



Energy Efficient Smart Street Light System based on Pulse Width Modulation

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Abstract: Across the country, majority of the electric power has been utilized for street lights. These street lights are always ON throughout the night and even in day times due to inefficient street light monitoring systems. An enormous rise in population and waning of natural resources has necessitated the prerequisite of efficient street light system. Therefore, an energy efficient smart street light system based on PWM and Arduino has been proposed. In this work, the power efficiency has been achieved through PWM by switching the brightness of the LED from 100% to 20% based on the vehicle traffic. Based on the vehicle traffic per hour, the duty cycle has been adjusted which inherently changes the width of the pulse. Initially, the lights are in OFF during day time regardless of vehicle movements(LDR is high); during night time or cloudy environment the lights are turn ON based on the vehicle motion detected by PIR. The brightness of the LED is 100% up to a specified time delay, thereafter the brightness has been reduced to 20%. These changes in stats of LED (ON/OFF) have been controlled by PWM duty cycle which is specified by analogWrite(). The performance measures have been evaluated for proposed system by means of power consumption. The experimental results demonstrated that, the proposed system achieves a power save (delay of 3 seconds) of 95% with zero vehicle movement, 92% with 30 vehicles per hour, 91% with 50 vehicles per hour and 87% with 100 vehicles per hour when compared to conventional street light systems.

Index Terms—Air purification, Arduino, Air quality, Optical dust sensor, Threshold.

I. INTRODUCTION

Over the past century, the population of the world has been quickly growing in urban areas. Therefore, the development of a city and its communities depends greatly on intelligent and sustainable development. Every public street and roads have a street lighting system as a standard service. The street lamp posts become Internet of Things (IoT)-based if they are equipped with sensors and communication technology. The use of lighting systems in streets is one of the major uses of electrical energy [1].

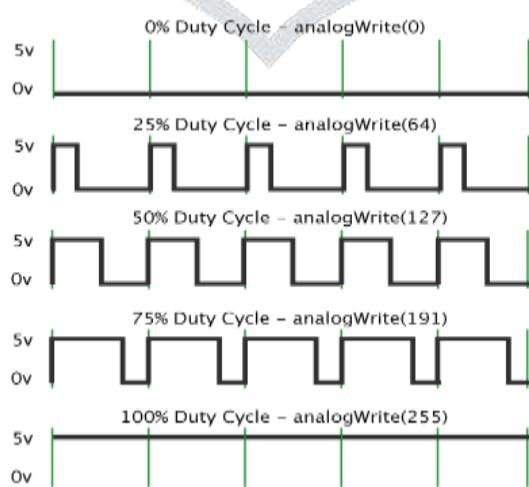


Figure 1. PWM Concept Through Arduino[4]

Therefore, it can be concluded that smart energy management in this region can be beneficial to for both aims given the considerable energy consumption in this system and the significance of individual and social security offered by proper lighting system in the city [2-3]. In this work, the power efficiency has been attained by means of PWM by altering the brightness of LED from 100% to 20% by varying duty cycle (see Fig.1) with respect to vehicle traffic. PWM, often known as pulse width

modulation, is a method for producing analogue effects using digital technology [5-6]. A square wave is produced via digital control, which is a signal that is toggled on and off. By altering the ratio of the amount of time the signal spends on compared to the amount of time it spends off, this on-off pattern can imitate voltages between the full V_{cc} of the board (for example, 5 V on a UNO board), and off (0 Volts). The pulse width is the length of the on time. By modulating the pulse width, can obtain different analogue values. With an LED, for instance, the on-off sequence quickly enough, it appears as though the signal is a constant voltage between 0 and V_{cc} controlling the LED's brightness.

II. LITERATURE REVIEW

To automate the current street light system, a variety of models, algorithms, and prototypes have been put forth by the researchers. A smart street lighting system should supervise in an effective manner to maximize quality and production. The cost, manpower, and energy requirements should all be considered when implementing a reliable, intelligent, and energy-efficient street lighting system.

The authors in [7], has proposed an effectual shrewd street light supervisory system for smart cities which are built through IoT. A detailed investigation of energy and pecuniary prospects of shrewd highway light structure has been presented in [8]. A detailed examination in Nagpur city has been presented for power efficient implementation. A graphical interface tool (GUI) for creating a secure and efficient network for smart streetlights has been developed in [9]. If there is no nighttime traffic on the road, there is no need for street lighting. Since there are less natural energy resources available, it is vital to find ways to conserve energy, especially by lowering the amount of energy used for street lighting.

The authors in [10] have proposed a smart system for energy-efficient street lighting control. Embedded device developments based on smart cities are becoming more and more significant today. It includes efficient public transportation, e-governance, safety and security, intelligent lighting systems, and more. The primary goal of authors in [11] is to offer a street light controller design that will reduce power consumption and enable wireless control, both of which will eventually result in a reduction in the budget needed for electricity for street lights.

A smart street light system has been implemented[12] which has a footstep power generator. In addition, there are numerous inventions for smart street lights based on Zigbee [13], GSM[14], solar panels[15], RFID[16], smoke sensors [17]. The main motive of the available literature is to brighten the atmosphere with less power. Hence this work is focused on reducing the power consumption through PWM.

III. ARCHITECTURAL DESIGN

3.1 Block Diagram

The proposed system (see Fig.2) incorporates with light dependent resistor (LDR), a passive infrared sensor, and LED which are interfaced through Arduino. When the light is glowing based on LDR and PIR answers at any moment, the suggested system is said to be intelligent. When there is sufficient sunlight, the LDR is in the ON state, which means that no current flows through the system because of the high resistance of the LDR. In addition, the brightness of the LED has been adjusted in such a way that it depends on time delay and duty cycle (defined through Analog Write()).

When the time delay increase, the duty cycle has been adjusted in the program which is nothing but the brightness of the LED depends on the width of the pulse. Hence, the brightness of the LED switched from 100% to 20% when there is no vehicle movement after the given time delay. In this way the power consumption has been reduced when compared to existing systems.



Figure 2. Proposed System Block Illustration

3.2 Circuit Implementation

The circuit connection of the suggested system based on PWM is shown in Fig.3.

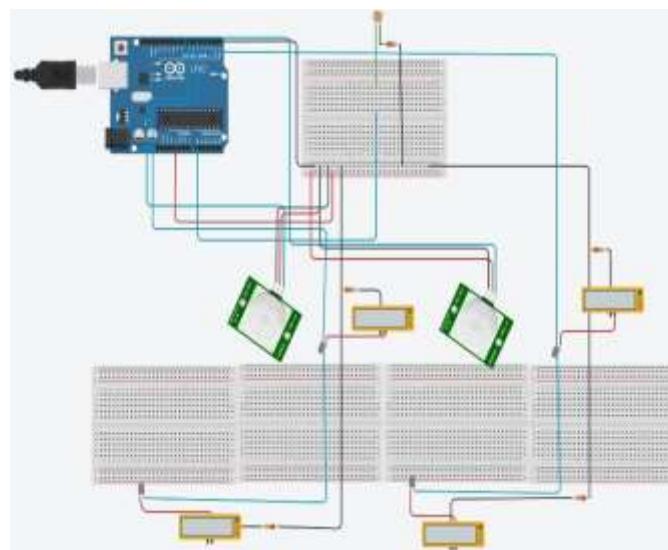


Figure 3. Circuit Implementation of Proposed Model

3.3 Proposed Hardware Model

The suggested model includes a PIR sensor has been illustrated in Fig. 3. The LDR has been fixed (see Fig. 4) so that it can detect the sun during the day.

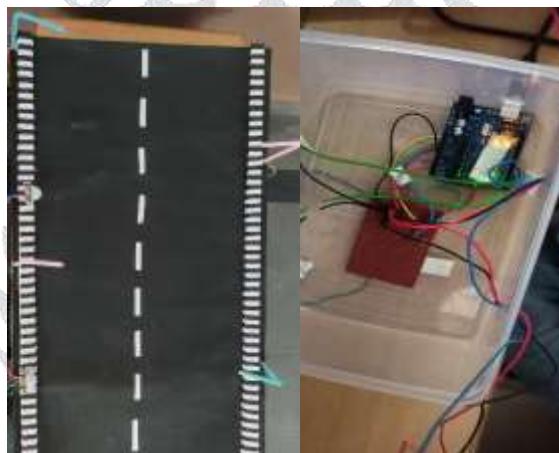


Figure 4. Developed Hardware Model

IV. EXPERIMENTAL RESULTS

The Arduino programming is done by using Arduino Integrated Development Environment (IDE).

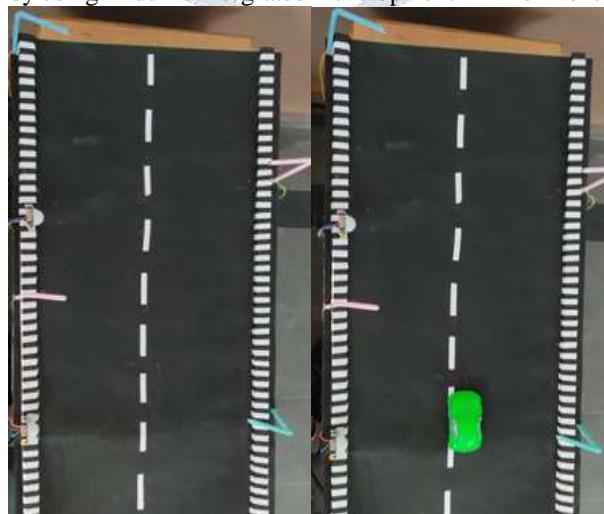


Figure 5. Status of the Proposed System During Day Time

The light dependent resistor is used to detect the daytime and night time automatically based on the resistance of the LDR. Passive Infrared Sensor (PIR) is used to detect the motion of vehicles and people. It triggers the street light controlled by an Arduino thereby controlling the brightness of Light (i.e., when a vehicle or person movement is detected by the PIR and it triggers the Arduino, which will increase the brightness of the light to 100%). Initially the brightness is maintained 0% but when an object

motion is detected the brightness will increase to 100%. Once there is no motion detected by PIR the brightness will fall to 50% from 100%. Further if there is no object motion detected the brightness will fall to 0%.

It is clearly depicted from Fig.6; the system is inactive and all lights are turned off during day time (LDR is exposed to sunlight). Even if there is any object motion, the PIR sensor will not detect the motion as the LDR is exposed to sunlight. Hence, during day time the lights are switched off automatically. Whenever, the sun light condition is not good or during night time, the LDR having low value, then the whole system is active and the brightness of light is initially maintained 0% and the PIR sensors are active.



Figure 6. Switching the brightness of lights from 100% to 20% depending upon vehicle movements.

Fig. 7 depicts that the, motion is detected by the PIR sensor and it will increase the brightness from 0% to 100% and stay at 100% till the motion ends. When no more object motion is detected then brightness will fall to its initial state gradually (passing through 50% and 25% to 0% based on duty cycle provided in algorithm).

V. CONCLUSION

Based on pulse width modulation and Arduino, an effectual road light arrangement has been projected. The power efficiency has been achieved through PWM by switching the brightness of the LED from 100% to 20% based on the vehicle traffic. Based on the vehicle traffic per hour, the duty cycle has been adjusted which inherently changes the width of the pulse. Initially, the lights are in OFF during day time regardless of vehicle movements(LDR is high); during night time or cloudy environment the lights are turn ON based on the vehicle motion detected by PIR. The brightness of the LED is 100% up to a specified time delay, thereafter the brightness has been reduced to 20%. The proposed system attained a power save of 95% when there is no vehicle movement and 87% with 100 vehicles per hour.

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