ISSN 1232-3829
tts 10/2013
Technika Transportu Szynowego koleje ▪ tramwaje ▪ metro

BRANDT Martin, MICHALÍK Ján

IDENTIFICATION OF FAILURE TRANSFORMERS 22/0,4 KV AND 110/23 KV USING SFRA METHOD

Abstract

The article deals with the identification type of faults in power transformer using the method SFRA. The results taken from this transformer are compared with the results taken from experimental distribution transformer.

INTRODUCTION

Sweep frequency response analysis (SFRA) theory is a method which can indicate some damage or changes in the winding or in the core of the transformer. The fundamentals of this type of measurements is to supply input winding of transformer by low voltage frequency impulses and the response in output winding is displayed as an amplitude frequency characteristic. [1 – IEC 60076-18].

In laboratory we have the experimental oil distribution transformer with the name plate data in Tab. 1. There was on this transformer created many types of mechanical failures – interturn short circuits, axial and radial displacement of windings, keep clear the core. We measured frequency responses of these failures to achieve better identification. The results were used for comparison and identification of failure type of tested transformer with other power transformers. In this case we used for measurement and diagnostics the power transformer with the name plate data in Tab. 2 located in transformer station Žarnovica (Slovakia).

1. THE MEASURED TRANSFORMERS

The name plate dates of measured transformers are in next tables:

Tab. 1. Nameplate data of measured the experimental transformer.

Manufacturer	BEZ, s.n. 231160
Year of manufacture	1983
Type	aT0294/22
Connection	Yzn1
Frequency	50 Hz
Nominal voltage	22/0,4 kV
Nominal power	100 kVA
Position of tap switch	3

Tab. 2. Nameplate data of measured the power transformer.

Manufacturer	Škoda T102, s.n. 937610
Year of manufacture	1972
Type, Connection	5ER 33M, Yy0/d
Frequency	50 Hz
Nominal voltage	110/23/6,3 kV
Nominal power	40/40/12,5 MVA
Position of tap switch	13
Temperature of transformer	19 °C

The general view on the experimental transformer is in Fig. 1. The transformer was demounted from the tank in order to realize experimental creating of mechanical failures on the windings and on the core.

Fig. 1. Experimental transformer BEZ aT0294/22 Yzn1.

Tab. 3. Table of SFRA measurements for experimental and power transformer.

1. Open circuit tests					
Primary winding			Secondary winding		
Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
A – N	B – N	C – N	a – n	b – n	c – n
2. Short circuit tests					
shorted a –b –c (ssek)			Shorted A – B – C (sprim)		
Test 7	Test 8	Test 9	Test 10	Test 11	Test 12
A – N	B – N	C – N	a – n	b – n	c – n

The test transformer used for an experimental ascertainment of mechanical faults of the windings and the core was liable to the measurements according to Tab. 3 by using of DOBLE M5100 apparatus. There are needed reference measurements for a detailed analysis of the measured frequency responses, (Fig. 2). Because of brevity, we introduce only results from the open-circuit measurements (test 1-6).

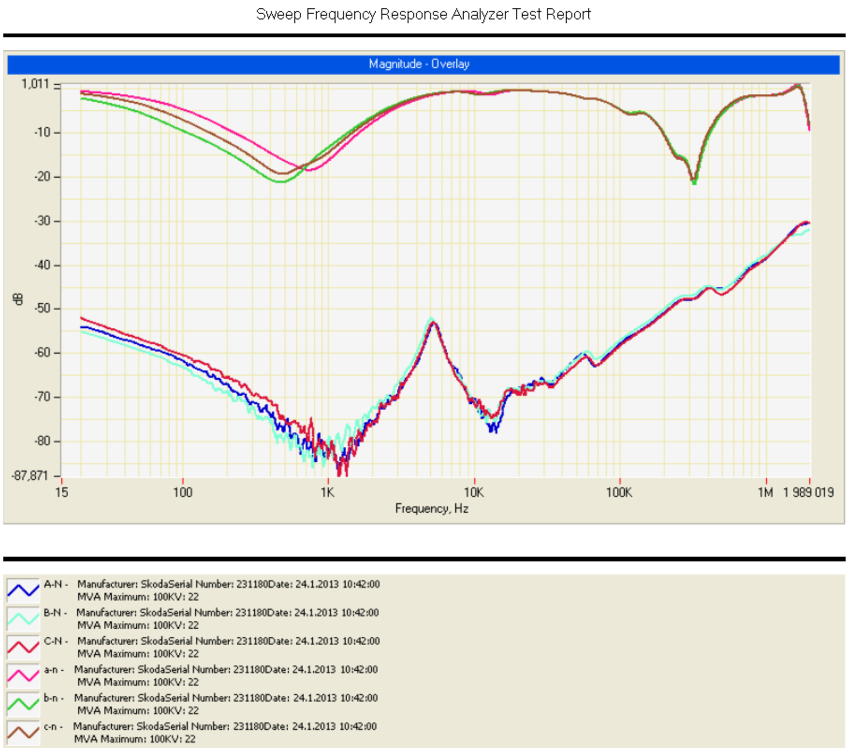

Fig. 2. Reference responses for the open-circuit methodology of the primary and the secondary windings.

2. THE CREATING OF THE FAULT IN THE EXPERIMENTAL TRANSFORMER

The change of a waveform shapes for a secondary and a primary winding can be seen from frequency responses shown in fig. 3.

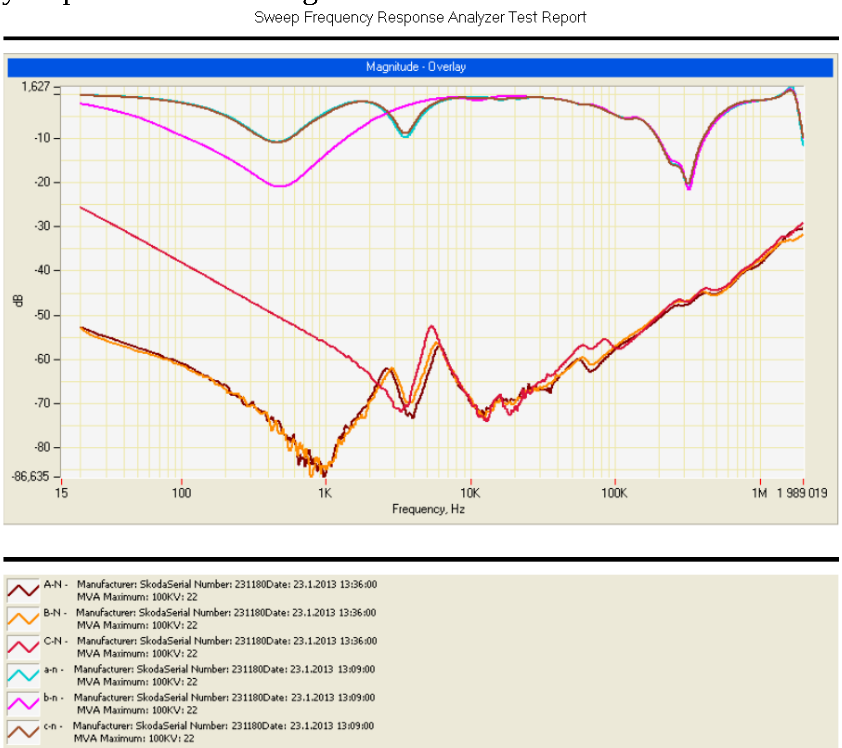

Fig. 3. Frequency responses after the interturn fault creating (open circuit methodology).

Either of fault on some winding, or on a core rebound in frequency response. In our case, the fault in the phase C of the primary winding is concerned. It can be seen that a shape of green waveform (C-N) is changed. The magnitude of the curve is displaced by several dB compared to other two phases in a frequency range of 10 kHz. The interturn fault affected a shape of secondary winding responses as well. The secondary winding is interconnected in star connection (zig-zag). It means, that change of a mutual inductances, interturn capacitances, capacitances between respective windings, capacitances between windings and the core, etc. affect the whole measured impedance values. Those express as a change of responses shape by measuring of two phases together, as they are split in a half and are on two pillars of the transformer core. Therefore, it is important to realize all measurements according to Tab. 3 for this transformer type. We are able in that case to identify a fault type and also its approximate location.

There are in Fig. 4 and 5 frequency responses for axial displacement fault. The fault was created mechanically on the phase A of primary winding. The detailed change is in Fig. 5, when the response is displayed for measuring A-N reference and after created the fault. It can be seen in Fig. 2 and then in Fig. 4 small differences between reference and after fault responses. The axial displacements faults are very difficult to identify when we do not have reference measurement, because these responses are identified also to fault in transformer core.

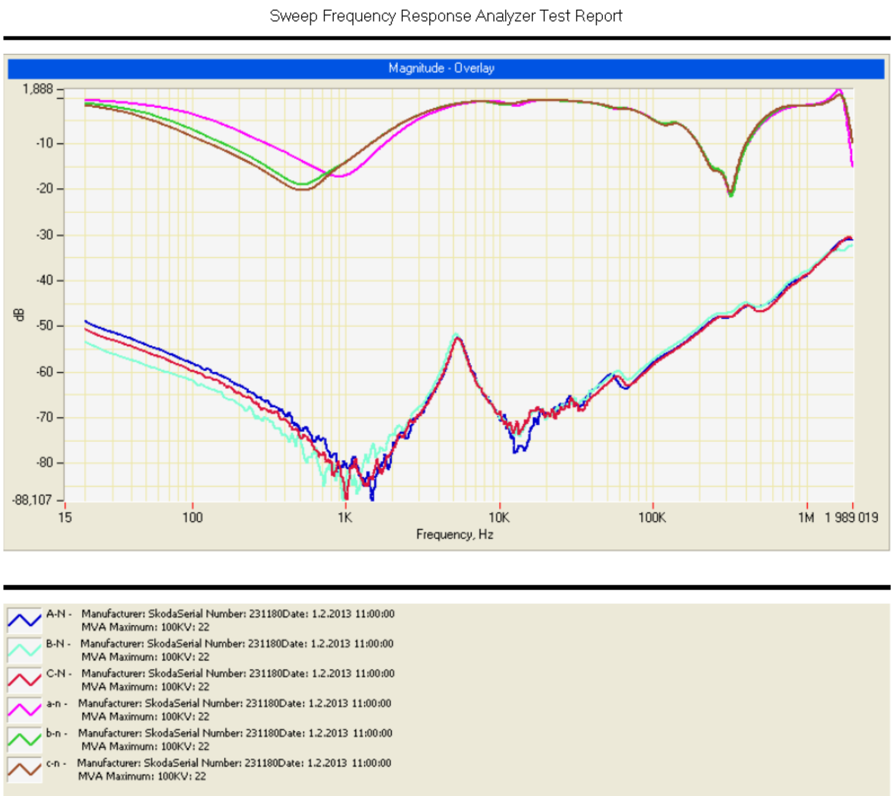

Fig. 4. Frequency responses after the axial displacement fault creating (open circuit methodology).

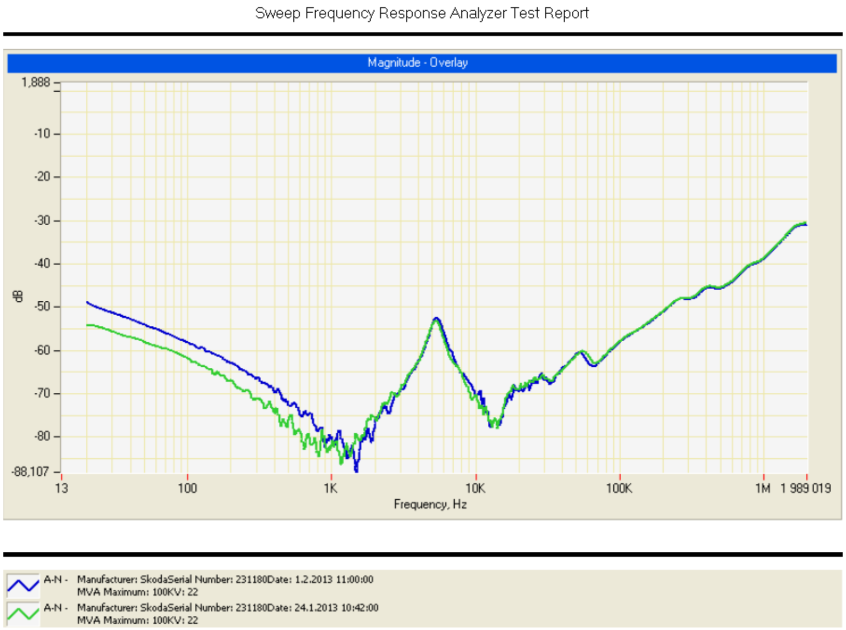

Fig. 5. Frequency responses A-N reference and after creating the axial displacement fault (open circuit methodology).

3. THE FREQUENCY RESPONSES OF THE POWER TRANSFORMER

The reference frequency responses of the power transformer SKODA type 5ER 33M are in Fig. 6, the transformer was measured on June 6, 2012, and then the transformer was switched off by the Buchholz relays on August 31, 2013. The parameters: insulance, capacitance, winding resistances, tg δ, SFRA, chromatographic of transformer oil were measured after switching off the transformer. The obtained results acknowledged the internal fault in measured transformer. The fault was evaluated from the results of SFRA measurement for specification.

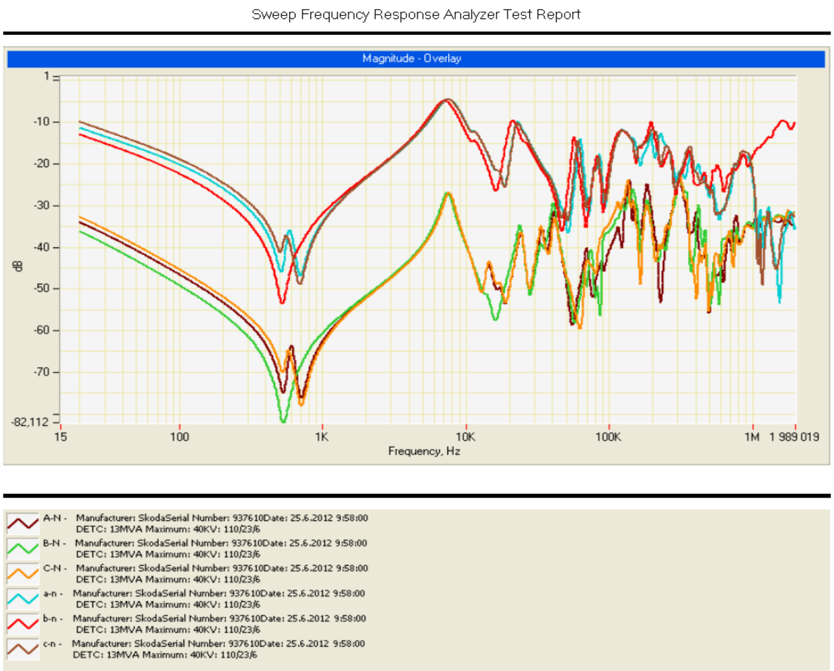

Fig. 6. Reference responses for the open-circuit methodology of the primary and the secondary winding power transformer T102.

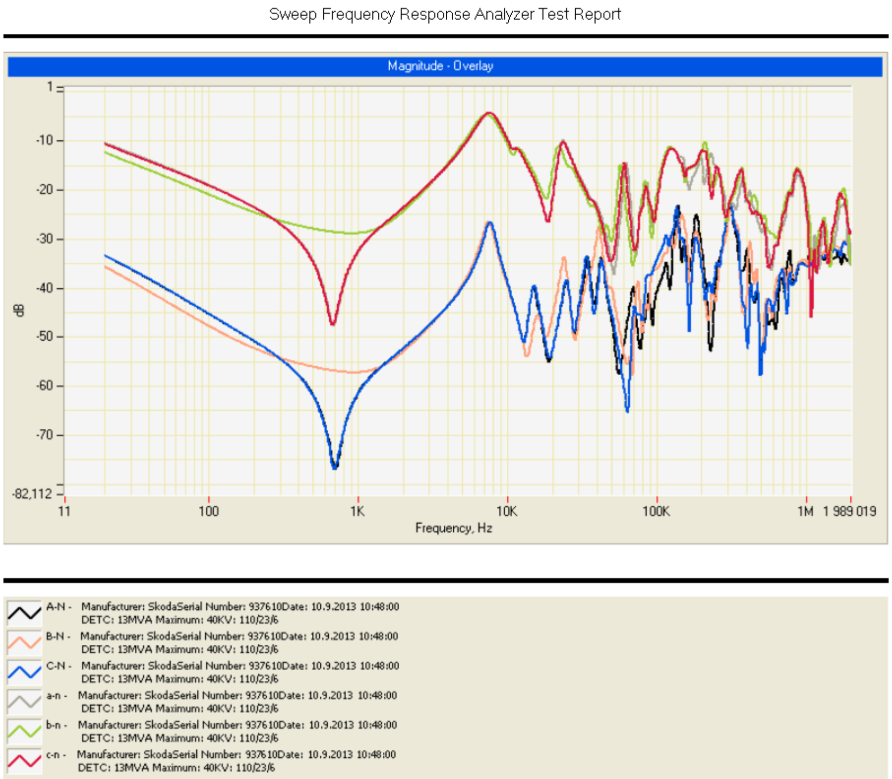

Fig. 7. Frequency responses after the fault for transformer T102 (open circuit methodology).

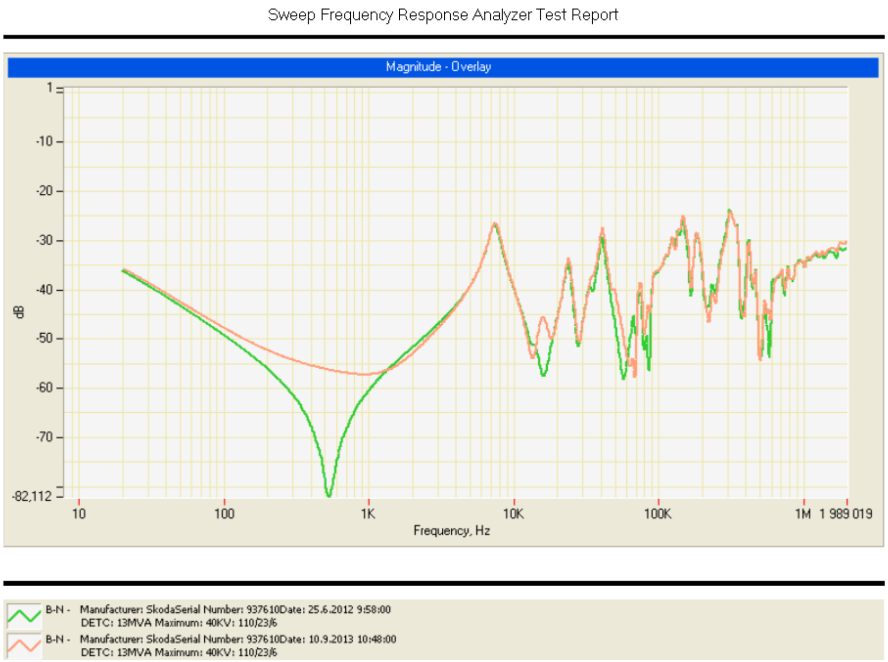

Fig. 8. Frequency responses B-N reference and after the fault for transformer T102 (open circuit methodology).

The frequency responses from transformer after switch off from the Buchholz relay are in Fig. 7 and 8. It can be seen in Fig. 7 the responses from B-N and b-n measurement which are different when A-N or C-N. These are responses from Open circuit measuring methodology. It can be consider from Open circuit measurement if the transformer is in mechanical fault, but the type of fault can be find from Short circuit methodology and from calculation of Cross Correlation Coefficients (CCFs) [3].

CONCLUSION

The transformer T102 has not tertiary bushings for SFRA measurement. The transformer has only one tertiary bushing for measurement of capacitance and isolation resistance. The results from measuring capacitances shoved on mechanical fault between tertiary and secondary windings. The capacitance between tertiary and secondary windings measured on June 6, 2012 had value 162.4 pF and after September 2, 2013 the capacitance value was changed to 14.22 nF. The changes in other capacitances were not markedly different. The results from SFRA analysis are very interesting. The methodology of Open circuit shoved the fault in phase B (is can be seen in Fig. 7 and 8.). The CCFs calculated between reference and after fault responses for the T102 are in Tab. 4. The good correlation has to be in interval 0.95 – 1.00.

Tab. 4. Cross Correlation Coefficients for the transformer T102 (Open circuit measuring methodology).

Frequency range	100 Hz - 1 kHz	1 kHz - 10 kHz	10 kHz - 100 kHz	100 kHz - 500 kHz	500 kHz - 1 MHz
A-N	0,9343	0,9993	0,9174	0,9926	0,9944
B-N	0,828	0,9958	0,8308	0,9794	0,9449
C-N	0,9826	0,9991	0,9338	0,9919	0,9844
a-n	0,9264	0,9992	0,9871	0,9956	0,9906
b-n	0,8022	0,9935	0,8819	0,9304	0,7664
c-n	0,9822	0,9989	0,9796	0,9929	0,9903

The CCFs are very different for measurement B-N (primary winding) and b-n (secondary winding). The changes in frequency responses for this measurement indicated on the type of fault of axial and radial displacement of phase B winding. We know that the transformer has not two tertiary bushings for SFRA measurement; the fault can be in this winding. We can gather from practical measurements, which were done on experimental transformer, that the fault has type of interturn short circuit on the tertiary winding of transformer T102. The transformer T102 will be open in December 2013, and then the type of fault will be acknowledged.

ACKNOWLEDGMENT

This paper was done within the project APVV-0703-10 – Analysis and diagnostic measurements of power transformer by Sweep Frequency Response Analysis.

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Authors:
University of Žilina, Faculty of Electrical Engineering, SLOVAKIA; Univerzitná 8215/1,
010 26 Žilina; E-mail: martin.brandt@fel.uniza.sk, jan.michalik@fel.uniza.sk.