

Switch Point Control Circuits with Small-size Safety Relays

Marek BARTCZAK¹

Summary

Relay-based railway signalling systems are constructed with safety relays, which are produced by the main signalling manufacturers. Such safety relays are hard to find on the market. Therefore signalling contractors frequently use small-sized, easily-available relays of the SF4 and H-464 type, which conform with the UIC736 normative requirements.

The paper presents safety relays of the H-464 type as well as three-phase switch point control circuits, which are based on such relays cooperating with switch point transducers and utilized in centralised mechanical signalling systems with electrical switch-over of the switch points.

Keywords: railway signalling, switch point control, safety relays

1. Introduction

Currently, electrical switch point switch-over circuits, which are utilized in centralized mechanical signalling systems operating on the railway lines managed by PKP Polish Railway Lines S.A., are constructed mainly with relays of the JRF type. Such relays are small-sized electromagnetic relays dedicated for use in railway signalling equipment. JRF relays have some advantages, especially their low power consumption, small dimensions and low weight. However, JRF relays are produced only by railway signalling manufacturers and only on request. As a result, a long time is required for construction of the mentioned switch-over circuits. This is why some signalling contractors are conducting work on switch point switch-over circuits based on safety relays, which have technical parameters similar to JRF relays and are easily accessible on the market. The SF4 type relays (manufactured by NAIS Matsushita) and H-464 type relays (manufactured by Hengstler GmbH) are examples of such safety relays.

The aim of the paper is to present switch point switch-over circuits elaborated by the author based on H-464 relays, which are easily accessible on the market and fulfil the binding requirements for railway safety relays. The elaborated switch-over circuits are dedicated to switch point switch-over in centralized mechanical systems. The circuits differ from each

other in their switch-over relays. One uses bistable single-winding switch-over relays, while the other uses bistable double-winding switch-over relays.

2. General characteristics of the H-464 type relays

H-464 relays [5] are small-size safety relays characterised by high operational reliability and low power consumption in operation. Such relays are manufactured as monostable relays and bistable relays (with magnetic holding of the relay anchor). They can have 8 or 10 contacts constructed as normally open (make contacts) and normally closed (brake contacts). Eight-contact versions can have contacts in the following arrangements: 5F+3B, 6F+2B, 3F+5F, 4F+4B and 2F+6B. Ten-contact versions can have contacts in the following arrangements: 5F+5B, 6F+4B, 7F+3B and 8F+2B. An overall view of a monostable relay of the H-464 type with eight contacts is shown in Figure 1.

Contact terminals are made of silver and cadmium oxide alloy (AgCdO) or silver and tin oxide alloy (AgSnO₂). Their surfaces are coated with a thin gold layer. The distance between open contact terminals is higher than 3mm. In comparison, the JRF type relays have a maximum distance between the contact terminal and terminal pin of 2×1.5 mm [1].

¹ Ph.D. Eng.; University of Technology and Humanities in Radom, Faculty of Transport and Electrical Engineering; e-mail: m.bartczak@uthrad.pl.

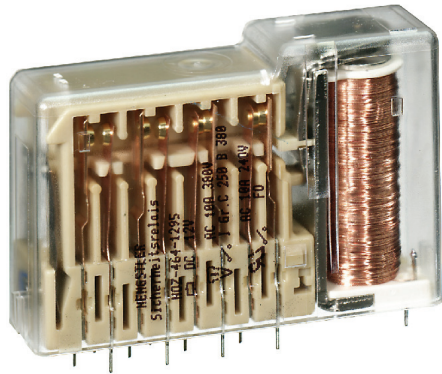


Fig. 1. Overall view of the H-464 type relay with eight contacts [photo by Hengstler GmbH]

Relays of the H-464 type are manufactured for direct current voltages: 6, 12, 24, 48, 60, 110 and 220 V. The maximum current-carrying capacity of the contact during switching-on equals 10 A, while its minimum continuous temperature load equals 5.1 A. Typical values of the operating time of the H-464 type relays are:

1. for excitation (energizing):
 - brake contact terminal – 22 ms,
 - make contact terminal – 29 ms;
2. for de-excitation (de-energizing):
 - make contact terminal – 5 ms,
 - brake contact terminal – 7 ms.

Mechanical durability of the relay (without load) is higher than 10^7 operations, while the connecting durability of the connectors under a nominal load equal 2A of direct current and 10A of alternate current under the electrical tension of 230 V is higher than 10^5 operations. H-464 relays are enclosed by a shield made of transparent material. They can be mounted on a printed-circuit board and into plug-in sockets, which indispose the changing of relays of a defined type into another type during relay exchange. H-464 relays in the plug-in form are protected against sliding out of the socket, similarly to the JRF type relays. H-464 relays are dedicated for operation in ambient temperatures from -25°C to $+80^{\circ}\text{C}$. The temperature ranges of the H-464 and JRF type relays are therefore similar. For the JRF type relays, ambient temperatures are from -40°C to $+70^{\circ}\text{C}$ [4].

The dimensions (length \times height \times width) of the H-464 type relays for the eight-contact and ten-contact versions are $77.4 \times 48.6 \times 20.5$ mm and $87.4 \times 48.6 \times 20.5$ mm, while their weights equal 120 and 130 g, respectively. In comparison, the dimensions of the JRF type plug-in relay enclosed by a transparent polystyrene shield are the following: length 114 mm, height 80 mm and width 40 mm, while its weight equals 0.5 kg [1].

The H-464 type relays are made in accordance with the recommendations given in UIC leaflet 736e [5]. Moreover, they are compliant with the IEC 61810-1 and UL 508 standards.

3. H-464 relay operational principles

The operational principles of H-464 relays are the same as those of the neutral (electrically neutral) direct current relays of the JRF type. Monostable relay excitation takes place disregarding polarisation of the electrical tension applied to winding. Switch off of the current in winding results in anchor release.

By contrast, in the case of bistable relays of the H-464 type, there are two windings on the magnetic core, similarly to relays with a magnetic holding of the JRK and JRF type. One winding is utilized for relay energizing, while the second is used for anchor releasing. Relay excitation takes place when electrical tension is applied to the excitation winding. The relay anchor after switching off the current in a winding stays in its position attached to a magnetic core as a result of high magnetic remanence of the magnetic circuit (magnetic core). Relay de-energizing takes place as a result of powering of the de-excitation winding, which leads to neutralisation of the magnetic field formed during excitation of the relay.

Bistable relays of the H-464 type to ensure correct functioning cannot be powered continuously by electrical tension to the excitation winding. They have to be powered only for a defined time, equal to between $100 \div 1000$ ms. Moreover, it is necessary not only to ensure a power supply for one winding, but also to detach the power supply from the second winding.

4. Three-phase switch point control circuit based on relays of the H-464 type

The following circuits can be distinguished in switch point control circuits with H-464 relays:

- key relays circuit,
 - control circuit,
 - switch-over time monitoring circuit,
 - supervising circuit,
 - switch-over circuit,
 - switch point bursting (forced switch opening) monitoring circuit,
- and control keys dedicated for: switch point, isolation shunting and withdrawing indication of the switch point bursting.

An example is shown in Figure 2, which depicts a block diagram of the three-phase switch point con-

control circuit with H-464 relays cooperating with a point transducer, which is located on the tracks after the ultimate point machine. Figure 2 also shows circulation of the signals necessary for correct functioning of the circuit.

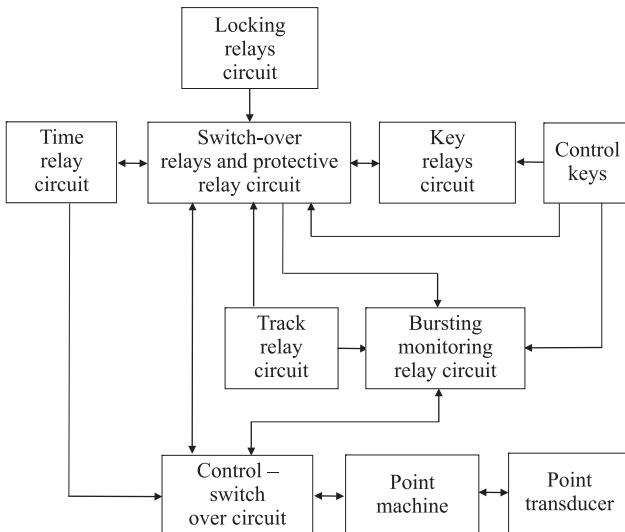


Fig. 2. Block diagram of the three-phase switch point control circuits with H-464 relays [own study]

The circuit of the key relays P^+ and P^- , depending on the version of the circuit, is composed of two monostable relays of the H-464 type or MY4 type relays for a 24 V power supply, with four switch-over contacts. One key relay is dedicated to one switch point switch-over direction. Energising of the key relay takes place thanks to operation of the switch point key. De-energising of the key relay, when the relay anchor is attached to the magnetic core, takes place thanks to the switch-over relay. Rectifier diodes, which are connected in parallel, cause prolongation of the de-excitation time of the relays, thereby ensuring the required time of the current flow in the windings of the switch-over relays.

The control circuit contains two switch-over relays N^+ and N^- as well as a protective relay Or like the control circuit utilized so far and described in [2, 3]. These circuits differ, however, as it is possible to use bistable single-winding relays and bistable double-winding relays respectively for the electrical tension of 12 and 24 V. The way bistable single-winding relays work depends on the polarisation of the power supply tension. The necessary number of contacts in the case of such relays can be reached by adding repeaters. The control circuit is open in its normal state. One of the switch-over relays is always in the excitation state and is the one associated with the location to which the switch point was set recently. The protective relay, disregarding the location of the switch points, is in a de-excitation state.

De-excitation of the switch-over relay takes place as a result of electrical tension being placed over the make contact terminal of the key relay, providing that the switch point is not locked in a route and is not occupied by rolling stock. Switching the switch-over relay to the de-excitation state breaks the supervising circuit and causes excitation of the protective relay. Switch-over relay excitation takes place as a result of closing the excitation coil circuit by the make contact terminal of the switch-over time monitoring circuit.

The protective relay, as opposed to the analogical relay utilized in the circuit described in [2, 3], is a single-winding relay. It is connected in series with switch-over relays and plays a safety function, ensuring exclusion of the possibility to switch-over the switch point omitting interlockings due to the appearance of an alien electrical tension in the control circuit. In the event of an alien electrical tension, protective relay excitation would not take place despite the excitation of the key relay and de-excitation of the switch-over relay. It would not close the power supply circuit of the switch-over time monitoring circuit with its contact terminal, which would then indispose switching-over of the switch point also when it is locked in a route or occupied by rolling stock.

The other purpose of the protective relay is to switch – for the switch point switch-over time – the supervising circuit into the switch-over circuit. This relay, during switch-over of the switch point, is powered by a rectifier circuit connected to the secondary winding of the transformer whose primary winding is interconnected into the switch-over circuit. The protective relay excitation and holding circuits are separated by rectifier diodes to ensure correct functioning of the relay.

The switch-over time monitoring circuit is based on a 555 time circuit, which performs the function of a mono-vibrator. The time relay PT, in comparison to the analogical relay utilized in the circuit described in [2], is de-energised in its normal state. Supervising the excitation of the time relay is performed in the excitation circuit of the switch-over relays and in the switch-over circuit, while supervising the de-excitation in the switch point location monitoring circuit. Hold time of the time relay in an excitation state depends on the resistance of the resistor and capacity of the capacitor attached to the 555 circuit. These values are selected to ensure the maximum switch-over time for the coupled switch points of about 14 s. In the described circuit for the switch-over of individual switch points with a maximum switch-over time equal to about 7 s, it is enough to make an appropriate connection between the shunting resistor and the resistor of the RC arrangement.

The supervising circuit contains the normal position monitoring relay Kn^+ and turnout position monitoring relay Kn^- and does not differ from the supervising cir-

cuit described in [2]. It contains two parts: the alternate current and direct current parts. The alternate current part is powered by an alternate electrical tension equal about 115 V, obtained from the transformer secondary winding. This tension, after rectifying in a point transducer, is used to supply power to the direct current part with a direct electrical tension equal about 30 V.

The supervising circuit is closed when the switch point is in a final position (normal or turnout). In this circuit, the states of all connecting wires and state of the winding of an engine, as well as location of the contacts of the point machine and states of the switch-over relays, protective relays and switch point bursting monitoring relay, are supervised. The correct state of the circuit elements conditions the excitation of an appropriate switch point location monitoring relay.

Monostable relays of the SF4 type manufactured by NAIS Matsushita, which fulfil the UIC736i document [6] requirements, can also be used as switch point location monitoring relays. The working principle of such relays is the same as that of the polarized direct current relays of the JRK type, which are utilized in E-type and PB-type interlockings. Polarized relay excitation takes place in the case of electrical tension with defined polarization in its winding. When current is cut from the winding, such a relay opens its anchor. The presence of electrical tension with opposite polarization in a coil does not cause excitation of the relay.

The switch-over circuit is the same as in the arrangement presented in [2, 3]. Closing the circuit is performed by contacts of the switch-over relay in excitation state. After switch-over of the switch point, the switch-over circuit is opened by contacts of the point machine. The switch of the circuit from switch-over to supervising is performed by contacts of the protective relay in the de-excitation state.

The switch point bursting monitoring circuit registers bursting of the switch point by rolling stock. In the normal state, the bursting monitoring relay Kr is in the excitation state. This relay make contact terminal is interconnected into the supervising circuit. De-excitation of the bursting monitoring relay is conditioned by the brake contacts of both switch point location monitoring relays and simultaneous brake contact of the switch track section relay. De-excitation of the bursting monitoring relay switches on with its contact terminal indication of the switch point bursting.

Switching the switch point from the normal to turnout position is ensured by the following operational schedule of the relays:

$$P^{\uparrow}, N^{\downarrow}, K_{n^+}^{\downarrow}, Or^{\uparrow}, PT^{\uparrow}, N^{\uparrow}, \\ \text{moving switch point, } P^{\downarrow}, Or^{\downarrow}, PT^{\downarrow}, K_{n^+}^{\uparrow},$$

where \uparrow means excitation and \downarrow means de-excitation of the given relay.

The operational schedule of relays for the switch-over of the switch point into the turnout position is shown in Figure 3.

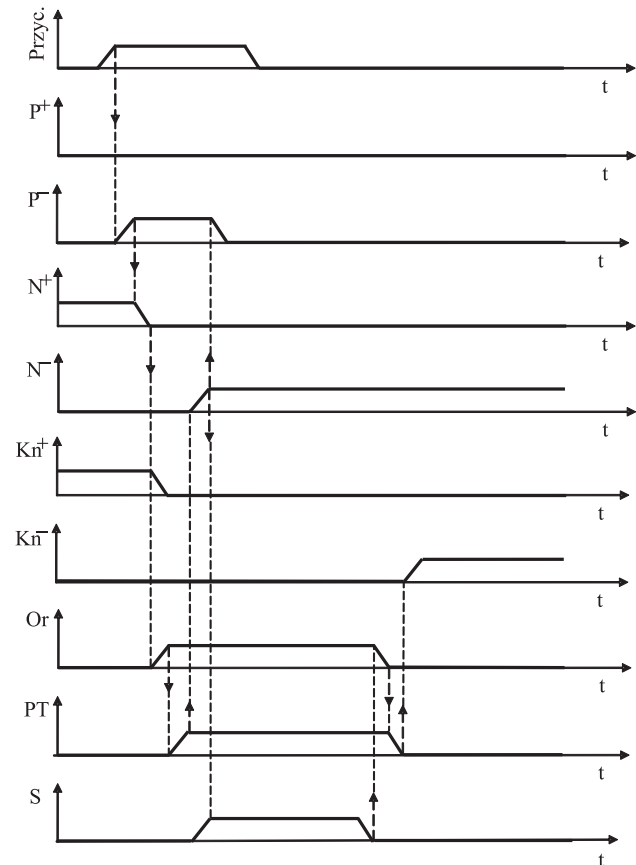


Fig. 3. Relays arrangement operational schedule for the switch-over of the switch point into turnout position, S – switch point engine [own study]

5. Conclusion

The elaborated switch-over switch point circuits with H-464 relays can be introduced instead of the previously utilized three-phase switch point control circuits, named N86 and N86F by the manufacturer, cooperating with switch point transducers. They can cooperate with general-purpose electromagnetic locks of the UZE-1 and UZE-2 types, which are utilized in mechanical centralised interlockings. They can also be adapted for cooperation with single-phase point machines and classic three-phase point machines in four- and six-wire versions. Therefore, they can be utilized in different electric signalling systems operating on the railway lines managed by PKP Polish Railway Lines S.A.

These arrangements are fail-safe and characterised by low power consumption, small dimensions and low weight. They use single-winding protective relays instead of double-winding ones. They contain, aside

from primary electrical circuits, a key relays circuit. Bistable relays are not powered by impulses generated by a microcontroller. For the high durability of the contact terminals of the protective relay switch-over, current may be given using triacs.

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