Street Lamp Control through an Infrared Sensor

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Abstract

In current electrical power distribution system many components are operating all the time and are liable to huge power loss without notice of users. One such identified appliances are street lamps or highway lamps which burn throughout night with same intensity. This can increases the consumption of fuel in a power plant. Hence, saving of power though such loads will gives the positive impact on power system economics by saving the fuel. In this paper, the microcontroller based prototype automatic street lamp control mechanism is designed and developed for power saving. It consists of infrared sensor, transformers, passive rectifier, pulse width modulation strategy, photodiodes along with controller. The presented hardware is tested in laboratory and its performance is obtained by two ways. One is the intensity of lamp is minimized and second the lamps are completely switched off when there is no objects comes in between road. This prototype model can become a tool for real time application.

Key Words: Sensors, Infrared, Light Emitting Diode, Microcontroller, Transformer and Capacitors

1. INTRODUCTION

The street light lamps are more essential for publics in upcoming smart city projects. The automatic street light control is an efficient and reliable way to save the power. The street lighting control is mainly constructed on power line network and the remote control system is used [1]. The wired transmission communication monitors the module of the substation and street light control nodes between the various existing power line transmission signals. Wireless transmission communication monitors for numerous sub stations. The small street in the city or town can have simple controlling mechanics of street lamps. These developed street lamps can reduce the stress on the grid during peak hours. In present scenario, most of the street lighting systems in the urban are manual control. The manual control switch is set in every street lamp placed at certain height of the pole. By controlling the street light control, it can meet the increasing demand by different strategies [2].

If the street light control is used in cities and towns, communities and different types of campus, it would have considerable economic and social benefits. With the help of multi-sensor system, the street light energy saving can be provided with solar street lamps. The multi-sensor system applied for infra-red sensor and sound sensor to collect and recognize the object in the roads. A solar street light has an important application of photovoltaic technology. Light Emitting Diode (LED) technique in the lighting system has an application of Photovoltaics(PV) technology, the energy saving is the main advantage of PV lighting system for this purpose the stability of the PV lighting system is improved[3]. An electronic devices are data logger that records data in overtime with the help of sensor. The purpose of data logger has accomplished monitoring of street lighting system based on SPV. Henceforth existing PV LED street lamps are not equipped by data logger, therefore monitoring of street lamps done by manually. Hence prototype development of a low cost data logger is based on microcontroller, equipped with internal memory for data storage, battery powered and sensors.

The developed system should be low cost and low power consumption [4]. To control and monitor of the street lighting, the pole controller was designed and implemented based on wireless sensor network, the controlling unit is installed at the end of each lighting pole. The main function of the street light control is the indispensable part of the city infrastructure to development the city without dark hours of the day, it easy to govern on or off the lamps [5].

The control system of the street lighting system in outdoor and street lighting system installation is more and more popular now days, many of the outdoor streets lighting installation system are controlled through automation [6]. In this paper the design and development of control system for the street lights using infra-red sensors and microcontroller has been developed. The prototype hardware has been implemented for testing and validation purpose.

The block diagram shown in Fig.1 includes step down transformer, rectifiers and regulators and power supply circuit. The sensor senses the signal and gives to the microcontroller further it performs the controlling of street lights. The infrared sensor identified the objects on the road and sends control action signal to the controller.

![Fig. 1 Block diagram](image_url)
2. EMBEDDED SYSTEM

The embedded system has got wide ranges of applications such as, military, aerospace embedded software applications, communication, industrial automation, process control software, intelligent, autonomous sensors etc.

2.1 Classification:

The embedded classified as, hard real time system and soft real time system. "Hard" real-time systems have very narrow response time. Example: Nuclear power system, Cardiac pacemaker. "Soft" real-time systems have reduced constrains on “lateness” but still must operate very quickly and repeatable. Example: Railway reservation system – takes a few extra seconds the data remains valid.

Transformer: Transformer converts AC electricity from one voltage to another voltage with a little loss of power. Most power supplies use a step-down transformer to reduce the dangerously high voltage to a safer low voltage.

The ratio of the number of turns on each coil, called the turn’s ratio.

\[ \text{Turns Ratio} = \frac{V_p}{V_s} = \frac{N_p}{N_s} \]  \hspace{1cm} (1)

Where, \( V_p = \) primary (input) voltage, \( V_s = \) secondary (output) voltage. \( N_p = \) number of turns on primary coil. \( N_s = \) number of turns on secondary coil. \( I_p = \) primary (input) current. \( I_s = \) secondary (output) current.

The ideal transformer ratio equation is,

\[ \frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_p}{I_s} \]  \hspace{1cm} (2)

Voltage Regulator: Features of voltage regulators are Output Current up to 1A. Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V. Thermal Overload Protection. Short Circuit Protection. Output Transistor Safe Operating Area Protection.

Rectifier: A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), current that flows in only one direction, a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals.

Filter: Capacitive filter is used in this project. It removes the ripples from the output of rectifier and smoothens the mains voltage and load is maintained constant. However, if either of the two is varied, D.C. voltage received at this point changes. Therefore a regulator is applied at the output stage.

Microcontroller AT89S52: The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel’s high-density non-volatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. The pin diagram of AT89S52 is shown in Fig. 2.

![Pin diagram of AT89S52](image)

1. **LEDs:** LEDs are semiconductor devices. Like transistors, and other diodes, LEDs are made out of silicon. When current passes through the LED, it emits photons as a byproduct. LEDs produce photons directly and not via heat, they are far more efficient than incandescent bulbs.

2. **Resistors:** A resistor is a two-terminal electronic component designed to oppose an electric current by producing a voltage drop between its terminals in proportion to the current, that is, in accordance with Ohm's law:

\[ V = IR \]  \hspace{1cm} (3)

Resistors are used as part of electrical networks and electronic circuits and are ubiquitous in most electronic equipment. Resistors are also implemented within integrated circuits, particularly analog devices, and can also be integrated into hybrid and printed circuits.

3. **Capacitors:** A capacitor or condenser is a passive electronic component consisting of a pair of conductors separated by a dielectric. When a voltage potential difference exists between the conductors, an electric field is present in the dielectric. This field stores energy and produces a mechanical force between the plates. The effect is greatest between wide, flat, parallel, narrowly separated conductors. In practice, the dielectric between the plates passes a small amount of leakage current. An ideal capacitor is wholly characterized by a constant capacitance \( C \), defined as the ratio of charge \( Q \) on each conductor to the voltage \( V \) between them:

\[ C = \frac{Q}{V} \]  \hspace{1cm} (4)

Sometimes charge build-up affects the capacitor mechanically, causing its capacitance to vary. In this case, capacitance is defined in terms of incremental changes:

\[ C = \frac{dQ}{dV} \]  \hspace{1cm} (5)

Work must be done by an external influence to "move" charge between the conductors in a capacitor. When the external influence is removed the charge separation persists in the electric field and energy is stored to be...
released when the charge is allowed to return to its equilibrium position. The work done in establishing the electric field, and hence the amount of energy stored, is given by:

\[ W = \int_{q=0}^{\infty} V dq = \int_{q=0}^{\infty} \frac{q}{C} dq = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} CV^2 = \frac{1}{2} VQ \]

(6)

The current \(i(t)\) through any component in an electric circuit is defined as the rate of flow of a charge \(q(t)\) passing through it, but actual charges, electrons, cannot pass through the dielectric layer of a capacitor, rather an electron accumulates on the negative plate for each one that leaves the positive plate, resulting in an electron depletion and consequent positive charge on one electrode that is equal and opposite to the accumulated negative charge on the other. The integral form of the capacitor equation,

\[ v(t) = C \int_0^t i(\tau) d\tau + v(t_0) \]

(7)

Taking the derivative of this, and multiplying by \(C\), yields the derivative form,

\[ i(t) = C \frac{dv(t)}{dt} \]

(8)

3. FLOWCHART

Flowchart for street lamp control is shown in Fig. 3.

![Fig. 3 Flowchart for street lamp control](image)

Fig 4. Shown is the hardware design as a prototype for the street lamp control and operation. In this, the infrared sensors are used as object detective device along with transmitter and receiver on either side of the road.

4. MODES OF OPERATION

There are two modes of operation for street lamp automatic control as shown in Fig. 5.

1. Transition of streetlights from dark to bright state.
2. Transition of streetlights from dim to bright state.

In the first mode of operation, when the vehicle is not present, all the streetlights will be in dark state. When a vehicle is sensed then the window of streetlights is illuminated in front of the vehicle.

![Fig. 4: Model of Street Light after ON](image)

![Fig. 5: Street lights from dark to bright state](image)

In the second mode of operation, initially when the vehicle is not sensed, all the streetlights will be in dim state as shown in Fig 7. This is achieved by use of pulse width modulation technique through the program stored in the microcontroller. Table 1 gives the parametric details of the system discussed in the research work.

![Fig. 7: Streetlights from dim to bright state](image)
Table 1. Ratings of the voltage regulator

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Input Voltage</td>
<td>V_i</td>
<td>35</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>(for V_o = 5V to 18V) (for V_o = 24V)</td>
<td>V_l</td>
<td></td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Thermal Resistance Junction-Cases (TO-220)</td>
<td>R_{jc}</td>
<td>5</td>
<td>°C/W</td>
</tr>
<tr>
<td>03</td>
<td>Thermal Resistance Junction-Air (TO-220)</td>
<td>R_{ja}</td>
<td>65</td>
<td>°C/W</td>
</tr>
<tr>
<td>04</td>
<td>Operating Temperature Range (KA78XX/A/R)</td>
<td>T_{opr}</td>
<td>0-+</td>
<td>125</td>
</tr>
<tr>
<td>05</td>
<td>Storage Temperature Range</td>
<td>T_{stg}</td>
<td>-65-+</td>
<td>150</td>
</tr>
</tbody>
</table>

5. CONCLUSION

The microcontroller based street lamp prototype model has been presented in this paper. The model includes infrared sensors to detect the movement of vehicles at certain height, placed in the electrical pole. The presented paper addresses the two control strategies one is to turn off the street lamp when no movements on the road. Second is minimizes the intensity of lamp. These two control schemes will save the power during the absence of movements on road. Hence, the research work presented is more advantageous than limitations.

Further this can be enhanced by using appropriate sensors for detecting the failed street light and then sending an SMS to the control department via GSM modem for appropriate action.

REFERENCES


