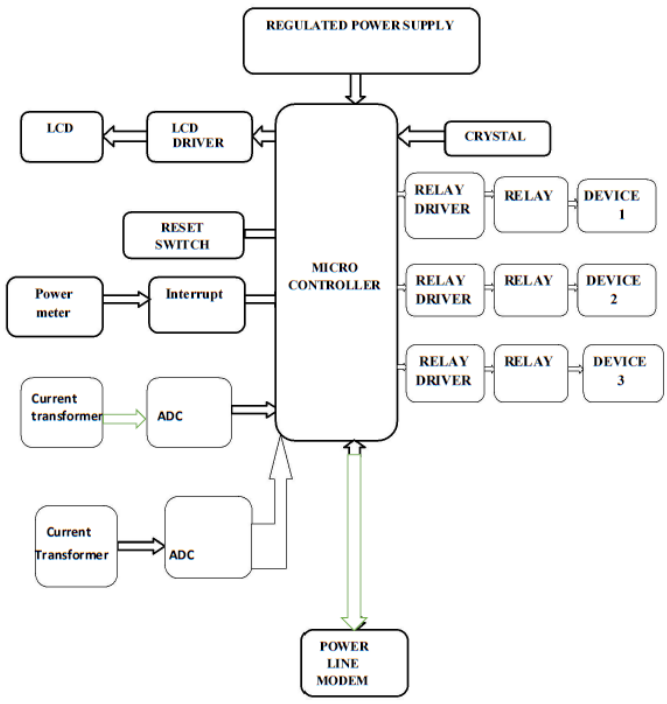

Fig -2: Home Section Block Diagram

The units entered by the consumer is received at the home section microcontroller via the power line modem, the

block diagram is as shown in the figure. This data is displayed on the LCD screen provided in the apparatus. The calibrate LED of the energy meter blinks 3600 times corresponding to the consumption of one unit. The microcontroller takes this signal as an interrupt and uses it to increment a counter. An optocoupler is used as an isolation to prevent sudden high voltages from entering the microcontroller circuit. Each time the counter reaches 3200, a unit is decreased from the allocation. On reaching 75% of the allocated amount of energy, a buzzer will sound to warn the user. On reaching 90% of full allocation, non-essential low priority circuit will be cut o_ from supply, and the user has to again recharge. The current theft detection system has two current transformers, one at the incoming and another at the exit of the energy meter. If the CT output values do not match when compared in a comparator, this indicates power theft by user. So the supply to users house will be terminated.

3. ALGORITHM OF OPERATION

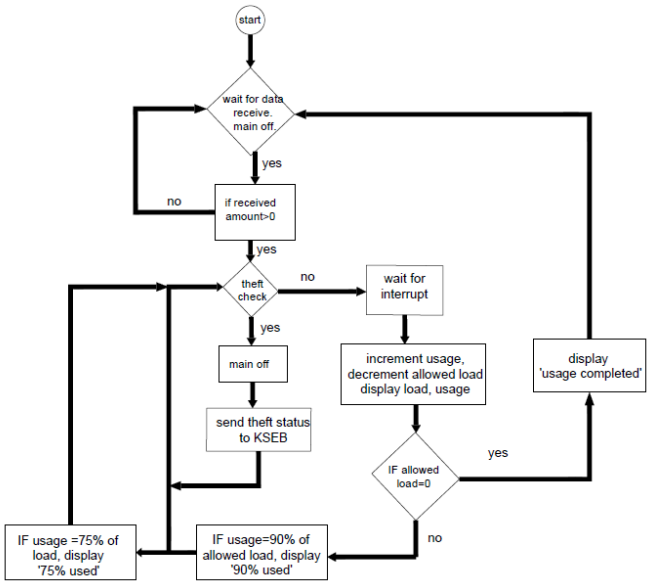

Fig -3: Algorithm

4. OPERATION

The power meter is connected to the ATMEGA32 micro controller through an optocoupler. An optocoupler is a light dependent transistor, or in other words it is a combination of LDR and LED. For each LED blink, it gives an interrupt to the micro controller. The 230v AC supply voltage is step downed to 12v AC by a voltage transformer. A bridge rectifier and capacitor filter circuit rectify the voltage to dc and then to voltage level of 5v with the help of a voltage regulator. This 5 v is given to the micro controller as input level. In both the sections LCD data pins are connected to microcontroller's port C. Slave microcontroller is also connected to the keypad, and there are 4 relays in the home section which are connected to port B of Microcontroller. The crystal oscillator is connected in between XTAL1 and XTAL2 to regulate the operating frequency of the microcontroller.

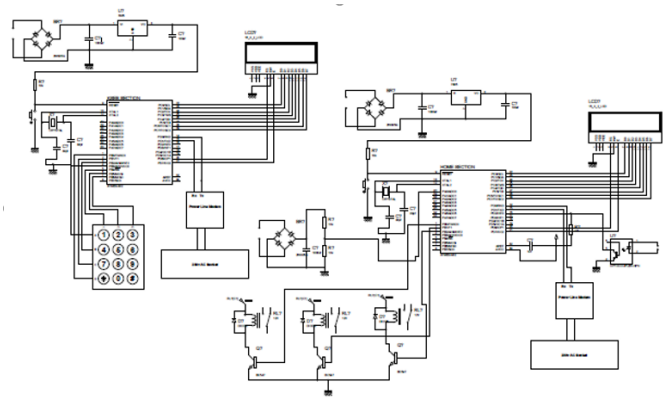

Fig -4: Main Circuit

5. EXPERIMENTAL SETUPS AND RESULT

In the project model 10 units of energy were allocated from KSEB section to the HOME section via power line for a prepaid recharge of 1000Rs.The LCD display at both sections properly displayed the consumed and remaining units. A count 'C' value was set to indicate each consumed unit. When count value reached 2, one unit was consumed by the home section. When 7 units (75%) were consumed by home section, it was indicated by the buzzer system at HOME section. When 9 units (90%)of the allocated energy was consumed the high power consuming bulb at load side was turned off. Whenever we turned on the bulb for theft, all the bulbs at load side were suddenly turned o_ and a message "Theft detected at H3" was displayed at both KSEB and HOME section. If the switch for power theft detection was opened to stop power theft, all the bulbs will start to glow again. This system design was successfully implemented and we obtained these desired results. Quite a few times the system did not respond correctly due to interruptions as well as noise problems. The noise caused several problems in the transfer of data from KSEB section to HOME section, and the reception of data signal was in effective quite a few number of times. The noise problem could be suitably solved by proper design of power line modem on which researches are going on.

Fig -4: Experimental Setup of Proposed System

5. CONCLUSIONS

The Home Energy Management System using power line communication worked satisfactorily as per our design. The success rate of the system was approximately 93%.The system was tested nearly 50 times and 3 times it failed to produce the intended result because of noise problems. The power theft detection in case of any illegal tapping was identified instantaneously at the time of theft. In short PLC played a vital role in making all these energy practices smart. PLC technology can be used in future for efficient use of electrical energy ranging from home automation to internet access. PLCC is mainly used for tele-communication, tele-protection and tele-monitoring between electrical substations. In future we could depend on power lines for internet access. More researches in power line modem technology is required to effectively tackle the noise problems and maintenance cost.

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