Optocouplers and Optoelectric Elements Controlled by Sensors

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Abstract – **It is well known that the control over optocouplers can be achieved in two ways – electronically and optically. In the current article a sensor control of both input and output optocoupler.**

Keywords – **Sensor, Optocoupler, Control, Optoelectronic elements**

I. INTRODUCTION

In the known from the practice sensor buttons [5] there is no galvanic separation between executive circuit and sensor plates. There is a risk of electrical damage for the operator when the high voltage circuits are controlled. This disadvantage is avoided through the proposed sensor buttons with galvanic separation, which is fulfilled with optocouplers. A classification of the sensor optocoupler buttons

According to the work principle:

– by means of the skin resistance (resistance which is introduced in the circuit by touch);

– introduced capacitance in the circuit (can be remotely applied);

– antenna effect – an introduced voltage which is generated by the human body

According to the number of sensor plates:

– with one sensor plate (touch button)

– with two sensor plates (contact button)

According to the used elements:

Circuits with discrete elements

– bipolar transistors

– JFETs

– MOSFETs

Circuits with ICs

According the place where sensor element is connected:

– in the light source circuit

– in the photo-element circuit

– in both circuits

The sensor buttons can be produced in two variants – with memory and without it.

The resistance between skin and electrode has inconstant characteristics and it depends on the contact area, distance between contact electrodes, skin conditions, human conditions, type of used voltage – DC or AC, frequency, etc.

II. INPUT CIRCUIT SENSOR CONTROL OF OPTOCOUPLERS

The circuit with p – channel JFET is presented on figure 1. The circuit work principle is based on the introduced resistance of human skin between the two sensor areas S.

The JFET VT_1 is off as well as the phototransistor VT_2 of the optocoupler O_1 when human finger is not touching the sensor plates. When touch is applied to the sensor, VT_1 goes on and there is current flow through LED.

In result VT_2 goes also on and the output voltage changes from high logical level to low. The threshold voltage of JFET (КП103Л) VT_1 is in the range from 2 to 6 volts ($U_{GO} = (2 \div 6)$ V.

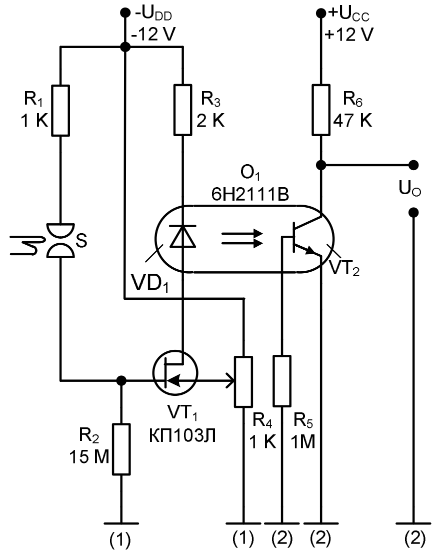

Fig. 1. Sensor button with JFET transistor

The sensor button shown on figure 2 works in the similar way, only in the circuit transistor VT_1 is n – channel MOS transistor.

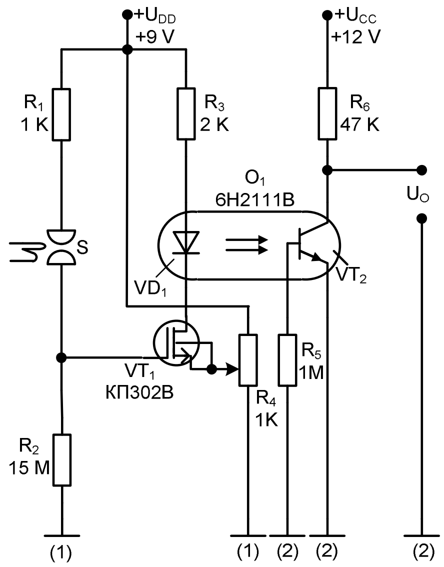

Fig. 2. Sensor button with MOS transistor

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III. Output circuit sensor control of optocouplers

In the circuit shown on figure 3, when the current I_F is zero and the sensor S is not touched, the transistors VT_1, VT_2 and VT_3 are off and the value of output voltage is little smaller than the supply voltage U_{CC}. When the sensor is touched, all of transistors in the circuit are on and the output voltage value is about 0,7 V ($U_O \approx 0{,}7$ V).

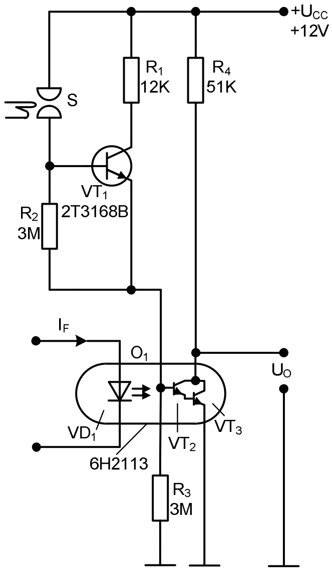

Fig. 3. Sensor button with bipolar transistor

There is a necessity of Schmidt trigger connected to the sensor button output which will provide steadily turn out of the sensor button – figure 4.

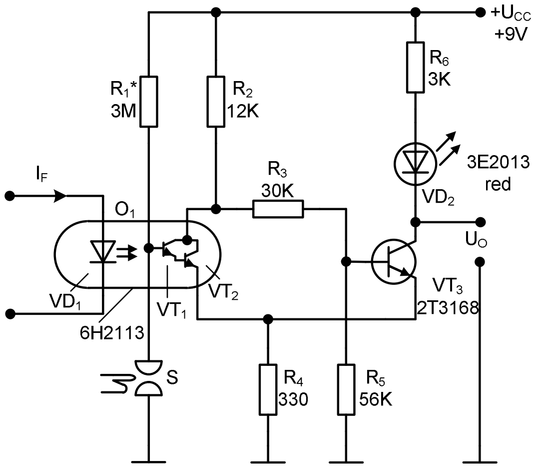

Fig. 4. Sensor button with trigger Schmidt

There is a necessity of Schmidt trigger connected to the sensor button output which will provide steadily turn out of the sensor button – figure 4. Such trigger is fulfilled with Darlington phototransistor VT_1 and transistors VT_2 and VT_3. Darlington phototransistor is on in the initial state when I_F is zero and the sensor is not touched, which results in off state for the outlet transistor VT_3 and high level for output voltage. When touch is applied to the sensor, the output voltage shifts to low logical level ($U_O \approx 0{,}7$ V). The LED VD_1 emits in the red part of the spectrum.

The proposed above sensor buttons have two contact plates.

E. Sensor button with one contact plate – on figure 5.

The work principle of proposed sensor uses inducted by human body voltage (antenna effect). All of the transistors in the circuit are off and output voltage is in high level state when the current I_F is zero and the sensor S is not touched. When touch is applied the current I_F remains zero but output voltage shifts to low state $U_O \approx 0{,}15$ V and LED VD_1 emits in the spectrum red portion.

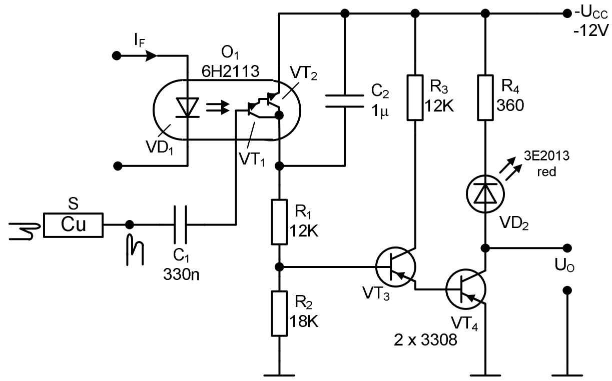

Fig. 5. Sensor button with one contact plate

When sensor S is not touched circuit is switched by the current I_F = 10 mA which flows through LED and in result output voltage transits in low state $- U_O \approx 0{,}15$ V. The foiled paper based laminate with sizes 10x15 cm is used to construct contact plate. When lower sensibility is needed the capacitance C_1 can be used as only part where touch is applied.

IV. Calculation methods for the sensor – figure 3.

A. DC point calculation

The Darlington phototransistor ($VT_2 \div VT_3$) is kept in off state by the resistor R_3 and the transistor VT_1 is kept off by the resistor R_2. Output voltage U_O is in high level state when the current through LED I_F is zero.

The only current that flows through the base of Darlington phototransistor is the transistor VT_1 reverse current.

The condition for the transistor VT_1 saturation is:

$$R_S < h_{21E_1}.R_1 \qquad (1)$$

where R_S is the finger skin resistance, h_{21E_1} is the transistor VT_1 current amplify coefficient.

The coefficient h_{21E_1} for the transistor 2T3168B is in the range from 180 to 460 and thus the resistor $R_S < 180.12.10^3$ kΩ = 2,16 MΩ.

The condition for the Darlington phototransistor saturation is:

$$R_1 < h_{21E_2}.h_{21E_3}.R_4 \qquad (2)$$

The LED current I_F which sets the Darlington phototransistor is on state can be described by the following equation:

$$I_F > \frac{U_{CC} - U_{CEsat}}{K_1.R_4} \qquad (3)$$

where K_1 is current transfer ratio of the optocoupler;

U_{CEsat} is the voltage between the Darlington phototransistor collector and emitter in the saturation mode.

The conditions (2) and (3) are implemented as the requirements are extremely exceeded by the resources used in the circuits.

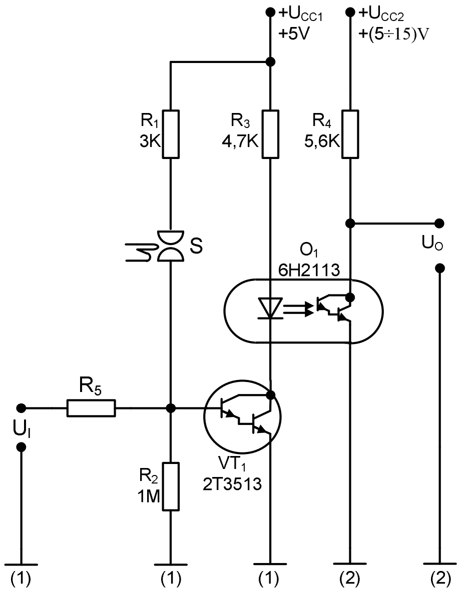

Fig. 6. Sensor button with Darlington transistor

In the circuits shown on figure 1 and 2, JFETs and MOS transistors are used in the inlet circuit to the sensor buttons. The circuit on figure 6 does not use such transistor, only it is also controlled by the inlet circuit. The output voltage transits to low logical level when touch is applied to the two sensor plates.

V. Application

Sensor control of the light sources, photoreceivers, optocouplers, optocoupler ICs as the two methods are used – by means of the introduced resistance of human skin and the inducted by human body voltage over the sensitive part of sensors.

Fig. 1, fig. 2 and fig. 6 – sensors buttons with galvanic decoupling. Fig. 3, fig. 4 and fig. 5 – sensor buttons with photodetector controlled of optocouplers.

VI. Conclusion

The current research intends to additionally expand the functional capabilities to control optoelectrical elements. For the present the known controls over optoelectric elements are by means of electric, optic, magnetic, thermal and mechanical impacts. The current research adds the sensor control to these as the main optocoupler function – the galvanic insulation is intact.

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