NEW GENERATION OF UNIVERSAL MAXIMUM-CURRENT SAFETY RELAYS

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RT-40 electromechanical current relays developed ten years ago are analogs of the even older ET-520 relay. These are still practically the only type of maximum-current safety relay widely used in the electrical-power industry, in powerful high-voltage drives, etc.

These relays involve considerable consumption of valuable resources and require considerable manual adjustment in production and use (regulation, cleaning, and bending of the contacts, etc.).

In powerful low-voltage electric drives, equally old maximum-current relays of the RES, REO-401, and other series are used. These devices are even larger and heavier and contain large quantities of copper, steel, and silver.

In modern economic competitions, these factors are of primary importance, and render the relays uncompetitive.

Semiconductor relays consisting of a set of commercial radiocomponents soldered to a printed circuit board are considerably more attractive and competitive. However, operation of microcircuit-based static relays, including the RST, RTZ-51 series and their analogs, in the YaRE-2201 safety unit of the Cheboksary Electrical-Equipment Plant reveals significant deficiencies hindering their widespread application: principally, inadequate noise stability and complex diagnostics and debugging [1].

An original approach that successfully combines the positive aspects of electromechanical and static current relays in a single design was outlined in detail in [1-8].

The present work describes the Kvazitron maximum-current safety relays, which went into production at the Inventor facility in 1993.

Two series of Kvazitron relay units are produced: Kvazitron-1 and Kvazitron-2. The Kvazitron-1 relay (Fig. 1) is intended to replace the RT-40 relay in existing and new electric power stations, and resembles that relay in casing design, dimensions, and triggering current (0.2-200 A).

The Kvazitron-2 relay is used in combination with special current monitors in powerful low- and high-voltage electrical equipment, in particular, to replace the REO-41, REV-571, and other analogous relays in the electric drives of powerful mechanisms.

Relays of both series have the same basic electrical system (Fig. 2), including an input interface [3] (L1, L2, K1), a time-specification circuit (R1, R2, R3, C1), an emitter repeater based on transistor VT1, an amplifying cascade based on transistors VT2, VT3, and an output electromagnetic relay K2.

The input interface and output electromagnetic relay ensure reliable galvanic uncoupling of the electronic component of the relay from the input and output circuits. Functionally, the electronic component of the relay is a pulse expander, and the input interface (L1, L2, K1) is an autonomous electromagnetic module acting as a threshold measuring unit in the relay. Structurally, the input interface consists of a separate element (Fig. 3) installed directly on the circuit board in the relay housing (Kvazitron-1) or on a separate external block outside the relay housing (Kvazitron-2) fitted with connecting pieces permitting the attachment of buses or large-diameter wires. This design allows the interface to be placed at different points of the equipment, in the immediate vicinity of the conductors. Several interfaces monitoring the currents in different circuits of the equipment may be connected in parallel to the input of a single relay electronic unit; they may also be set to different triggering currents. As well as a coil-type interface (Fig. 3) for currents of 0.5-50 A, other low- and high-voltage interfaces may

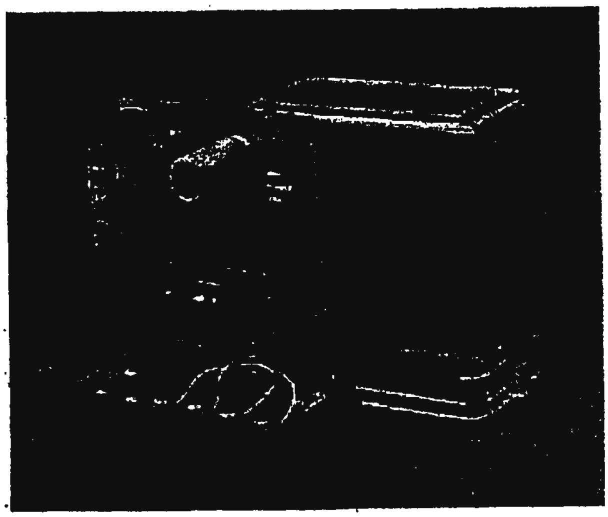

Fig. 1. External view of Kvazitron-1 relay unit.

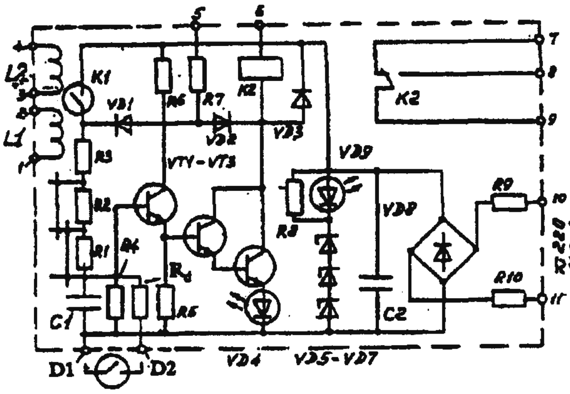

Fig. 2. Basic electric circuit of Kvazitron relay units.

be used in the Kvazitron-2 relay [3] (Fig. 4), including highly sensitive interfaces (with a triggering current of 0.05-5.0 A and insulation of the input from the output withstanding a voltage of up to 25 kV) for the current safety systems of powerful radioelectronic equipment [8, 9] and high- and low-voltage interfaces for installation directly at the current bus without disrupting it [2, 4-6]. Such bus interfaces correspond to Kvazitron-2 triggering currents of 50-10,000 A.

In Kvazitron-1 and Kvazitron-2 relays of special type D, there are additional output terminals D1 and D2 to which an external interface of any time may be attached. Terminals D1 and D2 form a suppression input, permitting differential protection [5]. In many cases, the use of external interfaces of different types permits reorganization of the relay safety system of low- and high-voltage ac equipment without the use of expensive and resource-heavy transformers.

The triggering threshold of the Kvazitron-1 relay is regulated by adjusting the interface tuning lever. This moves a plastic ampule containing a sealed-contact reed relay relative to the coil and, correspondingly, moves a needle along a scale.

The triggering threshold of bus-type interfaces is controlled by rotating the interface around its axis and then fixing its position.

All Kvazitron relays are fitted with red (VD4) and green (VD9) photodiodes permitting visual indication of the state of the relay in the course of its operation and also in adjustment and testing. Testing is possible without

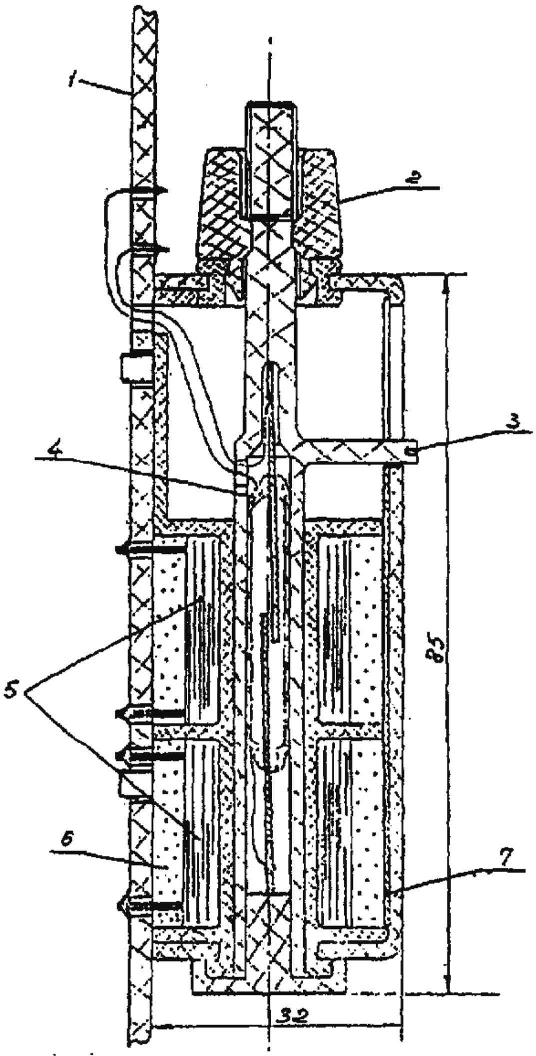

Fig. 3. Coil-type interface: 1) Printed-circuit board; 2) triggering-current control lever; 3) indicator arrow; 4) sealed-contact reed relay; 5) coil; 6) sealant (stearin, epoxide compound, etc.); 7) ferromagnetic screen.

disconnecting the relay from the external circuit, by short-circuiting (using a crosspiece or an external button) output terminals 5 and 6. This simulates the arrival of an input signal and at the same time blocks the output signal. The green photodiode goes out, and the red diode is lit.

To ensure optimal matching of the relay parameters to the operating conditions (detuning from the aperiodic component, current surges in triggering discharge units in the electrical grids, mechanical shocks to the relay housing), it is possible to choose the rated (at $I = 1.1I_{tr}$) relay triggering time (50, 150, or 300 msec), with the corresponding time–current characteristic (Fig. 5). The rated triggering time is changed by removing one or two of the wire crosspieces shunting resistors R1 and R2.

As a consequence of this method of changing the triggering time, the absence of a built-in switching unit for testing relay operation, and the choice of a sealed output relay K2, the relay's electronic component may be satisfactorily protected from dust or moisture by applying a two-layer coating of water-stable lacquer to the circuit

Fig. 4. External interfaces of Kvazitron-2 relay unit: 1) highly sensitive high-voltage coil interface for powerful radioelectronic equipment; 2) windingless low-voltage interface for electric drives; 3) windingless interface for direct installation on the (6-10)-kV bus of high-voltage equipment.

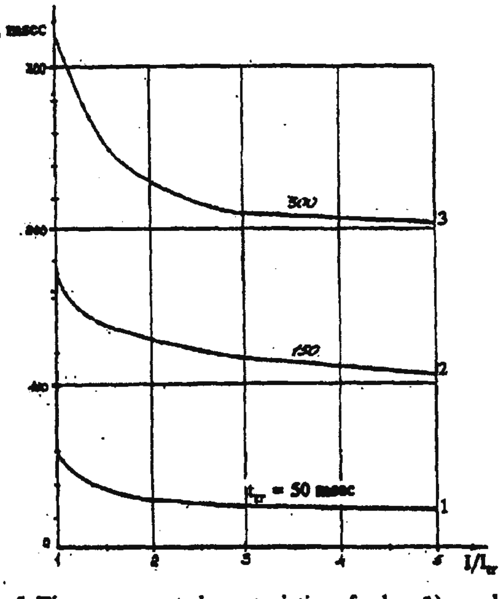

Fig. 5. Time—current characteristics of relay: 1) regular relay configuration; 2) one crosspiece removed; 3) both crosspieces removed.

board (the total-immersion method is used).

The relay is based on highly reliable components with ample current and voltage margins. For example, if the supply voltage, limited by stabilitrons VD5-VD7, is 45 V, KT6056M transistors and KD102A diodes with a permissible voltage of 250 V are used. While the permissible collector current of these transistors is 100 mA, the actual load current is no more than 10 mA; the stabilitrons also operate in the circuit with a tenfold margin with respect to the scattered power.

By using an input cascade at transistor VT1 in a common-collector configuration (with an emitter repeater), the current switched by relay K1 may be reduced to such a small level that electrical erosion of the contacts is completely eliminated (a so-called dry circuit).

Capacitor C2 enables the relay to withstand supply-voltage interruption of up to 10 sec, and the stabilizer corresponding to VD5-VD7 enables it to withstand supply-voltage fluctuations in the range 170-270 V. These

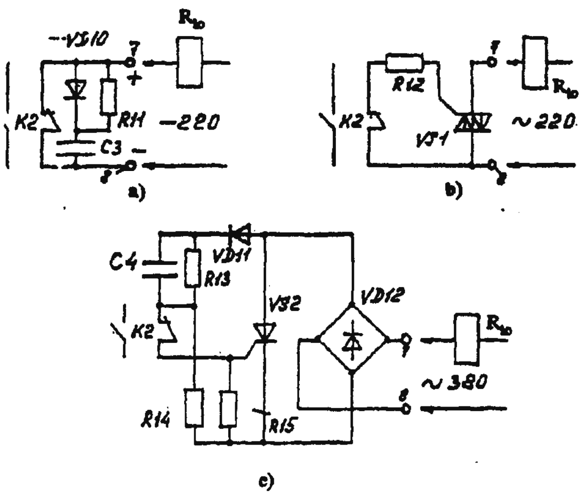

Fig. 6. Output switching units of relay: a) with spark-protection circuit for the dc switching of an inductive load; b) with a symistor for ac switching of a powerful load; c) for ac switching of a load with a rated voltage of 380 V.

components also protect the relay's electronic circuit from exposure to overvoltage pulses from the grid. The power drawn from the grid is no more than 4 W. To increase the switching ability of the Kvazitron relays, the output switching element may be based on a highly effective spark-quenching circuit (Fig. 6a), a symistor (Fig. 6b), or a diode–thyristor switch (Fig. 6c; Table 1). The latter option is adopted in Kvazitron-2 relays for operation in 380-V grids. The circuit in Fig. 6c may be used to control a relatively powerful load with a rated voltage of 380 V (the windings of powerful switch and starter units), by means of the relatively low-voltage terminal of the miniature relay K2.

The thermal stability of windings L1 and L2 of the coil interface corresponds to the RT-40 relay, and the greater sensitivity of the interface in comparison with the RT-40 relay permits considerable reduction in consumption of steel (fivefold) and copper (threefold). In addition, 60% reduction in the power drawn by the relay from the measuring transformer in the power system is possible. In comparison with the large, heavy REO and REV relays, the saving in active materials amounts to a factor of tens or hundreds.

The life of the relay unit and hence its region of applicability is basically determined by the life of reed relay K1, which vibrates at 100 Hz on triggering. Special tests of the reed relays used in relay units show that they are able to withstand 10 million triggering cycles in the conditions of the Kvazitron unit and then continue their normal functioning. In tests of two batches of 50 reed relays, no case of relay sticking was noted. The simplest calculations show that, if 50-Hz ac current is supplied to windings L1 and L2, the working life of the relay unit is no less than 27 days in the case of triggering twice per day with a delay time of 5 sec. As has already been established, the recovery coefficient of the relay is determined by the type of reed relay employed (its dimensions, the contact dimensions, etc.) and may be 0.7-0.99. Expert opinion is that the recovery coefficient of current safety relays must be as close to 1 as possible [10-12]. In the development process, relay prototypes with a recovery coefficient of 0.99 were produced, but tests at the Khar'kovenergo Power Combine and the Donbassenergo Power Combine led to the conclusion that such a high recovery coefficient reduces the stability of relay operation and is unnecessary; lower values are more expedient.

Accordingly, sealed-contact reed relays with a recovery coefficient of 0.85-0.95 are used for the Kvazitron-1 unit and those with a recovery coefficient of 0.70-0.85 for the Kvazitron-2 unit. By special order, units with a recovery coefficient of 0.98-0.99 can be produced.

The triggering threshold of the reed relay in the input interface is not sensitive to the form of the current, and hence the triggering current of the Kvazitron-1 unit, which is usually connected through a current transformer, does not change with errors of the current transformer of 78% or more.

Table 1

Versions of Kvazitron Relay with Different Output Switching Units

Version	Output unit	Switching conditions			Load	Current
		current, A	voltage, V	power, W		
1	Switching contact	0,001-0,3	0,5-120	10	Active	dc, ac
2	Closing contact with spark-suppression circuit	0,01-0,1	10-220	15	Active, inductive, $\tau \leq 0.01$ sec	dc
3	Opening contact with spark-suppression circuit	0,01-0,1	10-220	15	Active, inductive, $\tau \leq 0.01$ sec	dc
4	Symistor equivalent to closing contact	0,05-2,0* 3-10**	10-220	500	Active, inductive, $\cos\varphi \geq 0.4$	dc
5	Symistor equivalent to opening contact	0,05-1	10-220	200	Active, inductive, $\cos\varphi \geq 0.4$	ac
6	Diode–thyristor switch equivalent to closing contact	0,05-2* 3-10**	10-380	600	Active, inductive, $\cos\varphi \geq 0.4$	ac
7	Diode–thyristor switch equivalent to opening contact	0,05-1	10-380	300	Active, inductive, $\cos\varphi \geq 0.4$	ac

*Long-term.
**Short-term ($t \leq 3$ sec).

The recovery time of the relay is 50 msec in all conditions, and the time to reach the rated operating conditions after connection to the grid is no more than 0.5 sec.

The electrical strength of the input-interface insulation is no less than 5 kV (ac). The relay circuits withstand high ac voltages for 1 sec without damage: 1 kV at the terminals of the supply circuit and 2.5 kV between the outputs of different circuits.

The Ukrainian electric-power industry has decided to make wide use of the Kvazitron relays to replace RT-40 relays, including those used with 10-kV distributors produced by various Ukrainian plants. The engineering branch of the Sel'energoproekt Institute intends to use relays with high-voltage bus-type monitors in equipment for melting glaze. The national program for crane-building development in Ukraine plans to make wide use of Kvazitron-2 relays in the control panels of powerful crane electric drives. The Khar'kovenergo Combine has equipped a number of substations with arc protection based on Kvazitron-2D relays. Thus, Kvazitron relays are in fact universal, and may be widely used in electrical equipment.

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