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Analysis of possibility of shorted coil localization in power transformer on the basis of its frequency response (SFRA)

Kamil Lewandowski*, *Hubert* Morańda

Poznan University of Technology, M. Sklodowskiej-Curie Sqr. 5, 60-965 Poznan, Poland

Abstract. The article presents the results of transformer investigation using SFRA method. The 630 kVA unit with the Dyn5 connection system were investigated. The characteristics of the frequency response for the transformer without defect and with the shorted turns implemented defect were presented and analyzed. The shorted turns was performed in various parts of the HV transformer's winding in order to check the possibility of localization of this defect. The measurements were carried out in four different ways: measurement of the frequency response of the tested winding with shorted and on free potential line terminals of the remaining windings, and inter-winding measurement – inductive and capacitive. Based on the obtained results, the influence of the shorted turns location in the transformer on its frequency response was evaluated.

1 Introduction

Power transformers are key elements of the power system. Any transformer failure generates enormous costs of repairs and penalties for non-delivery of energy to the recipients. For these reasons, preventive diagnostic of transformers is extremely important [1]. In practice, many diagnostic methods are used to assess the transformer condition. One of them is Sweep Frequency Response Analysis (SFRA). In this method sinusoidal voltage signals with a wide frequency range are generated and given to transformer bushings. Then the voltage at the device input and output are measured [2].
The purpose of the conducted and described in the article researches was to assess the possibility of locating shorted coils in the transformer windings based on its frequency response.

2 Tested transformer and the way of performing measurements

During the tests 630 kVA transformer with a Dyn5 vector group was investigated. Active part of the investigated transformer was removed from the tank, but all bushings and cover was installed. The high voltage winding consisted of 64 coils.
During the research the following measurement procedure was carried out:

a) connecting the test leads and recording the frequency response of the "healthy" transformer – without a defect,
b) performing a short circuit in high voltage phase L3winding, by shorting selected ten coils with the use of copper wires (Fig. 1),
c) recording frequency response of the defected transformer
d) changing defect location,
e) repeating of points c and d.

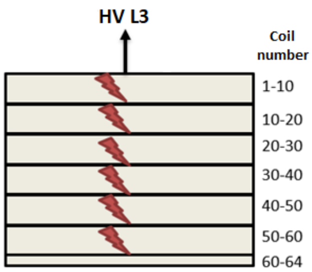

Fig. 1. Locations of modelled shorted coils in L3 phase high voltage winding.

Measurements were made in four configurations (Fig. 2).

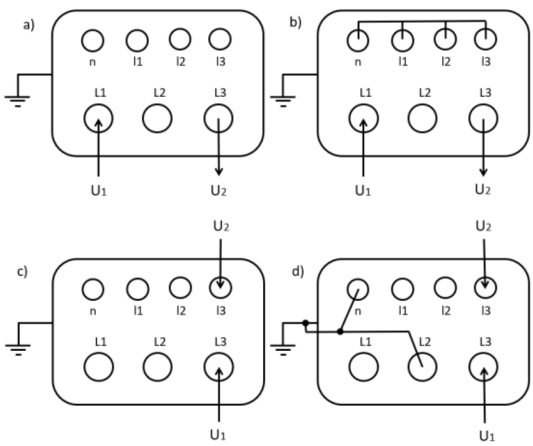

Fig. 2. Four realized measurements configurations: a) method A, b) method B, c) method C, d) method D [3].

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* Corresponding author: kamil.wo.lewandowski@doctorate.put.poznan.pl

3 Case study – results and interpretation

Analysis of selected characteristics has shown that the following frequency ranges are suitable for locating the shorted coils:

- between 6 and 10 kHz – for measurements in configurations A, B and D (Fig. 3, 4 and 6),
- between 6.5 and 8.5 kHz for measurements in configuration C (Fig. 5).

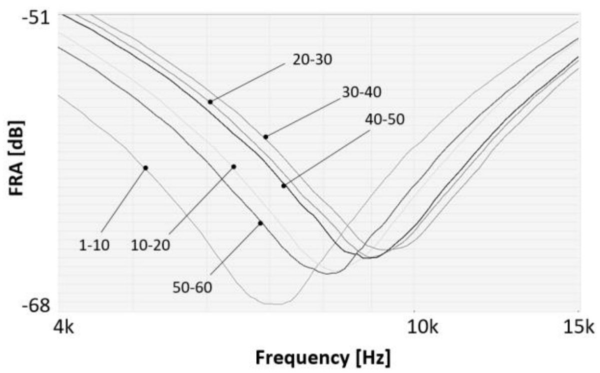

Fig. 3. Frequency responses of the investigated transformer with shorted coils, recorded between terminals L1 and L3 HV windings in configuration A; frequency from 4 kHz to 15 kHz.

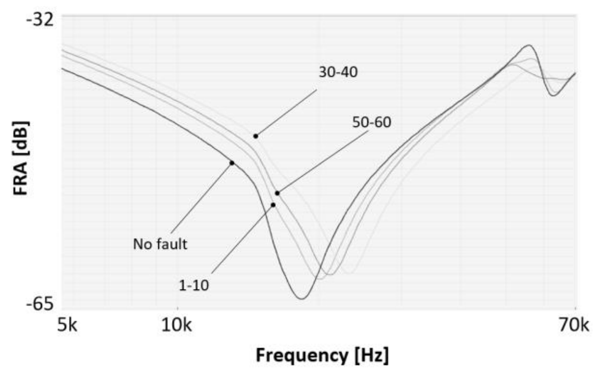

Fig. 4. Frequency responses of the investigated transformer with shorted coils, recorded between terminals L1 and L2 HV windings in configuration B; frequency from 5 kHz to 70 kHz.

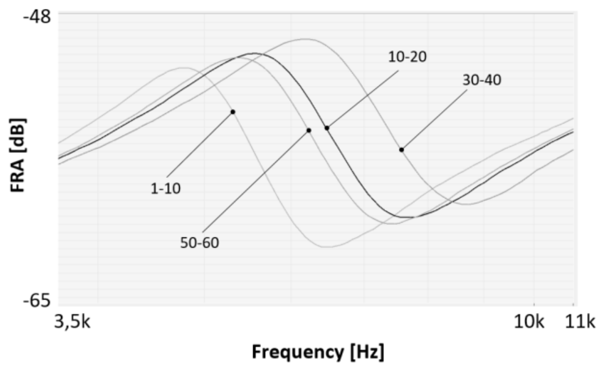

Fig. 5. Frequency responses of the investigated transformer with shorted coils, recorded between terminals L3 HV and LV windings in configuration C; frequency from 3,5 kHz to 11 kHz.

Analysis of the obtained measurement results allows to conclude that:

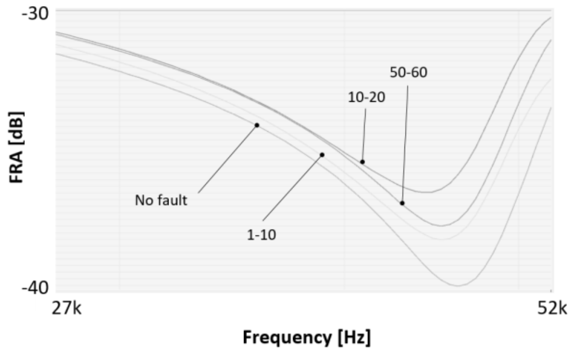

Fig. 6. Frequency responses of the investigated transformer with shorted coils, recorded between terminals L3 HV and LV windings in configuration D; frequency from 27 kHz to 52 kHz.

a) shorted coils are manifested in shifting the first resonant frequency for the measurement configuration A, B and D,
b) for the measurement configuration C the most convenient for shorted coils localization are resonances at frequencies between 6.5 kHz and 8.5 kHz,
c) finding the shorted coils location based on the first resonant frequency is partially possible; resonant frequency increases for from 1-10 to 30-40, while for shorted coils from 40-50 to 50-60 the resonant frequency decreases, almost coinciding with the results for shorted coils 1-10 to 30-40; analysis shows that it is impossible to clearly to point out the location of the coil fault, but based on the analysis of SFRA waveforms it is possible to assess how far from the center of the winding the shorted coils are located,
d) analysis of other resonant frequencies showed similar character of changes in frequency response depending on defect location, however, these changes are much less visible than in the case of the first resonances.

4 Conclusions

Finding location of shorted coils based on the analysis of the frequency response is possible but problematic. SFRA method allows to determine how shorted coils are far from the center of the winding, but it is not possible to indicate clearly the position of this defect.

References

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