Detecting Winding Faults of a 125V/50V Single Phase Transformer Using SFRA Method

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Abstract

This paper illustrates how the winding fault types can be determined by Sweep Frequency Response Analysis (SFRA). The authors have used the technique for creating the results are illustrated. The single-phase transformer of 125V/50V has been analyzed and simulated, and it will be explained how to determine faults in windings and core of the transformer, in addition all results have been discussed and presented. This work is prepared in the lab regarding the SFRA guide lines. The measurements for both windings and core faults are analyzed

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using sweep frequency of 20Hz up to 20MHz applied to a 125V/50V 1-ph transformer under both normal and defective conditions. The experiment results have been drawn and the conclusion has been also carefully illustrated.

Keywords: *Single-phase transformer, Winding movement, Sweep Frequency response analysis, Core, Frequency, Fault*

Introduction

One of the most complete measurements at the transformer deformation is Sweep Frequency Response Analysis (SFRA), which is detecting deformation mechanic structure within the transformer. SFRA is an effective device, it is able to supply complete information on the winding mechanical structure and also the center and clamping shape, that is critical as even little winding and core deformation in the winding and middle can spread into a failure of the transformer underneath fault circumstance. Center damage can be because of shrinking from a thin transformer, whilst harm's middle is caused by the quick circuit. SFRA method talks approximately about detecting the deformation mechanic transformer. SFRA is a diagnostic gear that may get a demonstration from a mechanic fault like a center or winding movement of a transformer, and electric powered fault, as an example, brief – circuit and partial discharge. based totally on the injected enter signal, there are special forms of SFRA such as impulse voltage-based totally evaluation response frequency, sinusoidal sweep frequency reaction evaluation, etc. [1]. Basically, offline FRA, which has been widely used for commissioning and situation monitoring. However, the translation and evaluation of the effects remains of research hobby because of the sensitivity of the take a look at too many one-of-a-kind parameters [2]. In this paper, a 125/50V 1-phase transformer is simulated using a new technical method termed sweep frequency response analysis (SFRA). This technique is used to examine winding properties in terms of frequency response. Figure (1) shown below is the type of transformer used for this study.

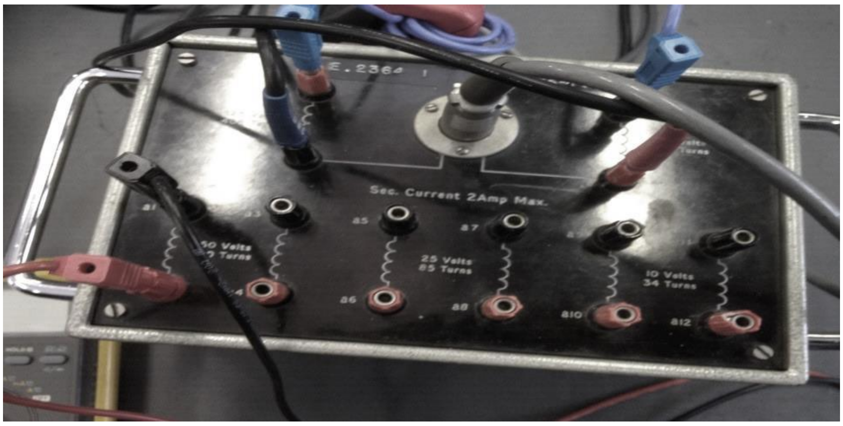

Fig.1 A 125/50V single phase transformer used for case study.

SFRA Application

The assessment of transformers transportation is a more and more famous application of the SFRA technique. this is reasonable because of the potential of SFRA to offer in-intensity information about the middle, the windings, and the clamping structures, as well as one set of exams. these kinds of components are at risk of transportation damage. As for all different programs of SFRA, appearing the test under the same situations is crucial to get dependable results. consequently, the preliminary test shall be done at the transformer in its delivery configuration [3]. This test is primarily used to detect incipient transformer defects. The collected results are compared to a reference data set, and differences are used to establish the fault type and location.

SFRA Measurements

There are two wonderful environments for the utility of sweep frequency response dimension: inside the manufacturing unit and inside the discipline. In both cases, the methods and precautions used to generate a great size are identical. however, there may be a distinction in motivation for the tests in every category. reasons to apply SFRA in manufacturing facility surroundings encompass exceptional warranty, baseline reference, relocation, and commissioning instruction. motives to use SFRA in an area surrounding include relocation and commissioning validation and post-incident: lightning, fault, brief circuit, seismic event, and many others [3].

Frequency response is the quantitative degree of the output spectrum of a machine or tool in reaction to a stimulus. it's miles a measure of magnitude and phase of the output as a feature of frequency, in contrast to the input. The regular implementation of this take a look at is based in introducing a variable frequency sinusoidal sign and measuring the magnitude and phase at the other side of the detail measured. A transformer may be taken into consideration as a complicated network of inductances and capacitances, and this community relies upon totally on mechanical/electrical parameters, the frequency reaction of a specific transformer acts as a fingerprint of this transformer and ought to continue to be the equal in the course of its lifestyles. The SFRA effects are based totally in the assessment of the fingerprint along the time, and consequently any parameter that might have affect inside the curve need to be prevented as those may want to inadvertently be understood as a transformer hassle. As a preferred guideline, shorted turns, magnetization and other problems related to the center adjust the form of the curve within the lowest frequencies. Medium frequencies constitute axial or radial actions inside the windings and high frequencies indicate problems regarding the cables from the windings to bushings. Figure (2) below illustrates an example of low, medium and high frequency generated by SFRA. SFRA (M5300 SFRA analyzer) is used to test a 125/50V single phase transformer [3-5].

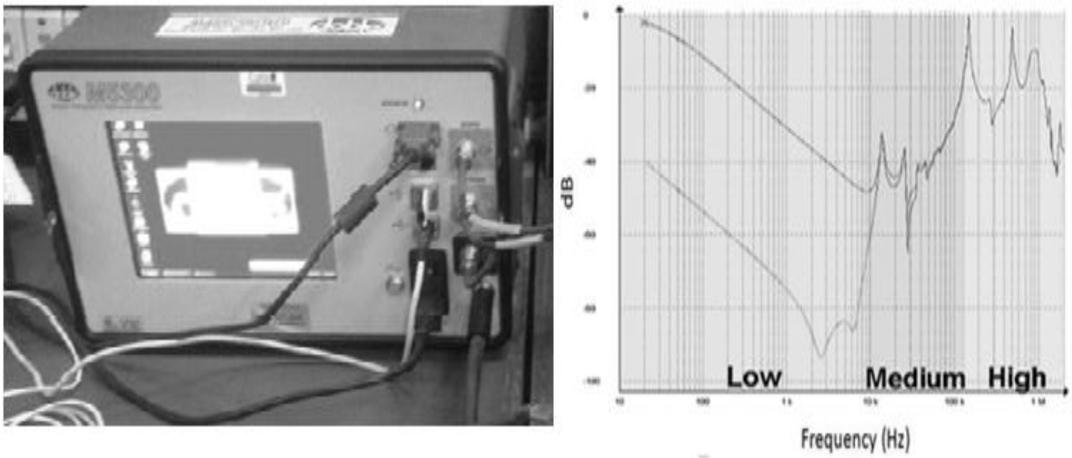

Fig.2 M5300 SFRA analyzer & an example of low, medium and high frequencies[3].

Case study and the laboratory experiments

The M5300 SFRA device was utilized to generate signals between 20HZ and 2MHZ in this experiment. The experiment's main goal is to determine the 1-phase transformer's fault types, which appears as waveforms of magnitude of transformer, impedance, attenuation, and voltage level. The SFRA approach will be used to emulate all of these parameter’s waveforms.

Figure (3) below illustrates how to test a 125V/50V 1-ph transformer using two, and three SFRA analyzer, respectively. The 1-phase transformer was linked to the SFRA device, which was then connected to the computer for viewing waveforms and findings. In general, the SFRA analyzer has input and output channels that are coupled to the primary and secondary windings of single-phase transformers, with the transformer being examined when it is out of service.

Essentially, this experiment is designed to examine the faults of a transformer. Basically, a one-phase transformer was examined with an SFRA5300 analyzer connected to a computer via an adobe software to determine winding parameters & fault types.

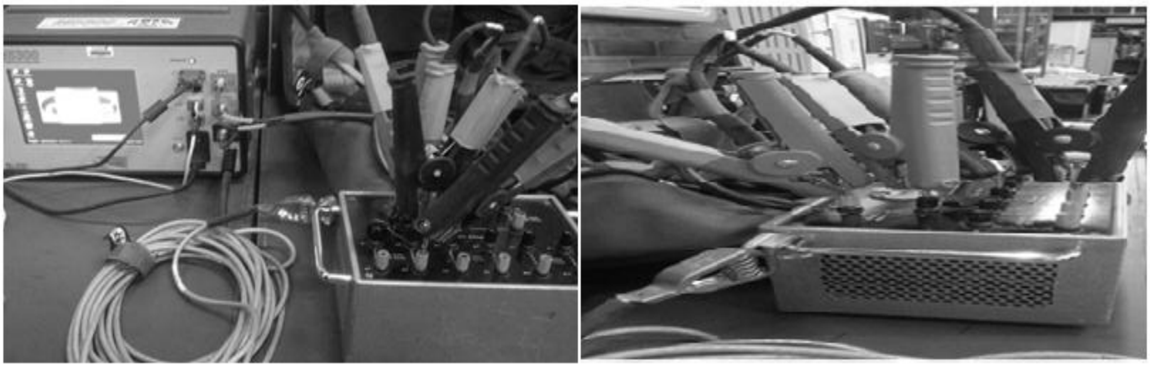

Fig.3 Case.1&2. Two & three SFRA laboratory experiments on a 125/55V single-phase transformer.

Measurement results & discussion

Case 1. Measurements results of two SFRA applied on a 125/50V single-phase transformer

The findings of the SFRA of the single-phase transformer response faults are shown in the following figures. The relationship between magnitude and frequency indicates how the response waveform evolves, as seen in figure (4.1). It is well known that identifying the faults of 1-phase transformers is critical, and in this test, it was discovered that the transformer began operating at a high frequency (2MHz), then started changing rapidly to a mid-frequency, and finally to a low frequency. This can be caused by the parameters and coils of the transformer causing the response not to be identical at any frequency. However, all of the figures below show that the transformer is working properly, with minor variations at the mid 5KHz – 50KHz and high 50KHz – 2MHz frequencies.

Figures below show also how windings compressive failure affects FRA readings. It's a mutual reason that could have an impact on the transformer windings. The SFRA response reveals a strong phase shift to high frequencies.

The variation in response in high and mid-frequency frequencies can be seen from the figures illustrated as below. It can also be seen that the SFRA in transformer can produce very similar results, so repeating the experiment many times will yield different results, but there will be variation in the traces, indicating that the windings have moved or deformed. The figures below show also the relationship between frequency and amplitude, impedance, admittance, in addition voltage waveform.

The results show that there have been changes in response in high and mid-frequencies, and the windings have been tested under different conditions (changed conditions), and there have been changes only at high frequency due to switching the transformer off, and the response has changed in high and mid-frequencies. It can be seen that the SFRA in transformer can produce very similar results, so repeating the experiment many times will yield different results. However, there is a significant variation in the windings in this set of results, implying that the windings have been affected by a capacitor used as a fault to produce different results.

The relationship between frequency and magnitude has changed, as evidenced by the results, and the windings have been tested under different conditions (changed conditions), with the change occurring at all frequencies as a result of changing the terminals of the transformer connected to the FRA device. The relationship between impedance and frequency, as illustrated in figure (4.2) that the winding fault is at the range of 1MHz up to 2MHz caused by the transformer components were more inductive or capacitive.

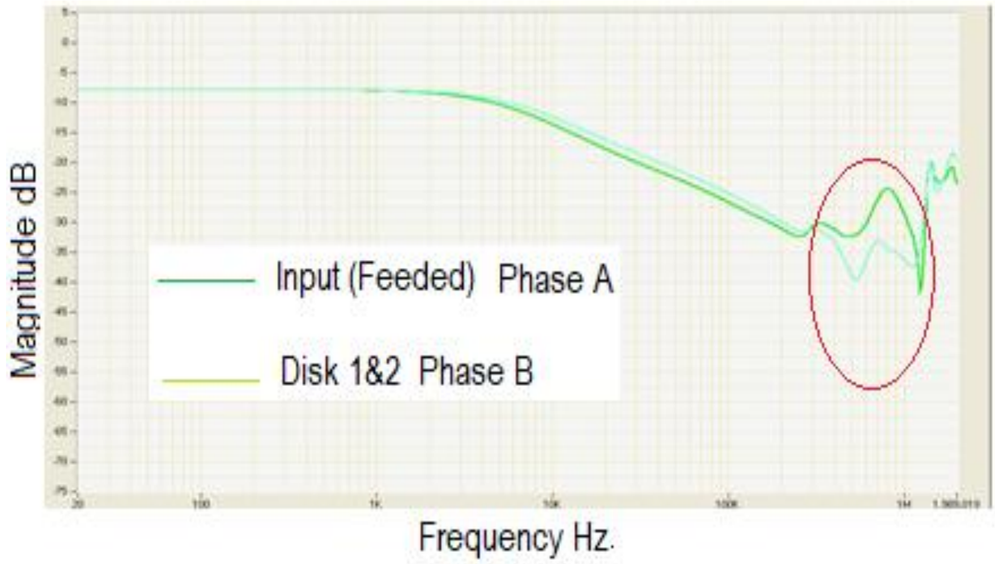

Fig.4.1 Winding compressive failure on SFRA measurements.

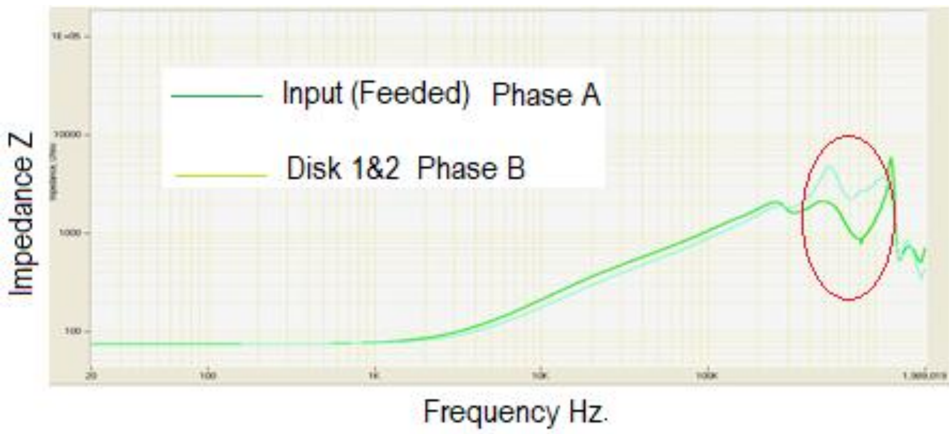

Fig.4.2 Winding compressive failure on SFRA measurements.

The SFRA measurement on a single-phase transformer (125V/50V) is shown in the figures below. The response of the transformer has changed to a short circuit fault, as indicated in the relationship between frequency and magnitude in figure (4.3). The SFRA in the power transformer has produced very different results, so repeating the experiment many times will yield different results, but in this case, there is a lot of variation in the measured response, which indicates that the windings have been moved. Moreover, the figures below show the relationship between the frequency and the measured response (Amplitude & impedance).

The results clearly show that the response has changed, and the windings have been tested under different conditions. The changes occurred at low, high, and mid frequencies from 80KHz to 100KHz. However, there is a significant change in the resulted waveforms from 100KHz to 2MHz when transformer is turned off, as illustrated in figure (4.4) below.

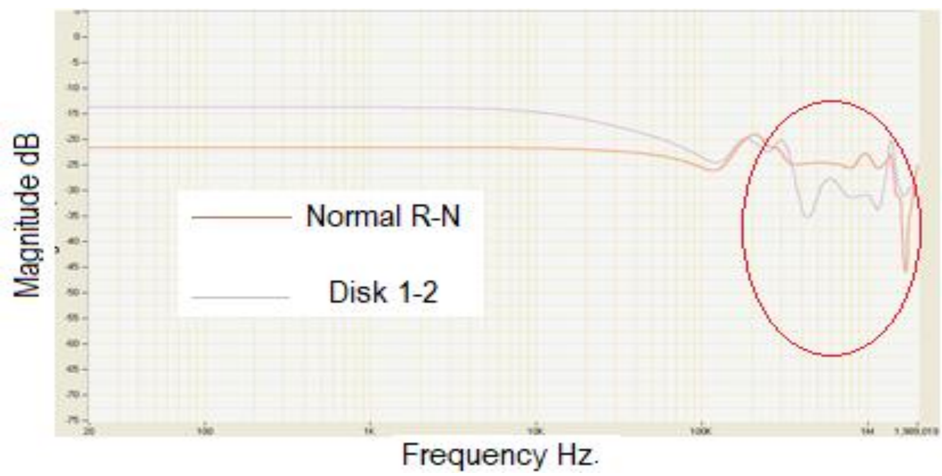

Fig.4.3 SFRA measurement winding compressive failure test under changed conditions.

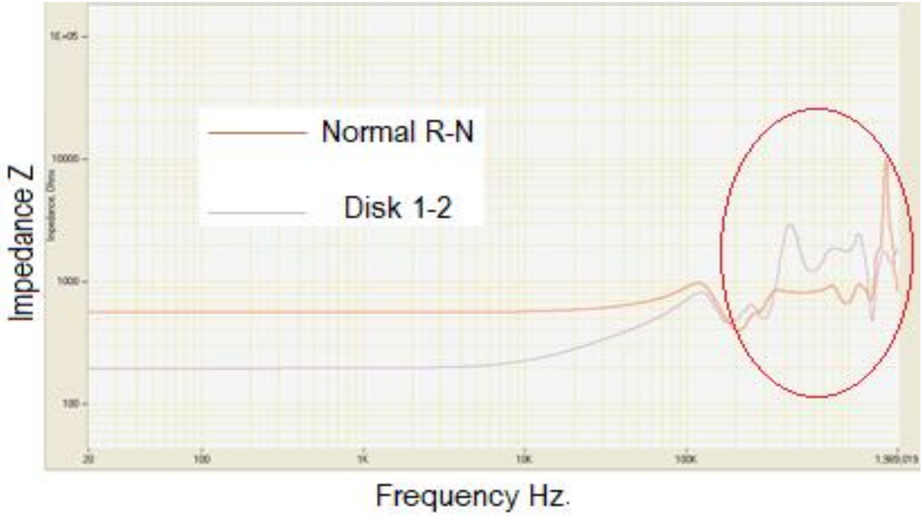

Fig.4.4 SFRA measurement winding compressive failure test under changed conditions.

The SFRA results for single-phase transformer are shown in the following figures. It can be seen that the SFRA in a power transformer can produce very similar results, so repeating the experiment many times will produce different results, but there is a lot of variation in the windings, which indicates that the windings have been affected by a capacitor used as a fault to produce different results, so the figures below show the relationship between frequency & amplitude, impedance, admittance, and phase angle. The result clearly shows that the response has changed, and the windings have been tested under various settings (changing conditions), with the change occurring at all frequencies as a result a fault due to turning off the transformer as illustrated in figures (4.5 – 4.7).

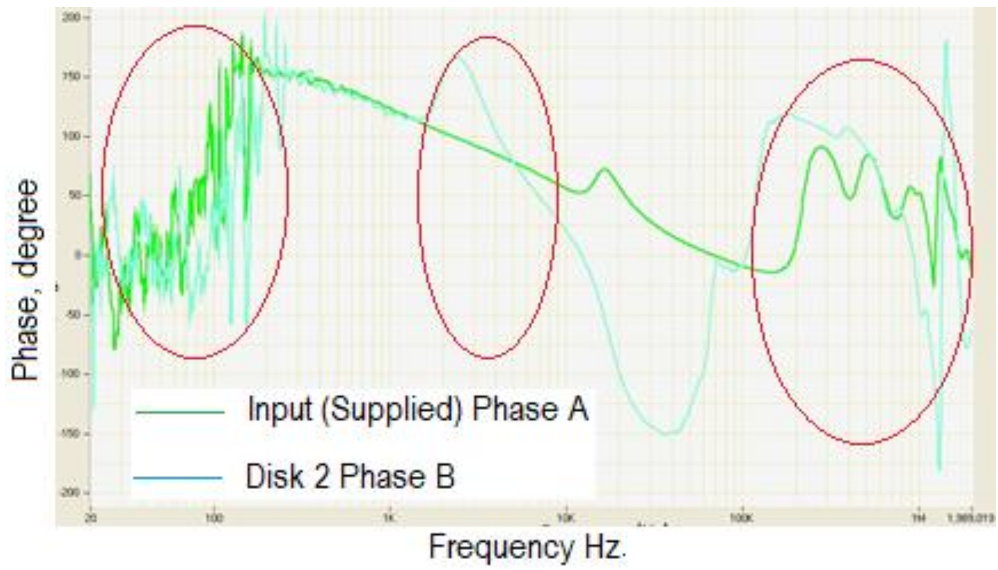

Fig.4.5 Comparison of pre-fault and after fault SFRA with HV open circuit.

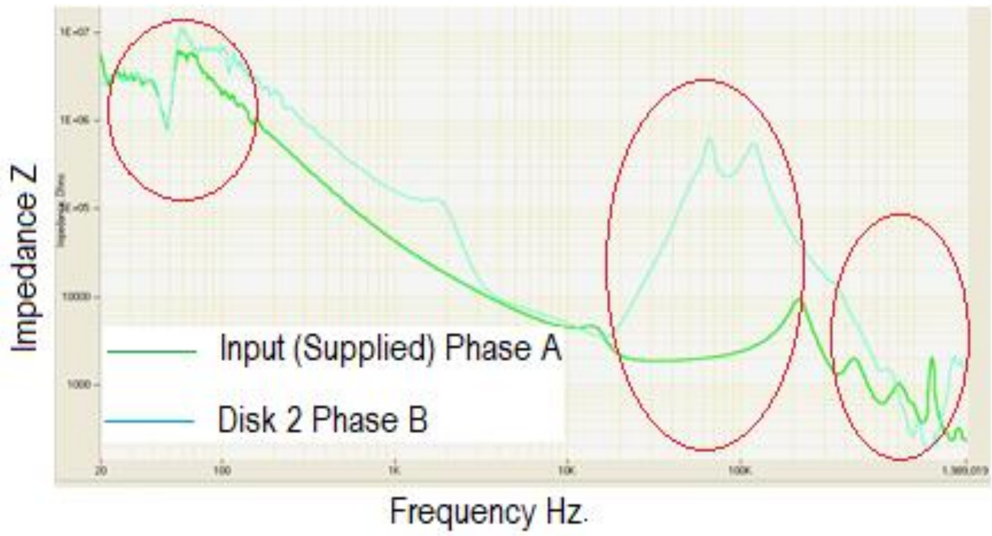

Fig.4.6 Comparison of pre-fault and after fault SFRA with HV open circuit.

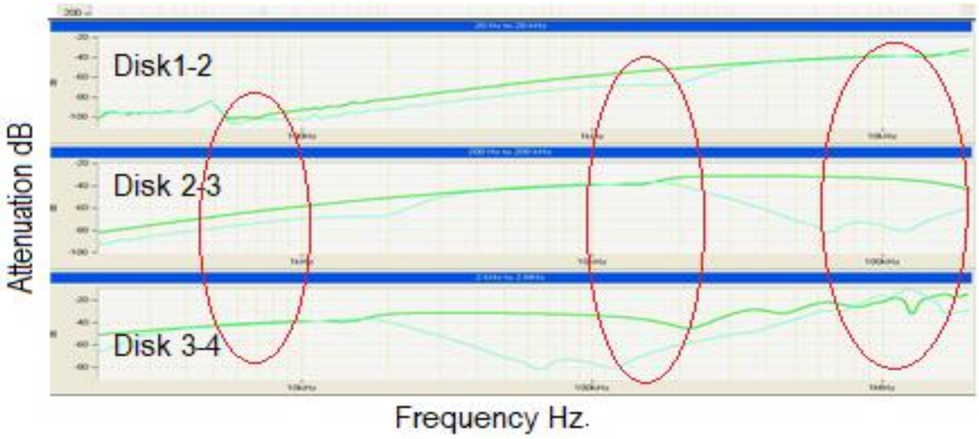

Fig.4.7 Comparison of pre-fault and after fault SFRA with HV open circuit.

In figure (4.8) below illustrates that there are changes of the winding characteristics from 5MHz to 2MHz, and this leads transformer windings get affected by fault type of deformation at LV side during open circuit test.

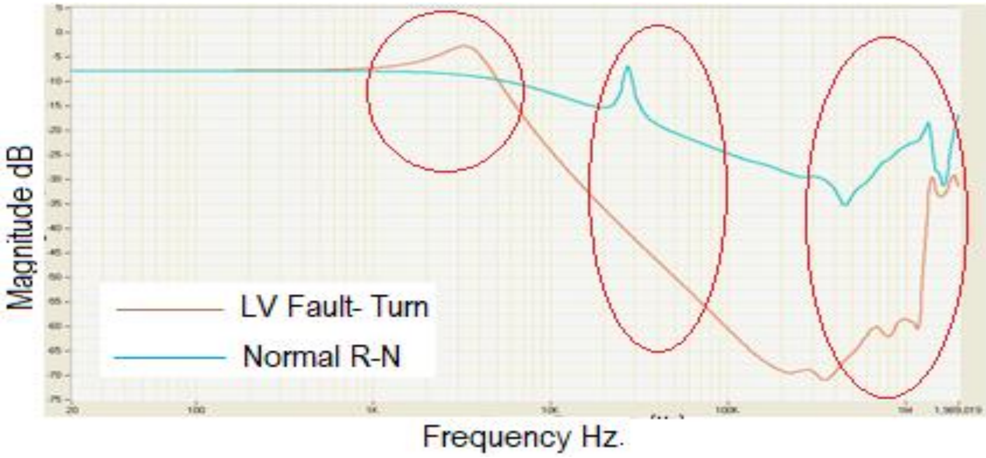

Fig.4.8 Comparison of the effect of LV inter-turn faults on SFRA, LV windings left open and measured from HV windings.

Case 2. Measurement results of three SFRA applied on a 125/50V single-phase transformer

The consequences of windings compressive failure due to axial displacement on SFRA measurements are depicted in figure (5.1). It's a mutual reason that could have an impact on the transformer. The SFRA response reveals a strong phase shift to higher frequency.

In general, the figures (5.2 & 5.3) reveal that there is a change in response in the high and mid-frequencies. It can also be seen that the SFRA in a power transformer can produce very similar results, so repeating the experiment many times will yield different results. However, there is variation in the traces in these results, indicating that the windings have moved or deformed. The figures below depict the relationship between frequency and amplitude, impedance and phase angle.

The results clearly show that there have been changes in response at high and mid-frequencies, and the windings have been tested under different conditions (changed conditions), and there have been significant changes at high frequency due to switching the transformer off, and the response has changed at high and mid-frequencies. All of the figures below, however, demonstrate that the transformer is performing well, with minor variations at the mid (7KHz – 50KHz) and high (60KHz – 2MHz) frequencies. Furthermore, the output voltage is reduced to zero due to short turn applied on the experienced transformer during the heavy test, leads to unhealthy windings in the transformer at illustrated in figure (5.4) below.

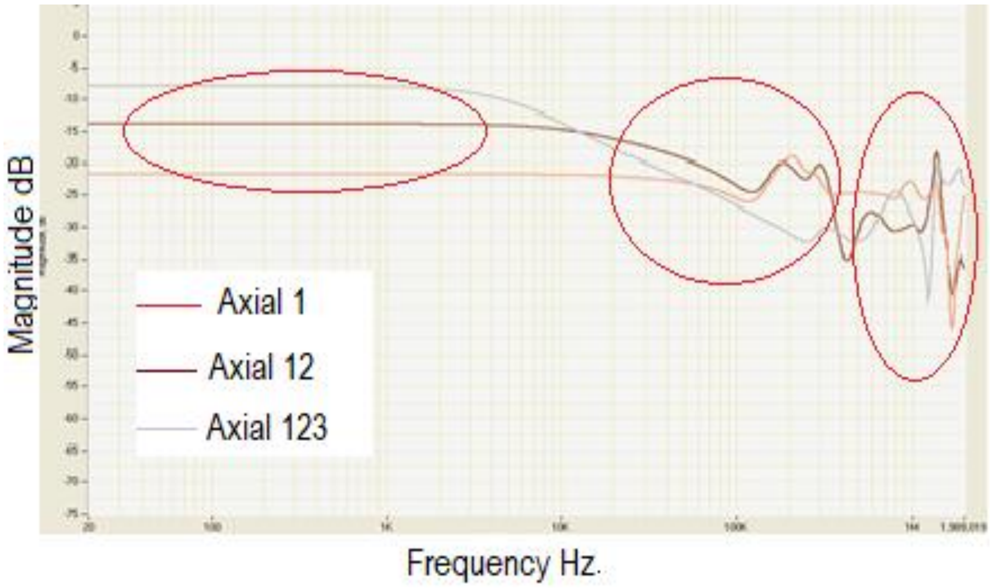

Fig. 5.1 Winding deformation and axial displacement characteristics.

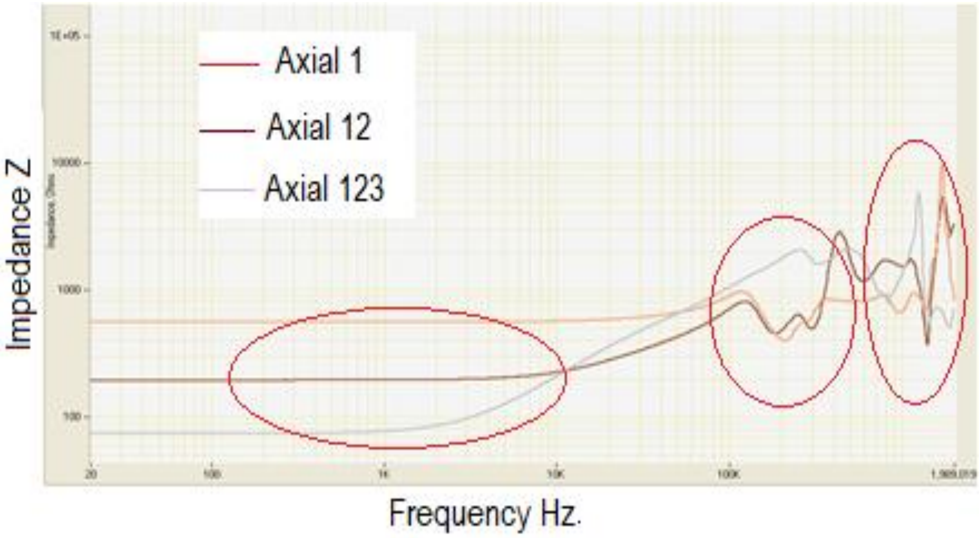

Fig. 5.2 Three SFRA measurement of axial displacement.

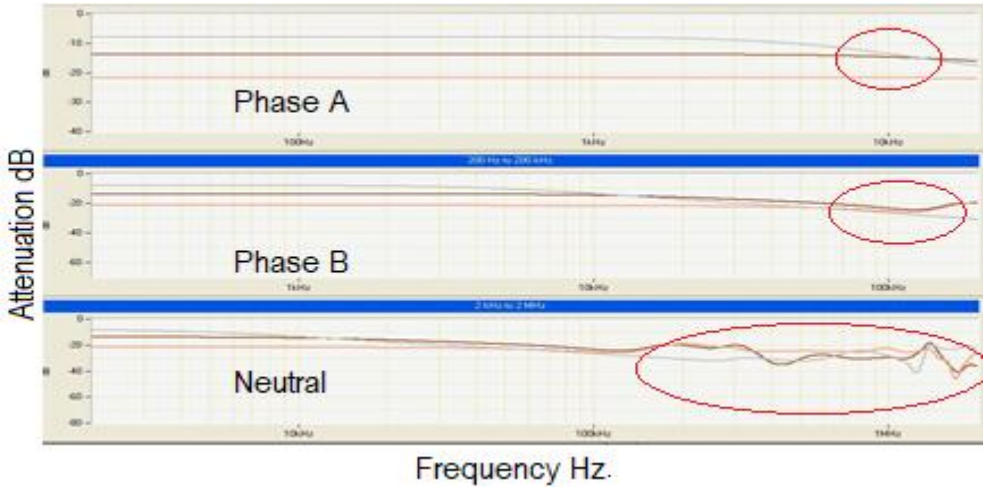

Fig. 5.3 Three SFRA measurement of core faults.

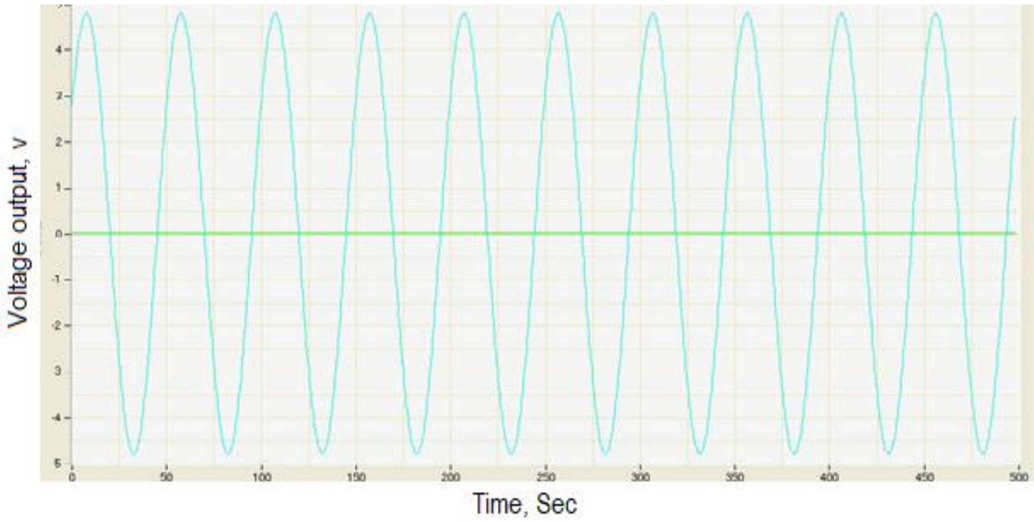

Fig. 5.4 Three SFRA measurement on unhealthy single-phase transformer.

Conclusion

This study was effective in introducing a new technique for determining a 125V/50V single-phase transformer's fault types. Essentially, the majority of transformer windings characteristics change as a result of experiencing the transformer by adding capacitors and inductors to its windings, which leads to the transformer being tested properly. In addition, the amplitude, impedance, and attenuation characteristics of the used transformer have been graphically identified. SFRA data from a 125V/50V 1-ph voltage transformer were used to apply the transformer model. Through frequencies up to 2MHz, the outcomes of winding fault types have been graphically presented and the simulated results were discussed.

References

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