Design of Multi-Functional Lighting System Based on Solar Power

Xiao Zhihong
School of Electronic Engineering, Xi'an Shiyou University, Xi'an, 710065, China
xzong@xsyu.edu.cn

Abstract. This paper introduces the multi-functional lighting system which is a national undergraduate innovation training program. In view of the increasing energy shortage and environmental pollution, a multi-functional lighting system powered by solar energy is designed by project team members. In addition to the lighting function, the system also has killing insect and counting functions on some special occasions. This system uses STC90C516 as the control center, uses infrared diffuse reflection photodiode switch and infrared human body sensor as the counting sensor, multi-color LED array as the lighting device, using the phototaxis of pests to attract pests and kill them with high-voltage power grid. The results show that the system is energy-saving, environmental friendly, accurate in counting, and has good insecticidal effect on many kinds of pests.

1. Introduction

1.1. The Undergraduate Innovation and Entrepreneurship Training Program
The Program is an important part of the Undergraduate Teaching Quality and Teaching Reform Project setting by educational authorities[1-2], which is divided into three levels of national level, provincial level and school level. The project construction cycle ranges from one to two years. Students are free to organize teams and complete innovative research project design, preparation of the project study conditions [2-3], the research report writing, the academic communication and so on autonomously. It can consolidate and deepen students' understanding of the theoretical knowledge, learn how to use their knowledge to solve problems in practice, their innovative ability and cooperation spirit were also improved.

1.2. The information of the project "the design of multi-functional lighting system based on solar power"
The project is a national undergraduate innovation training program.

1.2.1. LED. LED is a kind of semiconductor solid-state device. It has the characteristics of energy saving, environmental protection, long life and small volume. With the breakthrough of LED lighting technology, the continuous improvement of LED luminous efficiency and performance price ratio, the application market of LED lighting products in the lighting field is expanding. Many of the outline lighting of buildings and the lighting of parks and other places use LED as lighting devices. However, most of the outdoor LED lighting in China is powered by city power and has a single function.

LED is light-emitting diode, which can emit red, orange, yellow, green, blue, white and purple light. The spectral wavelength of white light diode is 450-465 nm, blue diode is 450-480 nm, green diode is
495-530 nm, yellow diode is 580-595 nm, orange diode is 600-610 nm and red diode is 615-650 nm [4].

1.2.2. Solar energy. There are abundant solar energy resources on the earth. In the context of global warming, the deterioration of the human ecological environment and the shortage of conventional energy, the solar photovoltaic industry has received widespread attention and support from governments of various countries. Solar energy belongs to "green energy". Its utilization is not only a good supplement to the shortage of conventional energy, but also plays a positive role in environmental protection. In recent years, photovoltaics has become more widely used as the conversion efficiency and production technology of solar cells have improved.

1.2.3. Use the phototropism of insects to kill pests. Most flowers, grass and fruit trees are endangered by insect pests. At present, pesticides are usually used to kill pests. It is true that chemical pesticides can effectively control the harm of agricultural pests in a certain period of time[4-5], but at the same time, pesticides remained in soil and agricultural products seriously exceed the standard and directly threaten human health. In view of the harm caused by pesticides to the environment, humans and livestock, Harmless pest removal methods have been studied in various countries.

Many insects have phototaxis, and it is an important research field for pest control to eliminate pests by using the color tropism of pests. Recent studies have shown that different pests have different sensitivity to light. The phototaxis of most existing pests to the monochromatic spectrum is concentrated at 320-590 nm [5-6]. The corresponding phototaxis spectra of insects such as Coleoptera, Lepidoptera, Diptera, and Hymenoptera are 360 nm, 400 nm, 460 nm and 520 nm respectively. For example, Grapholita molesta busck, one of the important fruit tree borers in the northern of China, has the strongest phototaxis of green light with a monochromatic spectrum of 520 nm, and the phototaxis of females is significantly higher than that of males[7-8]. The tea garden pest Dialeurodes citri Ashmead has the strongest phototaxis to the yellow light with a monochromatic spectrum of 590 nm.

Because insects have phototropism, light sources of specific wavelengths can be used for induce traps depending on the sensitive wavelength of pests. This is a physical control measure and has little pollution to soil and plants. This method will become a direction for pest control. The spectrum of LED is suitable for the phototaxis of most pests. So it can be used as a light source for trapping pests.

2. The composition of the system
The system is powered by solar energy, and multi-color LED array is used as lighting source. At the same time, the LED lighting technology and light trapping and killing technology are combined organically. By taking advantage of the light-seeking characteristics of insects, the LED of specific wavelength is used to induce pests, and the high-voltage power grid is used to kill pests. In addition, the system can also have a counting function for parks or farm gates to monitor the number of people entering and exiting.

This system is consists of microcontroller, power module, the clock module, temperature and humidity measuring circuit, illuminance measuring circuit, the display module, LED array module, high-voltage insecticidal grid module, counting module and the keyboard. The block diagram of the system is shown in Figure 1.

2.1. Microcontroller
The single chip microcomputer selects STC's stc12c5a60s2 as the main control chip, it is a high-performance CMOS 8-bit microcontroller with 8kB FPEROM-flash programable and erasable read only memory, it uses the classic MCS-51 kernel.
2.2. **Power module**

The system uses a solar power module consisting of 10W solar panels, a 12V8ah battery and a 10A solar controller. The solar battery adopts single crystal silicon material, it is packaged by tempered glass and waterproof resin, and the efficiency can reach up to 24%. The solar controller controls the working state of the entire system and acts as an overcharge protection and over-discharge protection for the battery. The battery outputs 12V DC voltage. With the help of the LM317 adjustable voltage regulator chip and peripheral circuits, the 12V voltage is adjusted to 5V to the microcontroller.

2.3. **LED array module**

The LED array module is divided into two parts, LED lamp board and drive circuit. LED lamp board consist of six types of light emitting diodes: Orange, yellow, green, blue, white and purple. The drive circuit consists of ULN2003 driver and relay.

2.4. **High-voltage insecticidal grid**

High-voltage insecticidal grid module is consists of a high-voltage killing net and its driving circuit. Drive circuit generates high voltage required for high voltage killing net. The 5V DC signal is generated a square wave signal by the driving circuit, then it is boosted by transformer to reach a high voltage of 700 V to kill pests.

2.5. **Counting module**

The counting function is used to monitor the number of people entering and exiting for parks or farm gates. The counting module uses infrared diffuse reflection photoelectric switch and infrared human body sensor as the counting sensor, the sensitivity of sensor is high and its reliability is strong, with ultra-low voltage operating mode, the operating voltage is DC 4.5V-20V. When the target to be measured passes, the effective signal is filtered and transformed and sent to the microcontroller for counting. The circuit can realize the discrimination function. When the target is passing in a positive direction, the counter value adds 1. When the target passes in reverse, the counter value subtracts 1.

3. **System Software Design**

The system software is designed modularly and consists of main program, temperature and humidity testing subroutine, illuminance measuring subroutine, key handler, LED array drive, LCD display subroutine, clock subroutine and serial communication subroutine, etc. The main program completes
the initialization of the device and calls the appropriate subroutine modules according to the system requirements.

4. Conclusions
After debugged, the system was tested for performance. The test results show that according to the phototaxis of different pests, the system flashes LEDs of different wavelengths, which can induce different pests and kill pests with high-voltage power grid. At the same time, it proved that the insect catch was large during the period from 19:30 to 20:30 and 22:45 to 7:00. Figure 2 is the system debugging picture. The result of counting experiment shows that all aspects of the system meet the requirements. The correct rate of counting has reached 100%.

![Figure 2. The system debugging picture.](image)

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