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Automatic Time-Based Street Light Control System

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Abstract

In this work, an Automatic Time-based Street Light Control System using microcontroller was designed, simulated, and implemented. The street light control system was designed using microcontroller (PIC16F690) and the micro chip was programmed using flow-code5 programmer to automatically turn ON and OFF the light based on the time required by the user. The designed system was simulated, implemented and then tested. The result of the test shows that it works as designed, thus it automatically turns ON and OFF the light as set by the user. In this system, cost of maintenance was drastically reduced and it provides an effective measure to save about half of the energy consumption with 86.4% efficiency by preventing unnecessary wastage of electricity, caused due to lighting of street-lights when it is not required.

Keywords: Automation; Energy Utilization; Flow-code5 programmer; Microcontroller

1.0 Introduction

Street lighting is one of the vital parts of a city's infrastructure where the main purpose is to light the city's streets during dark hours of the day. Lighting can account for 10-38% of the total energy bill in typical cities worldwide [1]. Street lighting is a predominantly critical concern for public authorities in developingcountries because of its strategic significance for economic and social stability[2].

In Nigeria, too much amount of energy is wasted on street lighting due to lack of automatic control system to turn On/Off were necessary e.g., the street light around the hostel of Bayero University Kano.Manual control is prone to errors and leads to energy wastages [3].The current trend is theintroduction of Automation Control Streetlighting [4]. Despite the current development of the automatic street light control in the world, the system is rare in Nigeria. Where available; the system is not home base design. Considering the need for automatic control of street light in Nigeria, this research is intended to design, simulate and implement a home base Automatic Time-based Street Light Control System. This is likely the first research carried out in Nigeria.

There are many numbers of control approach and the ways in which its been controlled such as Design and Implementation of CPLD based Solar Power Saving System for Street Lights[1], Design andFabrication of Automatic Street Light ControlSystem[4],Automatic Street Light Control System [5], IntelligentStreet Lighting System Using G.S.M [6],Automatic Street Lighting using PLC [7],Automatic Street Lighting System for Energy Efficiency based on Low CostMicrocontroller [8],A NovelDesign of an Automatic Lighting Control System for a Wireless Sensor Network with Increased Sensor Lifetime and Reduced Sensor Numbers[9],Power Consumption Reduction in a RemoteControlled Street Lighting System[10], and A high Efficiency Autonomous Street LightingSystem Based on Solar Energy and LEDs[11].

This research is intended to solve the aforementioned problem by employing automatic time-based light control schemes, with concern on programming and memory size storage. This research will focus on the aspect of programming the circuit using a flow-code5, which can be controlled bymicrocontroller PIC16F690. This circuit will be activated only when the time is equivalent to the On-time and will remain ON until the time is equivalent to the Off-time. Both the On-time and Off-time setting are saved in the Microcontroller memory. By using this as a basic principle, the intelligent system can be designed for the perfect usage of streetlights and other lighting control system (i.e. Home, Office, Theatre Art, etc.) in any part of country.

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Microcontroller sometimes called a single-board computer is a device which integrates numerous components onto a single chip thereby making up a complete control system suitable for electronics systems design. It is mostly used for building intelligent systems such as; military hardware, robotic systems, industrial automation, home application e.t.c.

2.0 Design Procedures of Automatic Time-Base Street Lighting Control System

Three stages have been incorporatedin to this design for the achievement of the system. Design architecture which is the main block function for the proposed design. While, the software development based on the proposed design will be discussed in software part. The hardware specification will point out the components involved in this design from the time setting components pending the controller selection.

A. Design Architecture

The system developments start with the design architecture of the proposed system. Transparent block diagram was used to produce the proposed design as shown in Figure 1. Two main components have been identified as the input to the system; Time setting and Power, while two components are declared as the output which are; display and lamps.

The On time setting, off time settingand main time setting are the three processes managed and controlled by the PIC16F690 microcontroller.

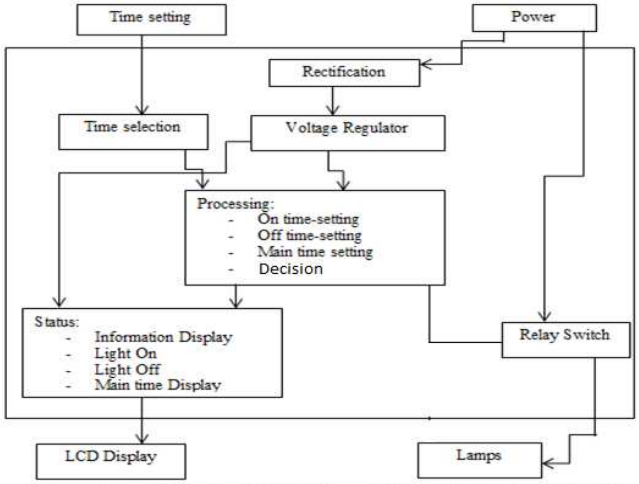

Fig. 1 Transparent block diagram of Automatic Time-bas Street Lighting Control System

The PIC16F690 is a microcontroller in the PIC family produced by microchip technology[12]. They allow electronics designers and hobbyists add intelligence and functions that simulated big computers for almost any electronics product or project. It features (8-bits), 18 input and output pins, and the remaining pins VDD and VSS are positive supply and ground reference respectively as shown in figure 2.

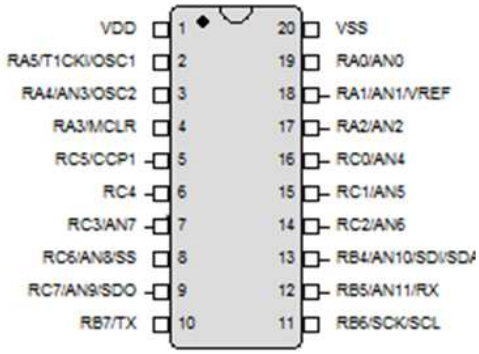

Figure 2. PIC16F690 Diagram

PIC16F690 microcontroller has been selected as the controller in the system due to the low cost, compatibility, compact size and easy interfacing over several type of other controller including Field Programmable Gate Array (FPGA) and Programmable Logic Controller (PLC). It has inbuilt oscillator of 4MHz and 8MHz, its uses serial programming algorithm, it's easy to erase and requires no special tools to do so, and high memory storage as shown in the Table 1. The status of the system operation is display on the LCD and the lamps.

Table 1. Memory Storage of PIC16F690 Mico Chip

	Total	Used	Free	% Used
ROM	4096 word	2670 word	1426 word	65.2
RAM	256 bytes	140 bytes	116 bytes	54.7
Heap size	115 bytes	79 bytes	36 bytes	68.7

B. Software Development

The microcontroller required a program to design and carry out the processes related to the proposed design. Flow-code5 programming tool has been used to construct the program for the proposed design. In this software development, several stages have been added as the stage of respond for the program. It starts with initializing the LCD; the LCD has been used to indicate the current operation in the system based on the programmes. The decision for the time on and time off will be taken care of by the processes or operation of the system.

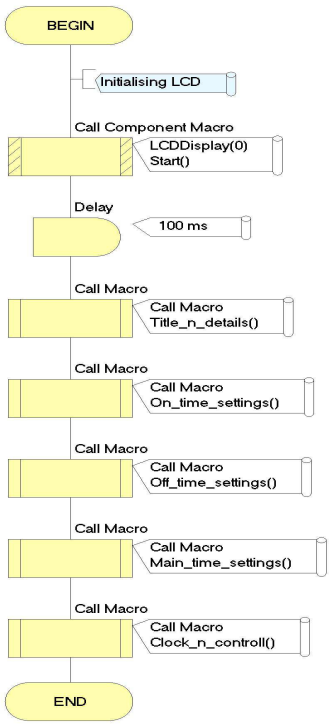

Fig.3: The flow-chat operation of the proposed design

The system is initialised by determining three set of time inputted by the user or operator. The first category is the On-time setting, the second category is the Off-time setting and the last category is the main time setting. The control unit will then make decision based on the description thus;the lamps will be activated only when the main time is equivalent to the On-time and remain ON until the main time is equivalent to the Off-time.

C. Hardware Specification

In hardware specification, the components for the proposed system have been classified based on the components group; input, control and output; two type of the input have been used in this system; the time setting and power supply.

The time setting is carried out by four buttons, this buttons are incrementalor plus, decremental or minus, SHIFT and OK.

The shift buttons is used to select either hour, minute or second while incremental and decremental are buttons used to set the corresponding hour, minute and second and OK is used for saving the time into the microcontroller memory while the power supply is used to power on the overall system.

LCD and lamp are the two outputs used in the proposed system and connected to the microcontroller. The function of LCD is to display the status of the system which include the main time, activate and deactivate,while the lamps are used as Prototype Street light. The complete circuit diagram for the system designed and the components involved is shown in

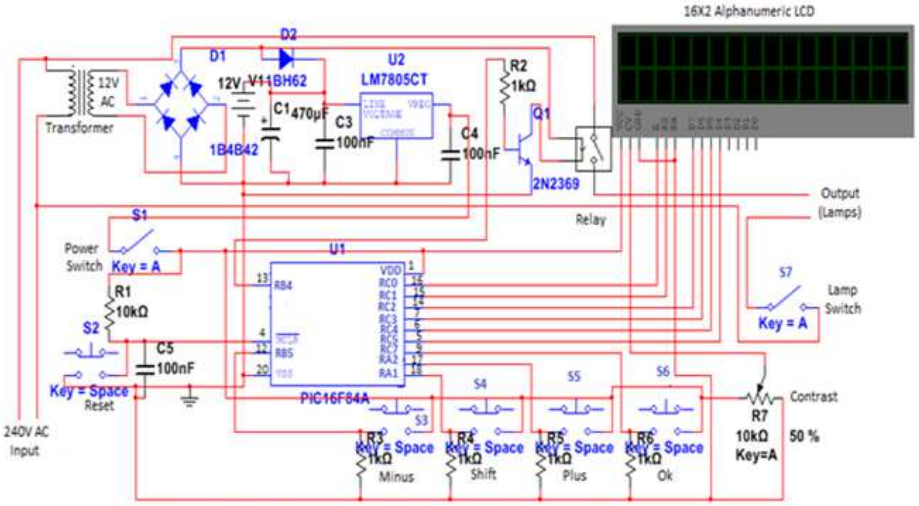

Fig. 4 Circuit Diagram of the proposed design

D. System Working Principle

System working principle has been used to summarize the principle of operation of the proposed design. When one terminal of 220-240V is applied to a transformer of 12V alternating current (AC) which is converted to 12V direct current by the means of rectification and then the output isinputted in to voltage regulator (LM7805CT) to produce an output D.C voltage of 5Vwhich is connected to power switch (S1)down to pin14 of the microcontroller and VCC of the LCD display, the same terminal is also connected to a relay to allow a small current flow circuit to control a higher current circuit.

When On-time, Off-time and the main time are saved on the microcontroller, as soon as the microcontroller senses the On-time or Off-time, the signal will be sent to the relay to be activated or deactivated which will set the lampsON or OFF.

This system also have an inbuilt battery of about 11.3V, the purpose of this battery is to ensure that the time saved on the microcontroller memory should not be interrupted even if there is light failure for a short period of time. The battery can last for about 3 hours even if the LCD display goes off, the memory is still in active mode. This battery will regain its energy from the main sources either the power system is ON or OFF, in as much as the system is connected to the main source and there is flow of current, then the battery will continue charging.

The details of this circuit can be summarized as follow:

1. Pin 1(VDD) of the PIC is connected to one of the terminals of the following componentsVCC of the LCD display, power switch (S1), R1, R3, R4, R5, R6 each with 1kΩ and R7 of 10kΩ.
2. Pin 18 (RA1)is connected to R2 is connected to reset bottom for resetting the circuit.
3. Pin 12 (Osc1 CLKIN) is connected to the other ends of R1, R3, R4, R5, R6, R7, RW and GND of the LCD.
4. Pin 20 (VSS) is connected to the ground.
5. Pins16 (RC0), 15 (RC1), 14 (RC2), 7 (RC3), 6 (RC4), 5 (RC5), 9 (RC7), are connected to E, RS, D7, D6, D5, and D4 of the LCD respectively.

E. Detail Procedure For Simulation, Construction, And Testing Using Flow-code5

Flow-code5 allows the creation of simple microcontroller applications by dragging and dropping icons on to a flowchart as shown in Figure.5to create simple programs. These programs can control external devices attached to the microcontroller such as LED's, LCD displays, switches, etc.

Once the flowchart has been designed, its behaviour can be simulated in Flow-code before the flowchart is compiled, assembled and transferred to a chip. Testing the system's functionality can be achieved by clicking on simulate iconand the effects display on-screen.

To achieve this, using Flow-code5, the following steps are performed:

1. Create a new flowchart, specifying the microcontroller that is to be usede.g. PIC16F690.
2. Drag and drop icons from the toolbar onto the flowchart to program the application.
3. Add external (input and output) devices by clicking on the appropriate icon, edit their properties, how they are connected to the microcontroller and call macros within the device.
4. Run the simulation to check that the application behaves as expected.
5. Transfer the programme to the microcontroller by compiling the flowchart to Hex Code.

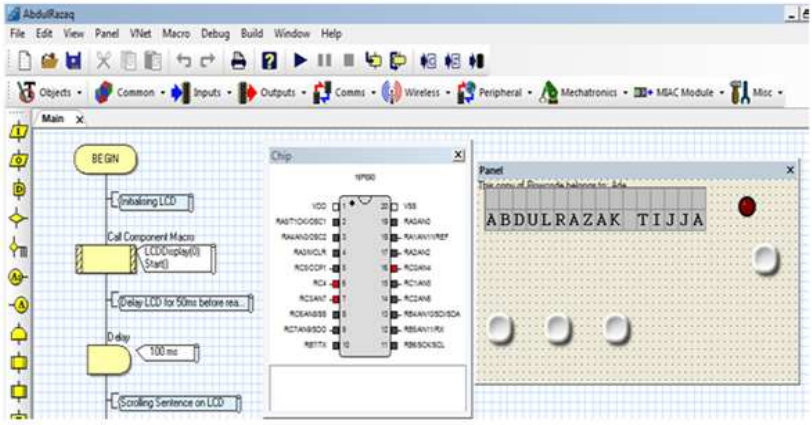

Fig. 5:Simulation of Automatic Time-base Street Light Control System

Construction

The system was constructed as described, and then mounted in a plastic casing of dimension 11cm x 11cm x 4.5cm. The components used are shown in Table 2.

Table 2: Component Used

S/N	COMPONENT	QUANTITY
1	4-Surface Connector	1
2	240V-to-12V Step Down Transformer	1
3	Full-wave Rectifying Diode	1
4	220uF Electrolytic Capacitors	2
5	7805 Voltage Regulator	1
6	100pF Mica Capacitors	3
7	PIC16F690 Microcontroller	1
8	On/Off Switches	2
9	Active-High Momentary Switches	5
10	10 KΩ Resistors	6
11	BD 137 NPN Transistor	1
12	SPST Relay Switch	1
13	3.7V Dry Secondary Cells	3

The Connector, Transformer, Rectifying Diode Electrolytic Capacitors, Voltage Regulator, Mica Capacitors, On/Off Switches and the Cells were used to make up the Power Unit of the Hardware; Microcontroller, Momentary Switches, Resistors and Transistor for the Control Unit of the Hardware; While the Relay Switch serves as the Actuating Unit of the Hardware.

The following are the steps taken while constructing the Circuit:

1. The components, along with Vero Board and Connecting Wires, were bought.
2. The components were then arranged in accordance with the Circuit Diagram in Figure 7, after which all terminals were soldered correctly.
3. General cross-checking was performed on each component arranged and corrections were made where necessary.

Design Equation and Calculation

The following values were obtained from the equation below;

$$V_{a.c} = 12V$$

$$V_{d.c} = V_{a.c} \times \sqrt{2} = 16.97V \quad (1)$$

Regulator Voltage

$$V_{in} = V_{d.c} - V_{drop}(diode) \ = 16.27V \quad (2)$$

The output voltage from the regulator (7805) is$V_{out} = 5V$.

Transformer

$$\text{Transformer Ratio } (T_r) = \frac{Primaryvoltage}{Secondaryvoltage} \qquad (T_r) = \frac{240}{12} = 20:1 \quad (3)$$

LCD Filament

$$R_{filament} = 800\Omega$$
$$R_{Limiting} = 270\Omega$$
$$V_{dc} = 5V$$

Using voltage divider;

$$V_{filament} = \frac{R_{filament}}{R_{filament+}R_{Limiting}} \times V_{dc} = 3.74V (4)$$

Testing

The Automatic Time-based Street Light Control System was tested using different power sources;the seconds, minutes and hours of its ON-time, OFF-time and Main-time were adjusted several times; and the system was finally left to continue running on Battery, to see how long the Battery can back-up the time function of the system. The Automatic Time-based Street Light Control System gave all expected outcomes with no error.

3.0 Results and Discussion

Results

The following results were obtained during the simulation and comparative of Energy utilization for different type of lamps.

(a) Simulation Result of Automatic time-base street light control system using Flow-code5

This system will be activated only when the main time is equivalent to the On-time and remain ON until the main time is equivalent to the Off-time as shown in Figure 6-9.

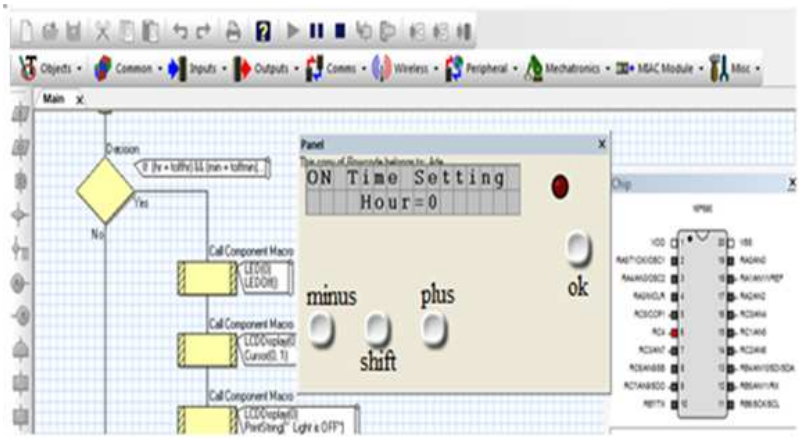

Fig. 6: On Time Setting

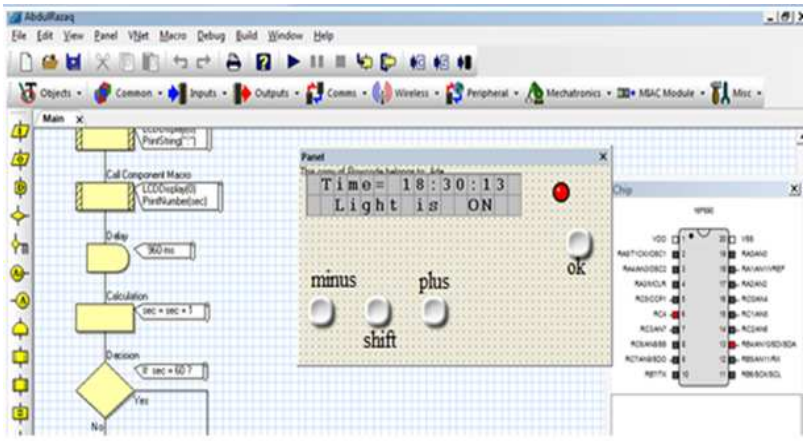

Fig. 7 Light On

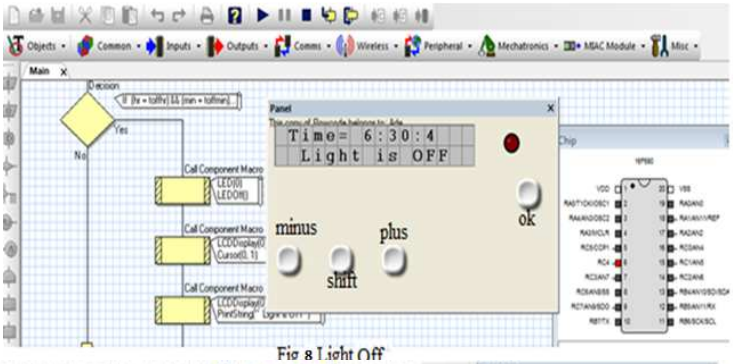

Fig 8 Light Off

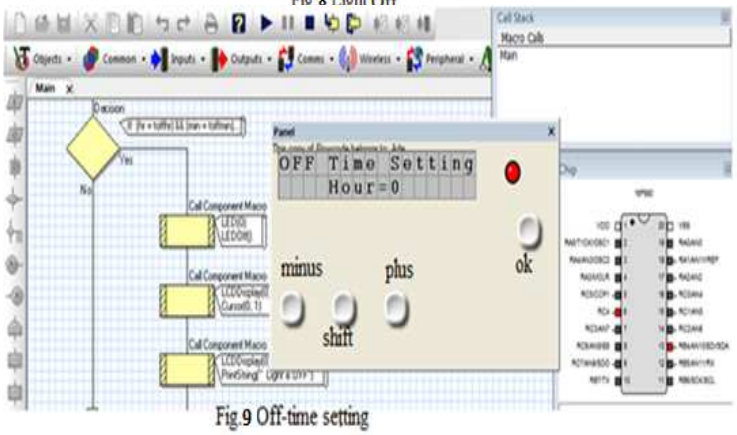

Fig.9 Off-time setting

(b) Comparative Results of Energy utilization for different types of lamps are shown onTable 3.

Table 3. Energy utilization for three different types of lamp based on 12 hours and 24 hours of light.

Lamps	Power in W	Energy for 12 hours in W-hour	Energy for 24 hours in W-hour
Neon	60	720	1440
	100	1200	2400
	200	2400	4800
Fluorescent	8	96	192
	15	180	360
	30	450	720
Halogen	1000	12000	24000

Based on research, majority of street light are ON from 18:30 to 6:30, in other words street lights are functioning completely for 12 hours a day. Assuming 3 nodes are to be operated using fluorescent bulb of 8W each, then the energy consumed for number of working hours per day is calculated below;

Numbers of hours = 12 hours
Number of nodes = 3
Bulb in Watt = 8W

$$\text{Energy consum} \quad \text{Number of nodes x Power x hours} \qquad (5)$$

= 288 W hour

If the system were to operate under the same condition but for 24 hours, then the energy consumed will be 576W hour [13]. This shows that about half of the energy is utilized.

$$\text{Efficiency} = (\text{Power output}/\ \text{Power input}) \text{ x } 100\% \qquad (6)$$

$$\text{Efficiency} = \left(\frac{\text{Power output}}{V_i I_i}\right) \text{x } 100\% \qquad [14]$$

$$\text{Efficiency} = \frac{8}{220.4 \text{ x } 0.042} \text{x } 100\% = \frac{8}{9.26} \text{x } 100\% = 86.4\%$$

Where $V_i and I_i$ are the input voltage and current respectively measured from the meter.

4.0 Discussion

Automatic time-base street light control system is designed, simulated and tested. This method is to build up the device with a PIC16F690 microcontroller which was programmed using flow-code5programming languages for microcontrollers, through the process of the research, it was found that cost of maintenance will be drastically reduced compare to manual control that will be assigned by an individual or offices and also provides an effective measure to save about half of the energy consumption with 86.4% efficiency by preventing unnecessary wastage of electricity, caused due to manual switching or lighting of street-lights when it is not required.

The time setting is carried out by four buttons, this buttons are increment or plus, decrement or minus, shift and ok.

The shift buttons is used to select either hour, minute or second while increment and decrement are used to set the corresponding hour, minute ` and second and ok is used for saving the time into the microcontroller memory while the power supply is used to power on the overall system.

LCD and lamp are the two outputs used in the proposed system and connected to the microcontroller. The function of LCD is to display the status of the system which include the main time, activate and deactivate while the lamps are used as Prototype Street light.

5.0 Conclusion

In this work, microcontroller time-base intelligent light control system was designed, simulated, implemented, and tested. The result of the test shows that it works as designed, thus automatically turn ON and OFF the light as set by the user. In this system, cost of maintenance was drastically reduced and it provides an effective measure to save about half of the energy consumption with 86.4% efficiency by preventing unnecessary wastage of electricity, caused due to lighting of street-lights when it is not required.

6.0 Acknowledgments

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7.0 References

[1] Devi,D.A., and Kumar,A. (2012). Design and Implementation of CPLD Based Solar Power Saving System for Street Lights and Automatic Traffic Controller, *International Journal ofScientific and Research Publications*, Vol. 2, Issue11, PP. 70-78.

[2] Mustafa, S., Abdulhalim, F., Ahmed, S., and Abdulroof, A. (2013). Automatic Street Light Control System Using Microcontroller, *Mathematical Methods and Optimization Techniques in Engineering*, ISBN: 978-960-474-339-1. PP. 92-96

[3] Floyd,D.B, and Parker, D. (1995). Field Commissioning of a Daylightdimming lighting system, In Proceedings of Right Light Three, 3rd European Conference on Energy Efficient Lighting, Newcastle, UK, PP. 83–88.

[4] Wazed, M.A.,Nafis, N., Islam, M.T., and Sayem, A.S.M. (2010). Design and Fabrication of Automatic Street Light Control System, *Engineering e-Transaction*, Vol. 5, No. 1, PP. 27-34.

[5] Sudhakar,K.S., Anil,A.A., Ashok,K.C, and Bhaskar,S.S. (2013). Automatic Street Light Control System, *International Journal of EmergingTechnology and Advanced Engineering*, Vol. 3, PP. 188-189.

[6] Rajput, K.Y., Khatav, G., Pujari, M., and Yadav, P. (2013). Intelligent Street Lighting System Using Gsm, *International Journal of Engineering Science Invention*, *Vol2*, Issue 3, PP. 60-69.

[7] Madhuri, V.V.S., Mallikarjuna, S.P., andSandhya, R.M.N. (2013). Automatic Street lighting Using PLC, *International Journal of latest trends in Engineering and Technology (IJLTET)*, Vol.2, PP. 353-357.

[8] Rohaid, H., Syed, A., and Zulkifli, A.M. (2012). Automatic Street Light System for Energy Efficient Based on Low Cost Microcontroller, ISSN: 1473-804X online, 1473-8031 print, PP.43-48.

[9] Mohamaddoust, R., Haghighat, A.T., Sharif, M.J.M., and Capanni, N. (2012), A Novel Design of an Automatic Lighting Control System for a Wireless Sensor Network with Increased Sensor Lifetime and Reduced Sensor Numbers, *Sensors*, Vol. 11, PP. 8933-8952

[10] Caponetto, R., Dongola, G., Fortuna, L., Riscica, N., and Zufacchi, D. (2008). Power consumption reduction in a remotecontrolled street lighting System,*International Symposium on Power Electronics*, Electrical Drives, Automation and Motion, Ischia, une, PP. 428-433.

[11] Costa, M.A.D., Costa, G.H., Dos Santos, A.S., Schuch, L., and Pinheiro, J.R. (2009). A high efficiency autonomous Street LightingSystem Based on Solar Energy and LEDs, *Brazilian Power Electronics Conference*, Bonito, PP. 265-273.

[12] Jasio, L., Wilmshurst, T., Ibrahim, D., Morton, J., Bates, M., Smith, D.J. and Hellebuyck, C. (2008).*PIC Microcontrollers: know it all*, Publishing Elsevier Science.

[13] Popa, M., and Cepişcă, C. (2011). Energy ConsumptionSaving Solutions Based on Intelligent Street Lighting Control System. *U.P.B. Sci. Bull.*, Vol. 73, April, PP. 297-308.

[14] Thereja, B.L., and Theraja, A.K. (2000). Electrical Technology 23rdEdition, S. chand and company, New delhi india. PP. 175-188