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DESIGN AND CONSTRUCTION OF AUTOMATIC STREET LIGHT BASED ON VEHICLE MOVEMENT

[*]Auwal Salisu Yunusa, [2]Mariya G. Mustapha, [3]Auwal R. Dan Sharif, [4]Mujittapha I. Wawo, [5]Shehu Atiku, [6]Nafisa Tijjani, [7]Aliyu Musa Sani, [8]Aliyu Sani Yahaya, [9]Umar Shehu

[1,5,6,7,8]*Department of Mechatronic Engineering, Kano State Polytechnic, Nigeria*

[2,3,4,9]*Department of Electrical/Electronic Engineering, Kano State Polytechnic, Nigeria*

[*]*(auwalsalis1984@gmail.com) Email of the corresponding author*

Abstract – The primary consideration in the present field of technologies is Automation, Energy consumption, and cost-effectiveness. Automation is intended to reduce manpower with the help of intelligent systems. Energy saving is the primary consideration forever as the energy sources are getting diminished for various reasons. As we all know that energy consumption has been increasing day by day so, to overcome these consequences we are using IoT devices. This research proposes a modal for modifying street light illumination by using sensors at minimum electrical energy consumption. When presence is detected, all surrounding street lights glow at their brightest mode, or else they stay in the dim mode. LED bulbs shall be implemented as they are better than conventional incandescent bulbs in every way. This shall reduce heat emissions, power consumption, maintenance and replacement costs, and carbon dioxide emissions. Massive energy savings are envisioned. The main aim of this research is to reduce power consumption when there are no vehicle movements on the road, the Smart street light will stay OFF, and when there are vehicles on the road some specific range number of lamps will be turned ON until the vehicle passes.

Keywords – Automation, Consumption, Illumination, Intelligent, Lightining

I. INTRODUCTION

One of the largest energy expenses for a city is street lightening. In most cases, an intelligent street lighting system can cut municipality street lighting costs as much as 50% - 70%. In this articles, the system is like the lights will be switched on in the evening before the sun sets and they are switched off the next day morning after there is sufficient light on the outside (Anupriya et al 2014). But the actual timing for these lights to be switched on are when there is absolute darkness. With this, the power will be wasted up to some extent. In sunny and rainy days, ON and OFF time differ discernibly which is one of the significant hindrances of the present street lights systems. Also the manual operation of the lighting system is completely eliminated. The energy consumption in entire world is increasing at the fastest rates due to population growth and economic development and the availability of energy sources remains woefully constrained. Resource augmentation and growth in energy supply has not kept pace with increasing demand and, therefore, continues to face serious energy shortages. Streetlights are an integral part of any developing locality.

They are present on all major roadways and in the suburbs too. Every day, streetlights are powered from sunset to sunrise at full strength, even when there is no one around. On a global scale, millions of dollars are spent each day on these streetlights to provide the required electrical energy. The maintenance and replacement costs of conventional incandescent bulbs are immense. They consume a lot of electric power to function and their heat emissions are also quite high. All of this contributes to greater demand for electricity production and consequently, more carbon dioxide emissions from powerhouses. So, along with unnecessary light pollution, this practice causes damage to our planet too. The main aim of the research is to provide an automatic street lighting system that would be a simple and effective solution to this would be dimming the lights during off-peak hours. Whenever presence is detected, the lights around it will glow at the normal (bright) mode. This would save a lot of energy and also reduce the cost of operation of the streetlights.

The current trend is the introduction of automation and remote management solutions to control street lighting (Mohelnikova et al., 2018). Within this evolution, microcontrollers progressively replace analogue controllers and the discrete solution even in low-cost applications. They are more flexible, often need fewer components, and provide faster time to market. Remote control facilitates a variety of operations around the home or offices from a distance such as fan regulators and mains power supply. It provides a system that is easy to understand and also to operate, a system that would be affordable, reliable, and easy to maintain. The system of remote control offers long durability. It adds more comfort to everyday living by removing the inconvenience of having to move around to operate a fan regulator. Most people are unaware of the remarkable benefits that dimmers can have, particularly for commercial lighting, all of which have been well documented with research and case studies (A. Jalan, G.Hoge, S. Banaitkar, and S Adam., 2017).

A voltage regulator is an electrical device designed to automatically maintain a constant voltage level. A voltage regulator may be a simple Feed-Forward design or may include negative feedback control loops. It may use electromechanical or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. Electromechanical regulators usually called voltage stabilizers have also been used to regulate the voltage on AC power distribution lines. These regulators operate by using a servomechanism to select the appropriate tap on an autotransformer with multiple taps, or by moving the wiper on a continuously variable auto-transformer. If the output voltage is not in the acceptable region, the regulation can be achieved by different techniques through the use of electrical and electronic circuitry. These circuits are coupled with servomechanisms or electromechanical relays to select the appropriate or desired voltage level. The voltage selection can be done automatically or manually as in Automatic Voltage Regulators (AVR) and AC stabilizers (Fan Regulators respectively). The manual voltage selection involves a lot of human labour, energy, and time wastage. Many electronic systems have been designed over the past years, to reduce these lapses and shortcomings involved in the manual voltage level selection. More efficient devices were invented, these include the design of voice-activated switches, clap-activated switches, remote control and switches, touch-activated switches.

II. Materials and Method

This stage discusses the design and implementation of the whole system. The system has sub-units: like the power supply unit circuit, the switching circuit, and the ultrasonic sensor. These sub-units are also made of some components and all those components have their individual specifications based on datasheets, like current ratings, voltage ratings, and power ratings. Because of this, proper design calculations and implementation of the designs have to be carried out on each of these sub-units to ensure that the system as a whole function properly as expected. The methodology implemented was divided into software and hardware method. The software involves simulation of the project using Proteus 8.6, designing the database by myself, and developing the program on Arduino IDE while the hardware involved bread-boarding, soldering, and casing. The system block diagram is shown in figure 1.

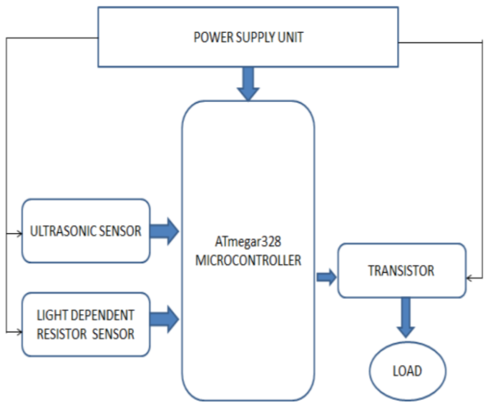

Fig 1. Block Diagram of the System.

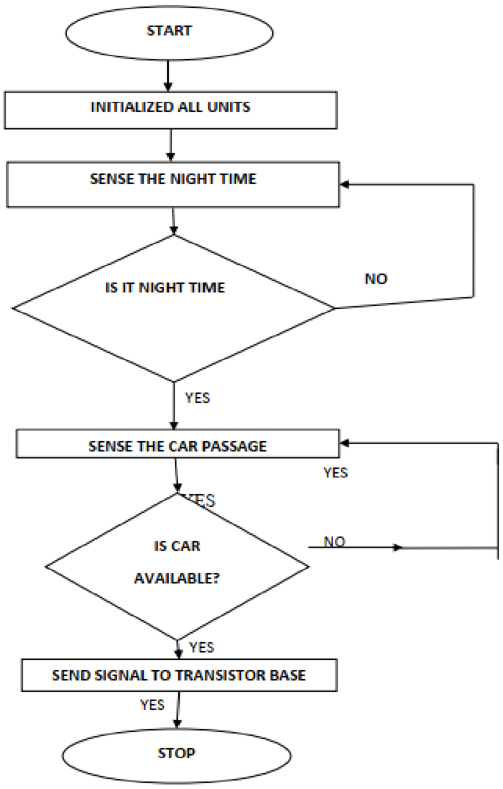

Fig 2. Flow Chart of the System

The block diagram above shows how the system operates. The operation starts as soon as the system is powered. The microcontroller will search for the available sensor (Ultrasonic or LDR). If any of the sensors goes above the programmed threshold. The sensors will be read by the pin of the microcontroller, and then feed the microcontroller with the data taken from the environment. Then the Microcontroller will then compare the data with what is been programmed. If the data correspond with the programmed condition of any of the two sensors, an electrical signal PWM (current) will be sent to the transistor through the base, the signal will then drive the transistor to saturation. After the transistor has been driven to saturation, current flows through the collector of the transistor in PWM form. At this stage, any of the transistors will be ON which will allow the corresponding load to energize true the PWM signal. And this process repeats itself frequently over and over again.

3.1. Hardware Design

3.1.1 Power Supply Unit

The power supply unit consists of a 240V/18V AC, 50Hz step down transformers, filters and a voltage regulator. The Power unit is the unit that energizes all other units of the system. Functionally, the Power supply converts AC Voltage of 50Hz Power line to DC voltage. In this design, 5V DC were required. The power supply unit consists the following components:

- Step down transformer
- Rectifier
- Filter
- Voltage Regulator

This can be represented as defected in figure 3

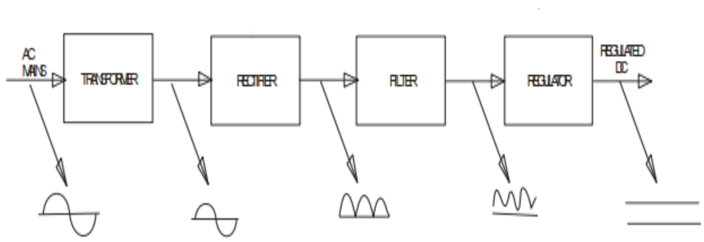

Fig 3. Power Supply Block Diagram

3.1.2 Step Down Transformer

This is used to reduce the alternating input voltage to a lower level. In this design a 240V AC is stepped down to 18V AC which is then rectified and regulated to 5V DC. The design parameters relevant to the transformers are as follows:

- Primary Voltage; 220V
- Secondary Voltage; 18V
- Output current; 500mA

The output power can be calculated as follows:

$$P_{Out} = I_{out} \times V_{out}$$

$$= 500mA \times 18 = 9mWatt$$

The 240V AC is stepped down to 18V AC using a transformer

$$V_{peak} = \sqrt{2} \times V_{rms}$$

$$= \sqrt{2} \times 18 = 25.46$$

3.1.3 Rectifier

A full wave bridge rectifier was used to achieve the conversion of the 18V A.C as shown in the figure below.

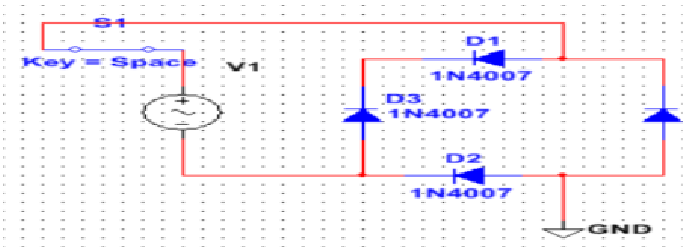

Fig 4. Rectifier Circuit

When terminal 1 is positive with respect to 2, diodes D1 and D3 conduct. When terminal 2 is positive with respect to 1, diodes D2 and D4 conduct, thereby giving a pulsating D.C output as shown below, the simulated bridge circuit is also shown.

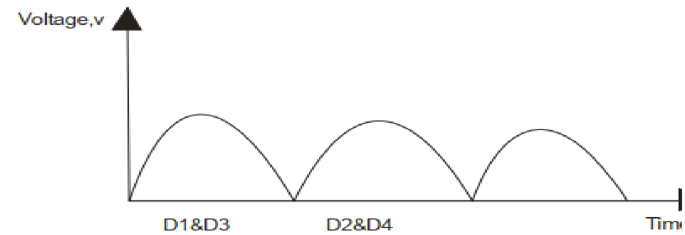

Fig 5. Diode Behavior

For this project four IN4007 diodes were used for the full rectification

$$V_{dc} = \frac{2}{\pi} \times V_{Peak}$$

$$V_{dc} = \frac{2}{\pi} \times 25.46 = 16.20$$

3.1.4. Filter

The function of the filter is to smoothen the pulsations present in the output voltage supplied by the rectifier. In practice, no filter gives output voltage that is as ripple- free as that of a battery, but it considerably reduces the ripple to a certain extent. A capacitor is used to achieve the filtering as shown figure below.

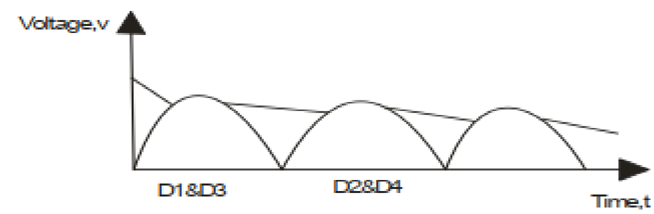

Fig 6. Rectified and Filtered Output

$$V_{dc} = V_s \,/\, (1 + \frac{I_{dc}}{4fCV_s})$$

The Equation above refers to the relationship between the filter capacitor and other supply parameters.

$$\begin{aligned} Where \quad V_{dc} &= expected\ DC\ output\ from\ regulator \\ f &= supply\ frquency \\ I_{dc} &= output\ curent\ of\ regulator \\ V_S &= transformer\ secondary\ voltage \\ C &= capacitance\ of\ the\ filter \end{aligned}$$

It is preferable to choose a filtering capacitor that will hold the peak to peak ripples at approximately 10% of the peak voltage. Therefore;

$$V_{ripple} = 0.1V_{Peak}$$

$$= 0.1 \times 16.97 = 1.62V$$

$$But\ also;\ V_{ripple} = \frac{1}{2}fc\ (for\ full\ wave)$$

$$\begin{aligned} Where\ \ I &= current\ taken\ by\ load \\ f &= frequency\ of\ supply\ voltage \\ C &= filtering\ capacitor \end{aligned}$$

$$C = \frac{2 * V_{ripple}}{f}$$

$$C = \frac{2 * 1.62}{50} = 648\mu F$$

3.2 Arduino Uno

Table 1: Unit Specification

Microcontroller	ATmega328
Architecture	AVR
Operating Voltage	5 V
Flash memory	32 kB of which 0.5 kB used by bootloader
SRAM	2 Kb
Clock Speed	16 MHz
Analog I/O Pins	6
EEPROM	1 Kb
DC Current per I/O Pins	40 mA on I/O Pins; 50 mA on 3,3 V Pin

3.3 Design of Microcontroller Oscillatory Circuit.

This unit is responsible for determining the frequency of operation of the microcontroller. The choice of ratings for the capacitors shown in Figure 21 will be based on the distribution shown in Table.1. The crystal oscillator C_1 has three types as shown in Table.1. The crystal oscillator chosen determines the range of selection for C_2 and C_3.

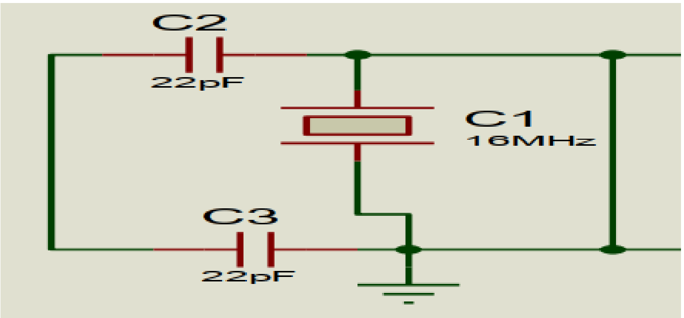

Fig 7. Oscillatory Circuitry for Microcontroller

A 16MHz high speed crystal oscillator was used as C_1 and the rating of C_2 and C_3 were chosen in accordance to the ranges specified in Table.1 with reference to the value of C_1.

Table 2: Crystal Oscillator Capacitors and their Frequencies

Types of Crystal Oscillator	**Frequency (Hz)**	**(F)**	**(F)**
Low Power LP	32k	33p	33p
200k	15p	15p	
Ceramic Resonator XT	200k	26-68p	26-68p
1.0M	15p	15p	
High Speed Crystal	4M	15p	15p
8M	15-33p	15-33p	
20M	15-33p	15-33p	

3.4. Capacitor Specification

Capacitor 2 22Pf, Capacitor 3 22Pf, Crystal Oscillator C1 16MHz Internal frequency of operation of the microcontroller and period of machine cycle needed to execute an instruction is computed below.

$$F_{internal} = \frac{F_{Quartz}}{4} = \frac{16MHz}{4} = 4MHz$$

$$T = \frac{1}{F_{Internal}} = \frac{1}{4} = 0.25\mu s$$

$F_{internal}$ = Internal clock frequency of microcontroller

T = Period or machine cycle

3.7. Ultrasonic Sensor

- Working Voltage DC 5V
- Working Current 15mA
- Working Frequency 40Hz
- Maximum Range 4m
- Minimum Range 2cm
- Measuring Angle 15º
- Trigger input signal 10µs TTL pulse
- Echo output signal Input TTL lever signal and range in proportion
- Echo output signal 45*20*15mm

3.8 Design Calculation for Light Emitting Diode (LED)

All the LED have the same rating and one current limiting resistor is sufficient

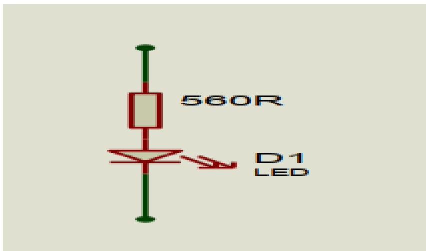

Fig 8. LED Design Analysis

$$R = \frac{V_s - V_d}{I_d}$$

$$R = \frac{5.0 - 2.2V}{5mA} = 560\Omega$$

3.9 Parts of the Components

3.9.1 The Control Unit

The control unit consists of the microcontroller ATmega328 chip. The chip belongs to

the mid-range family of the Atmel microcontroller devices. The block diagram of the device is shown in Figure 1.

3.9.2 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328p. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.

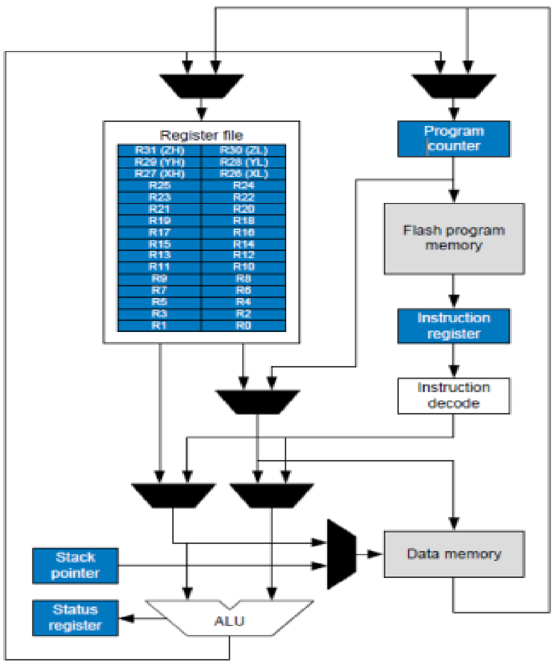

Fig 9. Atmega 328 Architecture

4. TEST

The components used for the implementation of this project were tested on breadboard
for better performance, and were later transferred to the Vero board and soldered. The heat applied during soldering was just moderate to avoid damage of the Vero and the components since most of the components have low heat resistance. The test equipment includes;

- Breadboard-To assemble and test individual components
- Digital multi meter to measure voltage, current, resistance and check for continuity
- Light emitting diodes
- Arduino sketch
- proteus simulation software

4.1.1 Test on Power Supply Unit (PSU) Result Obtained for the Power Supply Unit

Table 3: Result Obtained for the Power Supply Unit on No-load and Full Load

No Load Voltage (V)	**Full Load Voltage (V)**	
Output voltage	9.0	8.71

4.1.1 Testing the 5V Power Supply This power supply was tested under full load and no load conditions to also determine its voltage regulation. Using equation 1, the voltage regulation is calculated as follow No load voltage

Full load voltage

Table 4: Result Obtained for the 5V power Supply Unit on No-load and Full Load

Output voltage	**No Load Voltage (V)**	**Full Load Voltage (V)**
LM7805	5.0	4.81

4.1.2 Power Supply Test Results: The results obtained for the power supply unit as compared with the no-load and full load conditions are given in the table 5 below with the percentage voltage regulation computed.

Table 5: Result Obtained for the Power Supply Unit on Full Load

Output voltage	**Theoretical Value (V)**	**Measured Voltage (V)**	**% Regulation**
Transformer	9.0	8.71	3.2
LM7805	5.0	4.81	3.8

4.1.3. Proteus Simulation of the Power Supply Test Results. Power Supply Unit Proteus Simulation 4.3 Test to Determine the Performance Analysis of Ultrasonic Sensor in Obstacle Detection.

A distance calculated experiment was performed by placing an obstacle at a meticulous distance and calibrating. It concluded a faithful output until 2m the table shows calculated and measured values of analogue voltage produced at the ultrasonic sensor input

4.3.2 Experimental Result Analysis

Table 6: Performance Analysis of Ultrasonic Sensor in Obstacle Detection

S/N	Ranges (CM)	Theoretical values 3cm =10mv	Experimental values 3cm =10mv	% Error
1.	0.00	0	0	0
2.	5.00	16.67	16.64	1.02
3.	10.00	33.33	33.28	1.89
4.	15.00	50.00	49.86	2.20
5.	20.00	66.67	64.94	2.47
6.	25.00	83.33	81.87	2.92
7.	30.00	100.00	94.67	2.98

There is a slight difference amongst the values measured and observed as per the table. It shows that the device was not capable of showing exact values and ended in errors.

5. DISCUSSION

After successful integration and testing, it was observed that the system is functioning as required. Each unit of the sensor (Ultrasonic and LDR) can sense and then send a PWM signal to trigger a transistor into action. The test result obtained for the various power supplies clearly shows that the result obtained is approximate to earlier theoretical design. For instance, the central power supply had a voltage regulation of 3.2% and the 5V the power supply had a voltage regulation of 3.8%. This result correlated to the initial theoretical design for power supply where a 1% percentage ripple voltage was chosen although there were cases of small overshoot. A straight line with no ripples showed that perfect rectification was achieved for all voltage levels. The system is made of five ultrasonic sensors, one LDR sensor, one atmega328, and a couple of LEDs which have a separate function they play.

6. SUMMARY

The development of science and technology has affected in one way or the other the activities of human beings in all fields of their endeavours5. This article mainly focuses on an effective solution that will provide control of street lights as well as energy savings. The Microcontroller-based dimmable street light using a Light-dependent resistor (LDR), ultrasonic sensor, and transistors is designed to be able to vary the voltage being supplied to a lamp. This system is designed to achieve an automatic street light that works based on vehicle movement. An ultrasonic is used for detecting the distance from which the car is and the light-dependent resistor (LDR) for sensing the amount of ambient light, An Atmega328 microcontroller serves as the control unit, and the system is powered by a 5V power supply.

6.1. CONCLUSION

Based on this article, we can also estimate the speed of the vehicle, recognize the number plate, recognize the accidents that took place on roads, etc. This Smart Street light project not only helps in rural areas but is also beneficial in urban areas too. As we are moving towards more advancement we require more power so the use of renewable resources is useful and advantageous. With this project, we can even add smart parking for vehicles and it is even useful for driverless cars. With the advances in technology and good resource planning the cost of the project can be cut down and also with the use of good equipment maintenance can also be reduced in terms of periodic checks. The LEDs have a long life and emit cool light. For these reasons, our project presents far more advantages that can overshadow the present limitations. Keeping in view the long-term benefits and the initial cost would never be a problem as the investment return time is very less. The project has scope in various other applications like providing lighting in industries, campuses, and parking lots of huge 47 shopping malls. This can also be used for surveillance in corporate campuses and industries. This article Automatic Street Light Based on Vehicle Movement is a cost-effective, eco-friendly, and the safest way to save energy. It clearly tackles the two problems that the world is facing today, saving energy and also the disposal of incandescent lamps, very efficiently.

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