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Design of Lighting Control for Energy Saving Using Microcontroller System

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Abstract: *Electric lights are a necessity in our daily lives, and everyone cannot do without them. However, traditional lighting systems have many inconveniences to use, especially when turning on lights at night, which is very inconvenient and often leads to waste due to forgetting to turn off the lights. Although traditional lighting is suitable for use at home, it is not suitable for use in high traffic public places such as school classrooms, libraries, and offices. Based on the analysis of electricity consumption in various school classrooms, we design a lighting control system to solve the imperfect lighting control system. This design uses STC89C52 as the main control chip, infrared sensors to sense the presence of human signals, and a circuit composed of photoresistors to measure the lighting intensity. When there are people in the classroom and the lighting intensity is weak, the system will automatically turn on the lighting. This design can switch to manual mode by switching the switch button, control the lighting by manual operation, and display the number of pedestrian-detection through two digital tubes.*

Keywords: *Intelligent lighting; Energy saving; Microcontroller; Pedestrian detection*

1. Introduction

The global electricity consumption is already an astonishing number, and non-renewable energy is gradually decreasing, such as the oil, natural gas, and coal [1]. Therefore, energy conservation and emission reduction work have important practical significance. There are many energy saving methods which include intelligent lighting control system [2], occupancy sensing [3], daylight harvesting and automatic dimming control [4]. For those energy saving applications in light emitting diode (LED) filed, Chew et.al. And Wang et.al. proposed their methods [5,6].

This paper is inspired by the course teaching content of the microcontroller system and the energy saving need of the classroom. Consequently, a prototype of a simulated energy-saving control system using microcontroller system is designed to consolidate teaching effectiveness and validate design ideas.

2. Main Functional Design

Due to the main purpose of design being to simulate energy-saving system, rather than truly used as a consumer grade product, some modules consider the simple sensor devices. As shown in figure 1, the microcontroller system is used for processing the signal and data. The input part includes the light detection module, infrared detection module and the button module. The output part has buzzer module, digital tube display module and the LED control module.

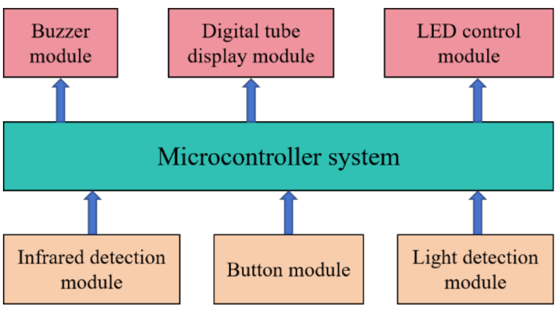

Figure 1: Overall functional diagram.

When the photosensitive detection circuit detects that the indoor light is on and the infrared detecting

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module detects that there is no one inside, the lighting system will be turned off. On the contrary, when the indoor light is dim but pedestrians are detected entering, the number of lighting lights will be increased. The number of people entering the room is displayed on a digital tube. If one person is added, the number on the digital tube will also increase by 1, and vice versa, it will decrease by 1. If there is no one indoors, the buzzer will sound and the lighting system will be turned off after a delay. To avoid incorrect switching of the lighting system due to incorrect detection, the system provides manual mode, which means that personnel can manually control the lighting system.

3. Hardware Design

This hardware design is a total circuit diagram consisting of a microcontroller as the main chip, button circuit, display circuit, alarm circuit, lighting circuit, light detection circuit, and infrared tube circuit, as shown in figure 2. The left middle part is a STC89C52 which is used as the main control chip [7], equipped with an 8-bit microprocessor, 8KB program memory (Flash ROM), 512 bytes of data memory (RAM), and an external expandable 64KB data memory. The upper left corner is the digital tube circuit and the lower middle corner is the LED analog part of the lighting system. The buzzer is shown in the upper right corner and the lower right corner is the photosensitive resistor and infrared emitter circuit section.

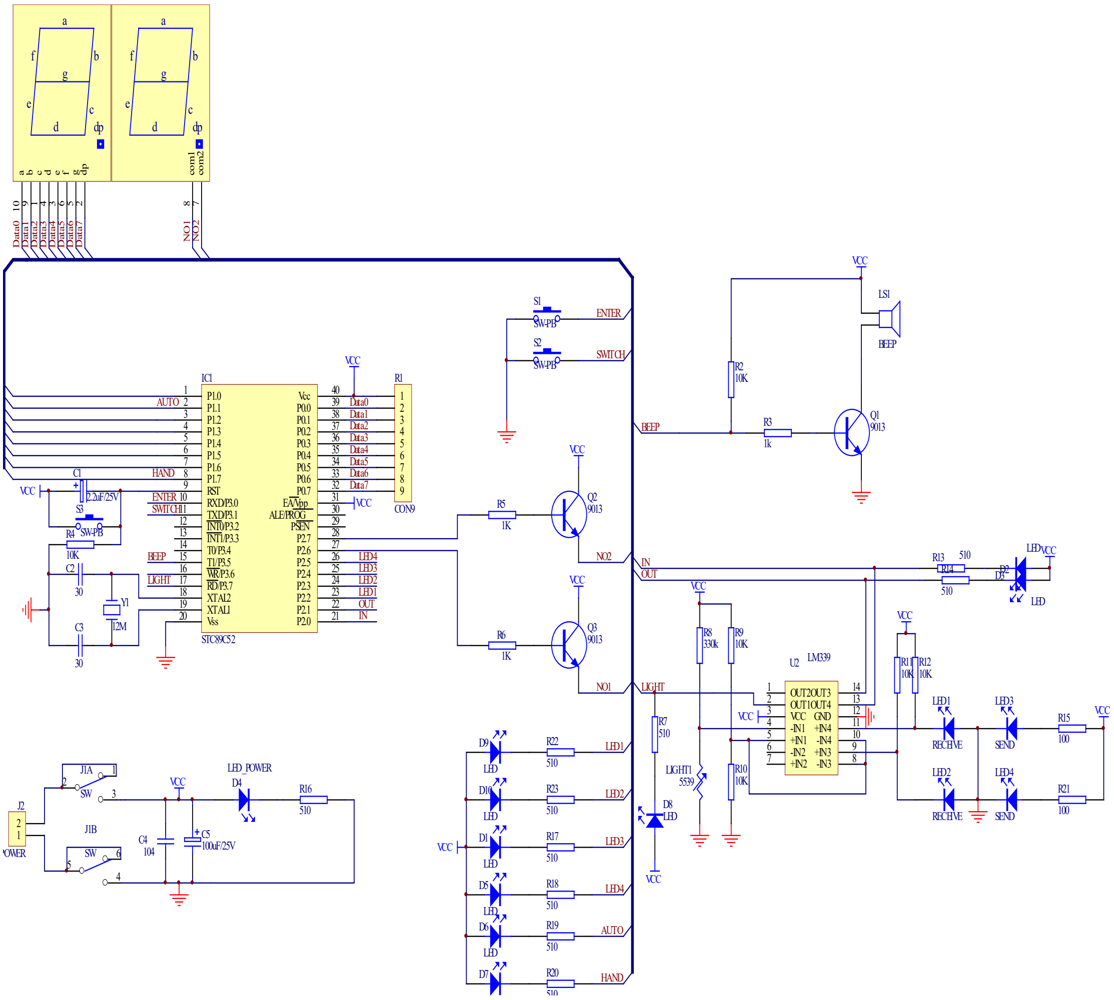

Figure 2: Overall circuit schematic diagram

4. Software Design

The software part mainly completes tasks such as data collection, keyboard scanning, and displaying results. The desired effect of software design: (1) The controller can count and display the number of people, and the system has two modes: automatic and manual. The two modes can be switched freely, and the buzzer will sound when there is no one or no light. (2) In automatic control mode, the controller automatically controls the lighting according to the intensity and number of people in the classroom, and

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automatically turns off all lights when there is no one in the classroom. (3) In manual mode, the number of lighting lights can be controlled based on the number of times the button is pressed.

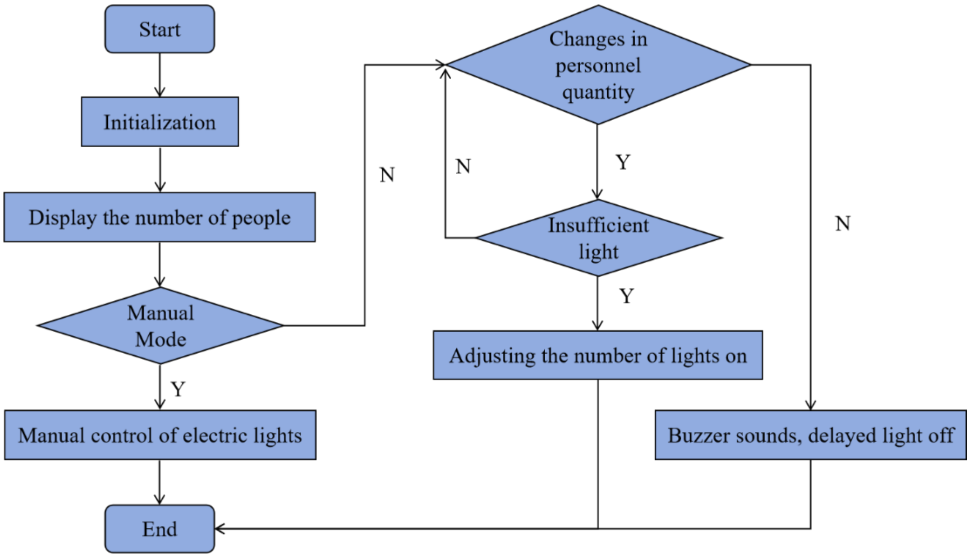

Figure 3: Software flowchart

The software flowchart is shown in figure 3 where the quantity of the people inside the classroom is decided by the statistics on the quantity of entry and exit inspections. After the system controller is powered on, it first initializes each module, detects the number of people in the classroom in real time, and displays it on the digital tube. The system is in automatic control mode by default. Only when the classroom lighting is weak and there are people indoors can the lighting be activated. The number of lighting lights should also be automatically activated according to the number of people. The lighting in the classroom will not be turned on even when there is strong light or no one present.

5. Physical Prototype Testing

Only after debugging both the hardware and software parts without errors can the system run normally. The initial debugging of the hardware and software parts is carried out independently, and they do not affect each other. After welding the hardware part, the hardware can be debugged immediately, and faults in each module can be checked one by one. Check for any missing or excessive soldering during the welding process, and check whether the circuit pins are connected correctly. Use a multimeter to check if each circuit is open, ensuring that the circuit voltage is normal, in order to avoid chip damage caused by high voltage or power polarity connection. The physical image after welding and debugging is shown in figure 4.

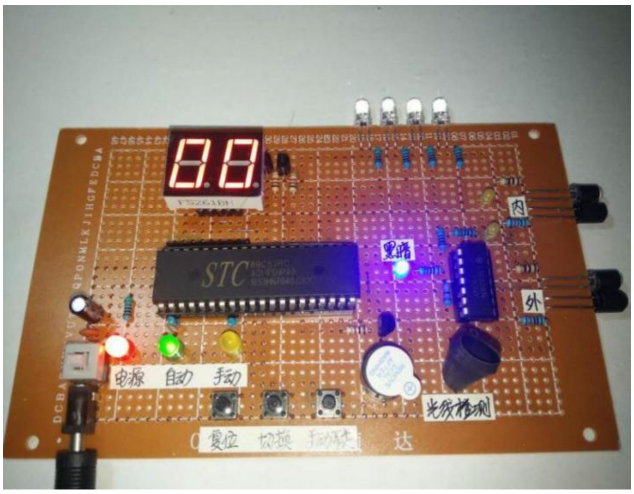

Figure 4: Physical prototype of the system

Detect the voltage of the photoresistor in both light and no light environments, and use a heat shrink

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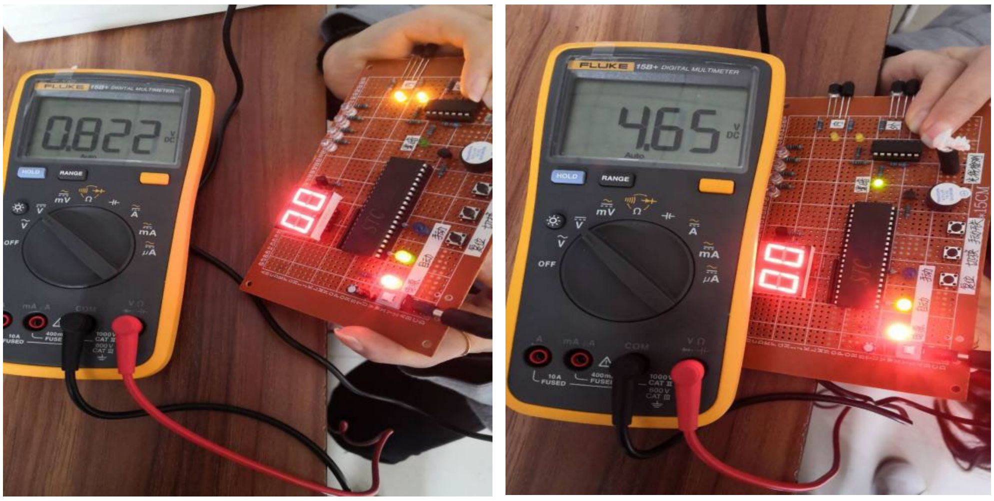
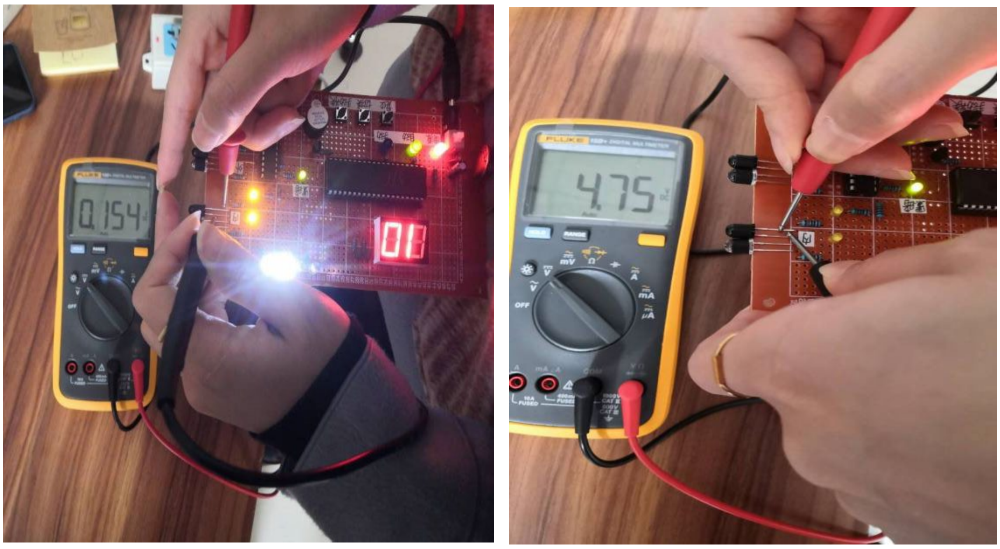
sleeve to cover the photoresistor and simulate a no light environment. Measure the voltage of the photoresistor input to the inverted input terminal of the fourth pin of the voltage comparator using a multimeter in two situations. Through the measurement results, it can be known that the voltage of the photoresistor is lower than the comparison voltage by 2.5 volts when there is sufficient light, and higher than the comparison voltage by 2.5 volts when there is insufficient light, which conforms to the design principle of this design. The measurement results with light are shown in figure 5(a), and the measurement results without light are shown in figure 5(b).



(a) Illuminated *(b) No illumination*

Figure 5: Voltage measurement results under different lighting environments

Measure the voltage value input to the voltage comparator when someone passes through the infrared tube and when no one passes through the infrared tube, and simulate human movement between the two teams of infrared tubes by hand. From the measurement results, it can be seen that when someone passes by, the voltage input to the positive phase input terminal of the voltage comparator is lower than the voltage to be compared, and the voltage comparator will output a low level. When no one passes by, the voltage input to the positive phase input terminal of the voltage comparator is higher than the voltage to be compared, and the voltage comparator will output a high level. The module meets the design requirements of this design by judging whether someone has passed through the low level. Someone measured the results as shown in figure 6(a), while no one passed through as shown in figure 6(b).



(a) With pedestrian *(b) Without pedestrian*

Figure 6: Voltage measurement results under different pedestrian passing conditions

After the initial debugging of the software and hardware parts is correct, use the program download software STC-ISP to download the program to the microcontroller chip. Dynamically debug each module one by one, identify obstacles, and modify them. After all modules have no errors, the controller can

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work normally.

6. Conclusion and Suggestion

This article simulates the intelligent control of classroom lighting system through the software and hardware modules of the microcontroller system, in order to achieve the goal of energy conservation. Although there is still a certain gap between this system and actual use, it still has value as an application in teaching microcontroller courses.

In future research, we will consider using computer vision techniques to identify pedestrians that is more effective and precise. In the era of artificial intelligence, the deep learning trained model also can be introduced into the energy saving system [8]. In addition, the detection of pedestrians entering and exiting the classroom can be achieved through deep learning methods [9,10].

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