Intelligent Household LED Lighting System Considering User Satisfaction and Energy Saving

Ankita B. Kolhe, P. S. Choudhary

Abstract*— this paper aims to provide experiences from field tests using wireless technologies and the associated solutions, for energy management of household appliances. The system saves energy by maximizing the use of daylight, capable of controlling lights, fans in a room. All these parameters are measured through various sensors and the controlling is done by microcontroller. The system itself consumes very low power and helps in saving a significant amount of energy. The system can be applied to government offices, private firms, residential buildings, schools; colleges etc. so as to avoid the wastage of electricity and maximum use of day lighting, also reduces our dependence on conventional energy and will help in conserving energy. The system architecture is described and experimental results are provided for monitoring and intelligent control of home appliances, enabling demand response in real-time.

Index Terms*— Energy Efficiency, Home Automation, Situation Awareness, User Satisfaction.

I. INTRODUCTION

Observing microclimate changes is one of the most popular applications of wireless sensor networks . Sensor nodes can be deeply embedded and densely deployed to enable up-close monitoring of various indoor or outdoor environments. Home environment monitoring is one of the application fields where wireless sensor networks and consumer electronics technologies make a good combination. Given the energy waste problem in household appliances and the consequent need of optimal energy use, we propose automatic real-time management of their energy consumption within user-defined limits making it capable to control and achieve efficient energy management in order to avoid current energy crisis and green house effect. Lighting control systems provide many benefits such as operational convenience, scheduled control, reduced energy consumption, and moderation of peak demand. Lighting controls not only offer electricity savings but also offer further benefits depending on the application they can improve comfort, reduce maintenance costs and impart greater flexibility to the use of a workspace. Automated lighting control is one of the important components in intelligent buildings and green buildings. Light accounts for approximately 20% of World's total energy consumption. Thus the invention of LED is expected to alleviate the energy consumption of light because LEDs lighting device consumes 50% of the energy consumption. Most of all, the existing lighting systems have problems in power consumption, controlling an environmental pollution aspects and can support only simple ON/OFF or dimming control according to user movement or brightness of surroundings, which is hard to implement in complex environments like house or offices. In this paper, we design and implement a system that overcomes the unnecessary power consumption occurring during the daytime which has plentiful sunlight by having autonomous ON/OFF control and variation in brightness of illumination based on human body sensed. Our system focuses on the real-time watt per hour power consumption and translated price, and averaged consumptions over different periods. Also the system does not need the continuous human supervision at setup providing a user satisfaction. In order to verify the efficiency of our system, we implemented our system in real test bed and conducted experiments. The design and implementation allows the system for autonomous power saving using is approximately % as compared to that of the conventional lighting control system.

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II. PAPER ORGANIZATION

The rest of the paper is organized as follows: section II discusses proposed work regarding Intelligent Lighting Control System based on multi sensors and wireless communication technology. Section III discusses design and implementation tools for realization of the proposed Lighting Control System. Section IV discusses the Experimental results of proposed system and a compares its performance with respect to existing Lighting systems. Section V concluded and discuss about the future work.

III. PROPOSED ARCHITECTURE

The proposed system provides intelligent mechanism for effective energy management using multi sensors and wireless communication technology to control LED light according to user's state and surroundings. We use environmental sensors like illumination sensors (LDR), motion sensor (PIR), temperature sensor (LM 35) which allows the system to vary brightness of illumination, fan speed required according to the sensed data.

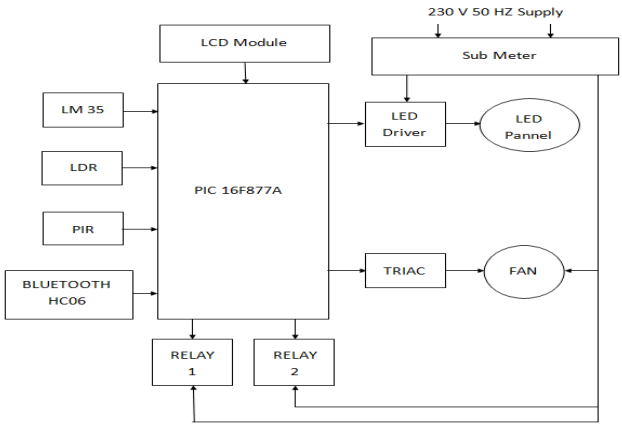

Figure 1: Block Diagram of the Proposed System

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The system using PIR sensor decides whether a user is in a room or not and control the brightness of lights connected with microcontroller. The microcontroller continuously monitors the sensors. In LED lights, it is possible to adjust the brightness of the lights by using PWM. i.e. if the illumination of surrounding is sensed, uses can be provided the regular brightness through brightening or darkening the lights freely. Also it varies the illumination according to the insulation of the season or the time of day. When the movements are rarely detected, system autonomously turns the LED lights off or adjusts the weaker brightness to save power consumption. The system uses Bluetooth receiver module to intercommunicate with the home appliances. Also have the remote control over the appliances using speech recognition application of mobile phone. All the devices mentioned are using very low power and operated on DC supply. Liquid Crystal Display (LCD) is incorporated to enhance the system quality by the displaying temperature, illumination intensity, etc. A 5V DC source is required to supply power to the circuit. The switching circuit is controlled with the signaling from microcontroller. Whatever power consumed by these appliances is detected by the sub meter. Using this IC we observe the energy efficiency provided by our system. The corresponding energy consumption observed by using the proposed system are compared to that of the existing system to analyze energy efficiency and user satisfaction. These signals are generated on the basis of the sensors input to the microcontroller. The complete system is self-controlled, reduces human efforts and efficient in terms of power savings.

A. Automatic Room Light Control:

The PIR sensor is used as transmitter and receiver which senses the movement of user bidirectional. The sensed signal is further amplified which boost the analog signal given next to microcontroller which digitalize it and accordingly switch ON/OFF the light relays.

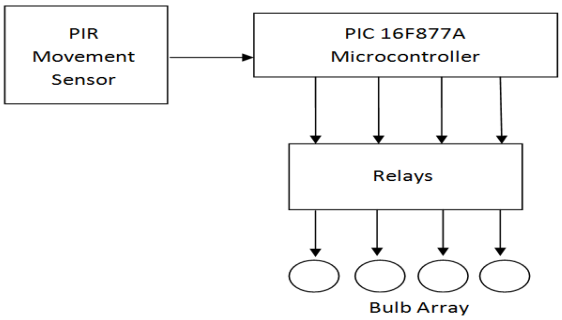

Figure 2: Automatic Room Light Control

B. Automatic fan Regulation with temperature

The analog temperature signal by the temperature sensor is digitalized and given to the microcontroller. The TRIAC Driving circuit drives the motor and varies the fan speed.

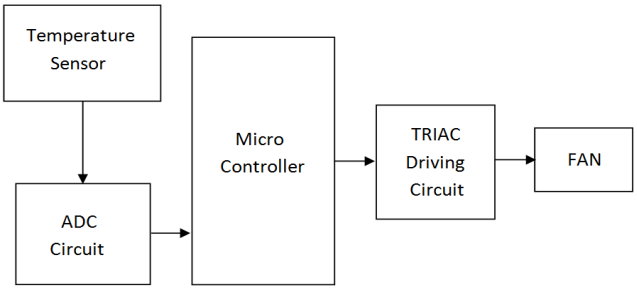

Figure 3: Automatic Fan Regulation

IV. EXPERIMENTAL RESULTS

Developed system can easily be implemented with the existing setup. The complete hardware system consumes very less amount of power. The technology adopted in this project is quite simple, very logical and economical too. Making it more compact and producing it on a large scale, can make this device even more durable and help reduction in the cost. This system is simple and easy to use. It can be installed by anyone for saving energy in home, schools, offices etc.

The designed demo hardware has been installed in a room where daylight was not sufficient. The circuit is examining with connected load of 120W (one light and one fan each 60W) in the month of April when the temperature is more than 30C. The test result with the hardware and without the hardware is shown in the Table 2. With the help of the developed system using one light and one fan approximately 133 units (kWh) of electricity can be saved in a year. Developed system is focused on wastage of energy which happens due to improper switching and careless use. System itself consumes very low amount of power which is 0.845 W. A comparison is also done to show the importance and the electricity saved by the developed hardware.

Components	*Average Current (mA)*	*Operation Voltage (V)*	*Average Power Consumption (W)*
Microcontroller	123	5	0.615
PIR Sensor	35	5	0.17
Light Sensor	0.5	3.6	0.002
Temperature Sensor	10	5	0.05
LCD Display	0.6	3	0.003
Power Consumption by the model			0.845

Table 1: Power Consumption of the Proposed System

Days	*On time of the Appliances (hrs)*		*Energy Consumption (W/hrs)*		*Total Energy Saved (W/hrs)*
	With Dev. H/W	*Without Dev. H/W*	*With Dev. H/W*	*Without Dev. H/W*	
Sun	7.92	11.00	950.4	1320.0	369.6
Mon	6.55	10.00	786.0	1200.0	414.0
Tues	7.15	10.25	858.0	1230.0	372.0
Wed	7.40	9.22	888.0	1106.4	218.4
Thurs	6.33	9.70	759.0	11.64.0	404.6
Fri	12.40	16.62	1488.0	1994.0	506.4
Sat	10.15	12.38	1218.0	1485.6	267.6

Table 2: Energy Consumption of Appliances

V. CONCLUSION

In this paper, we have developed a hardware is designed and implemented automatically switches the household appliances to reduce the wastage of electricity accordingly to certain sensor output. Thus the problem such as demand and supply gap of electricity is minimized, maximum use of day-lighting and saving conventional sources

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of energy. The developed system is such that it can easily be applied to government offices, private firms, residential buildings, schools, colleges etc. so as to avoid the wastage of electricity. With the increasing cost of conventional energy, this system is an efficient means of saving energy. The power supply used, is from renewable source which helps in reducing dependence on conventional electricity.

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