Design of Intelligent Power Saving Socket Based on Infrared and Mechanical Control

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Abstract. In order to effectively solve the problem of power waste caused by forgetting to cut off the power supply during standby, reduce the waste of power resources and improve the safety of electrical appliances, this paper designs an intelligent power saving socket which can be used in many scenarios. The design fully considers the cost of equipment, reliability and practicability, can greatly save electricity, so as to achieve the purpose of energy saving and emission reduction.

1. Introduction
Electric energy is the most widely used secondary energy in daily life. It is full of food, clothing, housing, transportation and industrial production. Its application makes people's life more colorful and greatly promotes the progress and development of human society. But in today's era, with the acceleration of people's pace of life, fast food culture has become the mainstream, which also spawned a distorted waste culture, the most representative of which is the waste of electricity.

At present, most people's awareness of power saving electricity is still relatively weak, and in a few people with the idea of power saving electricity, there are quite a number of people do not understand the correct way of power saving, people generally think that the electrical standby is to turn off, but in fact, electrical appliances will still consume power in the standby state. For example, computers, many people think that can turn off the display, but the computer in the standby state will also produce greater power consumption; such as example, water dispenser, if the heating state all day, repeated heating of water will also produce greater power consumption[1].

According to the survey of domestic standby energy consumption done by China Energy Conservation Certification Center in the early 2010 century, the standby energy consumption accounts for about 10% of the domestic power consumption. Take the TV as an example, the average standby energy consumption per TV is 8.07W, by 16 hours of standby per day, and the power consumption is about 0.128degrees per day. According to the survey, each use of electricity consumes 400grams of coal, emitting 1kg of carbon dioxide and 30grams of sulfur dioxide, having a bad impact on the environment[1]. It can be seen that the research of reducing the standby loss of electrical appliances is of great significance. At the same time, saving electricity consumption is also a practice of the theory of "clear waters and green mountains are gold and silver mountains" proposed by General Secretary Xi Jinping, which is in line with the new concept of green, coordinated and sustainable environmental protection.

Based on this, an intelligent power saving socket switch device is designed to detect the working state of electrical appliances. Firstly, a suitable input sampling circuit system is designed to convert
220V alternating current through the Jack into a DC voltage signal that can be accepted and processed by the single chip microcomputer. Finally, the mechanical output execution system is designed to control the power supply circuit. This device can improve the power waste caused by subjective energy saving consciousness or passive behavior, and achieve the purpose of saving environmental protection.

2. Design scheme
The intelligent power saving socket switch device designed in this paper consists of three parts: input sampling circuit system, information processing system and mechanical output execution system. Firstly, the scheme of identifying the standby state of electrical apparatus is determined, and then each part is designed in turn.

2.1. Identification scheme for determining standby state of electrical apparatus
Scheme one: the single chip microcomputer obtains the digital circuit signal related to the electrical power through its built-in ADC module, so as to determine the standby power of the electrical appliance in advance, and then calculates its corresponding digital signal value accordingly. This value is set to a threshold as a criterion for judging whether the motor enters standby state. When the digital signal obtained by the single chip microcomputer is greater than the threshold value, the electrical appliance is judged to be in working state and normal power supply; when the digital signal obtained by the single chip microcomputer is less than the threshold value, the single chip microcomputer determines that the electrical appliance is in standby state and the output signal controls the mechanical output actuator.

Scheme two: set a scanning period, single chip microcomputer measures the voltage of adjacent two time points according to one scanning period, compare the difference of digital voltage signal measured twice, and determine the appropriate difference range by multiple scans. If the difference of digital voltage signal is beyond the range, it is considered that the output signal makes the mechanical output perform the device action and avoid standby loss.

Through the analysis of the above two schemes, it can be found that the second scheme is less operable, the way to determine the range of voltage difference is more complicated and the accuracy is difficult to guarantee, and when time t and voltage U are used as functions, In scheme 2, the system continuously scans and reads. Therefore, the first option is to identify the standby state of the motor, and the structure diagram is shown in figure 1.

![Figure 1 Structure of central processing agencies](image1)

2.2. Input sampling circuit system
Since the current through the Jack is 220 V AC, it can not be directly processed and recognized by the information processing system, so it is necessary to design an input sampling circuit system, which is shown as figure 2. The main function is to convert alternating current into DC voltage signal which can be accepted and processed by single chip microcomputer. Firstly, the AC is converted into a simple DC signal by AC-DC module, which is easy to measure and calculate. Finally, the processed DC analog voltage signal is input to the central processing system for analysis and processing.

![Figure 2 Flow chart of input sampling circuit](image2)
2.2.1. AC-DC module (U1-U2). Since the current through the jack is 220V AC and it is necessary to be converted into DC signal processed by single chip, the topic is planned to use AC-DC module for AC-DC conversion, and the circuit diagram is shown in figure 3. As for AC-DC module, the topic is proposed to choose XD308H chip, which has the advantages of high pressure resistance characteristics, excellent frequency width, good comprehensive performance and so on, and can handle the original signal well, and the upper level AC signal changes to the corresponding DC signal according to a certain function relationship, which is used as the steady-state input of the latter level\[3\].

![Figure 3 AC-DC schematic diagram of the module circuit](image)

2.2.2. Voltage stabilizing module. The main function of the voltage stabilizer module is to stabilize the output voltage and amplify it to the appropriate interval to facilitate the processing of the single chip microcomputer\[4\]. This paper intends to select AMS1117 as the main control chip, which can provide 1 A output current, and the working pressure difference can be as low as 1 V; At the maximum output current, the minimum pressure difference of the device is guaranteed not to exceed 1.3 V, and decreases with the decrease of load current. The circuit principle is shown in figure 4.

![Figure 4 Circuit schematic diagram of voltage stabilizing module](image)

2.2.3. leOptical Coupling Modu. In order to improve the anti-interference of the system and prevent the external circuit from interfering with the single chip microcomputer, TLP521 series of optocoupler modules are used to isolate and protect it, as shown in figure 5.

![Figure 5 Schematic diagram of tlp521 series optocoupler modules](image)

2.3. Information processing system

The information processing system intends to select MSP430F1611 single chip microcomputer as the main control board to process the DC analog voltage signal input by the input sampling circuit system and convert it into digital signal through the ADC module\[5\]. The working state of the electrical appliance is judged and the mechanical output actuator is operated according to the output signal. When the single chip microcomputer detects that the electrical appliance is in standby state, the output signal manipulates the mechanical output actuator action to disconnect the power supply circuit of the electrical appliance; when the power supply needs to be restored, Only one input signal (such as infrared signal) is given to the information processing system.

2.3.1. Feasibility Analysis of Identification of Standby State of Electrical Appliances Based on Power. As a result, the current flowing through the electrical apparatus and the jack is greatly reduced, so the current is converted into a voltage signal that can be recognized and processed by the single chip microcomputer through the input sampling circuit system, and the DC analog-to-digital converter is...
used to convert the DC analog-to-digital converter of the single chip microcomputer, and compared with the preset threshold value. According to the comparison results, the single chip microcomputer outputs different results and controls the mechanical output to perform system actions, To achieve the power supply circuit on and off, to avoid electrical standby loss.

2.3.2. ADC Module Selection Analysis. Due to the obvious difference between power consumption during normal operation and power consumption at standby, the voltage signal changes greatly, so that the accuracy requirement of the converter is not high, so the project plans to directly use the 12-bit ADC digital-mode converter built in a single-chip computer to simplify the structure and save cost.

2.4. Mechanical output execution system
The main function of the mechanical output execution system is to work under the control of the information processing system to realize the on-off of the power supply circuit. Therefore, a mechanical structure based on electromagnet is used as the output actuator. The control of socket on-off is realized by controlling electromagnet.

2.4.1. physical construction. As shown in figure 6, the mechanical part of the mechanical output execution system mainly consists of electromagnets, armature, slide core, two-part copper ring, reset spring, and package sleeve. Among them, the two copper rings connected together (figure 7) are set in the heart of the slider, made of flame retardant plastic, insulation and flame retardant. Armature is located directly above the heart of the slider and forms the sliding valve.

As shown in figure 8, the sliding valve is located above the reset spring, concentric with the sleeve and in the sleeve, the top of the micro large distance solenoid, the inner wall has two outer copper rings connected to the external circuit and load.

2.4.2. principle of operation. The working principle of the mechanical output execution system designed in this paper can be expressed as follows:
When it is not detected that the electric appliance is in standby state, the device does not work and the electromagnet has no current passing through. At this time, the copper ring on the sliding valve is located below the sleeve two copper rings, and the two are not in contact, so the circuit and load can not be switched on.

When it is detected that the electric appliance is in standby state, the electromagnet is started by the voltage of the control circuit, and the electromagnetic force acts on the armature, which causes the armature to drive the sliding valve up. At this time, the two copper rings on the sliding valve are in contact with the two copper rings on the sleeve.

When the socket needs to restore the power supply, the electromagnet loses power again, the magnetic force of the electromagnet disappears, the sliding valve recovers to the original position through the action of the reset spring, and disconnects the circuit and load.

2.4.3. Device layout. Because the ultimate purpose of the device designed in this paper is to control the on-off of the Jack, the mechanical output actuator is installed in the plug board. The specific arrangement is shown in figure 9, and each Jack corresponds to an executive device. Thus, the on-off of each Jack does not affect each other and works independently.

3. Conclusion
The device has a unique way to solve the problem of power waste in daily life by reducing the standby loss of electrical appliances. The working mechanism is to realize automatic power-off by judging the working state of electrical appliances, and it is suitable for different types of household appliances and has simple structure; the input sampling system of the device not only satisfies the basic AC/DC conversion function, but also adds the necessary protective measures to make the device work stably and reliably and improve the safety of electricity consumption; the information processing system of the device adopts MSP430 series of single chip microcomputer, which can simplify the structure and reduce the energy consumption on the premise of meeting the working requirements; the mechanical output actuator of the device adopts electromagnet as the control part, which is compact in structure, sensitive in action and reliable in working condition.

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