Energy Efficient Street Lighting System Based on Microcontroller

Deepa Sivaram, Kala Bharathan, D.Vaithiyanathan

Abstract*: *This paper aims to present an Intelligent Street Light System which is used to control the intensity of street lights based on motion detection of people and vehicles and to turn on the LED lights only when required. The system provides a cost-effective and an energy efficient solution for street lighting applications. The system operates in two modes, Bright state and Dim State. Passive Infrared (PIR) Sensors are used for motion detection. On detection of motion, the LED Bulbs are put into BRIGHT state, which otherwise remain in DIM state. The change in intensity levels from DIM to BRIGHT and vice-versa is achieved by a dimmer circuit. Detection of motion is also communicated to neighboring street lights, over WiFi, which also then change their state to BRIGHT state. The microcontroller used is ESP8266.

Keywords: Dimmer Circuit, Motion Detection, Intensity Control, Microcontroller, Embedded Systems

I. INTRODUCTION

Intelligent street lighting system is an automatic street lighting technology where the intensity of the street lights are controlled based on detection of motion of vehicles and people. The present system used for street light control, in India, is timer based. Lights are turned on at dusk and turned off at dawn. Hence they remain on for the entire 12 hour period. However, this is wasteful in terms of power since the lights are powered throughout the night when pedestrian movement and vehicle density is at its least. This paper, thus aims to provide a more efficient system which conserves power and reduces wastage by turning on the lights to full intensity only when motion is detected. At all other times, the lights are maintained in dim state (twenty percent of full intensity)

II. SYSTEM DESIGN

The block diagram of the system is shown in Figure 1. Each unit in the system comprises of a Passive Infrared (PIR) sensor, a microcontroller (ESP8266) and a dimmer circuit connected to a LED bulb. The LED lights operate in two brightness states – DIM state and BRIGHT state.

Initially when the system is powered ON, all LED bulbs are maintained in DIM state. When the microcontroller (ESP8266) receives an input from the PIR sensor or from a neighboring Node MCU, indicating presence of motion, the LED bulbs are put into BRIGHT state. This is done as follows. A timer is started for a reconfigurable amount of time, say two minutes. If a timer is already running, this timer is reset. A pulse is sent by the microcontroller to the dimmer circuit, which triggers the gate of the TRIAC and puts the LED bulbs into BRIGHT state. At the same time, all neighboring microcontrollers also receive a signal to change the state of their corresponding bulbs to BRIGHT state. The LED Bulbs remain in BRIGHT state as long as the timer value is non-zero. When timer value reaches zero, another pulse is sent to the dimmer circuit to put the LED Bulbs into DIM state. The bulbs remain in DIM state till the microcontroller receives an interrupt from the PIR Sensor or a signal from the neighboring microcontroller.

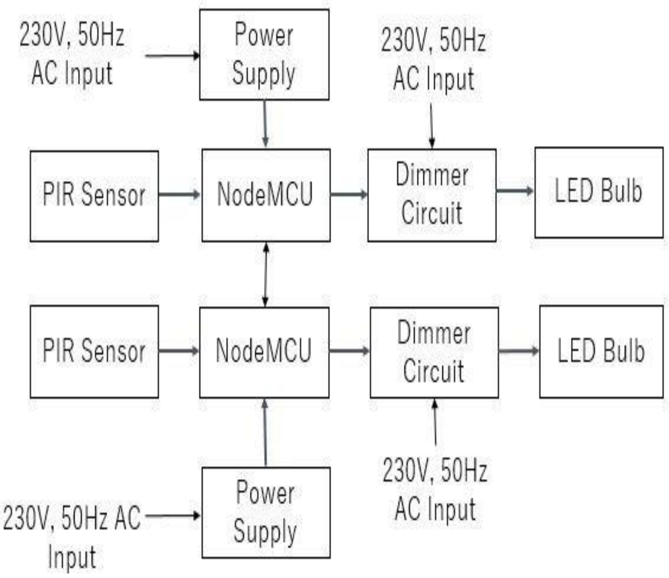

Fig. 1.Block Representation of the System

A. *Dimmer Circuit Design*

The dimmer circuit, as shown in Figure 2, is used to control the intensity of the LED bulbs. An AC voltage controller is implemented using a TRIAC. The dimmer circuit comprises of a zero crossing detector which takes the Line and Neutral voltages as input and produces a pulse

Revised Manuscript Received on November 22, 2019.
* Correspondence Author
Deepa Sivaram, Department of Electronics and Communication Engineering, PESIT, South Campus, Bengaluru, India, Email: deepa.s.sivaram@gmail.com
Kala Bharathan, Department of Electronics and Communication Engineering, PESIT, South Campus, Bengaluru, India, Email: kala@pes.edu
D.Vaithiyanathan*, Department of Electronics and Communication Engineering, National Institute of Technology Delhi, India. Email: dvaithiyanathan@nitdelhi.ac.in

every half cycle of the input (i.e. at every zero crossing). The output of the zero crossing detector is fed as an interrupt to the microcontroller, ESP8266. The microcontroller also receives an input from the PIR sensor or a neighboring microcontroller indicating presence of motion.

When the microcontroller ESP8266, receives an input indicating detection of motion, a pulse, delayed by the appropriate value, is sent to the opto-coupler MOC3023 which in turn triggers the gate of the TRIAC. This causes the TRIAC to switch to ON state and hence a part of the ac voltage is chopped off. This results in dimming of the LED bulb which is connected in series to the TRIAC.

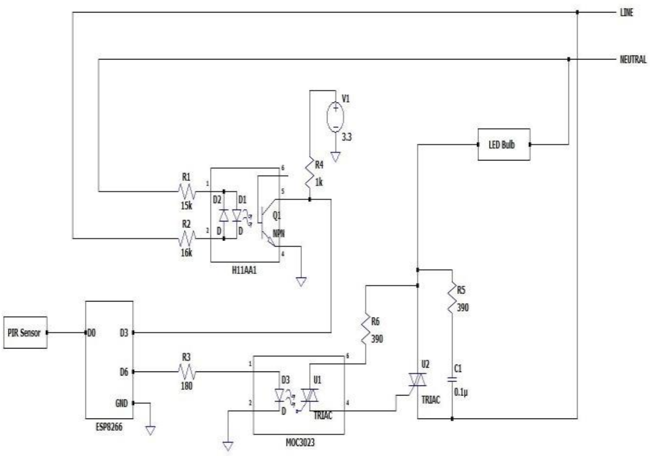

Fig. 2.Controller Circuit

B. Communication between Microcontrollers

Each NodeMCU is assigned a static IP address. On power ON, all the NodeMCU's find out their static IP's from their unique MAC addresses. After finding out their static IP's, they locate the number of peers connected and the IP addresses of their immediate neighbors. When the NodeMCU receives an input from the PIR Sensor, indicating presence of motion, a UDP packet is formed and sent to all the peer nodes. The NodeMCU also continuously checks for incoming UDP packets from other NodeMCU's. When a UDP packet is received from a neighboring node, the ESP8266 verifies the contents and calls the appropriate function to put the LED Bulbs into BRIGHT state.

III. Results and Discussions

The final system implemented is as shown in Figure 3. To demonstrate the final outcome, the system was tested using three nodes. Each node has a PIR sensor (interfaced with a NodeMCU), a dimmer circuit and a dimmable LED bulb. Node 1's NodeMCU was configured to act as an access point where it creates its own Wi-Fi network to which other node NodeMCU's, configured as stations, connect.

Whenever the PIR sensor connected to the first node detected any motion, the LED connected to that node changed to bright state. This was also communicated to its neighboring nodes (node 2 in this setup) and the LED at node 2 also changed to bright state simultaneously. When node 2 detected motion, LED at node 2 changed to Bright state along with the neighboring node LED's - node 1 and node 3. When node 3 detected motion, LED at node 3 along with its neighboring node (node 2) changed to bright state. Once the LED's were turned ON, they remained in BRIGHT state for a certain amount of time after which they returned to DIM state if no more motion was detected. If there is continuous motion detected, the LED lights stay on as long as there is motion. This system is configured to work in both directions - forward and reverse.

Fig. 3.Prototype of the implemented system

IV. Conclusion

This system effectively demonstrates the change in brightness levels (dimming action) of LED Bulbs on motion detection and the communication, of the same, between NodeMCU's. It is shown that, on motion detection, the LED Bulb corresponding to the node at which motion was detected, changes to BRIGHT state. At the same time, its neighboring node's LED Bulb's also change to BRIGHT state. It is seen that, once the LED Bulbs change to BRIGHT state, they remain in the BRIGHT state for a certain amount of time (re-configurable) after which they change back to the DIM state. The DIM state is 20 percent of full brightness level. Thus, an energy-efficient and cost-effective solution has been effectively implemented.

REFERENCES

1. Deepak K Srivatsa, Preethi B, Parinitha R, Sumana G and A. Kumar, Smart Street Lights, 2013 Texas Instruments India Educators Conference, Banglore, India, 4-6 April 2013.
2. Gul Shahzad, Heekwon Yang, Arbab Waheed Ahmad and Chankil Lee, Energy-Efficient Intelligent Street Lighting System Using Traffic- Adaptive Control, IEEE Sensors Journal, vol 16, July 2016
3. Sitaraa Kumar, Divya Dhiraj, Christina Cibi, Sowmya S, Sabitha S, "Smart Alarm Clock", Communication and Electronics Systems (ICCES) 2018 3rd International Conference on, pp. 999-1001, 2018.

4. K.Bagya Lakshmi, M. Suresh Kumar, S.Sindhuja, R. Padmavathy and P. Jayabharathi, "IoT Based Garbage Monitoring and Street Light Control", Asian Journal of Science and Applied Technology, Vol. 07, No. 02, pp. 33 - 37, 2018.
5. Aziera Abdullah , Siti Hajar Yusoff , Syasya Azra Zaini , Nur Shahida Midi , Sarah Yasmin Mohamad, " Smart Street Light Using Intensity Controller", 2018 7th International Conference on Computer and Communication Engineering (ICCCE), Kuala Lumpur, Malaysia, 19-20 Sept. 2018.
6. Jianhui Zeng , Wei Ni , Runsheng Zhang , Liangping Shi , Chang Guo , Yuyan Chen," Intelligent Street Lamp Control System with Dynamic Light Control Function", 2018 17th International Symposium on Distributed Computing and Applications for Business Engineering and Science (DCABES), Wuxi, China, 19-23 Oct. 2018.
7. Omkar Rudrawar , Siddharth Daga , Janak Raj Chadha , P.S. Kulkami," Smart street lighting system with light intensity control using power electronics", 2018 Technologies for Smart-City Energy Security and Power (ICSESP), Bhubaneswar, India, 28-30 March 2018.
8. Junjian He , Zhaoyou Zhu , Fugui Wang , Junhua Li, " Illumination Control of Intelligent Street Lamps Based on Fuzzy Decision", 2019 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS), Changsha, China, China, 12-13 Jan. 2019.
9. Bilam Roy , Aditya Acharya , Tanmoy K. Roy , Sudip Kuila , Jayita Datta, "A smart street-light intensity optimizer" 2018 Emerging Trends in Electronic Devices and Computational Techniques (EDCT), Kolkata, India, 8-9 March 2018
10. Gourab Das, " An intelligent method for optimizing the street-light-intensity", 2018 2nd International Conference on Electronics, Materials Engineering & Nano-Technology (IEMENTech), Kolkata, India, 4-5 May 2018.
11. Shichao Chen , Gang Xiong , Jia Xu , Shuangshuang Han , Fei-Yue Wang , Kun Wang, " The Smart Street Lighting System Based on NB-IoT", 2018 Chinese Automation Congress (CAC), Xi'an, China, 30 Nov.-2 Dec. 2018.
12. Karthik S Murthy , Parul Herur , B R Adithya , Harshita Lokesh," IoT-Based Light Intensity Controller", 2018 International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, 11-12 July 2018.

AUTHORS PROFILE

Deepa Sivaram received the B.E. degree in Electronics and Communication Engineering from Visveswaraya Technological University, India in 2019. Her research interest is Embedded System and VLSI Design

Kala Bharathan received her M.E degree in VLSI Design from Easwari Engineering College, Chennai and PhD from College of Engineering Guindy, Anna University, Chennaui. She currently serving as Associate Professor in the Department of Electronics and Communication Engineering, PESIT, South Campus, Bengaluru, India. Her area research interest includes Embedded Systems and Optimization of VLSI architecture.

D.Vaithiyanathan is currently working as Assistant Professor in the Department of Electronics and Communication Engineering, National Institute of Technology Delhi, India. From 2010 to 2017, he held the position of Teaching Fellow in the Department of Electronics and Communication Engineering, College of Engineering Guindy, Anna University, Chennai. He received his M.E degree in Applied Electronics from Government College of Technology Coimbatore and Ph.D from College of Engineering Guindy, Anna University, Chennai. His research interest includes Embedded System, Memory Design, Low Power Design and VLSI Architecture for Digital Signal and Image Processing.