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Improvement of ultrasonic method for testing of power transformers

Danijel Brezak[a], Dalibor Filipović-Grčić[b]

Končar Electrical Engineering Institute, Transformer Department, High Voltage Laboratory,
Fallerovo šetalište 22, 10002 Zagreb, Croatia
[1]dbrezak@koncar-institut.hr, [2]dfilipovic@koncar-institut.hr

Abstract

Ultrasonic method of detecting PD is based on the fact that the electrical energy of the PD transforms in a mechanical energy, an ultrasonic acoustic wave that spreads through the transformer to the tank wall. These mechanical waves are detected with piezzo-electric sensors and transformed into electrical signals which are processed with a special instrument called Acoustic Emission System (AES).

Since not only defects inside the transformer can produce acoustic waves, during analysis there is a problem distinguishing the actual origin of the detected acoustic waves.

Therefore, additional sensors can be added to the system which monitor some parameters of the transformer such as temperature of the tank, load, OLTC operations, fan and pump operations, PD level during laboratory testing (in accordance with [1]) etc.

These parameters can simplify analysis using a time correlation between detected hits (hit is a designation for event when sensor detects an acoustic wave) and in-service parameters of the transformer.

Another problem with location of the source in 3D system is the lack of knowledge of the zero time of the hit.

Using a high frequency current transformer (Rogowski coil) and the fact that the electric signal has a high propagation velocity, zero time can be added to the system providing higher accuracy.

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Keywords: Ultrasonic method; Power transformers; Partial discharge, Transformer diagnostics, Location of PD, Rogowski coil, Parametrics

1. Introduction

Ultrasonic method of detecting PD is based on the fact that the electrical energy of the PD transforms in a mechanical energy, an ultrasonic acoustic wave that spreads through the transformer to the tank wall. These mechanical waves are detected with piezzo-electric sensors and transformed in to electrical signals which are

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processed with a special instrument called Acoustic Emission System (AES) From time difference of wave detection on different sensors, a possible location of the source can be estimated. Since the method detects ultrasonic acoustic waves spreading through the tank it can detect other transformer deficiencies such as loose contacts and local overheating of oil (T>200 °C) which gives this method a unique diagnostic status [2].

Since not only defects inside the transformer can produce acoustic waves, during analysis there is a problem distinguishing the actual origin of the detected acoustic waves. Therefore, engineers should have as much data of the transformer state as possible. Monitoring systems can provide that data but it is not always easy to implement that data from another system in the acoustic system. Therefore, additional sensors can be added to the system which monitor some parameters of the transformer such as temperature of the tank, load, OLTC operations, fan and pump operations, PD level during laboratory testing etc.

Using the parametric inputs, data can be directly loaded in to the system avoiding an error of incorrect time synchronization between the time of AES and monitoring system of the transformer in substation. These parameters can simplify analysis using a time correlation between detected hits (hit is a designation for event when sensor detects an acoustic wave) and in-service parameters of the transformer. Based on time correlation, hits that can originate from mechanical sources such as OLTC operation can be excluded from the analysis. Of course, these mechanical noises can be distinguished from the actual source from the characteristics of the recorded hits, but that is not always the case. AES is equipped with analog inputs 0-10 V, so current and temperature transducers were implemented in the circuit [3].

Another problem with location of the source in 3D system is the lack of knowledge of the zero time of the hit. The system needs 4 sensors to detect the hit to find the source locations based on different arrival times to each sensor. Using a high frequency current transformer (Rogowski coil) and the fact that the electric signal has a high propagation velocity, zero time can be added to the system providing higher accuracy. Another possibility is to discriminate the signals measured by acoustic method if there is no correlation with the signal on the Rogowski coil. Laboratory tests were performed to investigate the advantage of using the method with zero-time as a parameter.

2. Implementation of new instrumentation parts

2.1. Parametric inputs

Current and temperature sensors are connected to the system using an analog input box (AIB) which is used to transfer the 4-20 mA signal from the sensors to an accepted signal level on the parametric inputs of the AES, 0-10 V. Besides the signal conditioning it is used to power the sensors using a loop-power principle.

AIB consists of 8 input channels and an internal 499 Ω resistor for transforming 4-20 mA signals to a 0-10V signal [3].

Loop-powered sensors are used because there is no need for extra wiring that is usually used for external sensor powering. On the same wiring, sensors are powered and the measured signal is sent.

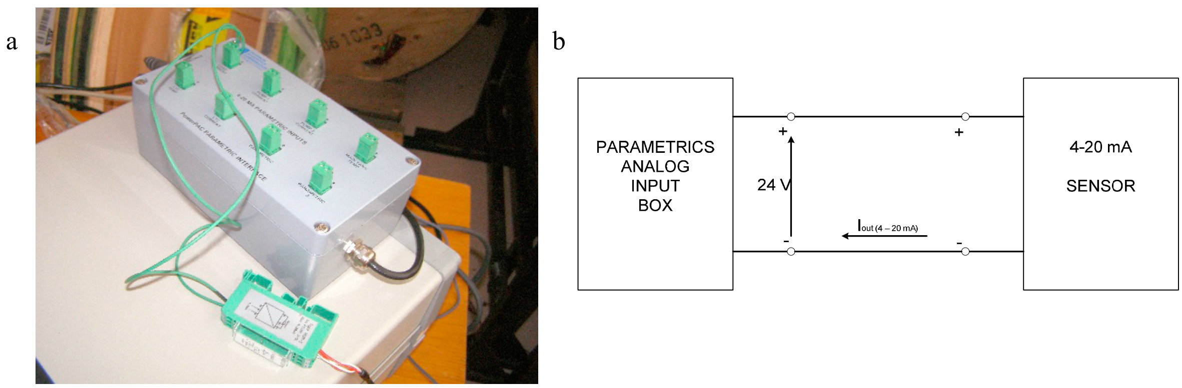

Fig. 1. (a) AIB and HSM-I temperature transducer; (b) Loop-powered sensor