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Research Article

Rationalization Energy Based on Automatic Street Lighting System

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Abstract

Conservative street lighting systems in zones with a low frequented passerby are lightened most of the nighttime without purpose. The result is that a large amount of energy is wasted uselessly. With the broad availability of electronics components like LDR that sense the light and control on it, powers conserving street lighting systems become reality. Therefore, the purpose of this invention is to provide a smart street lighting system which saves power of lighting street at night instead of loss it because the load of cars and walkers is few. This purpose is accomplished via use of controlling circuit which turns on a group of lamps at a specific time and after the time over, this group is turned off while another set of lights are turned on also with a specific time and so on. This work is focusing on developing automatic lighting system with using of light-dependent resistor (LDR) as a sensor of the sunshine and using a timer (NE555 IC). This system is low cost as it does not contain expensive sensors and it is also easy to implement as take very low space for installation.

Keywords: *Lighting system; Automatic; LDR; Timer; NE555; Control circuit; Sensor; Voltage regulator*

1. Introduction

Lighting systems are an important facility of cities. A constant lightening is the best solution in busy areas. In the former case, a lot of people are walking around all night long, moving from their workplace or a shopping tour to restaurants, cinemas and parks. However, only a low number of residents and passersby using the streets during the night coming from their work moves to their homes. The temporal need for lighted streets is in relation to a continuous illumination of streets, often incredibly small. As energy consumption is an issue of increasing interest due to possibility of saving energy in public street lighting systems (R Műllner *et al*, 2011). The research focus followed in this work is to introduce an efficient street lamp switching system.

2. Proposed System

This work is mainly focused on alternatings in street lighting control and a rationalization in the management of street lighting. This is complemented by an controlling circuit that controls on lighting the street at 24 hours and this is based on a sensor that senses the sunlight and it is called light dependent resistor (LDR). The controlling circuit consists of the following main components: (NE555 IC, light dependent resistor (LDR), Relay DS2Y–S–DC5V). The principle operation of the proposed system is as follows: all day time, all lights in the street are turned off. At night time, all the lights of the street are switched automatically to illuminate the roads. But at midnight, there are a few flow of cars and walkers in the street and no need for full lighting, therefor, the control circuit will turn on a group of lights and turn off the other group. After a specific time, the first group will be turned off and will turn on the others and so on. The diagram of the system is as shown in Fig.1.

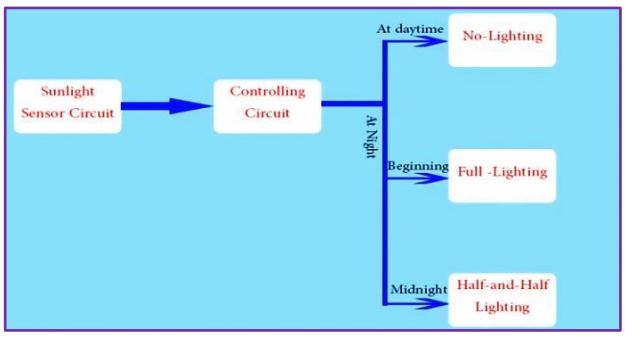

Fig.1 Block diagram of the proposed system

The main features of this work are:

- System is applicable, fast response, reliable, and very efficient because the controlling on lighting is automatically without using any switches.

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- Low cost and the components are simple and available in market relatively.
- Easy maintenance and low space for installation and low power supply.

3. Basic Theory of the System

This system consists of three main parts (three blocks, or three circuits) as shown in Fig.2 and each part will be explain as follows.

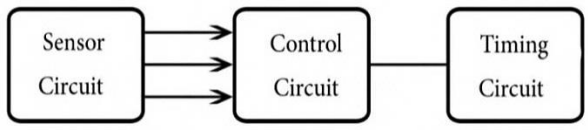

Fig.2 Parts of the automatic lighting system.

3.1. Sensor Circuit Block

The aim of this circuit is to sense the sunlight at day time and gives a signal to the control circuit to turn off lights in the street. And at night, this circuit send a signal to the controlling circuit to turn on the lights in the street. This circuit consists of main following electronic components:

I. Light dependent resistor (LDR).
II. NE555 IC.
III. Voltage regulator L7809CV.
IV. Necessary resistors, transistors and capacitors.

I. Light dependent resistor (LDR)

LDR (Light Dependent Resistor), photoconductor, photocell or photoresistor is a device which has a resistance that changes according to the amount of light dropping on its surface. When the light falls on LDR, then the resistance varies as shown in Fig.3.

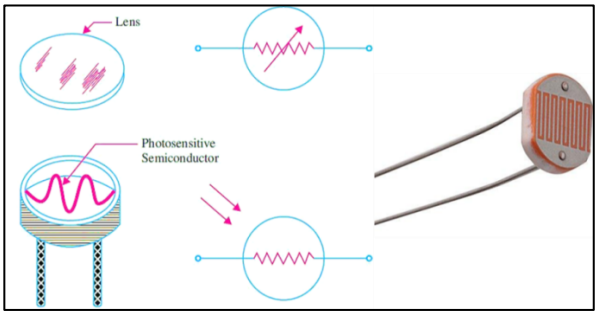

Fig.3 Light dependent resistor and its symbols (B.L. Theraja *et al*, 2005).

LDRs are used in circuits where it is required to detect the ambient level of light and the presence of light in order to generate a light triggered switch. The resistivity of a semiconductor depends on the number of free charge carriers available in it. When the semiconductor is not irradiated, the number of charge carriers is small and hence resistivity is high. But when light in the form of photons strikes the semiconductor, each photon delivers energy to it. If the photon energy is greater than the energy band gap of the semiconductor, free mobile charge carriers will be free and the resistivity of the semiconductor is decreased. Light dependent resistors are an inexpensive and simple detector in any electric circuit which turned on and off automatically according to the level of ambient light for example, light-measurement, light detecting circuits and night security lighting (B.L. Theraja *et al*, 2005).

II. NE555 IC

The NE555 timer is a multipurpose and widely used IC device. It is a highly stable controller able to generate accurate timing pulses. There are two types of 555 operation: firstly, a stable operation that the frequency and duty cycle are accurately controlled with one capacitor and two external resistors. The second status is the monostable operation in which the time delay is controlled by external capacitor and resistance as shown in Fig.4. After IC is triggered, there will be a time delay before the chip changes states. It is called 555 because it consists of three internal resistors of 5 KΩ. It has some of important features those are: High current drive capability (200mA), adjustable duty cycle, turn off time less than 2μSec, timing from μ Sec to hours and operation is specified for supplies of 5 V-15 V (M. Morris Mano *et al*, 2006).

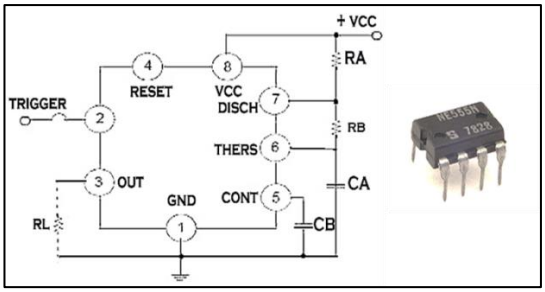

Fig.4 NE555 monostable circuit (M. Morris Mano *et al*, 2006).

III. Voltage Regulator L7809CV

There are sets of batteries that act as voltage sources; a 1.5V, 3V, 4.5V, 6V, 9V and 12V. A power supply can be built using a transformer connected to the AC supply to step the AC voltage to a required amplitude, then the AC voltage is rectified and filtering with a capacitor, and finally the DC voltage is regulated using an IC regulator that shown in Fig.5. The regulators can be designated for operation with load currents from hundreds of mA to tens of amperes, matching to power ratings from mW to tens of watts. The operation of DC voltage conversion to another DC voltage is called a DC-to-DC conversion and the element which does this operation is called DC-to-DC converter or step-down (buck) PWM DC-DC converter or step-up (boost) PWM DC-DC converter or a voltage regulator. Also, it is providing a thermal overload protection and short circuit protection (R. Boylestad *et al*, 2009).

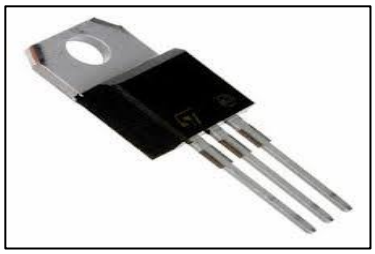

Fig.5 Voltage regulator (R. Boylestad *et al*, 2009)

3.2. Control Circuit Block

The function of this circuit is summed up in receiving the signal coming from NE555 IC and control on it to turn on or turn off the lighting in the street opportunely, where in the daytime all the lights are turned off and in the night all the lights are turned on and at the midnight half-and-half lighting. This circuit consists of main following electronic components:

I. NE555 IC in which explained in the previous section.
II. Relay DS2Y–S–DC5V.
III. Necessary resistors, transistors, diodes and capacitors.

II. Relay DS2Y–S–DC5V

Relays are control electrical switch that can be switched using low current to control a high current load. All relays operate using the basic principle. Relays have two circuits: a control circuit and a load circuit as shown in Fig.6. The control circuit consists of a small coil that controls the operation of the load circuit which has a switch. When no voltage is applied, there is no current flow through the coil. No current means no magnetic field induction, and the switch is open. When the voltage is supplied to coil, the current flows through the coil produces the magnetic field required to close the switch and hence operation of load. The relay is a widely used element in telecommunication equipment, office equipment, computer peripherals, security alarm systems, medical equipment and for control circuit purposes (A. E. Fitzgerald *et al*, 2003).

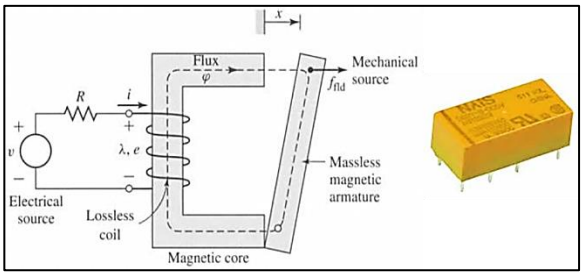

Fig.6 Schematic of relay (A. E. Fitzgerald *et al*, 2003)

3.3. Timing Circuit Block

The function of timing circuit is to generate a three alternative times at midnight. This function is implemented according to the control circuit. This circuit consists of main following electronic components:

I. Three NE555 IC.
II. Necessary resistors, transistors, diodes and capacitors.

4. Practical Work and Results

All electronic components of each section (sensor section, control section and timer circuit) are wired to perform this system as shown in Fig.7. The operation of the overall proposed circuit can be simplified to the following points:

1- The LDR is connected at triggering Pin of NE555 (U4-Pin2) as shown in Fig.7 and Fig.8. At daytime, the LDR resistance equals to 100Ω which prevent triggering NE555-U4. Therefore, the output of it is low and all the circuit is off. Consequently, there are no-lighting in the street.

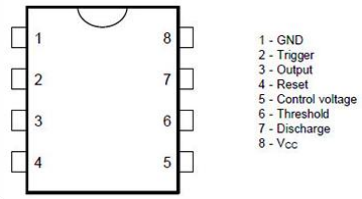

Fig.7 Pin description of NE555IC (M. Morris Mano *et al*, 2006).

2- At the beginning of the night, the LDR resistance equals to 2MΩ which allows to trigger NE555-U4 making the output voltage of (Pin3 of U4) is high and this output will go to transistor NPN337 which turn on relay-X3 to turn on all lights in the street (full–lighting in the street). On other hand, the same output of NE555-U4 goes to the Pin1 of NE555-U5 to be as GND (ground). Consequently, the output of NE555-U5 will be connected to coil of relay-X1 which turn off the relay-X3 according to timer of NE555-U5.

3- After the time of NE555-U5 is finished, the output of it will be low and this output goes to transistor PNP and this makes the relay-X1 is on. Because of the double side relay-X1 contacts, the first side of contacts will cut the power supply of NE555-U5 with relay-X3, and thus cancelling the full lighting state. On the second side of relay-X1 (relay-X2), the NC state of relay will be NO to turn on the timing circuit which consists of three NE555 ICs (U1-U2-U3). With each NE555-U1-U2-U3, there is a capacitor (C3) between Pin3 of first NE555-U1 and Pin2 of second NE555-U2 and also between U2 and U3 as well as U3 and U1. When NE555-U1 is operate as timer to turn on a group of lights, the capacitor will charge and after the time is over, the capacitor will trigger the second timer (U2) because the capacitor is connected to the Pin2 of the timer. And the same operation is repeated to the third timer (U3) and back to the first timer NE555-U1.

4- After continuity operation of alternating lighting in the street until the morning, the LDR again will be as a low resistance and this make the circuit off.

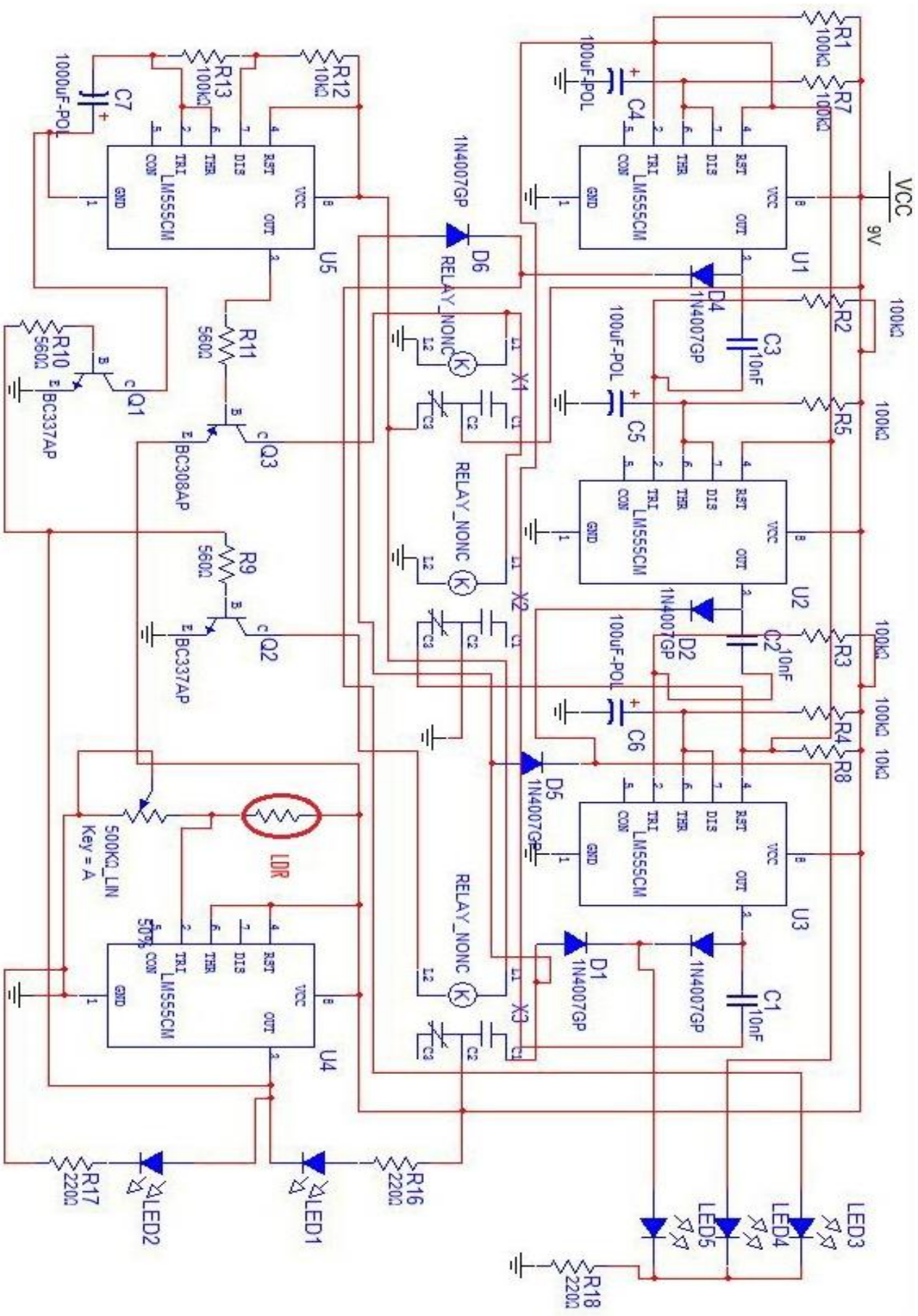

Fig.8 Wiring circuit of overall proposed system

The obtained results for three cases are:

1. The no lighting case when there the sunlight incidents on LDR sensor at daytime as shown in Fig.9.

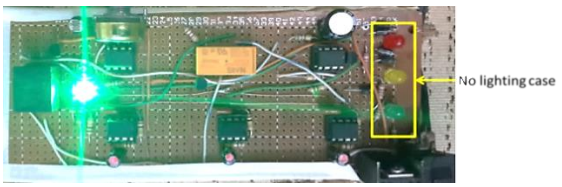

Fig.9 No lighting case at daytime

2. The fully lighting case when the sunlight is absent from LDR sensor at the beginning of the night as shown in Fig.10.

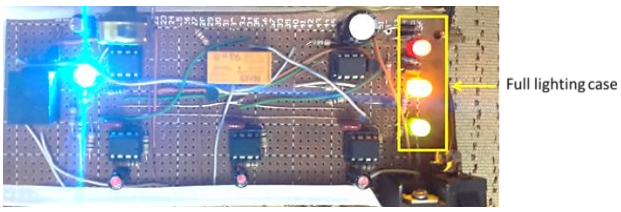

Fig.10 Full lighting case at night

3. Half and half lighting case (alternating lighting) at midnight period as shown in Fig.11.

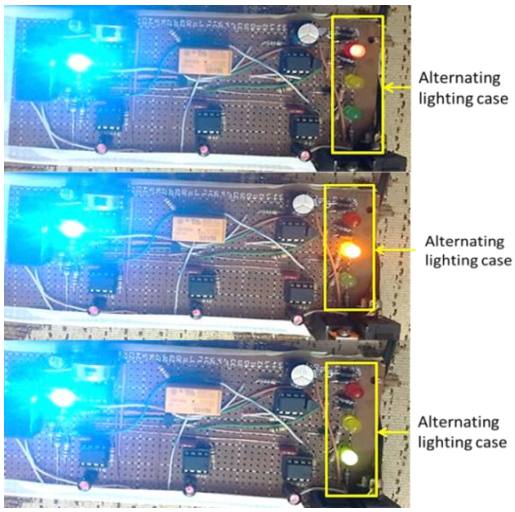

Fig.11 Alternating lighting case at midnight

Conclusions

The research focus followed in this work is to introduce an efficient street lamp automatic switching system. Simply, replacing common bulbs with energy saving LED lamps can reduce energy consumption. Also, a timely switching of street lights which depend on pedestrians personal is an important and essential solution to reduce the useless energy consumption. The idea of this work summarized in using a smart system for street lighting based on automatic switching of street lights by making the system turned off the lights at daytime and turned on these lights at beginning of lights and after that alternating lighting at midnight period. This work can be updated for a future work by:

- Using a microcontroller PIC with LDR sensor.
- Operation of the system wirelessly (the control on it wirelessly).
- Using the same electronic circuit to be as a traffic light by canceling the state of no lighting at daytime.
- Using this system in industrial applications such as operation of three water pumps alternately and this status is found in pumps water filter.

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