INTERFACE RELAYS

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Technical difficulties caused by the presence of functional components isolated from each other, not permitting direct connection owing to a high difference of potentials are encountered in devising systems for control and protection against emergency conditions in modern power, electrophysical, X-ray, large radio electronic installations. To guarantee information and electrical compatibility, and also to implement the required algorithms for interaction of functional components of equipment special control instruments are required that have received the name "interface relays" or "isolating interfaces" in the foreign technical literature. The general principle of design of these instruments is the presence of a special galvanic decoupling unit between the receiving and final controlling systems of the relay.

Interface relays with a working voltage of more than 1 kV are of the greatest interest for these areas of engineering, to which the present review is devoted.

Equipment with relay characteristics, which according to the adopted terminology [1] belongs to the "electrical relays," is manufactured in the USSR by plants of different ministries. Traditions have taken shape in each of the branches in naming and denoting manufactured products, which causes some problems in classification of relays. For example, according to [1] thyristors in terms of properties and characteristics fall fully under the definition of electric relays, but in practice, as is known, they are classified in an entirely different group of elements - semiconductor instruments.

In devices classified as interface relays various physical principles are widely used, some of them not being used in electric relays of other types.

As is known, any electromagnetic relay has a specific level of isolation of the output circuits from the input circuits, i.e., it functions secondarily as an interface relay. However, in ordinary relays this function is not decisive and is not considering at all in the existing system of classifications. In the interface relay the property of galvanic separation of the circuits has been repeatedly intensified and the parameters of the galvanic decoupling unit are decisive from the standpoint of the function performed by this relay. On the other hand, the parameters associated with switching capacity are secondary and can significantly be interface relays with the same level of galvanic decoupling.

Considering the division that has occurred in the USSR with electrical relays into low-current and high current, the interface relays drop out of the traditional nomenclature of components, which has been reflected in the many years of controversy surrounding the affiliation of interface relays to one or another class. In this connection an artificial assignment of interface relays to the existing classes does not seem to be expedient but rather their classification in a separate type of electrical equipment having an intrinsic structure based mostly on classification according to characteristics of the galvanic decoupling unit. For example, according to the decoupling voltage level: low level (to 10 kV); medium level (from 10 to 100 kV); high level (above 100 kV).

According to principle of action: optoelectronic, pneumatic, radio-frequency, electrohydraulic, transformer, ultrasonic, electromagnetic, and with mechanical transmission.

According to speed: superfast (to 100 μsec), fast (from 100 μsec to 3 msec) and inertial (above 3 msec).

Despite the arbitrariness of such classification, it fully reflects the most important properties of interface relays which have a decisive effect on the functions performed by them.

Interface relays of the optoelectronic type have become the most common. In the USSR such relays are manufactured under the name "optronic modules," consisting of the following series: MTO, MTOTO, MDO, MDTO, MTOD. The first are designed in the form of hybrid integrated structures containing two power optothyristors and a light-emitting element, the second contain optodiode pairs light diode-photodiode, from one (MDO-1) to three (MDO-3). The optronic modules of the type MTO-2-10, MTO-2-16, MTO-2-25 are capable of switching currents from 10 to 25 A at a repeating pulse voltage of 400 to 1200 V. Power modules of the MDTO

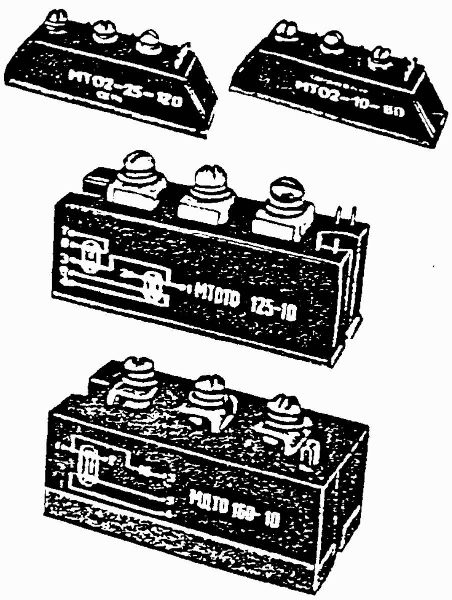

Fig. 1

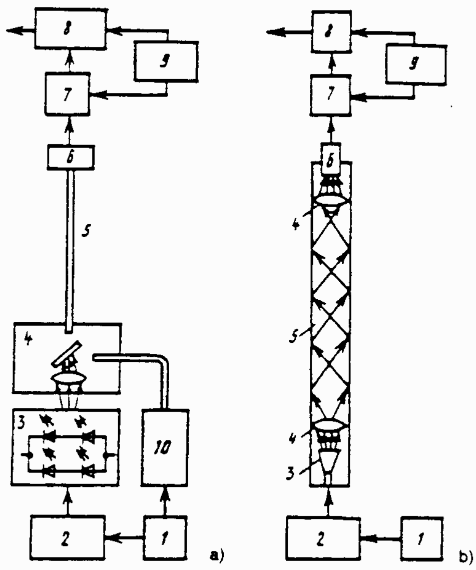

Fig. 2

Fig. 1. External view of power semiconductor modules.

Fig. 2. Structural schematics of interfaces based on fiber optic cable (a) and a light guide (b): 1) power supply at ground potential; 2) control pulse shaper; 3) optical emitter; 4) optical system; 5) optical channel; 6) photo receiver; 7) electron amplifier; 8) output actuator; 9) power supply at high-voltage potential; 10) unit for monitoring working order of emitter.

series have average direct currents of 10-160 A at a repeating pulse voltage of 200-1400 V [2]. And, finally, the optodiode modules MDO-1, MDO-2, MDO-3 have switching currents to 30 mA and a voltage to 1.5 V. The maximum galvanic decoupling voltage of these optronic modules is 3.5 kV.

Abroad the instruments that are called optronic thyristors in the USSR and contain a light-emitting element built into the semiconductor structure are also classified as interface relays.

The optronic thyristors of the TO-12;5, TO2-40; TO-132 and TO-142 series are produced for currents from 10 to 80 A at a commutated voltage to 1400 V and have a galvanic decoupling voltage between the control circuit and the power circuit to 3 kV (actual values) [3]. Similar galvanic decoupling voltages are also present in the low-power instruments manufactured under the name "optrons": AOD133A (1 kV), AOD134AC (1.5 kV); AOD130A (3 kV).

In order to significantly increase the galvanic decoupling level of interface relays of the optoelectronic type a fiber optic cable of appropriate length is installed between the light-emitting and photo-receiving elements, while the light-emitting and photo-receiving elements are equipped with an electronic pulse shaper and an amplifier based on hybrid integrated microcircuits. Interface relays of this type have received the name volstron [4]. At a length of about 1 m of the optical cable connecting the transmitting and receiving units the galvanic decoupling voltage ensured by the volstron can reach 40 kV.

Interface relays of the optoelectronic type have also found application in electrical power [5] (Fig. 2b), in which the transmitting and receiving units are connected by hollow porcelain insulators of fairly large dimensions, equipped with a built-in optical system. Such relays are used in the USSR in 110-330 kV networks to control the drives of high-voltage circuit breakers, as relays for protecting shunt capacitor batteries, etc.

Interface relay technology is being developed abroad along the same lines. The Siemens and Magnecraft Electric companies (FRG) manufacture a variety of interface relays with an optical galvanic decoupling unit for a voltage to 4 kV. The Dutch division of the Brown Boveri Co. manufactures a wide range of interface relays of the

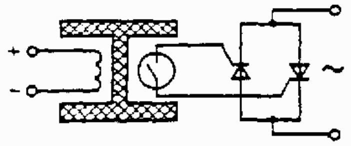

Fig. 3. Electrical circuit of an interface relay with a galvanic decoupling unit of the electromagnetic type.

R1500, R100, and R110 series with galvanic decoupling units for a voltage to 1.6 kV, based on traditior optoelectronic components and on built-in isolating transformers [6].

Analysis of the parameters of interface relays produced by these and other foreign companies indicat that they differ little from each other in terms of commutation parameters and galvanic decouplings voltage, whi mostly does not surpass 4 kV. Exceptions of the relays manufactured by Band R Electrical Products (Gre Britain), the galvanic decoupling voltage of which reaches 10 kV (the design features are not reported) and ai the optoelectronic relays of the CNR-21 type for a decoupling voltage of 15 kV from the Telefunken Co. (FRC

The developmental trends of interface relay technology suggest that the use of optoelectronic systems the prevailing design principle for galvanic decoupling units. It is agreed that the most important characteris feature of optoelectronic systems is their noise immunity, insensitivity to electromagnetic fields. However, it is n considered here that, in addition to the fiber optic line itself and the output actuator, such a system includes shaper of light pulses on the transmitting end and amplifiers on the receiving end that are generally based microcircuitry. It is precisely these elements, which have low activation levels, that are damaged by pulse noise the side of the high-voltage power equipment, which negates the main advantage of optoelectronic systen Moreover, the optical fibers themselves are subject to a severe negative effect of ionizing radiation and exterr mechanical influence. It is known that even microbends of fiber optic cables lead to a severe weakening of lig flux. Cases of failure of cables as a result of penetration of moisture beneath the cable sheath are known frc operating practice with interface relays of this type. The light diodes used as light-emitting elements ha inadequate lifetime and semiconductor lasers suffer from so-called catastrophic degradation.

Interface relays with a galvanic decoupling voltage of medium level are also fairly costly.

All this indicates that preferential use of an optoelectronic galvanic decoupling unit in interface relays not always warranted, and sometimes is merely the consequence of stereotypical thinking of developers anc tribute to a peculiar technical style.

The Brown Boveri Co. has started a special program for development of the SIGMA-SWITCH interfa relays [6], in which development and introduction of essentially new interface relays are contemplated togeth with the usual optoelectronic system, in particular, with a galvanic decoupling unit of the electromagnetic type (F 3). However, we should mention that Brown Boveri does not have priority in the creation of interface relays th function on this principle.

The Magnecraft Electric Co. has already started industrial production of such relays of the 102 V, 102 F types based on vacuum reed relays that switch currents to 200 mA at a voltage to 10 kV and have a galva decoupling level to 12 kV [7]. As early as 1977 such relays were proposed at the Khar'kov Institute of agricultu mechanization and electrification [8] and by the time the SIGMA SWITCH program was published there a already a number of varieties protected by tens of certificates of authorship (Fig. 4). The devices of this ty developed in the USSR received the name gerkotrons. These instruments greatly surpass prototypes of the Bro Boveri and Magnecraft Electric companies in terms of their parameters (Table 1).

Analysis of the characteristics of gerkotrons, experience in creating them and using them show that th have a definite area of use within which they enjoy distinct advantages over other type of interface relays. I mostly a question of transmission of discrete control commands, protection, and warning of the "yes-no" ty following with a frequency to 50-100 Hz and an admissible speed of 1-2 msec, between parts of equipment un a potential difference to 150 kV. Within these values of the parameters the gerkotrons are characterized by highest simplicity and reliability and possess broad functional capabilities. Such properties of gerkotrons as h overload capacity of the control circuit and a large output circuit, insensitivity to pulse noise, mechanical stren of the design, preservation of serviceability over a wide range of temperatures, pressure, humidity are particul

Table 1

Parameters of Some Types of Gerkotrons of the Viking Series

Name of parameter	Type of gerkotron			
	1 (1M)	2	6	9
Galvanic decoupling voltage level (maximum value), kV dc	45	5	150	6
Test voltage (50 Hz), actual value, kV	60	7,5	170	10
dc activation current (A)	0,005—5,0	0,05	0,05	0,01
Power consumed by the control circuit, W	1—5	1,0	2,0	0,01
Switchable power, W	30 (1000)	10	30	10
Range of switchable currents (A), ac or dc	10^{-6}—1,0 (briefly to 50 A)	10^{-4}—3,0	10^{-6}—0,25	10^{-4}—0,5
Switchable voltage, V:				
dc	150	5000	125	180
ac	220	—	125	130
maximum commutation frequency, 1/sec	50	50	50	100
tripping time, no more than, msec	1,5	3,0	1,5	1,0
Dimensions, mm	140×80×47 (140×120×47)	90×30×28	Ø160×450	47×33×33
Working temperature range, °C	(—60 — +85)	—40 — +60	—40 — +60	—60 — +60
Mechanical effects	vibration (10—500) Hz 15 g shocks 10 g 100,000	According to group M25 of GOST 17516-72		According to group M25 of GOST 17516-72

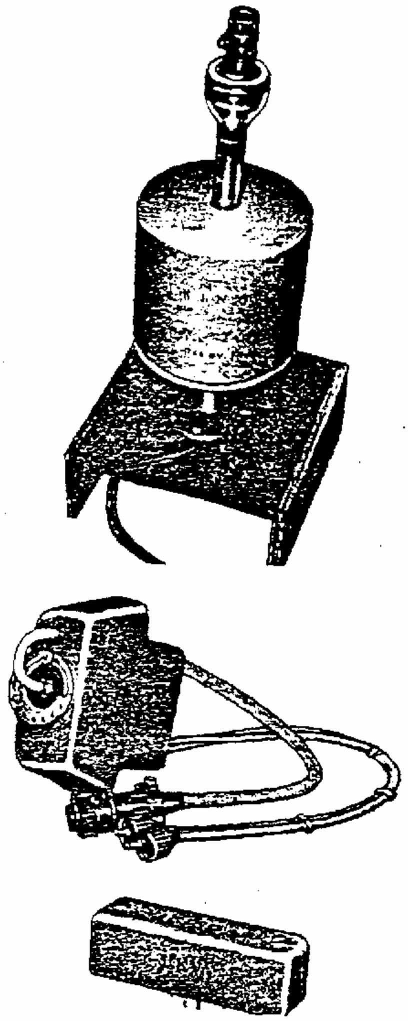

Fig. 4. External view of interface relays of the Viking series.

attractive. These properties of gerkotrons are responsible for their widespread use in on-board and mobile radioelectronic equipment [9], in relay protection and automation systems of electrical networks of the 6-35 kV class [10-12], in electrical equipment construction [13], in electrophysical installations [14], in power converter technology, etc.

The low cost of gerkotrons is of no small importance in a number of cases. For example, at a demand for interface relays with a test voltage of 5.5 kV ac for diagnostic and alarm systems of large thyristor converters of electric rolling stock of a 100,000 per year, gerkotrons with the required parameters, having a manufacturing cost of about 1.5 rubles, are the only acceptable variant from an economic standpoint.

Interface relays of the Viking-9 and Viking-1 types have now been proposed for industrial production. The latter design is the base for an entire series of interface relays: differential; with a multiplication unit of the output circuit; with a built-in thyristor switch; with a built-in bridge scheme for coupling the reed relay to a large three-phase thyristor starter; with a special control winding that withstands surges to 35 kV, etc. Quasi-analog dc meters have been developed based on these devices in high-potential circuits, along with a group of relay protection and automation devices for electric circuits and other types of equipment.

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