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Design and Implementation of Intelligent Energy Distribution Management Using Mesh Topology

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Abstract: Electricity being an essential part of human life today, needs better management and allocation techniques than the existing systems, such that it will be possible to ensure maximum utilization of the available electricity, thus ensuring almost no power cuts. Mostly load shedding occurs because of excessive usage of power at peak hours. This project proposes a technique that forces people to use lesser power at peak hours, thereby supplying each consumer the necessary power rather than cutting it off for a few. For implementing this process each consumer, either home or commercial, is fitted with an embedded controller which is capable of receiving real time instructions from the EB using a wireless link. The device has a power cut off feature, a display and an alarm built on it. These devices could replace the existing EB meters as well. The EB Office on the other hand has a computer based system, capable of tracking the available power and accordingly transmits data to the consumer device. There can even be a higher power tariff for operation at peak hours. In extreme cases where the consumer does not comply with the instructions, the power could be cut off directly. Thus this system can very effectively ensure power availability to various consumers causing them least inconvenience.

Keywords: Mesh Topology, Peak-load period, Intelligent energy distribution and management, Embedded systems, End-consumer load management.

I. Introduction

In spite of tremendous advances in technology and computing, one sector that is still found to be lacking of a proper solution is the use of technology for making efficient use of electricity in India. This generation is facing quite a lot of problems due to electricity scarcity. Electricity being an essential part of our life today needs better management and allocation techniques than the existing systems. The design and implementation of intelligent energy distribution system based on mesh topology, provides power distribution based on the needs of the customer. Uninterrupted power supply can be guaranteed ensuring zero power cuts. In today's situation one of the major problems for which we are still not able to find a proper solution, is electricity scarcity. Better management and sharing of electricity could ensure maximum utilization of the available electricity. The development of a system that includes the above mentioned feature is presented in this paper. Load shedding is a major problem that occurs because of excessive power usage at a particular period of time. Often, this happens at peak hours when there is a high demand for power, while only a lesser amount is available at the supply system. This project proposes a system that would force people to use lesser power at peak hours or at a deficient time period, thereby supplying everyone with the necessary power instead of cutting it off when the available power is finally drained.

II. Existing System

With growing population, electric power is one resource that is not available in sufficient amount for the people in India. This leads to major problems like power cuts for hours together, which cause lot of inconvenience to consumers. Such is the scenario that, nowadays power cuts have become a part of life both in cities and elsewhere. Power cuts happen because of uncontrolled and uneven distribution of electricity. Putting it in a nutshell, proper distribution methods are not practiced in our country.

At present, a method called smart grid system is being implemented and used, by which they switch over between electric networks that are laid to transmit power at different voltages. In detail, smart grid is a power distribution system in which the electric board authorities control the distribution of power for any particular area without

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considering the nature of the customers. As of now, even this method in not fully implemented in our country except for a few cities. Even though this method is advantageous to a certain extent, it has a lot of disadvantages too. The main drawback is that this method uses huge manpower to control and monitor power distribution and the cost of installation is also very high. This method uses two or three network connections which pass different voltages and the electric board authorities switch over between these networks based on the availability of the power. Thus, it includes a large cost for installation since two or three networks have to be implemented. Moreover, this method does not detect power thefts as the security level is the same as that of the existing system.

III. Proposed Methodology

A. Power Cut Avoidance

Load shedding often occurs because of excessive usage of power at a particular point of time which could, on an average be controlled within limits. This happens most commonly during peak hours when there is a demand for excessive power and because of this, deficiency occurs in the supply system. This creates a need to force people to use lesser power during peak hours, thereby supplying everyone with the necessary power and avoiding power cuts that would have occurred otherwise. This is possible by switching off unwanted devices that are left on, during peak hours. For example, the electric water heater could be used at non-peak hours rather than at peak hours when power would be needed for a few other devices that have to be used unconditionally. Similarly in a commercial setup, high power machines could be shut off at peak hours leaving the other necessary devices like lights and fans on. To implement this, each and every consumer, be it home or commercial, is fitted with a special device that has an embedded controller in it. This device is capable of receiving real time instructions from the EB through zigbee communication at any point in time, using a wireless link. The device has a power cut off feature and also a display and an alarm built into it, and it is capable of replacing the existing EB meters.

The EB Office on the other hand has a computer based system, from which it can track the available power and transmit data to the consumer device accordingly. For example, if the power available is lesser than the demand during peak hours, then the EB end would transmit information to the consumer end device indicating that their power consumption should be reduced to a certain maximum limit. There can even be a higher power tariff for operation at peak hours than at normal hours. In extreme cases, power could be cut off directly if the consumer does not comply with the instructions from the supply end. Thus this system can very effectively and efficiently ensure power availability to various consumers causing them least inconvenience. The controller we use here is ARM 7 LPC2148. We fit this in all the consumer units (residences and commercial units alike) and the module used for communication is Zigbee which consists of a transmitter and receiver. GSM is used for mobile communication. That is, it sends and receives messages with details about the bill. Thus, even if the electricity that is available is of a meager amount, it is shared among all the consumers and it is left to them to use it wisely, that is to use the available electricity only for the need of the hour, thus ensuring almost no power cuts or very minimal power cuts.

B. Current Theft Avoidance

The concept of tracking and avoiding power theft is also introduced here. Since the device is fitted in all the consumer units, it would be easy to note the extra power consumption and to identify the line that uses the power that is being stolen illegally. That is, the microcontroller that is fixed in the consumer's end displays the details of the bill amount depending upon the amount of power used, and at the supply end the EB office also gets these details through Zigbee. So, during power transmission it would be easy to identify the point of electricity theft and take necessary actions to avoid it.

C. Replacement Of Manpower

The power management system consists of Zigbee Digital Power meters installed in each and every consumer unit and an Electricity e-Billing system at the energy provider side. The Zigbee Digital Power Meter (ZPM) is a single phase digital kWh power meter with an embedded Zigbee modem which utilizes the wireless sensor network to send its power usage reading. At the power provider side an e-billing system is used to manage the received zigbee meter reading, compute the billing cost, update the database, and to publish the billing notification to its respective consumer through a wireless medium.

Traditional meter reading for electricity consumption and its respective billing is done by human operators who move from one consumer unit to the other to note down the exact reading. This process requires a huge number of labourers or operators and it takes long working hours to complete the data reading and billing of the entire area. Human operator

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billing is also prone to reading errors, because at times, the electric power meter is placed in a location where it is not easily accessible. All these problems could be easily avoided as everything in our proposed method is digitized hence decreasing the possibility of errors. And if the consumers had failed to pay their bills, it would be possible to cut the supply of power to that particular consumer directly from the power provider end, since the power consumption details are sent directly to the microcontroller with the help of zigbee. Due to this facility, it also seems unnecessary to send labourers to take down readings in the houses of consumers, thus replacing the need of manpower.

IV. Overall System Module

This block diagram represents the entire module of the system. It consolidates the system for power cut avoidance, management of power theft and the system that replaces manpower. The microcontroller is interfaced with the passive infrared (PIR) sensor and the light dependent resistor (LDR) sensor along with the relay drivers and the signal conditioning circuit. In addition to this, an LCD display is also connected to the microcontroller.

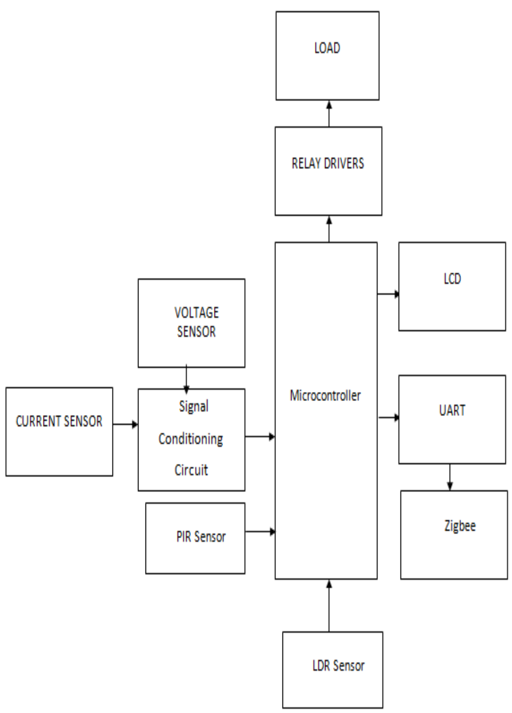

Fig.1. Block Diagram for the proposed system

V. Hardware Description

A. Power Supply

This is the power supply unit which aids in regulating and supplying current depending upon the requirement of the circuit. The ac voltage is stepped down to the desired dc level from 220V rms by connecting it to a transformer.

B. Zigbee Unit

Zigbee is used for transmission between electric boards and customer residences. Zigbee and IEEE 802.15.4 are used to provide network infrastructure in wireless sensor network applications. 802.15.4 defines the physical and MAC layers, and Zigbee defines the network and application layers.

C. LCD Display

The current reading, bill amount and the power to be consumed in peak hours are displayed in the LCD display.

D. ARM Microcontroller(LPC 2148)

The LPC2148 microcontrollers are based on a 32/16 bit ARM7TDMIS CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB.

E. LDR Sensor

LDR (Light Dependent Resistor) sensor senses the presence of objects (humans) in the residence. This system automatically switches off the power when there is nobody at home.

F. PIR Sensor

PIR (Passive Infrared) sensor is an electronic sensor also known as passive infrared motion detector to measure infrared light radiated from those objects present in its field of view.

G. RS232 Communication

Either serial or parallel mode of transmission is used to transfer information in the form of digital data between data processing equipment and peripherals.

VI. Software Output

A. OrCAD Capture CIS

The schematic diagram of the project is created in this software. OrCAD Capture CIS efficiently manages the components and is designed to reduce production delays and cost overruns.

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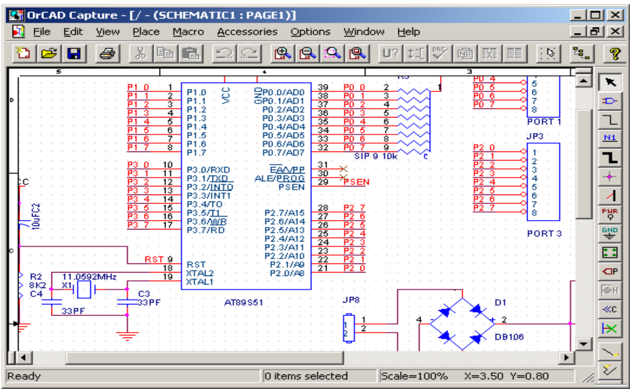

Fig.2. OrCAD Output

B. Keil C Compiler

This provides a platform to create a program code. The program coding is then burned into a microprocessor using this.

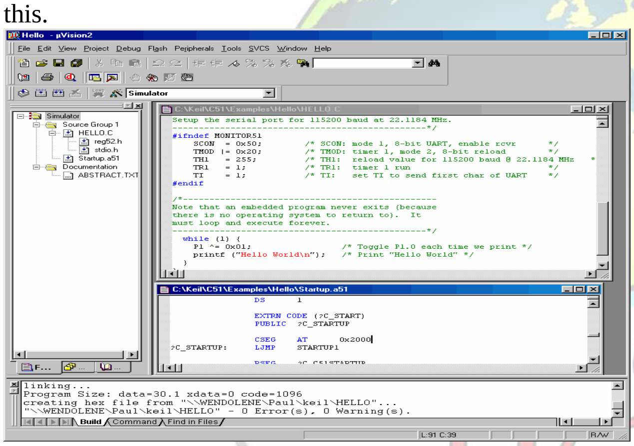

Fig.3. Keil Output

The codes are then dumped into the kit to produce the desired result in the hardware components.

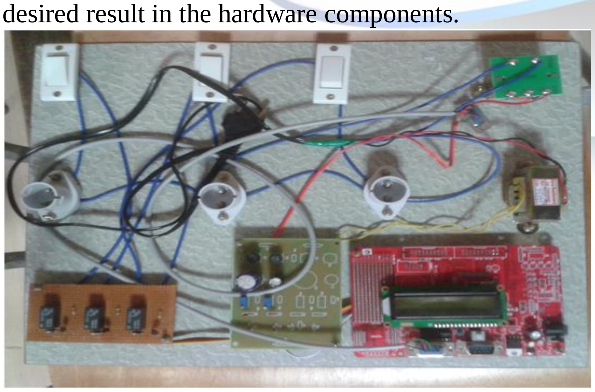

Fig.4. Hardware tools

VII. Conclusion

This project develops a system for better management and sharing of electricity, ensuring maximum utilization of the available electricity at the peak hours using an embedded microcontroller. Using this system, it is possible to avoid power cuts, reduce the use of inverters, and electricity theft can also be effectively monitored and avoided. Thus, power distribution can be effectively managed at a very low cost and this system can very effectively ensure power availability to various consumers causing them least or no inconvenience at all.

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