Energy Efficient Light Monitoring and Control Architecture Using Embedded System

P. Rathnavel, T. Baldwin Immanuel, P. Rayavel

Abstract--- In this paper, we propose an energy efficient RF-based outdoor light monitoring and control system that can monitor and handle outdoor lights more efficiently as compared to the conventional systems. The proposed system uses the RF-based wireless devices which allow more efficient lamps management. The designed system uses sensors to control and guarantee the optimal system parameters. To realize effectiveness of the proposed system, the prototype has been installed inside the University, where the experimental results proved that the proposed system saves around 70.8% energy for the outdoor street environment because of using sensors, LED lamps, and RF based communication network. To implement wireless control system of lights, several comparable architectures have been applied for outdoor lighting. In the design of the intelligent lighting system by considering the system cost as the main factor beside the energy saving. In, the author tries to reduce the number of sensors on each lighting nodes, but this reduction will result in less accuracy of the system due to more packet loss and hence will result in performance degradation. Furthermore, the authors in and designed the energy efficient lighting controls system by utilizing the WIMAX and GPRS as backbone technology, respectively, to communicate with the control center. One of the drawbacks of utilizing WIMAX and GPRS is the utilization of licensed spectrum, which will result in interference with the existing WIMAX and GPRS users. Hence, the lighting system will also require efficient interference avoiding algorithms to cope with interference, but this is not suitable for the lighting systems. These systems also have no capability to change the light intensity according to the users' requirement because they statically control the energy consumption and do not consider the user requirements in the sense of light intensity and the user's presence while dimming or turning off the lamps. In order to fill this research hole, we design the energy efficient RF TRANSRECEIVER-based outdoor light monitoring and control system. In addition to all these things ,an additional led is given as backup light, which will be used during main led light failure or when the operating temperature of main led exceeds the optimum range.

Index Terms--- WSN (Wireless sensor Network), MSD (Mass Storage Device), HID (Human Interface Device), LDR (Light Depended Resistor).

I. INTRODUCTION

Energy efficiency is one of the key factor while designing indoor or outdoor lighting systems. The street lights consume almost 30-40% of the entire city power consumption. Thus, control system able to efficiently manage the lighting is absolutely advisable. For this aim, because of its design based on the old lighting standards and inefficient instruments and devices, the traditional lighting systems are not suitable resulting in energy losses, frequent replacement of devices. Moreover these traditional systems suffer from the lack of pervasive and effective communications, monitoring, automation, and fault diagnostics problems.

To address these challenges, many technologies has been utilized in the literature to save energy such as: the utilization of the light emitting diode (LED) instead of metal halide (MH) lamps. But the systems based on these technologies need further improvement to increase the energy efficiency.

To further reduce the energy consumptions and to simplify the wiring structure, numerous lighting control systems have been proposed to solve that problem such as: occupancy sensing approach, light level tuning, and power line communication (PLC). Despite of reducing the wiring structure in PLC based designs presented in, occasional drops may occur in PLC networks operating on low voltage power lines.

These drops are caused by noise and attenuation, and can last from a few minutes to few tens of minutes. Due to carrier signal attenuation, there may be high latency or communication failure in PLC based design. On the contrary, deploying communication infrastructure based on wireless sensor networks (WSNs), such as low power ZigBee or RF, eliminates wiring overheads and save lots of energy.

To implement wireless control system of lights, several comparable architectures have been applied for outdoor lighting. In the design of the intelligent lighting system by considering the system cost as the main factor beside the energy saving. In this, the author tries to reduce the number of sensors on each lighting nodes, but this reduction will result in less accuracy of the system due to more packet loss and hence will result in performance degradation. Furthermore, the authors in and designed the energy efficient lighting control system by utilizing the WIMAX and GPRS as a backbone technologies, respectively, to communicate with the control center. One of the drawback of utilizing WIMAX and GPRS is the utilization of licensed spectrum, which will result in interference with the existing WIMAX and GPRS users. Hence, the lighting system will also require efficient interference avoiding algorithms to cope with interference, but this is not suitable for the lighting systems.

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These systems also have no capability to change the light intensity according to the users' requirement because they statically control the energy consumption and do not consider the user requirements in the sense of light intensity and the user's presence while dimming or turning off the lamps.

In order to fill this research hole, we design the energy efficient RF TRANSRECEIVER-based outdoor light monitoring and control system. The proposed system also implemented the standard mesh routing algorithm which results in better network performance as compared to the conventional systems. The proposed system also fulfills the user satisfaction by using occupancy and illumination sensors. Hence, the design of this system dynamically controls the energy level of outdoor users while guaranteeing their predefined minimum satisfaction level.

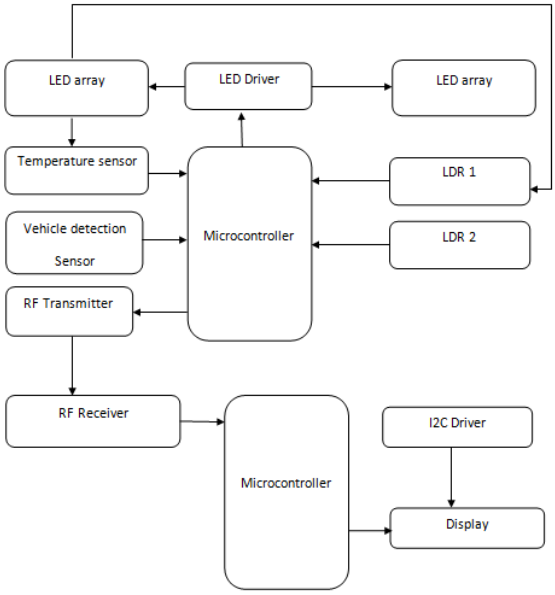

Figure: Block Diagram Of Energy Efficient Lighting System

II. CIRCUIT DIAGRAM

RF transmitter

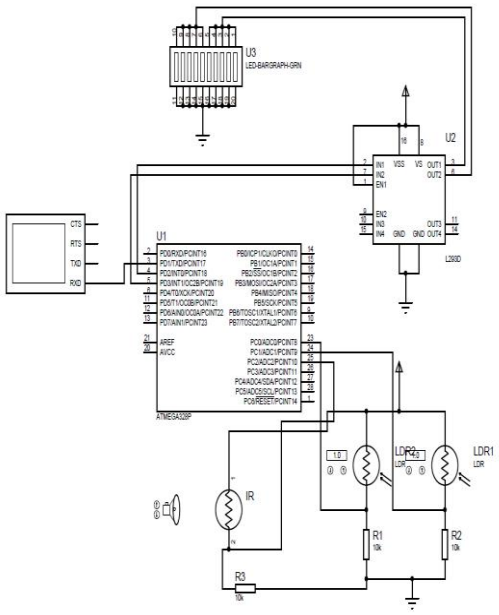

Figure: Circuit diagram of rf transmitter

RF Receiver

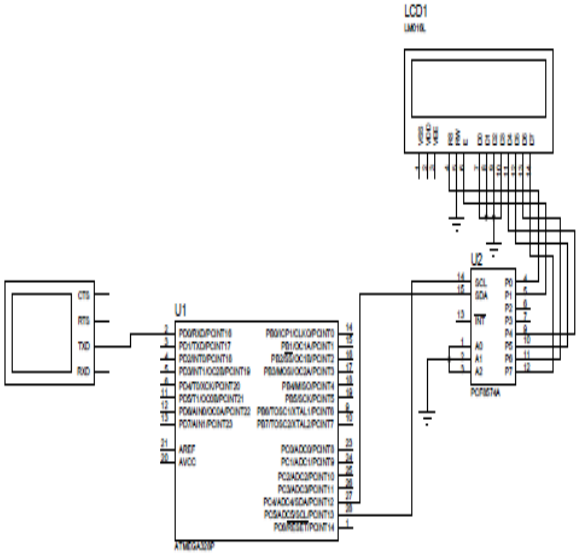

Figure: Circuit diagram of rf receiver

III. CIRCUIT SIMULATION

Proteus is a software package for computer-aided design, simulation and design of electronic circuits. It consists of two main parts, the ISIS, the circuit design environment that even the simulator VSM includes, and the ARES, the PCB - Designer. Developer and manufacturer of the software package is the company Labcenter Electronics.

Virtual System Modelling (VSM)

The VSM, V irtual S ystem M odeling (Virtual System Modeling), provides a graphical SPICE circuit simulation and animation directly in the ISIS environment. The SPICE simulator is based on the Berkeley SPICE3F5 model. It may microprocessor-based systems are simulated. With the VSM-Engine can interact during the simulation directly to the circuit. Changes of buttons, switches or potentiometers are queried in real time as well as LED indicators, LCD display and "Hot / Cold" -Wires displayed.

Proteus VSM for microcontrollers

- PIC12 / PIC16 / PIC18
- PIC24 / PIC33
- HC11
- 8051/8052
- BASIC Stamp
- ATMEL AVR
- 8086
- MSP430

The microcontrollers are (with a few exceptions that are explicitly stated in the instructions) in the periphery and in the Code fully supported (interrupt, ADC, I2C, USB, comparators, etc.). It includes a debugging environment for the program code of the microcontroller. To simulate the .HEX and .COF file of the compiled software are necessary. The clock is simulated in real time.

Proteus VSM Advanced Simulation

- Generating frequency responses
- Analog and digital transient analysis
- Analysis of the analog behavior of digital sources
- Analysis of the noise behavior
- Generation of custom waveforms using the Easy HDL Scripting Language
- Display in magnitude and phase in dB or linear
- Audio analysis of waveforms in exportable WAV
- Meter reading supported by graphics cursor

Proteus VSM USB Simulation

- Debugging USB applications with the support of USB device classes
- Mass Storage Device Class (MSD)
- Human Interface Device Class (HID)
- USB Transaction Analyzer
- Illustration of USB Packages

Software

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 project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and provides simple one-click mechanism to compile and load programs to an Arduino board. A program written with the IDE for Arduino is called a "sketch". The Arduino IDE supports the languages C and C++ using special rules to organize code. 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:

setup(): a function that runs once at the start of a program and that can initialize settings.
loop(): a function called repeatedly until the board powers off.

After compiling and linking with the GNU tool chain, also included with the IDE distribution, the Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal coding that is loaded into the Arduino board by a loader program in the board's firmware. Using arduino we can program the instructions using c and convert them into machine language that can be understand by the microcontroller .

Power LED and Integrated LED on Arduino Compatible BoardPower LED (red) and integrated LED on Line 13 (green) on Arduino compatible board, made in China Most Arduino boards contain an LED and a load resistor connected between pin 13 and ground which is a convenient feature for many tests.

IV. SIMULATION OUTPUT

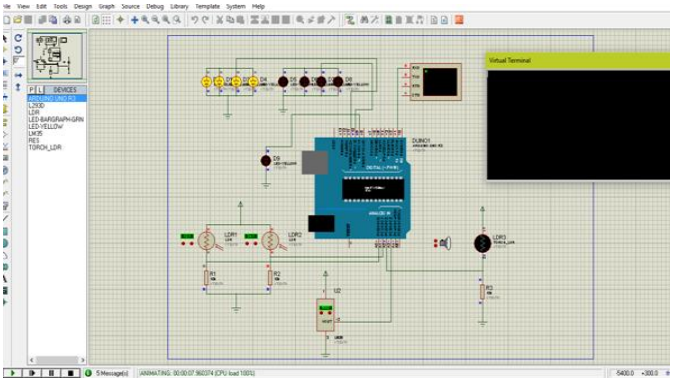

Figure: When the ambient light level decreases the led will turn on immediately using LDR sensor

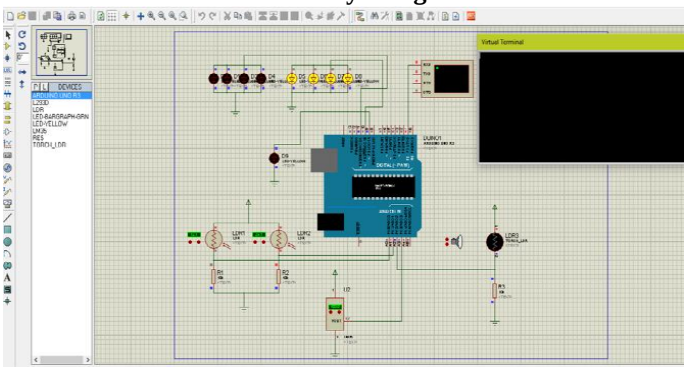

Figure: When the LED optimum temperature is exceeded then another set of LED will glow while the default one turns off

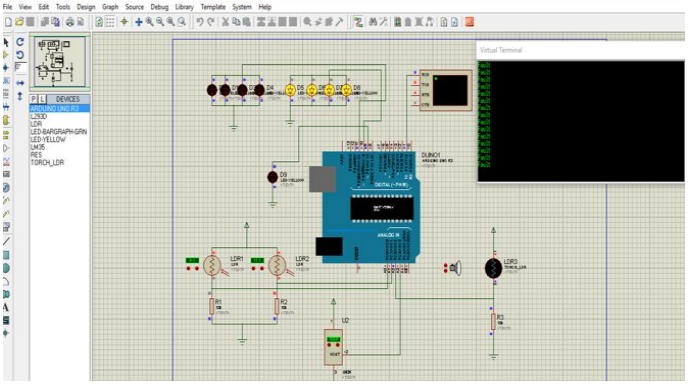

Figure: When the first set of LED fails then the lighting will be switched to another set of LED so that no interruption in lighting the street

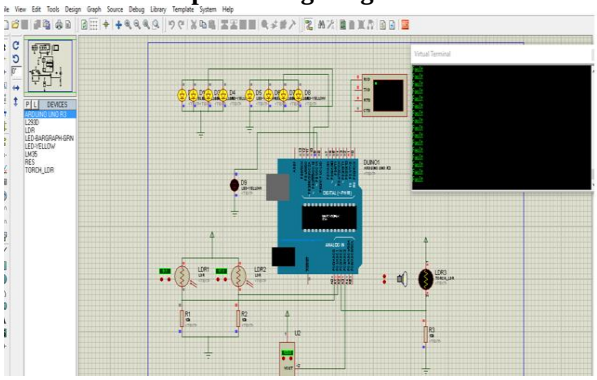

Figure: When the vehicle approaches the light it will glow with max brightness

V. PROTOTYPE MODEL AND OUTPUT

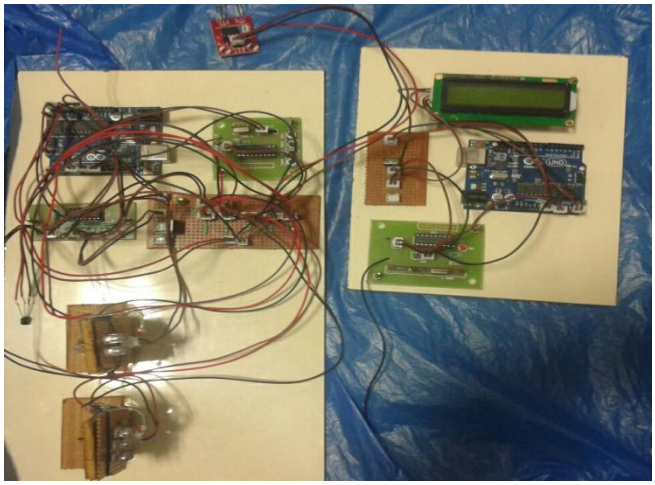

Figure: Prototype Model

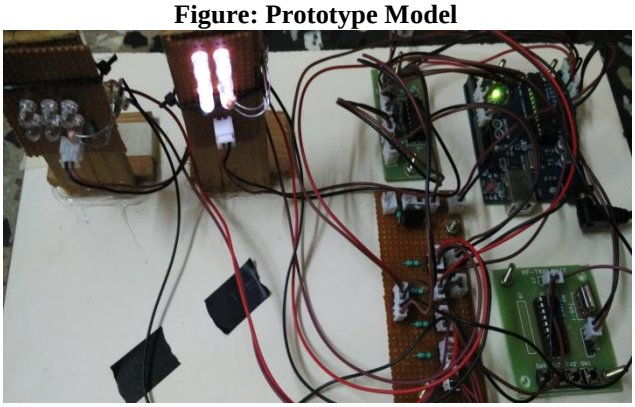

Figure: When the ambient light level decreases the led will turn on immediately using LDR sensor

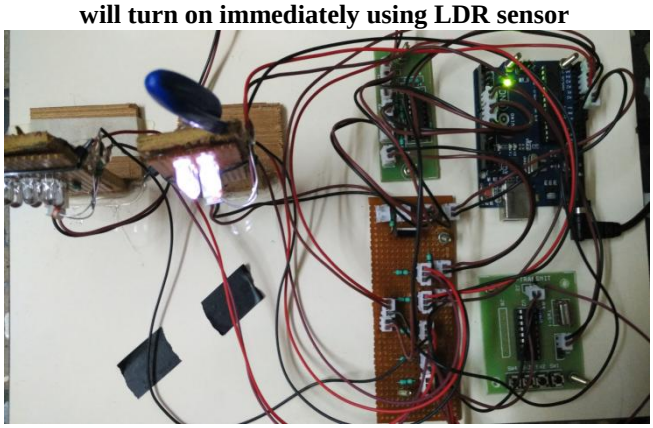

Figure: When the vehicle approaches the light it will glow with max brightness

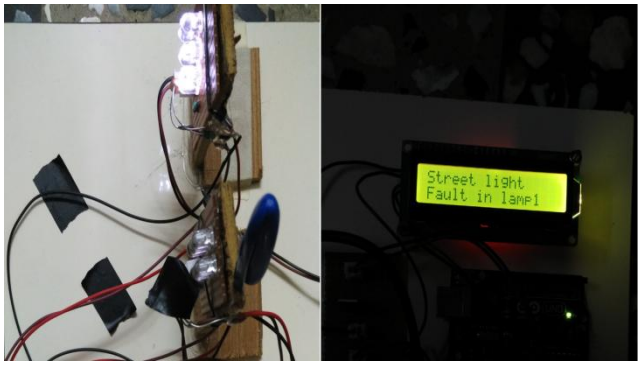

Figure: When the first set of LED fails then the lighting will be switched to another set of LED so that no interruption in lighting the street and error is sent to the control room.

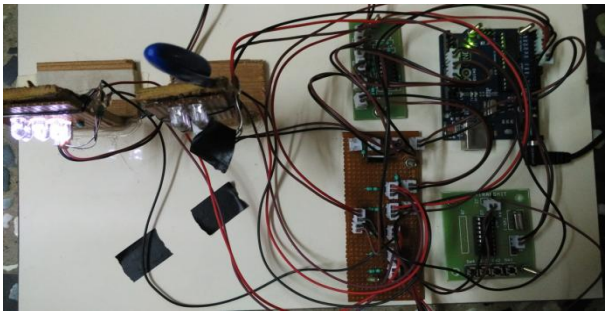

Figure: When the LED optimum temperature is exceeded then another set of LED will glow while the default one turns off

VI. CONCLUSION

The centralized and smartly monitoring of outdoor lights is the cost effective and energy efficient way of saving precious energy. In this paper, the novel sensor based system is proposed, which can smartly adjust the intensity of the LED lights according to the sunlight conditions. In addition, the designed system can remotely monitor the lights status. By using the proposed system, the faults in the lights can be easily detected remotely and can be recovered with less time, which will save the labor cost for frequently monitoring the system. It can adopt to the changing conditions in a more proactively and timely manner. Furthermore, the proposed system is suitable for outdoor lighting in urban and rural areas with slight modifications where the traffic can be low or high during different time intervals. The designed system is flexible, extendable, and fully adaptable to the user needs.

REFERENCES

1. W. Yue, S. Changhong, Z. Xianghong, and Y. Wei, "Design of new intelligent street light control system," in Proc. IEEE International Conference on Control Automation, 2010, pp. 1423–1427.
2. C.Ozcelebi, and J. Lukkien, "Exploring user-centered intelligent road lighting design: a road map and future research directions," IEEE Trans. Consum. Electron, vol. 57, pp. 788-793, May 2011.
3. P.Rathnavel, S.Surendernath and S.Saravanan, "An Interleaved High-Power Flyback Inverter for Standalone Application Using MPPT Algorithm" Journal of Advanced Research in Dynamical & Control Systems, 11-Special Issue, November 2017.
4. L. Chushan, W. Jiande, and H. Xiangning, "Realization of a general LED lighting system based on a novel Power Line Communication technology," in Proc. IEEE Applied Power Electronics Conference and Exposition, 2010, pp. 2300-2304.
5. P. Elejoste et al., "An Easy to Deploy Street Light Control System Based on Wireless Communication and LED Technology," Sensors (Basel), vol. 13, no. 5, pp. 6492–6523, May 2013.
6. F. Leccese, M. Cagnett, and D. Trinca, " A Smart City Application: A Fully Controlled Street Lighting Isle Based on Raspberry-Pi Card, a ZigBee Sensor Network and WiMAX," Sensors (Basel), vol. 14, no. 12, pp. 24408–244424, Dec. 2014.
7. L. Yongsheng, L. Peijie, and C. Shuying, "Remote Monitoring and Control System of Solar Street Lamps Based on ZigBee Wireless Sensor Network and GPRS," Electronics and Signal Processing Lecture Notes in Electrical Engineering, vol. 97, Springer, 2011, pp. 959-967.
8. Z. Kaleem, I. Ahmad, and C. Lee, "Smart and Energy Efficient LED Street Light Control System using ZigBee Network," in Proc. FIT, 2014, pp. 361-365. Ember Corporation, "EM250 single-chip ZigBee/802.15.4 solution," 120-0082-000V datasheet, May 2013.