Design Report of an Energy-Saving Switch in Apartments' Lighting System

Designers: Xiaoguang Jiang, Chen Wang, Xinyuan Xia
Department of Automatic Test and Control, Harbin Institute of Technology, Harbin, China
Cell: (86)13624617937
Email: jxg19891103@163.com

Introduction

As we all know, "Short-Circuit Protection Switch", which can protect wires and devices, is one of the most important equipments in electric apparatus. Innovatively, an "Open-Circuit Energy-Saving Switch" is now designed.

Most of us may have the following experience that the water supply is suddenly cut off while the tap, for some reasons, is still left on because of mindless, thus much water will be wasted once the water supply is restored.

Similarly, there is a common situation in most of universities and high-schools in China: power supply of dormitories is uniformly cut off near bedtime, and restored early next morning. However many students forget to cut off their lamp switches, and the lamps automatically turn on early next morning when the master switch of the apartment is reclosed. This has been a long-lasting problem in student dormitories that not only wastes the energy but also severely annoys the students.

In order to solve this problem, we creatively designed this "Energy-Saving Switch" through circuit structure design, device selection and performance analysis. This new switch has the same function of ordinary switch and an extra function to solve the above problem.

There are many merits of this "Energy-Saving Switch". Such as originality, structure simplicity, low in price, good reliability, practicability, and easy to spread. It perfectly combines the needs of life convenience and energy conservation.

Key Words：Energy conservation, Switch, Lighting System, Practical, Simple.

1. Background and Significance

According to the data published by the United Nations, 19 percent of the total global electricity generation is used to light, in China the rate is 12 percent, over 300 billion kilowatt hour. Therefore, saving lighting power has great significance in energy conservation, pollution reduction and even containment of global warming.

This “Energy-Saving Switch” contributes to energy conservation by solving the mentioned problem in student apartments. And no similar product has ever been found either domestically or internationally.

2. Design Plan

2.1 Design Ideas

Many methods can be used to achieve the on-off control of Electrical Circuits, such as using power electronic devices, logic control circuits, even MCUs. However, as for the lamp switch the design must be practical and low-priced. So it will be better to reform the existing products in order to realize the “Energy-Saving” goal. Moreover, the switch must be able to work properly under the conditions of 220v, 50Hz AC. So take all the above arguments into consideration, all the chosen devices are ordinary, simple, cheap, and durable ones.

In the absence of mass production manufacturing, we still tried to design it into a small size. We have chosen the Electromagnetic Relay as the central device to achieve the control of the switch. However, common uses of the Electromagnetic Relay cannot achieve this goal. So an innovative use of the Electromagnetic Relay is introduced.

2.2 Basic Principle

The design thoughts will be illustrated by the following circuit diagrams.

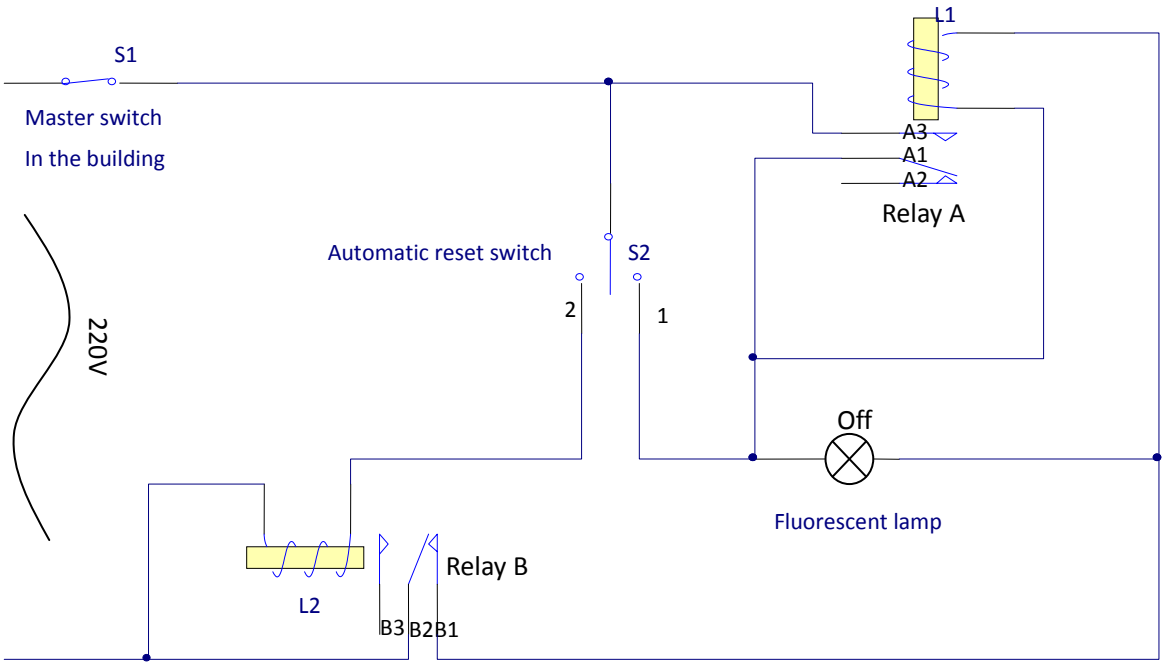


Figure 1 Work State 0

Figure 1 is the schematic diagram of the energy-saving switch. It contains two relays and one Automatic Reset Switch packaged in one ordinary switch box. Switch S2 to 1 to turn on the lamp and Switch S2 to 2 to turn off the lamp. Relay A is a normally open relay, while B is a normally closed relay. The so-called “Automatic Reset Switch” has the character that either S2 is switched to Contact 1 or Contact 2, it will automatically detach from them. The automatic reset function is realized by using two limit switches.

We define the state showed in Figure 1 as State 0, when S1 is closed and S2 is open. Now there is no current in L1 and L2, A1-A2 (means A1 is in touch with A2), B1-B2 (means B1 is in touch with B2); the lamp is not lighted.

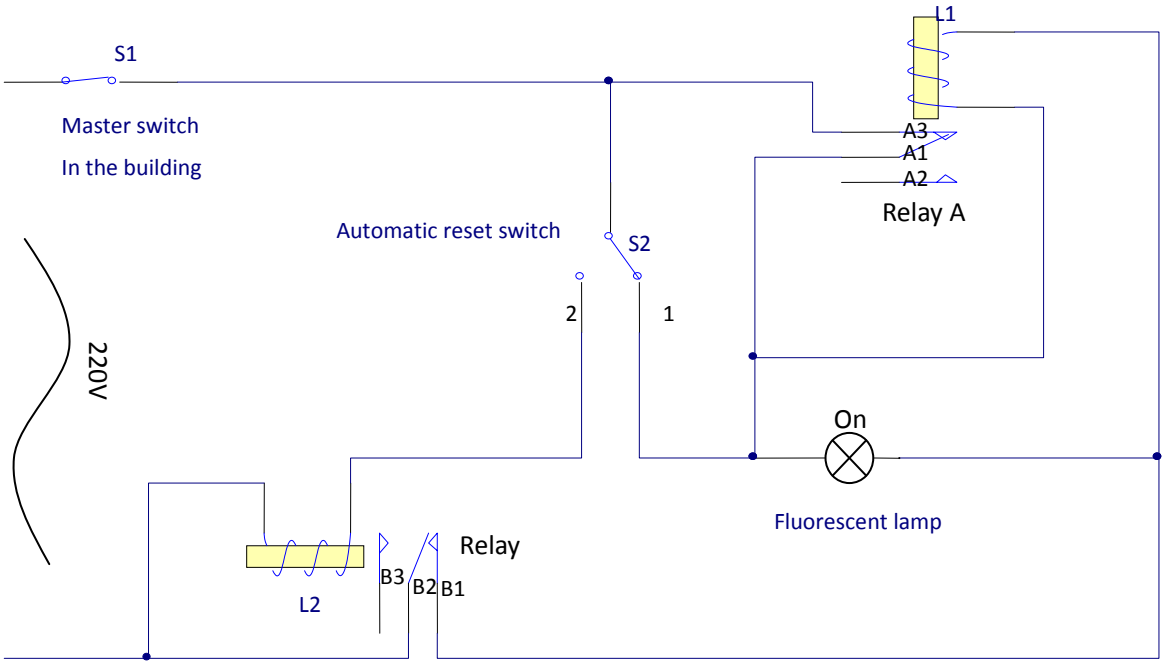


Figure 2 Work State 0-1

The state in Figure 2 is State 0-1, indicating the exact moment when S2 is switched to Contact 1. When S2 get in touch with Contact 1, L1 is energized and A1-A3. At the same time, the lamp is turned on and the state of Relay B is not changed.

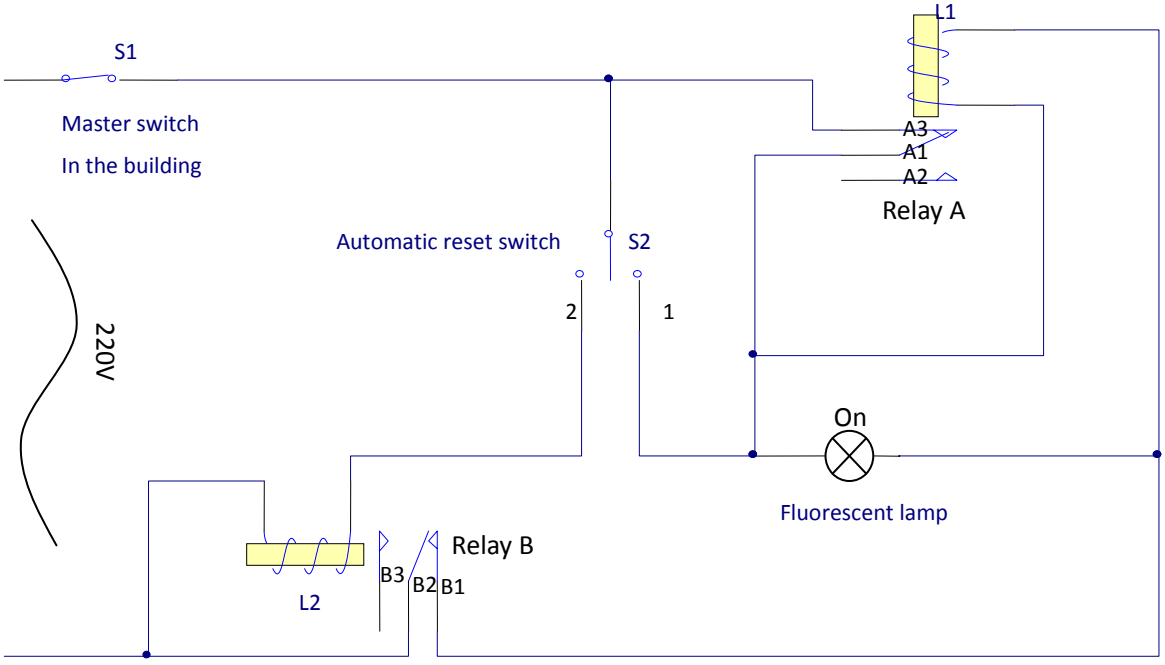


Figure 3 Work State 1

The state in Figure 3 is State 1, the difference between State 0-1 and State 1 is that S2 is automatically reset to its original state, and the Fluorescent lamp keeps on lighting.

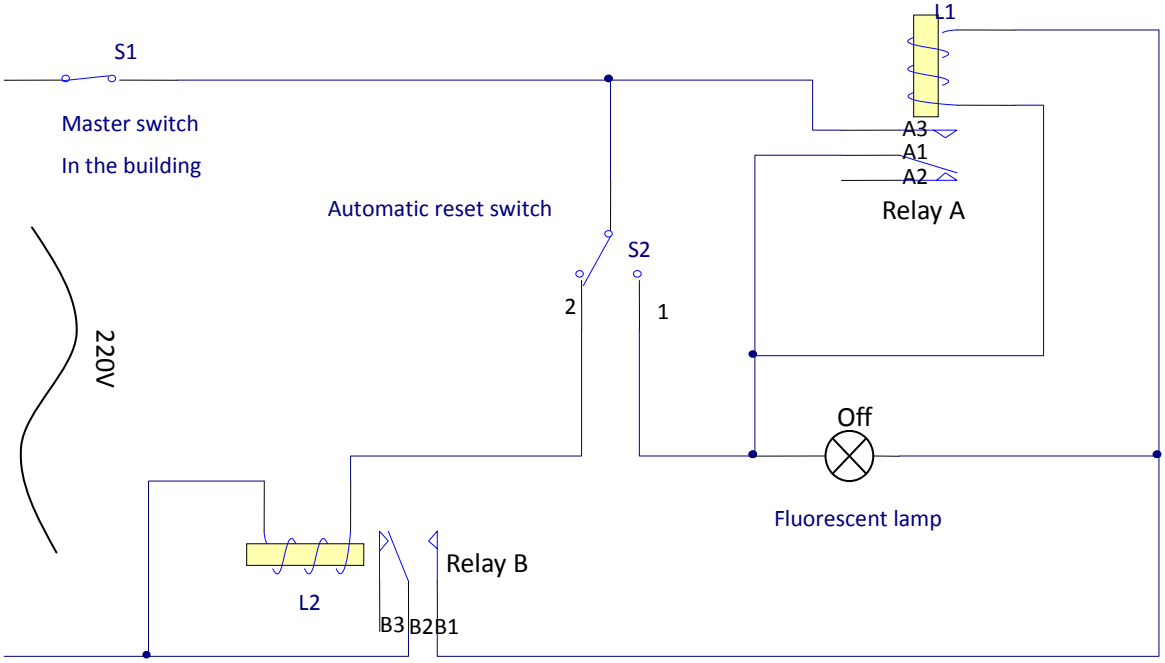


Figure 4 Work State 1-2

The state in Figure 4 is State 1-2, indicating a moment when S2 is switched to Contact 2. When S2 get in touched with Contact 2, L2 is energized and B1-B3 -- thus the circuit is cut off and L1 loses its power which further leads to A1-A2, and further turns off the lamp.

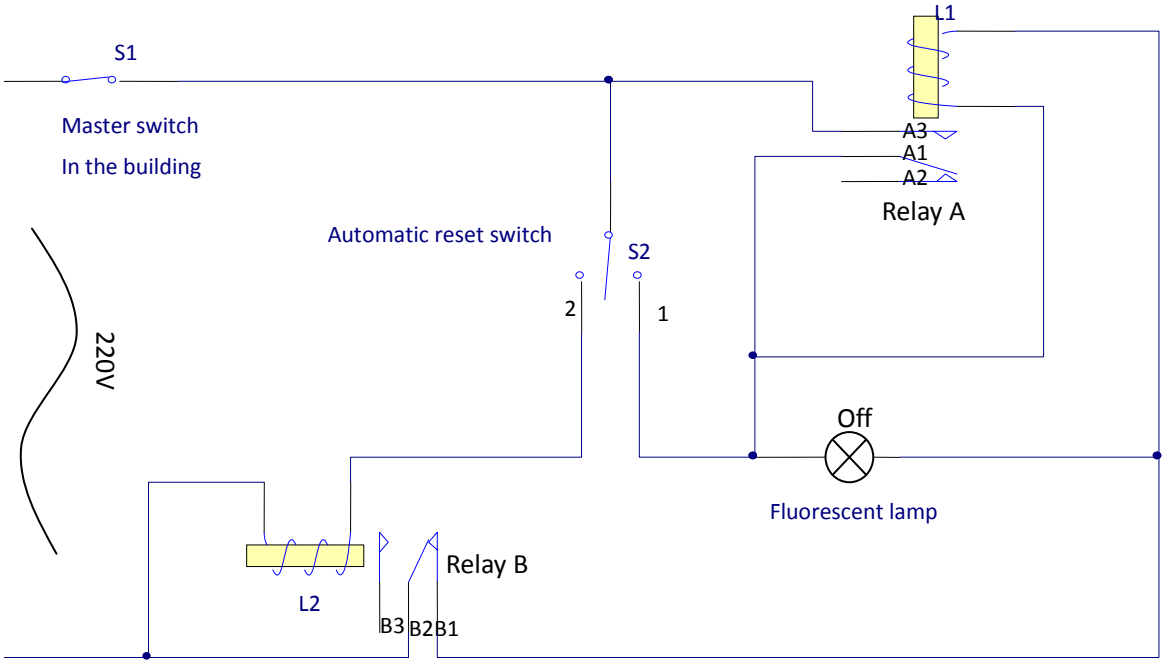


Figure 5 Work State 2

The state in Figure 5 is State 2, the difference between State 1-2 and State 2 is that S2 is automatically reset to its initial state. Thus L2 loses its power, B1-B2, and the

Fluorescent lamp remains off. Compared with Figure 1, these two diagrams are the same actually, which means the circuit has experienced a 4 states circle and returned to its original state.

Figures from 1 to 5 explain what will happen when the master switch of the student apartment is suddenly cut off at night. And the following pictures will illustrate what happens when the master switch is restored next morning.

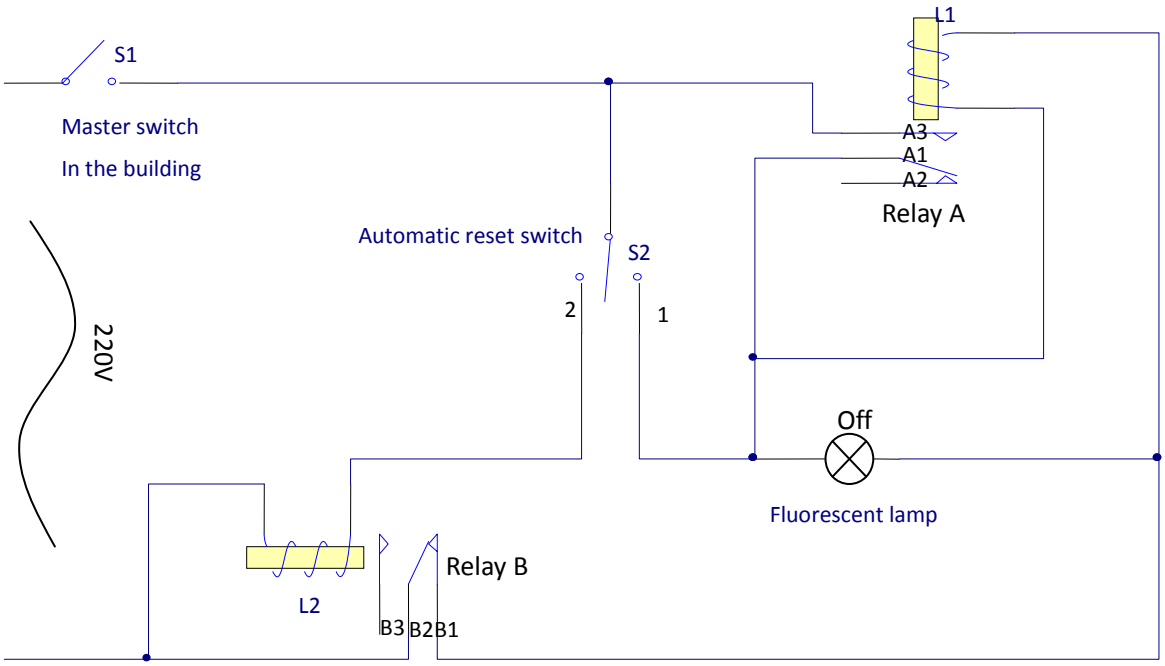


Figure 6 Work State 3

When the circuit is working under State 2 with the lamp lighting, and S1 is suddenly cut off, the circuit then turns into State 3 as showed in figure 6. Because S1 is cut off, then the circuit is cut off, L1 loses its power, A1-A2, and the lamp is turned off.

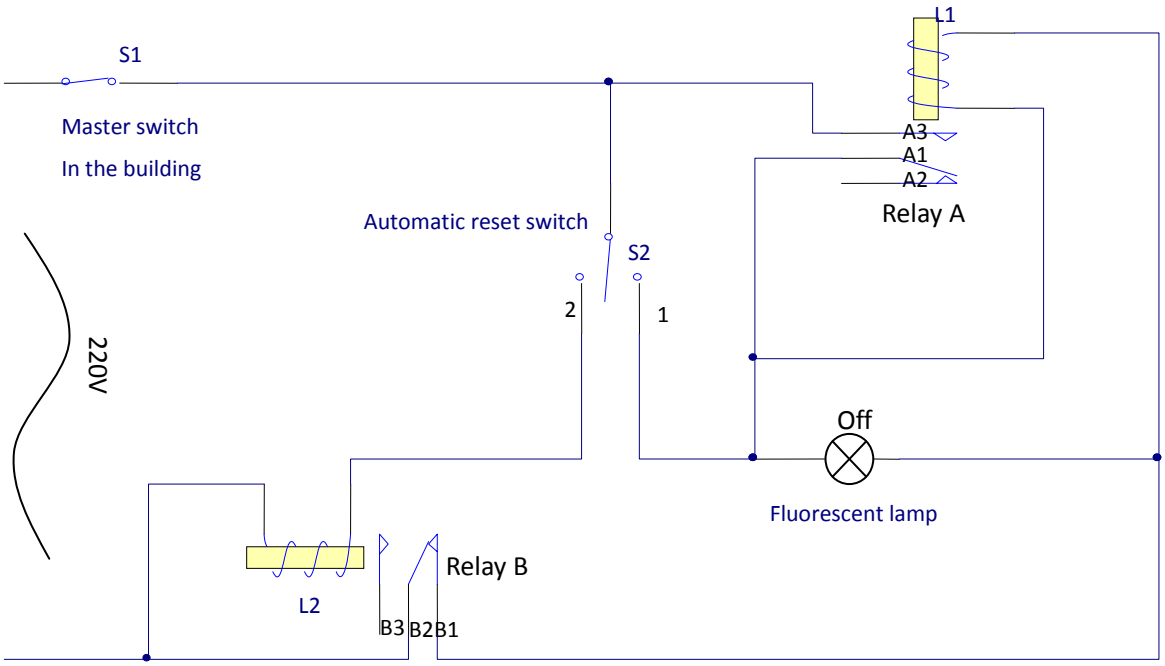


Figure 7 Work State 4

If S1 is reclosed under State 3, then the circuit turns into State 4. Now the lamp remains off and the circuit returns to its original state --State 0.

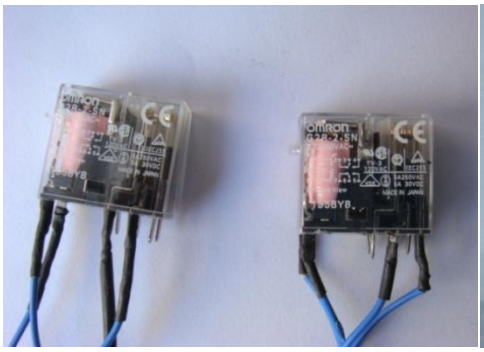
As S2 is automatically reset, there's no need for the students to cut off their lamp switches after the master switch is cut off at night, and the lamps just won't be turned on when the master switch is reclosed next morning!

The above is a brief explanation of how the new-designed switch works.

2.3 Devices

2.3.1 Summary

Omron Relay G2R-2-SN -- 2
PCB Board -- 1
Limit switch -- 2
Ordinary switch box -- 1
Some wires
Pictures:



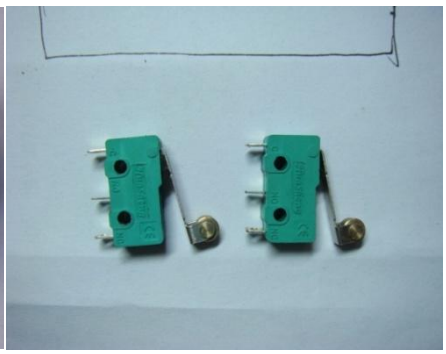


Figure 8 Picture of Omron Relay G2R-2-SN Figure 9 Picture of Limit switch

2.3.2 Parameters of Central Devices

2.3.2.1 Parameters of Omron Relay G2R-2-SN

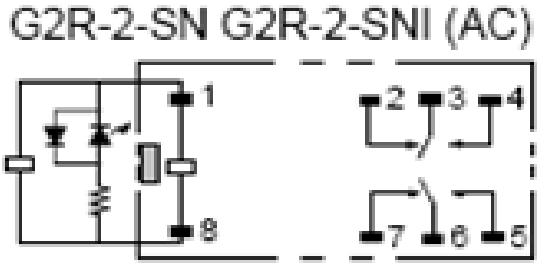


Figure 10 Structure of Omron Relay G2R-2-SN

Table 1 Coil parameters of Omron Relay G2R-2-SN

Rated Voltage		230VAC	240VAC
Rated Current	50HZ	4.7(3.7)mA	4.7mA
	60HZ	3.8(3.1)mA	3.8mA
Coil Resistance		26860（30000）Ω	30000 Ω
Coil Inductance	Armature OFF	62H	65.5H
	Armature ON	124H	131H
Cut-in Voltage		161V	168V
Release Voltage		69V	72V
Maximum Voltage		253V	264V
Power Consumption		Approx. 0.9 VA at 60 Hz (approx. 0.7 VA at 60 Hz)	

2.3.2.2 Parameters of Limit Switch

Table 2 parameters of Limit switch

Rated Current	10A125/250VAC	Vibration Resistance	10-500HZ Acceleration 49m/s^2
Contact Resistance	≤0.02 Ω	Operating Pressure	0.98-2.45N
Insulating Resistance	≥1000MΩ	Ambient Temperature	-25±85℃

Dielectric Strength	≥1500VAC	Ambient Humidity	MAX.85%RH
Actuating Length	0.2-0.6mm	Mechanical Life Expectancy	1000000 times
Differential Movement	≤0.2mm	Electrical Life Expectancy	8000000 times

2.4 Prototyping

The manufacturing processes are shown in figures from Figure 11 to Figure 15:

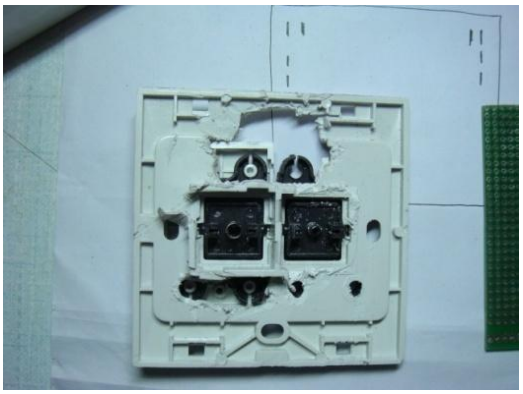


Figure 11 some rearrangement of the structure of the ordinary switch box

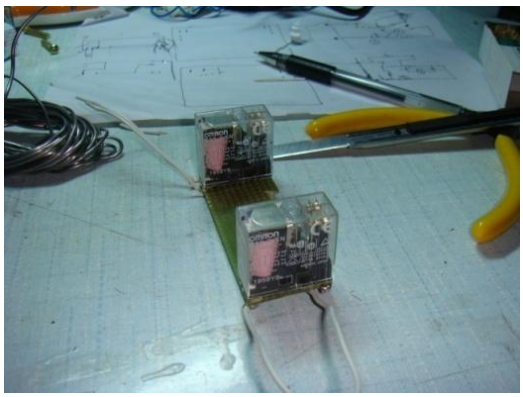


Figure 12 Fix the Relay

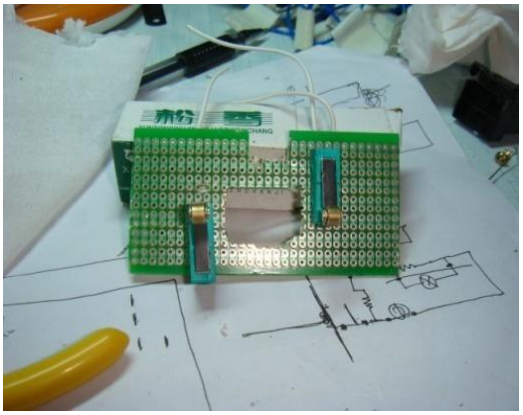


Figure 13 fix the limit switch

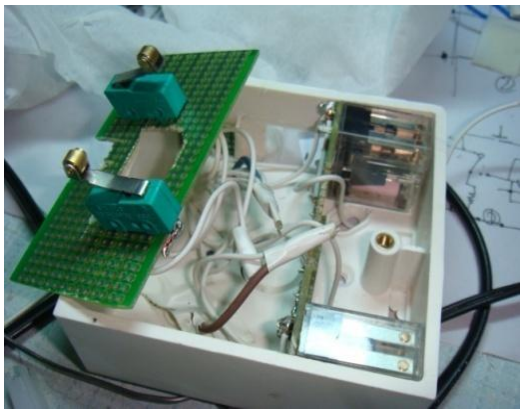


Figure 14 assembly

Figure 15 Complete package

2.5 Reliability Analysis

This energy-saving switch has a simple structure which assures the low accident rates and high Reliability thus more reliable to be put into daily use. Its reliability and longevity are mainly decided by its two central devices -- the relay and the limit switch. However, these two kinds of products are long widely used and have relatively mature techniques. According to Table 1 and Table 2, the switch we designed can easily meet the longevity needs of civilian use, and can be replaced by ordinary switches. So we conclude that what we got is a reliable, useful and energy-saving product.

2.6 Conclusion and Extension

In our university, the energy supply for dormitories is restored before 6 o'clock in the morning while most of the college students get up around 7 o'clock. Thus if our switch is put into use, 60 minutes of lighting power can be saved on average. The general duration of lamp use in college dormitories rages from 3 to 5 hours per day, thus this switch can save approximately 25 percent of the lighting power on average. On the other hand, with little alteration the design can be changed into "energy-saving socket", and more energy will be saved from other electric equipments. And apart from the student apartments the switch is also necessary in many other places like companies, factories, etc.

To sum up, we think our design to be a useful product and believe it can contribute to energy conservation and will be welcomed by the students.

3. Extra Information:

The prototype will be available on request.

4. References:

[1] All the parameters in this report are available at http://www.ecb.omron.com.cn/