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Research Article

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Research on the design and installation techniques of solar LED pest control light

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ABSTRACT

The solar LED pest control light is environmentally friendly, energy-saving, easy to use and independent of the electricity. Taking into consideration of the actual situation, this paper utilized the sensor to access to environmental information and then designed the fuzzy control circuit, aiming to carry out fuzzy control for the operating conditions of solar LED pest control light. Based on the phototaxis of targeted pests, it adopted the strobe light way to reduce power consumption and save energy, thus extending the working hours in the rainy days.

Key words: solar; LED pest control lights; strobe; sensor

INTRODUCTION

LED (Light Emitting Diode) pest control light is an electronic device using the phototaxis and chemotaxis to induce pests to touch the high-voltage power grid, thus killing them. It has become one of the primary means to control the insect attack. The LED pest control lights could effectively reduce the dosage of pesticides as well as their pollution on the agricultural products, soil and water. The solar LED light is easy to use and can be applied to various crops, thus, it has been wide applied in tea plantation, orchards, vegetable, cotton fields which are far away from the power grid or unsuited for stringing [1]. The solar LED pest control light is mainly composed by solar panels, batteries, control circuit, control keyboard, LED lamps, boost circuit, high-voltage grid, sensor and bracket and other components. During the day, energy from the solar panels will be stored in the storage batteries; at night, the electrical energy from the battery could drive circuit of LED light to control pest [2].

1 Design of the solar LED pest control light

First, select the appropriate LED light as a light source to trap pests; the boost circuit should make the high-pressure of pest control net over 6KV voltage, thus killing most of the pests toward the light and ensuring the body safety at the same time; based on the load power of LED lamps, high-voltage network and control circuit, make a reasonable choice for the capacity of batteries and solar panels to guarantee of 8h; design a control circuit for the solar panels to control the battery charging and discharging as well as protect the system. Meanwhile, it could control the LED pest control light which means the light could automatically turn on at night and off during the daytime, coupled with the lightning protection, anti-rain, short circuit prevention of high-voltage network caused by the dew, the prevention of accidentally injure of human and animals caused by the high-voltage network, the prevention of electric shock accident caused by the pest control light.

1.1 LED pest control light

The design of LED pest control light includes three steps: information collection, light design and control system. First, determine the operating environment of LED pest control light; then, study the major pest species with phototaxis to determine the target pests. Collect some important information, such as sensitive wavelength of pests, light intensity, living habits of pests, activity patterns, etc.; then, based on the above information, select the appropriate LED as the light source to attract pests and complete the design. Finally, determine the mechanical

structure and complete the control system and the whole design of LED pest control light [3].

Based on the sensitive wavelength range of most of the pests with phototaxis, LED is selected as the light source. Carry out superimposing light distribution and utilize the phototaxis and chemotaxis of the target pests to attract and kill pests. For the booster circuit, NE555 etc. constitute the pulse oscillation circuit to output high-frequency pulse signal, drive high-power conduction and perceive high voltage pulse in the secondary level of the transformer. Then by the rectifier diode output, we can obtain 6KV voltage and apply it to the power grid with horizontal network structure [4].

Automatically turn on the light at night and utilize the light source to trap the target pests, so that they will contact the peripheral high-voltage grid when flying to the light source and then be killed by the instantaneous discharge of high-voltage power grid. The high-voltage power circuit consists of two parts: the basic constant standby power; the killing power, which is not easy to be accurately measured due to different species and number of pests, so in the actual situation the average power of the high voltage circuit is used.

1.2 PV system

The PV system should be designed in accordance with a principle, that is, under the premise of satisfying the needs of electricity load and guaranteeing the reliability and economy, determine the minimum battery capacity of solar battery and storage battery to minimize investment. The LED pest control light in this paper completely relies on the electric power generated by the solar battery, so the design of the solar power system is the key point of this system. The following two factors should be attached great importance to: first, the design-related parameters, such as load power, and the number of consecutive rainy days; then, the selection and design of main peripheral devices or circuit, such as the battery capacity, the power of the solar cell modules, charging and discharging control circuit, the inverter circuit, the booster circuit.

The control system of solar LED pest control light system takes into account latitude, annual average sunshine time and other factors. It studies the maximum power point tracking (MPPT) and a variety of charging and discharging strategies. However, as its power supply completely replies on the weather, the daily amount of charge has a strong randomness and uncertainty, coupled with the uncertain amount during the next day. The current control strategy is to ignore the weather and the output power of street lights at night is the same. As the output power of the solar panel is apt to be influenced by the illumination intensity, temperature, load fluctuation and other factors, the continuous rainy days in Southwest China will caused the insufficient energy of the battery of the LED pest control light. The untimely charge may lead to the LED light's failing to operate and the damage of the battery [5]. Therefore, the weather factor is a key point in solar LED lights pest control strategies.

1.3 The control circuit

In the solar LED pest control light system, the electric power from the solar panels is stored into the battery, and by measurement and accumulation, the charge is obtained. Meanwhile, by the real-time measurement of light and temperature and other parameters, identify the weather conditions and get the fuzzy quantity of the weather. When the battery is charging and discharging, measure the internal resistance, polarization voltage and terminal voltage of the battery, thus obtaining the residual capacity of the battery. The controller utilizes the fuzzy controller decisions to adjust the output power of LED pest control light based on the fuzzy quantity weather and the residual capacity of the battery. Therefore, in the sunny days, the battery is fully charged and has the high output power. Conversely, in rainy days, the residual capacity is low and its output power is small [6].

The residual capacity of the storage battery is another fuzzy quantity and it is not easy to be measured directly but by the discharging method. The residual capacity of the storage battery is related to the internal resistance, terminal voltage and polarization voltage, so the online measurement for these parameters could predict the residual capacity of the storage battery. The internal resistance of the storage battery is highly correlated with the charge degree and its residual capacity can be accurately predicted by the online measurement of the internal resistance. Add AC signal which changes faster than the polarization process to the battery and then measure the terminal voltage, current, and the angle between them to obtain the internal resistance, thus predicting the residual capacity.

As the nocturnal insects have regular activities at night, the insects with phototaxis may also have the fixed time of flying to lights, which may affect the effect of LED pest control light. Turn on the light when the insects have regular activities and turn off the light when they have few activities, which could both save energy and reduce the damage to natural enemies and neutral insects. In the summer, most insects have regular activities within half an hour to one and a half hour after lighting, small insects followed by large species. Considering the weather and the amount of the charge, conduct fuzzy control for the solar LED pest control light combined with the residual capacity of the storage battery [7].

The intelligent dimming system of LED pest control light based on the multi-sensor fusion is to get the ambient light illumination by the light sensors mounted on the light, and get the environmental humidity by the humidity sensor [8]. Use the sensor information fusion theory to fuse the sensor and send the fused control information to the control microcontroller. The microcontroller generates luminescence signals and simulates the flicker of glowworm by the software programming to adjust the control strategies of LED pest control light. The solar LED pest control system is a fuzzy controller. The input includes the fuzzy quantity weather, the amount of charge and the residual capacity of storage battery; the output refers to the operating current to control the on-and-off time of LED pest control light. This could solve the problem of low battery in continuous rainy days and ensure the normal operation of the light.

The core device of control circuit is the MCU, the charge and power supply of the solar LED light is done by the MCU. When charging it, MCU could measure the battery and then charge it based on the state of the super capacitor. When discharging it, the MCU detects that the battery has low power and then immediately stops the load power supply, which means MUC could protect the battery. It could also prevent the reverse polarity of solar panels, storage battery and the operation with insufficient voltage, etc.; it could achieve the intelligent light control, the control circuit is the core of solar LED pest control system and the charge-discharge control will directly affect the application of the system, so it should have the charge and discharge protection, the maximum power tracking, overcharge protection, over-discharge protection, short circuit protection, automatic switching and time adjustment. MCU could detect the humidity by the humidity sensor and prevent the short circuit of high-voltage pest control net caused by rain and dew.

1. INSTALLATION

When the light travels through air, its intensity will be weakened with the increase of distance. The greater the light intensity indicates wider radiation range, and vice versa. When we install the pest control lights in the field installation, if the distance between lights is greater than the radiation range, it may result in inadequate pest trapping; if the distance between lights is smaller than the radiation range, it may lead to resource waste. Set different light distances according to the experiment to conduct trapping, and then identify the appropriate one by the comparative analysis. Since the natural distribution of most of the insects is aggregated distribution in a small-scale range, the trapping experiment should be carried out in the large range to ensure the uniformity. The solar pest control lights are set as automatically lighting at night and turning off during the day. Fill the basin with water and put it under the light every day, add detergent in it, and then classify the insects falling in the basin the next morning. Record the number of the insects and number them, drying them for preservation. Average the dry weight of insects respectively collected under two light distances and then map by date. By comparing the number of insects under different light distances, find the reasonable one [9].

The light intensity is related to both the distance and the installation height. Theoretically speaking, the higher the position of the light source is, the farther the light propagation will be, coupled with more obstacles and more trapping insects. This is appropriate for the smaller insects. However, for the big insects, it is difficult to achieve trapping when they fly too high, so there is no need to install the light source too high for these kinds of inspects. In one word, the height of the solar LED pest control light should be determined based on the flying ability of insects.

CONCLUSION

As the meteorological factors have great influence on the solar LED pest control lights, temperature, humidity and season are all closed related to insects. Rainfall and increase of the wind speed will lead to a decline in the trap quantity. Under the sunny days, the moonlight will reduce the trap quantity and the full moon and new moon respectively has the greatest and least influence. Therefore, during the days with high winds, rainfall and full moon, the pest control light can be turned off. It is necessary to set a reasonable opening and closing time, which could save energy, extend its service life and reduce the damage to these non-target insects.

With the growth in the living standard, it is necessary to supply a large number of environmentally friendly green agricultural products. The ineffectiveness of chemical pollution prevention of agricultural products and energy shortage has promoted the application of physical mechanism. Solar LED lights are the key point of many research institutions and electrical manufacturers. Until now, there are few researches on it at home and abroad, so it is of great importance to study its influence on the pest control of agricultural products and provide pollution-free agricultural products.

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