ENERGY CONSERVING ECONOMICAL AUTOMATED SMART CONTROL SYSTEM FOR STREET LIGHTING

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***Abstract*— In a set of street lighting systems, there are switches fixed to the street light poles that are situated along the roads, usually, people neglect to switch off and wasting energy during the day. A set of street lights with a single switch to turn on and off is another type and this system requires additional wiring for controlling. The street lights that are connected to a photodiode operates according to the sunlight level is another type of street lighting and cannot be operated remotely as it automatically turns the lights on and off. Thus, a massive amount of energy is wasted. The street light system of wireless operated also not suitable for street lights in developing countries such as Sri Lanka, because the wireless automation unit cost is high. Hence it is conclusive that a smart control system for street lighting is a necessity. This research scrutinizes the feasibility of an economical automated system for the street lights which subsequently will reduce power wastage and increase efficiency. By using the planned system, every light can be controlled whenever needed, without additional cost for wiring to control the lights and switches for every pole. For the experiment, home electrical system automation protocol X-10 has been selected as the power line communication protocol. With the proposed system, the control signal can be sent over the power lines. Instead of the requirement of wiring, another line for controlling is advantageous than wired and wireless systems. Fixing the implemented receiver unit for every light is sufficient. The cost of the receiver unit also will be less compared to the existing systems and the cost of energy wastage.**

Keywords: X-10 protocol, power line Communication protocol, energy conservation,

II. OBJECTIVES

Automation is the primary concern in present field technologies. Then comes the question of power consumption and cost-effectiveness. Automation is meant to scale back the use of the workforce with the assistance of intelligence systems. The main aim of this project is to design an x-10 automated module for controlling street lights. Therefore villages, towns we can style intelligent systems for the usage of streetlights.

I. INTRODUCTION

There are several reasons to use an automated system for Street lights. The main reason would be to reduce the waste of power. Wastage of power through the street light system of Sri Lanka is a huge problem that is faced by the country. Present time the street lights in a particular area are controlled by the respective municipal council. As we go along a road, we can see that most of the street lights are on during the daytime where there isn't any requirement. Implementation of this control system will result in saving a substantial amount of energy as well as man-hours utilized for control purposes.

Decreased overhead cost is an important factor. The pertaining street light system of Sri Lanka is underdeveloped in relevance to modern-day technology. In some parts of the country, a cluster of street lights is controlled by a single wire placed along with power lines. If this wire is provided individually, the cost for wiring will increase.

The smart control system of light system is essential. In a normal Sri Lankan wired street light system every bulb can't be controlled individually. In some instances, some roads do not need every bulb. Using an automated system, we can turn on only required bulbs and switch off others to save energy. Now with the development in urban areas, most of the street lights are connected to a photodiode which will operate according to the daylight level. These cannot be operated remotely but they will automatically

III. HOW DOES IT USE

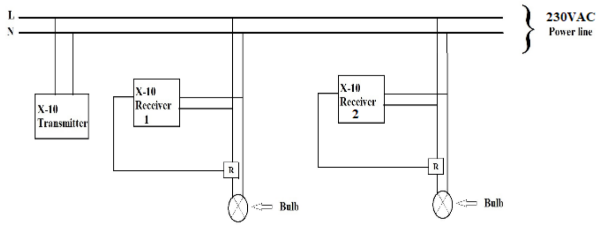


Fig 1. Basic block diagram

This is the basic idea of this project. Form the planed system x-10 transmitter is connected through the power lines. The transmitter consists of the zero-crossing detector and 120 kHz signal generator. The signal is sent to AC power lines by the transmitter. The signal sent to the AC power line is detected by receiving circuit According to the given command can be light on-off and control the lights.

IV. EXCITING RESEARCH

A. Zero-Crossing Detector

In X-10, information is timed with the zero-crossings of the AC power. A zero-crossing detector is easily created by using the external interrupt on the RB0 pin and just two external component, a resistor & small transformer, to limit the current into the PICmicro.

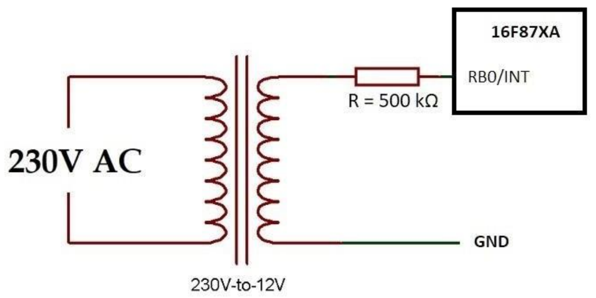


Fig 2. Zero Crossing Detector

Vrms = 12 VAC, and the peak line voltage is 17V. If we select a resistor of 500kΩ, Ipeak = 17 V/500kΩ = 34 μA

B. Transmitter

The transmitter module is responsible for generating the control signals and sending them over the existing power lines. It consists of a zero-crossing detector and a 120 kHz signal generator. The zero-crossing detector detects the zero-crossings of the AC power, allowing the control signals to be synchronized with the power grid. The 120 kHz signal generator generates the carrier frequency required for X-10 communication.

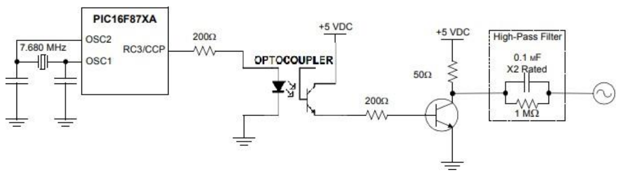


Fig 3. 120 kHz Carrier Generator

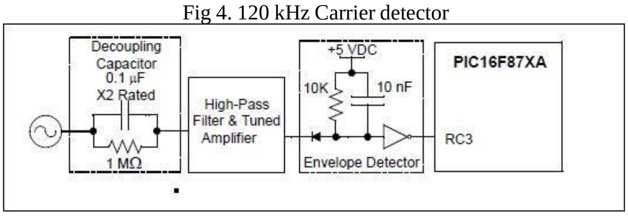
120 kHz signal will generate from the Microcontroller and signals send through the transistor to power it. We required a high-frequency signal, from the High Pass filter only High-frequency signals are sent to other blocks. Signals that come from high pass filters send to the AC power line.

X-10 uses 120 kHz modulation to transmit information over 50 Hz power lines. It is possible to generate the 120 kHz carrier with an external oscillator circuit. A single I/O pin would be used to enable or disable the oscillator circuit output. External frequency generators can be avoided by using microcontroller inbuilt frequency divider.

C. Receiver

The receiver module is integrated into each street light and receives the control signals transmitted over the power lines. It comprises a zero-crossing detector and a 120 kHz carrier detector. The zero-crossing detector helps in identifying the synchronization with the AC power, while the carrier detector detects the presence of the 120 kHz signal, extracting the encoded control information.

Fig 4. 120 kHz Carrier detector



This carrier detector is accomplished with a decoupling capacitor, a high-pass filter, a tuned amplifier, and an envelope detector. The components of the carrier detector are illustrated.

To receive X-10 signals, it is necessary to detect the presence of the 120 kHz signal on the AC power line.

A decoupling capacitor is used to reduce the effect of noise caused by the other circuit. From the envelope, the detector is an electronic circuit that takes a high-frequency signal as input, and the capacitor in the circuit stores upcharge on the rising edge.

After that signal decodes from the PIC and takes the information that we need.

D. Protocol that using

For this single transmission, I used a very simple protocol.

- Four-bit for start code
- Eight-bit for Light address
- Four-bit for command

This is the overview of this protocol.

Example:

"1010 11010101 1001".

In this example light address is 8bit one. Therefore it can control lights using that protocol. If we want to change no of bulbs that we control we can change it.

E. System Implementation Process

The transmitter module is installed at a central location, typically within the control room or a designated facility. It is connected to the power grid and synchronized with the AC power through the zero-crossing detector.

Each street light is equipped with a receiver module that integrates the zero-crossing detector and the carrier detector. These receiver units are fixed at the street light poles and connected to the power lines.

The transmitter module generates control signals containing the start code, address code, and command code.

These signals are modulated onto the 120 kHz carrier frequency.

The modulated control signals are sent over the existing power lines, riding on the AC power. As the signals propagate through the power lines, they reach the receiver modules attached to each street light.

Upon receiving the control signals, the receiver modules decode the information, identifying the target street light and the desired action. Based on the command received, the street light is turned on, off, or adjusted to the specified dimming level.

For enhanced management, real-time monitoring of the street lights' status and energy consumption can be implemented. This can be achieved through a central monitoring system, allowing administrators to oversee and optimize the lighting operation.

The system's automated control eliminates the need for manual intervention, reducing the chances of energy wastage during the day and ensuring efficient utilization of street lighting resources. By intelligently managing the street lights, the proposed system significantly contributes to energy conservation and cost-effectiveness, while also promoting sustainability in urban lighting infrastructure.

V. Methodology

Searched through the internet, books, articles, and find the information about previous researches, projects, etc. And also got some ideas from the senior engineers about selecting a topic, how this information extends, and what are the area must cover through research.

VI. Limitations

While the proposed "Energy Conserving Economical Automated Smart Control System for Street Lighting" presents a promising solution to the energy wastage issue in street lighting systems, there are certain limitations that need to be acknowledged.

The successful implementation of the X-10 protocol depends on the existing electrical infrastructure and the compatibility of the system with the street lights in use. Some older street light fixtures may not support the integration of the receiver units required for automation.

Although the cost of the receiver units is expected to be less compared to other existing systems, there will still be an initial investment required for the installation of the automation system. The feasibility of the project needs to be carefully assessed in consideration of the budget available.

Any automation system requires periodic maintenance and monitoring to ensure its proper functioning. Factors such as environmental conditions, electrical interference, or wear and tear may affect the reliability and performanceof the smart control system over time.

While the proposed system allows individual control of each street light, the scope of control is still limited to the on-off functionality and basic dimming. More advanced features, such as color temperature adjustment or dynamic lighting effects, may not be achievable through this protocol.

Implementation of an automated control system for street lighting may require adherence to specific regulations and standards set by the municipal authorities or governing bodies. Compliance with these regulations should be ensured during the planning and execution stages.

Despite these limitations, the "Energy Conserving Economical Automated Smart Control System for Street Lighting" project remains a viable and promising solution to tackle the energy wastage challenge in street lighting systems. By conducting thorough research, regular evaluations, and addressing any potential challenges, we can maximize the benefits of this smart control system and contribute to a greener and more sustainable future for our communities.

VII. Conclusion

The main aim of the project is to save the power, by using effectively we can save more power, as we know there is a shortage of power. So to overcome that we can provide streetlights using an x-10 automated system. Using x-10 automated system we can control the streetlights, switching on street lights only required times and switch on less no of bulbs that lights not required areas and can save more power as well as save the cost of controlling wiring cable. So in the future, we can design many more advanced technologies to save power.

This paper explained how to use x-10 automation for street light systems. How we design the Transmitter, Receiver, and how we send the frequency over 230Vac line.

Finally, this control circuit can be used in long roadways between the cities. Here we are saving a lot of power and cost of wiring.

VIII. Further Development Side Of Project

Using this x-10 system we can turn off not required bulbs. It is very useful to the method as power-saving just like over country. Control the opacity of bulbs in non-required areas is also we can implement through this project. But the problem is if we use that project in practice it is required to change over Sri Lankan bulbs to LED bulbs because normally Sri Lankan using street lights can’t control opacities. If we can change Sri Lankan bulbs to LED bulbs from that also we can save energy.

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