Circuit Breakers Timing Test System

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Abstract. *The paper presents the construction and principle of operation of a designed and constructed meter for testing the operation times of three-phases circuit breakers. The measurement is performed by the digital time-pulse conversion method. The design is based on a micro-controller. The block scheme of the meter and principle of operation are given, along with the results illustrating the metrological parameters of the device.*

Keywords: circuit breaker timing tests, the operation times of a breaker, circuit breaker monitoring

1. Introduction

Circuit breakers constitute an important and critical component in the electric power system. Because of their key role, circuit breakers are periodically tested. One of the earliest and most successful test methods was the timing test, which consists of measuring the mechanical operation time of the breakers contacts. Timing tests will always be important to prevent damages of circuit breaker. Incorrect operation of circuit breaker can have of disastrous consequences on the equipment or the substation personnel.
Different measuring devices can measure the operation times of a breaker. First- generation devices were based on oscillographic mode of record curves and currently are not used. Second generation testing methods based on digital timers with time-pulse conversion e.g. circuit-breaker timer produced by Vanguard Instruments Company [1] began about 1988 year and are continued until today. Very interesting are also new conceptions for testing of circuit-breakers based on analysis of mechanical vibration signal [2].
Generally commercially produced timers for testing circuit-breakers are expensive. Information on the design and principle of operation of the offered devices are usually too general or unavailable. In view of the above, an attempt was made at developing our own solution of design of a microprocessor-based meter for measurements of operation times of three-phase circuit-breakers.

2. Operation Times of Circuit breakers

Important parameters describing the technical quality of a three-phase circuit-breaker are the so-called operation times characterising the processes of the contacts opening and closure. Definitions of these time parameters are presented in international standards IEC 56.3.105 (International Electrotechnical Commission) [3]. The quantitative description of the switching on and off process is usually made with the help of the mentioned below time parameters:

- time discrepancy between the contacts t_d - interval time characterising the divergence from coincidence of connection or disconnection of the breaker contacts (non-simultaneous switching)

- closing time t_c – the interval of time between energizing the closing circuit, the circuit breaker being in the open position, and the instant when the contacts touch the poles

- opening time t_o of the breaker -. the interval of time between the instant of energizing the opening release, the circuit breaker being in the closed position, and the instant when the contacts have separated in all poles.
Fig.1 illustrates the process of the switch opening and closure and definitions of operational times.

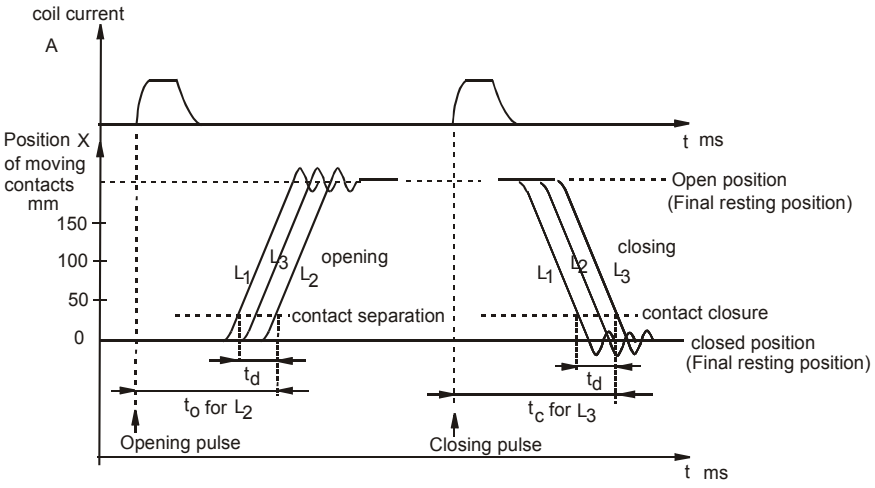

Fig.1 The operation times of a circuit-breaker

It is worth noting that the time discrepancy t_d between the contacts of the breaker must be within certain tolerance limit – usually 5 ms. The time difference between opening or closing all contacts may generate huge voltage spikes that could potentially damage network and its equipment.

3. The Meter Block Diagram and Principle of Operation

A block diagram of the designed and constructed meter is presented in Fig.2.

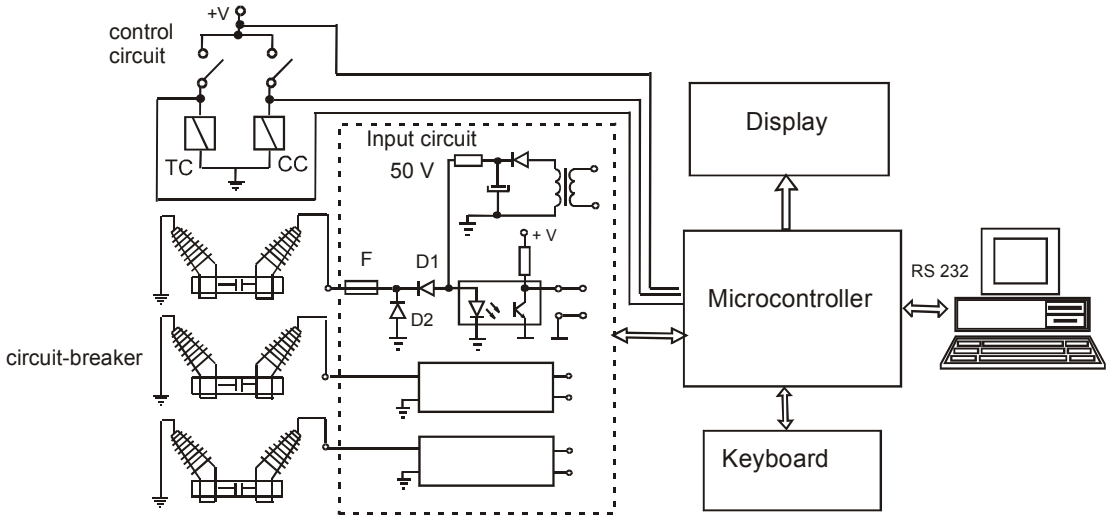

Fig.2 Block diagram of a meter for measurement of operation times of circuit breaker

The meter is built of the following interconnected functional blocks: input circuits, microcontroller being a central unit of the meter (single-circuit microcontroller AT89C51), display and a keyboard. The input circuit plays very important role, because makes possible

to eliminate disturbances and protects the microcontroller circuit. The input circuit of described devices includes a converter of the output voltage of 50 V, a transoptor ensuring optical insulation between the part of the device connected directly to the breaker tested and the other circuits of the meter, protecting elements and digital circuits ensuring the signal standardization for further digital processing. The diodes D1 and D2 protect the input circuits against the short-duration voltage signals appearing as a result of electrostatic phenomena, penetration of disturbances or errors of operation. In case of appearance of a voltage signal of the polarity inverse to that of the voltage supplied by the converter, the current generated is closed through the diode D2 and a fuse F, causing the breaking up of the circuit.
The principle of the measuring procedure is based on the known time-pulse method in which the pulses of a standard frequency *f* are counted in time intervals. Two modes of work of the meter are possible. The first is principally designed for measurement of the opening and closing times time of the breaker. The principle of the meter operation in this mode is illustrated in Fig. 3

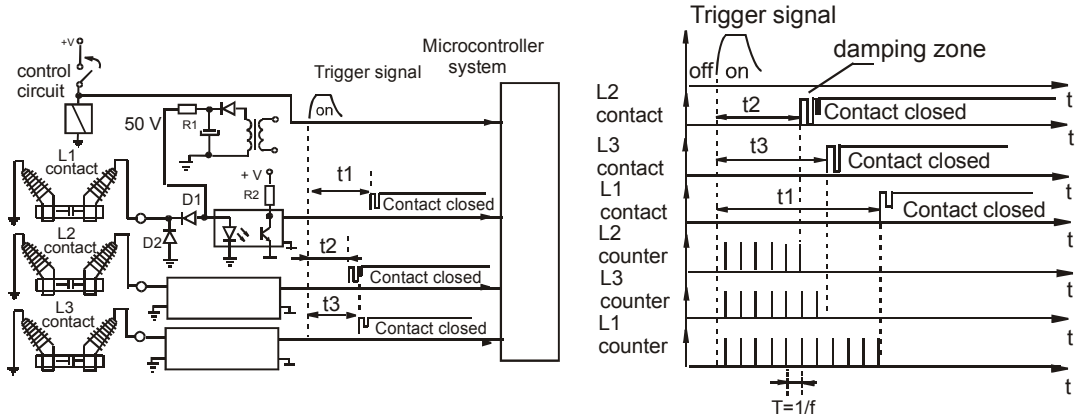

Fig.3. The time courses of the signals for the mode of the meter operation designed for measurements of the opening and closing times.

The microcontroller software written for this purpose permits the use of the microcontroller counter counting the pulses of a standard frequency. The counting of pulses is triggered by an external electric signal obtained for example from the drive system of the breaker. The time gates *t1, t2, t3* are closed by a signal corresponding to closing (or opening) of each contact of the breaker. At the moments when the signals of the contacts closure L1, L2, L3 (or opening) appear, the subsequent contents of the counter are copied into the regions of the memory area designated for recording results for each of the contacts. The number of pulses counted is proportional to the time elapsing from the moment of triggering signal to the moment of closing (or opening) of each contact. The counter provides the information not only on the opening and closing times, but also on the time discrepancy between the contacts being the difference between the longest and the shortest times. The values of particular times are displayed in three separate windows of the liquid crystal display.
Sometimes the release signal is unavailable and then the meter should work in the second mode of work designed exclusively for measurements of the time discrepancy between the contacts. The principle of the meter work in this mode is illustrated by the time courses of the signals shown in Fig.4. In this mode the counter is triggered by the signal from the contact that acted as the first. This signal opens the times gates which are assigned to the other contacts, whereas the indication of the counter assigned to the contact that acted as the first is written as zero. The times gates of the other two counters are closed as a result of activation of the other two contacts of the breaker. The counter of the highest indication determines the time discrepancy between the contacts.

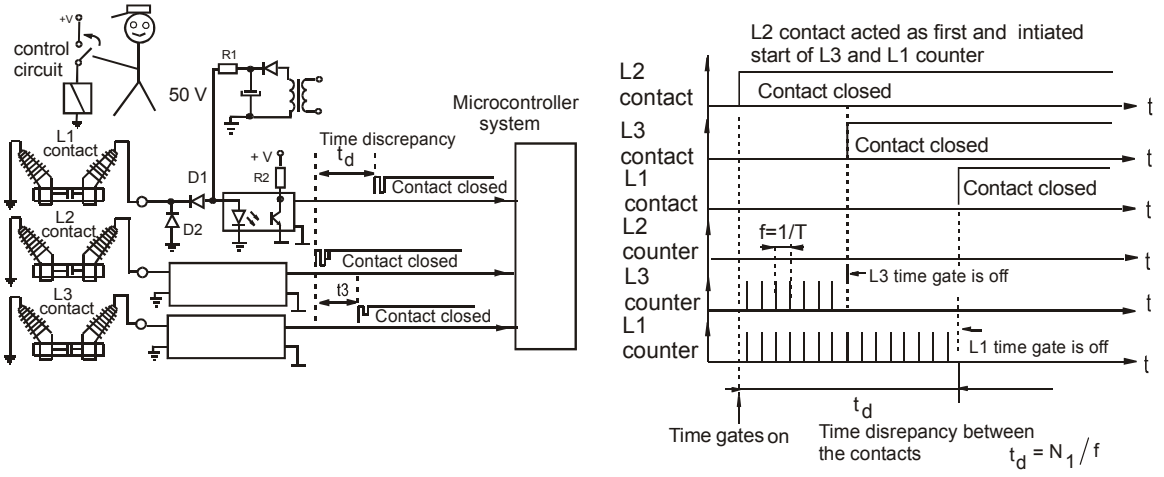

Fig. 4. The time courses of the signals illustrating the second mode of the meter work designed for measurements of the discrepancy times between the contacts.

The most important specification of the meter designed for measurement of the operation times of a breaker:

- Inner source of constant voltage for testing of contacts: 50 V,
- Galvanic insulation between the meter and the breaker tested: 1000 V,
- Range of times measured: 10 s
- Measuring resolution: 0,1 ms,
- Error of measurement: 0,1 ms,
- Number of entrances recorded in memory: 100,
- Input of the signal triggering a change in the breaker state: 60 - 300 V

4. Conclusion

The microprocessor-controlled meter for measurements of the circuit-breaker operational time has been designed and constructed. The design has been made taking into regard the need of the system protection against the disturbances and over-voltage caused by the voltage induced in a given breaker. The advantages of the meter are easy operation, user-friendly interface for communication and easy readout of the results of measurements. The model of the meter constructed is equipped with a series RS 232 connection ensuring communication with a computer. Good metrological parameters, relatively small size and low cost seem promising for possible implementation of the meter in testing of circuit-breakers.

References

[1] http://www.vanguard-instruments.com/datasheets/ct3500.pdf

[2] M.Runde, B. Skyberg, M. Ohlen, Vibration Analysis for Periodic Diagnostic of Circuit-Breakers Circuit-Breakers, High Voltage Engineering Symposium 22-27 August 1999, Conference Publication No 467, IEE, 1999

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