Independent Controlling the Consumer of Electricity from Several Points

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Abstract – In this project, a device that independently manages the electricity consumer from several places and is completely safe was developed and constructed.

The purpose of this development is safe management by the consumer of electricity in the domestic premises (staircases, corridors, etc.), even without replacing the old electrical wiring due to 5 V.

Practical results – the simulated device was tested at a power consumption of 20 to 1000 W and showed a steady work of this design. The prototype of this device is successfully used at the Department of Electrical Engineering of the Mykolaiv National University.

Novelty – control of electrical devices designed for power 220 V with the help of several switches, connected with each other by a wiring, calculated at 5 V.

Keywords – convenient, easy to manage, safe, economical, constructed.

I. Introduction

This development has spread in various directions, for example, in the direction of "smart home" and is a *convenient*, *safe*, *economical* version of the solution to the problem of controlling devices from multiple points.

Existing multi-point consumer control systems are not sufficiently advanced, as they require an extra 220V electrical wiring to be put into operation, which requires additional costs.

One of the options for solving the problem is switching switches. Depending on the position of the switch key, the mobile contact closes with one of the fixed contacts.

Sometimes the situation requires management from three, four or more places. Here some pass switches cannot do. The circuit must be supplemented with four contact switches – so-called cross switches.

Another option is a bistable (pulsed) relay – these are relays that switch their power contact when applied to their coil or short circuit pulse control circuit.

II. The Original Version

An economic system for controlling electricity consumption from several points was developed and *constructed* which:

1) Connects to an existing circuit breaker.

2) *Convenient* and *easy to manage*.

3) Carries out the independent management of the consumer from several points.

4) Control lines which are absolutely *safe* (low voltage, low current, galvanically isolated from the electric network).

5) Has a stable position of switches "on-off", which allows users to determine the state of the consumer of electricity.
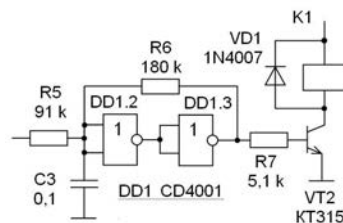

Fig. 1. The trigger

The basis of the device is a Schmitt trigger (Fig. 1), which remembers the last action of the usual switch. The state of the trigger is transmitted to the electronic key that controls the electromagnetic relay. The relay contacts or switches are the consumer circle.

The scheme can only be in one of the stable states – zero or single:

1) If the circuit is in a null state, it can be converted to a single state by feeding the trigger through the resistor R5 to a voltage close to the supply voltage for a short time (several microseconds).

2) From a single state, the circuit is translated, giving the trigger input a low voltage level.

3) After setting any state the trigger will stay there indefinitely.

For the formation of single or zero impulses, an amplifier of voltage with a differential link, R4C2 at its input is used. With an increase in voltage at the input of the differential link, a positive pulse is generated by a voltage close to the supply voltage, which lasts several tens of milliseconds for trigger reliability.

In order to increase the voltage at the input of the differentiator when each switch is switched on and its reduction when one of the switches is switched off, the idea of constructing digital-to-analogue converter (DAC) on the logical element DD1 .4, which operates in the linear mode of the inverse voltage amplifier is used.
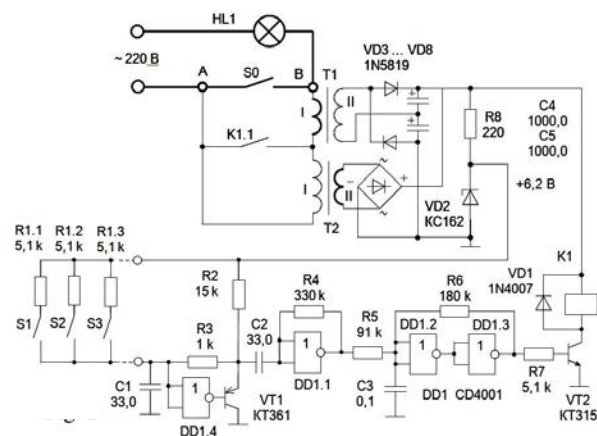

Fig. 2. The original version

With open contacts S1, S2 and S3, the amplifier on the DD1.4 element and the VT1 transistor are covered by the feedback on the resistor R3 is in idle mode. Voltages at

the input and output of the amplifier are equal to and equal to 0.5 voltage supply (6 V), that is 3 V.

When one pair of contacts, such as S1, is closed, through the resistor R1.1 the current flows, the voltage at the input of the element will increase. Since the amplifier is inverted, the voltage at the output of the amplifier on the emitter VT1 will decrease. Through the differential link, C2 R4 will generate a negative voltage pulse, which will be amplified by the inverse amplifier on the element DD1.1 and will form a positive impulse on its output. This impulse will roll the trigger on the elements DD1.2 and DD1.3 into a single state. From the output of the trigger, a single signal will go to the base of the transistor VT2 and open it, which will trigger the K1 electromagnetic relay. Contact relay K1.1 will close and switch on the consumer.

Up to 8 switches can be connected to the device, but reliability will decrease. The device works well with up to 4 switches.

III. The Improved Version

In the further development of the device, the trigger was modelled by a universal digital controller, and the electromagnetic relay was replaced by a combination of an opto-coupling resistor. This couple solved the circle of the controller and the triac (Fig. 3).
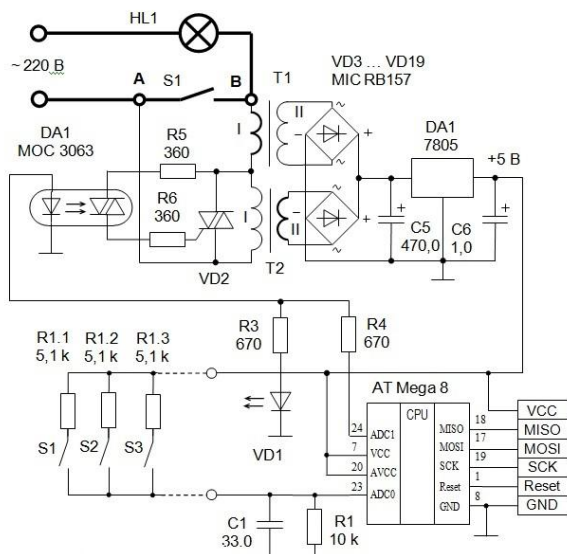
Fig. 3. The improved version

Reducing power consumption is possible by replacing the electromagnetic relay with a triac, and the logic chip is a universal controller. In the schematic there are only a few changes: the Schmitt trigger was replaced by the ATMega8 microcontroller, and the electromagnetic relay was replaced by a triac.

The advantage of the triac is that it is completely silent, non-sparking.

When the power user is switched off, it is possible to take power of the switch via a reducing transformer and a rectifier. The current consumed by the power supply is so small that in no way affects the consumer's state.

The operation of the power supply stops when the contacts of the switch of the customer are closed. For this case, you must install a second power supply that will use the current energy that flows through the connected consumer. The power consumption of a current allows the current transformer to be similar to that used to measure large industrial currents. It will be a small current transformer. In a small current transformer, the magnetic saturation of the core is rapidly applied and the subsequent increase in the current strength does not lead to an increase in the voltage of the secondary winding. Thus, the output voltage is stabilized, just as it happens in the ferroresonance voltage regulators. In the secondary winding of the second transformer, a rectifier is installed which connects in parallel with the first rectifier, forming a common power supply for the control unit (Fig. 4).
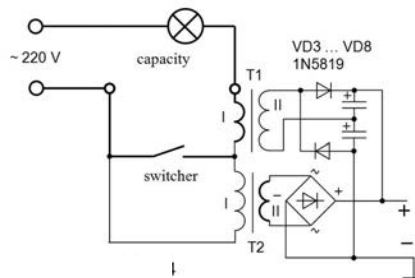
Fig. 4. Power supply

Conclusion

In the process of searching, the principle of constructing a device for controlling an electrical device from several points was chosen. The basis of the design is a Schmitt trigger, which remembers the last action of the usual switch. The state of the trigger is transmitted to the electronic key that controls the electromagnetic relay. The relay contacts or switches on the consumer circle.

The most difficult was the node of the independent power supply. The energy for the design work was used from the switch itself, a small proportion of it was taken at the expense of the consumer. This was realized on the basis of the use of a transformer current with a saturated core that stabilized the output voltage and a voltage transformer with an unsaturated core. Transformers provided galvanic isolation between the switches and the electrical network, which made the structure absolutely *safe*. Such a solution to the problem in the literature was not found.

In the further development of the device, the trigger was modelled by a universal digital controller, and the electromagnetic relay was replaced with a combination of a optoelectronic coupler. This couple solved the circle of the controller and the triac.

The simulated design was tested at a power consumption of 20 to 1000 W and showed a steady work of this design.

References

[1] A. V. Ivannikov, D. R. Livyi, "One consumer – three switches". In the bag "The issue of improving the content and methods of teaching physics in secondary and high school". Materials of a problem scientific methodical seminar and master's readings. Issue 22. – Mykolaiv, 2016.