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HIGH CURRENT PULSE TRANSDUCER FOR METAL-OXIDE SURGE ARRESTERS

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Высоковольтні розрядники класу 160 кВ і вище на основі оксидно-цинкових варисторів є відповідальними і дорогими апаратами. Головним недоліком відомих пристроїв для моніторингу варисторів є необхідність участі людини в роботі з ними. Запропонований простий, повністю автоматичний датчик імпульсних струмів для контролю розрядників, включений в систему SCADA за допомогою комплексу радіопередавач-приймач.

Высоковольтные разрядники класса 160 кВ и выше на основе оксидно-цинковых варисторов являются ответственными и дорогостоящими аппаратами. Главным недостатком известных устройств для мониторинга варисторов является необходимость участия человека в работе с ними. Предложен простой, полностью автоматический датчик импульсных токов для контроля разрядников, включенный в систему SCADA посредством комплекта радиопередатчик-приемник.

The zinc-oxide arresters (varistors) used in high-voltage networks (160 kV and higher) for protecting lines and high voltage equipment against over-voltages, are on the one hand rather important devices since the reliability of the power supply depends on them, and on the other hand, expensive devices demanding time-and-expense consuming maintenance. Therefore for a fairly long time special devices facilitating diagnosis of the varistors' condition have been developed. Many manufacturers of high-voltage arresters based on zinc-oxide varistors already supply (and have for a long time) them with electromechanical surge counters. One basic reason for the lack of such counters is that personnel of substations, who should periodically read information on quantity discharges and list counter indications in a log-book, seldom do. Such records are seldom kept in real life, and the information that is recorded is frequently doubtful, as it is not known what currents passed through the arrester at discharge, and when, and that is the major parameter determining the resources of an arrester.

Original detectors of arresters' operation on the basis of ferrite cores were developed in the Kharkov Polytechnic University in 1970's. According to the degree of magnetization of cores of the multistage detector it was possible not only to fix the fact of arrester operation, but also to estimate the current level that passed through the arrester. The basic item that was lacking – the necessity of participation of personnel in reading indications of the detector, was also kept along with these developments.

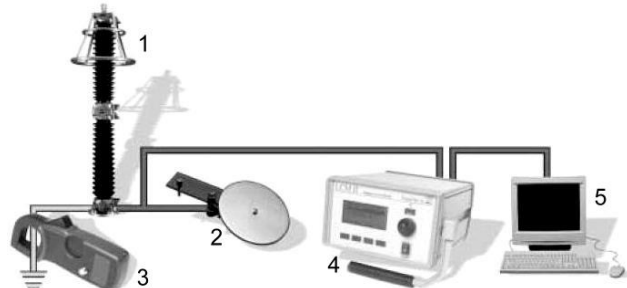


Fig. 1. The Computerized diagnostic complex for monitoring of condition of high-voltage arrester

1 – surge arrester; 2 – special field probe; 3 – clip-on current probe; 4 – leakage current monitor; 5 – computer

In the last few years many versions of devices for diagnosing the condition of varistors built on various principles [1] have appeared in the market. The spectrum offered is very wide: From the most complicated computerized systems (fig. 1, [2]) in which it is possible to receive a broad set of parameters and full information regarding the varistor's condition, up to the most elementary electronic surge counters (fig. 2, [3]).



Fig. 2. Electronic pulses counter, records of quantity of arrester discharges (produced by ABB)

There is no doubt regarding the efficiency of the measuring systems, allowing precisely enough to estimate the condition of the varistors and to predict their service life. However, the high cost of such equipment and necessity of participation of highly skilled personnel essentially constrain its wide application. On the other hand, regarding the transition from electromechanical counters to electronic ones, little has changed from the point of view of functionalities of the device.

It was suggested to the author to solve this problem by developing a device capable of fixing a quantity of arrester discharges, the ranges of current passing through it at each operation, automatically transferring this information using the SCADA system, this being inexpensive and accessible to manufacturing even by a power company's own staff. Dr. E. Volpov from the Israel

Electric Corp. also took part in the formulation of this problem and the formation of initial requirements for this device.

The developed device will consist of one three-band transducer of pulse currents on each arrester and a low-power nine-channel send/receive device (SRD) on a group of three arresters (three phases). The reception part of everyone's SRD is included in the SCADA system, containing microprocessor-based transient and events recorders. Usually all analog inputs of such recorders are occupied recording currents and voltages; however a lot of not involved logic inputs, which can be used for registration of operation of arresters, are always present. It is only necessary to appropriate a code number for each range of currents and to transfer this number together with a digital signal regarding the varistor's operation. That supposes that the majority of SRD type's being used are low-power industrial type SRD's. With such use of transducers there is no necessity for introduction of function of internal storing of the information; therefore its design can be extremely simplified. Such a transducer (fig. 3) is built as a metal-plastic case with universal fastening elements and a deep slot with an arrester grounding tie passing through. The fastening elements of the transducer are universal and assume it is directly fastened to the grounding tie or the concrete rack.

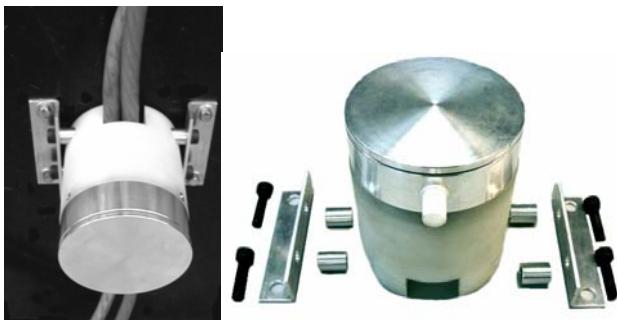


Fig. 3. Developed pulse currents transducer

In the body of the transducer a "bookcase" is located with two assembly boards and a compartment with an unscrewing cover, in which a terminal board for external connections is located and in parallel are connected two tiny 12 V batteries from a car security system (MN21/23 type, for example). A standard 9 V battery can also be used. On the bottom side (closer to the slot) there are inductive current sensors (three coils without cores), wound with different diameters of wire and having different numbers of coils located (fig. 4). On the top side a printed circuit board with electronic components is located (fig. 5), which consists of three identical channels with inductive current sensors on the inputs.



Fig. 4. The unit of inductive sensors for high current pulses

Each channel represents a high-speed pulse expander. At receiving on input a short pulse of current of any polarity, opens a thyristor VS1 and charges the capacitor C2 beginning through limit resistor R5.

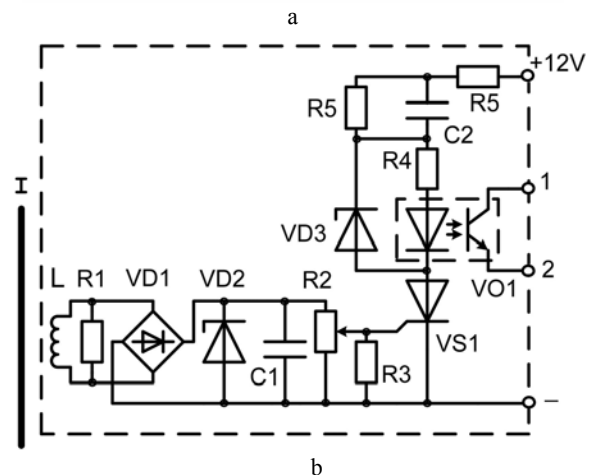
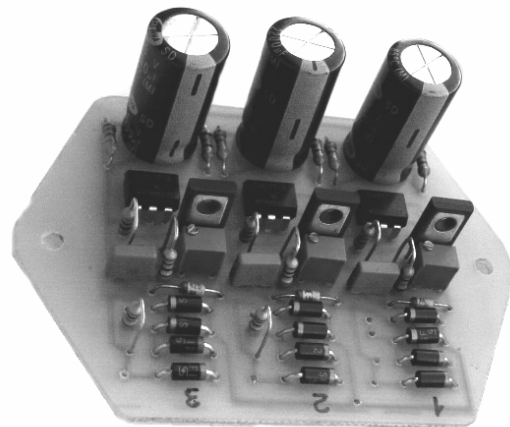


Fig. 5. An electronic part of the device:
a – three channels printed circuit board;
b - circuit diagram for one channel

During all this time, while the value of the capacitor charge current remains higher than the thyristor holding current, the thyristor remains in a conductive condition and the output element of the VO1 optocoupler remains in a conductive condition as well. This period of time takes up to one second. Thyristor VS1 will lock and the output element of the optocoupler will also come back to a non-conducting condition after the full charge of capacitor C2. Capacitor C2 will discharge through high-resistance resistor R4 within several seconds. Then the device will again ready to receive another current pulse.

Potentiometer R2 adjusts a pickup threshold, and Zener diode VD2 protects the device from over-voltages at receiving an extremely high pulse input signal. For maintenance of a constant condition of output transistor in the optocoupler VO1 within one second at any change of current on the optocoupler's input during the charging process of the capacitor C2, this optocoupler should be chosen with a low control current (a LED's current). For this purpose the optocouplers of CS700, CH370, HCPL-2300, 6N139, SFH618A series, etc., with input currents as small as 0.5 - 1.5 mA, are recommended. For protection of such sensitive optocouplers from high current at the initial stage of capacitor C2 charge, a low-voltage and low-power Zener diode VD3 is used.



Fig. 6. Oscillogram of input/output signals in device during laboratory testing with a low-voltage simulator of high currents.
1 - the pulse of a current generated by a simulator;
2 - a signal on device output

Thus, on receiving a short current pulse on an input device with duration of a few microseconds, this scheme will generate a wide pulse with duration about one second (fig. 6). The first channel is adjusted on pickups at a current of 800 A. The second - at a current of more than 5 kA, and the third - at a current of more than 10 kA in a grounding tie.

The device has passed laboratory tests on a low-voltage simulator of high currents (fig. 6), and also on the Haefely high-voltage pulse generator, forming standard pulses of a current corresponding to a natural lightning pulse in all ranges of device sensitivity (fig. 7).

The optocoupler's output elements (transistors) of each channel are connected to corresponding inputs of a low-power transmitter with a small service area. One transmitter with nine digital (on-off) channels can use with three transducers (three-phase set).

Compact industrial radio transmitter/receivers with suitable parameters (fig. 8), are offered today by many companies, including such well-known as Phoenix Contact, Honeywell, Sony, Ericson, Acksys, Omnex, etc.

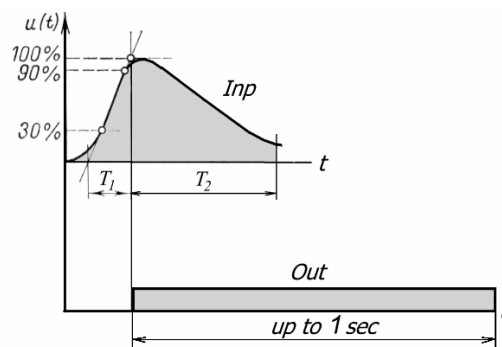


Fig. 7. Pulses of current on input and output of the device during tests on a high-voltage pulse current generator, produced by Haefely.
 $T_1 = 7 \mu\text{s}$; $T_2 = 21 \mu\text{s}$



Fig. 8. Some types of compact industrial radio transmitter/receiver devices, with service area up to 1 km

Thus, due to integration with existing systems of transfer and registration of information available today at modern substations, the developed device allows to reception of information sufficient for practical needs regarding arrester discharges (quantity of current pulses through an arrester, the range of currents of these pulses, and the exact times of operation of the arrester). Therefore it is much simpler and less expensive than existing analog devices, and its installation does not necessitate driving additional control cables in the substation territory. When desired, such a device can be constructed by the power company's own staff.

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