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Harmonics ratios of resistive leakage current as metal oxide surge arresters diagnostic tools

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ABSTRACT

Metal oxide surge arresters are important equipments that apply to power system for protection against switching and lightning over-voltages. Surge arrester monitoring technique based on leakage current analysis is a conventional monitoring method. Lack of proper features and thresholds is most important limitation of this method. In this paper, new monitoring indexes for surge arrester diagnostic are proposed to determine surge arrester condition under different situations including clean condition, surface contamination and ultraviolet aging. The experimental tests have been performed on polymer surge arresters to evaluate the ability of the proposed indexes for distinguishing the operating condition of surge arresters. Results have been shown the viability of the new indexes on surge arrester monitoring procedures. The investigation and the discussion of the produced results can give good ideas the electric engineers in order to easily analyze arresters' condition leading to effective schedule maintenance.

1. Introduction

Metal oxide surge arresters (MOSAs) are one of the most important equipments applied in power system for protection against switching and lightning over-voltages. Thus, they positively contribute to increase reliability and performance of the power system. Therefore, failures on surge arresters can damage to other substation equipments and risks to technical personnel. Consequently, their condition monitoring has significant influence on the reliability of power system [1–3].

Many offline and online approaches have been presented in literature for condition monitoring of surge arresters such as: power loss method [4], *V–I* characteristic curve analysis [5], leakage current measurement [6–11], temperature measurement [12–14], and electro-magnetic field measurement [15,16]. Thermo-vision and electro-magnetic tests are non-destructive monitoring methods which are used for surge arresters condition monitoring. The advantages of these methods are that there is no need to disconnect the equipment and secure distance from object. However, difficulty of data analysis and requirement of expensive equipments for these experiments are drawbacks of the methods.

Accurate results may be obtained by using the offline methods. Requirement of expensive equipment for these experiments and the need for disconnecting the surge arrester from the system are drawbacks of offline method. Total leakage current decomposition of their capacitive and resistive components under operating voltage system is the most popular methods. Portable instruments, which connected to the earth terminal of the arrester by means of a clip-on, or permanently installed current transformer have been used to measure online leakage current [6–11]. The main purpose of most diagnosis techniques are based on resistive current analysis, because the resistive

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component is a sensitive indicator to determine surge arresters conditions [1–3]. Lack of proper features and thresholds is most important limitation of these methods. Thus, new criteria are proposed based on the development diagnosis methods to overcome the limitations of the leakage current methods.

In this paper, new indexes based on the ratio of third to fifth resistive harmonic components (i_{r3}/i_{r5}) and the ratio of resistive to total leakage current fundamental components (i_{r1}/i_{t1}) have been proposed to identify surge arresters conditions. A harmonic components database of total current signals and their components (resistive and capacitive currents) has been produced in the laboratory to evaluate the viability of the new monitoring indexes. This database has been obtained from 20 kV polymer housed surge arrester with different operating conditions such as clean virgin and clean aged conditions, superficial pollution after ultraviolet (UV) aging and superficial pollution before UV aging. According to the experimental results, there are obvious differences between extracted features of aforementioned conditions. Obtained results show the significant performance of proposed indexes for different condition monitoring of surge arresters.

Proposed technique explains in Section 2 in brief. Leakage current measurement experimentally and experimental setup illustrate in Section 3. Section 4 presents leakage current analysis of clean housed surge arrester under operating voltage. Section 5 studies leakage current of polluted surface surge arrester before and after UV aging process. Section 6 discusses the leakage currents of different case and clarifies the main differences between them. Section 7 includes conclusion with a summary of the key results.

2. Proposed technique

A monitoring and diagnostic system with the ability to identify the operating conditions of surge arresters has been proposed which is based on characteristics extracted from the total leakage current and resistive component. First, surge arresters behaviors have been investigated under different situations such as virgin and aged clean conditions, surface contaminations and housing aging due to the ultraviolet (UV) in high voltage laboratory. Finally, the new indexes have been obtained to identify different operating conditions of surge arresters.

Multi-coefficient method [17,18] has been used to extract capacitive and resistive components of measured leakage currents. Extracted harmonic components from the measured currents have been used to distinguish the different operating conditions of surge arresters.

According to the experimental results, total and resistive leakage current amplitudes have been raised under all types of the considered conditions. Consequently, an increase to the resistive component of a surge arrester, which is installed on a distribution or transmission line, does not necessarily caused by degradation. However it probably is a consequence of temporary factors such as moisture and pollution on the arrester's surface. Therefore, regular basis measurements or proper indexes should be existed, in order to decide accurate conclusions about surge arresters conditions.

Experimental results have been shown that i_{r3}/i_{r5} and i_{r1}/i_{t1} had good coordination with the samples' different conditions. Thus, the focusing this paper has been performed on them. In Fig. 1, an overview of the proposed technique is presented. First, the total current signal is obtained from a surge arrester installed on the field or tested in laboratory. Next, harmonic contents are extracted from current signal and required proposed indexes are extracted. Finally, surge arrester condition is determined based on extracted features variation in comparison with new surge arrester ones.

3. Leakage current measurement

The experimental arrangement is shown in Fig. 2 to obtain MOSA total leakage current. According to Fig. 2, experimental setup consists of a high voltage transformer with adjustable voltage between 0 and 100 kV, capacitive divider and data acquisition system. Data acquisition system, which uses for leakage current measurement, comprises a digital oscilloscope, back to back connected Zener diodes for overvoltage protection and a 470 Ω shunt resistor (R_{sh}) for measuring leakage current. Capacitive divider is used for measuring surge arrester applied voltage. The leakage current through the surge arrester and total applied voltage have been captured using two channel digital storage oscilloscope.

3.1. Tested samples

Polymer housed surge arrester has been used for artificial pollution and UV aging tests, as shown in Fig. 3. Three numbers were chosen to apply experimental tests. Table 1 shows the technical surge arrester characteristic.

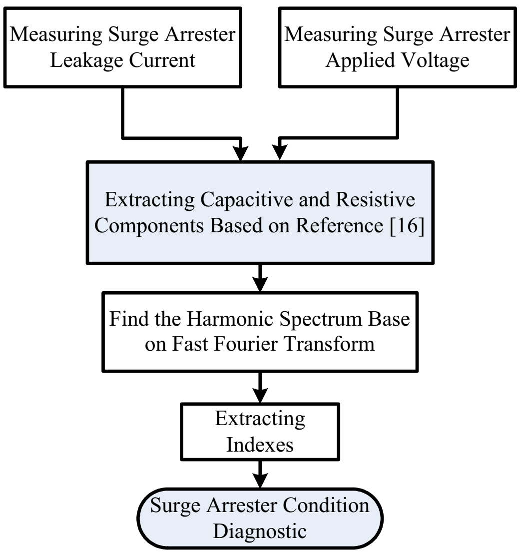

Fig. 1. Proposed technique overview.