Analyzing a 440/55V 3-ph Transformer Characteristic Using SFRA Technique

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Abstract

Power transformer is the most expensive equipment in power system, and because the function of power transformer pivotal for utilities, hence the reliability of power transformer is required during the prohibition aspects in the power system. Consequently, a new technique must be invented for detecting the three phase transformer operations that must be always investigated whether it is operating as it should be or not. In this paper, the characteristics of a 440/55V three-phase

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transformer will be detected using Sweep Frequency Response Analysis (SFRA), which is a powerful graphical technique used for detecting varied characteristics in three-phase transformers.

KEYWORDS. *440/55V Three Phase Transformer - Coil - Core Windings - Faults – SFRA – Magnitude – Impedance – Admittance – Attenuation – Frequency – Time.*

1. Introduction

In the past decades, the massive improvement and optimizations in transmission and distribution energy systems have not been developed effectively, but for the ability of connecting the transmission lines and generators as well as the distribution systems, which are the secondary part that can distribute the powerful energy to the varied loads through this power system. Power transformer is challenged matter. Consequently, the failure of equipment like power transformer is huge problem. Power transformer can be damaged by over voltage levels, overloading, and not investigating it for a long time, therefore all these issues can generally affect in the 3-ph transformers.

Power transformer faults can happen at any moment; hence if there are no illustrations or powerful techniques used, the power transformer will be damaged. Consequently, a new technique should be provided for detecting the faults of power transformer. In this paper, a new technical method called sweep frequency response analysis used for detecting and analyzing a three-phase transformer characteristic as shown in figure (1). This technique used to test both windings characteristic and their frequency response too.

Fig.1 A 440/55V three phase transformer model used for the study (Curtin University Laboratory).

2. Sweep Frequency Response Analysis Technique

Frequency Response Analysis (FRA) is a technique used to monitor the condition of high-priced power equipment. The FRA is used to measure the passive element (RLC) frequency response; for example, the transformer winding impedance over a large range of frequencies. This test is primarily designed in order to diagnose transformer incipient faults. The results obtained are matched against a reference data set and differences can be used to determine the type of fault and its location [1,2]. Is this paper, a 440/55V three phase transformer characteristics will be detected using Sweep frequency response analysis technique (M5300 SFRA analyzer) as shown in figure (2) below.

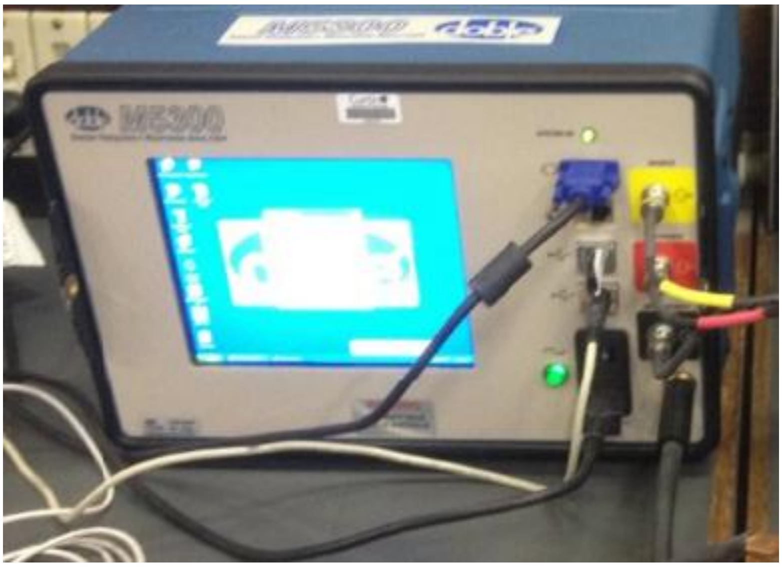

Fig.2 M5300 SFRA Analyser, Curtin University Laboratory.

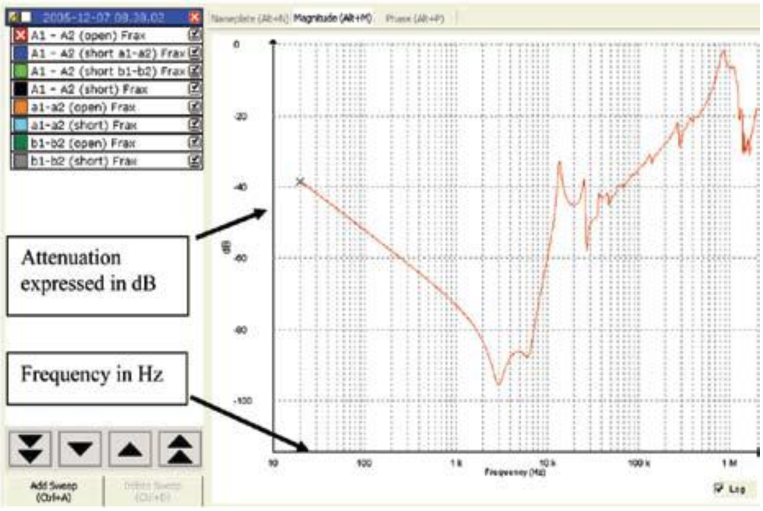

Fig.3 FRA or SFRA is used to measure and analyze characteristic response curves of a transformer [3].

3. The Laboratory Experiment & Case Study

In this experiment, M5300 SFRA device being used for generating signals from 20HZ – 2MHZ. Basically, the purpose of the experiment is to identify the characteristics of the three-phase transformer which are phase angle of power transformer parameters, and also attenuation. Furthermore, amplitude, impedance, and finally admittance. All these characteristics will be tested respecting to SFRA technique.

It can be seen from figures (4.1 & 4.2 & 4.3) below how to test the 440/55V 3-ph transformer using one, two and three SFRA analyzer respectively. Basically, the three-phase transformer connected to SFRA device, and then connected to the computer to view the waveforms and results. Basically, there is input and output attached to SFRA analyzer, and these channels connected to the primary and secondary windings of the three phase transformers, considering that the transformer is tested while it is taken out of service. Basically, this experiment is used and designed to analyze the power transformer characteristics.

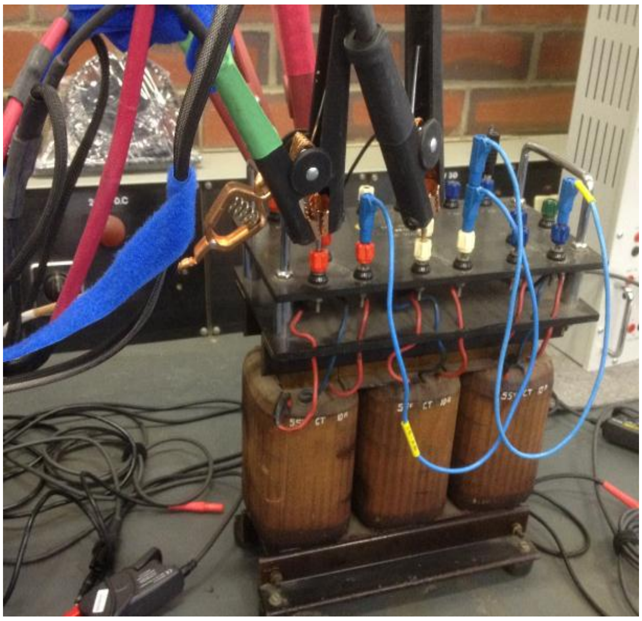

Fig.4.1 Case.1. One SFRA laboratory experiment on a 440/55V 3-ph transformer.

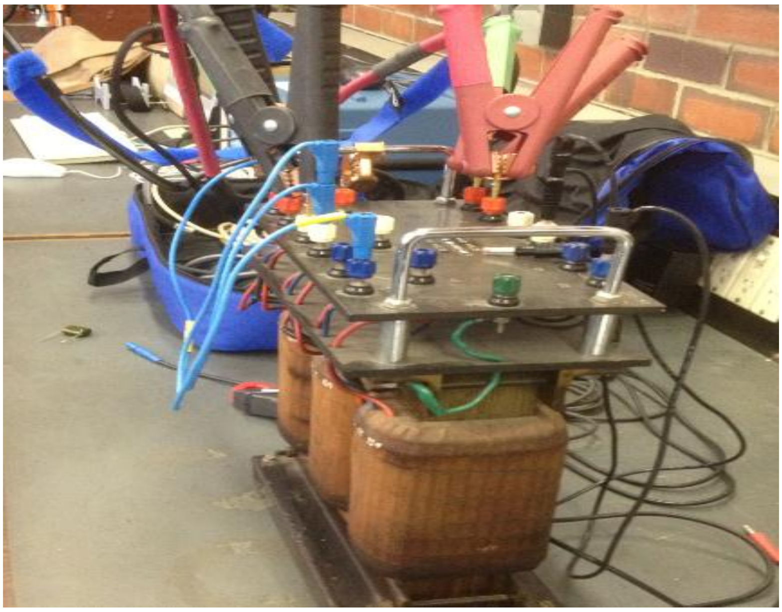

Fig.4.2 Case.2. Two SFRA laboratory experiment on a 440/55V 3-ph transformer.

Fig.4.3 Case.3. Three SFRA laboratory experiment on a 440/55V 3-ph transformer.

4. Simulated Results & Discussions

Case 1: One SFRA measurements measured on a 440/55V 3-ph transformer

The following figures show the SFRA of the three phase transformer response characteristics results. It can be observed from figure (5.1 – 5.5) how the response waveform changes. It is known that the three phase transformers are very complex to identify their characteristic, and in this test, it can be figured out that the transformer started operating at high frequency (2MHz) then goes down to mid then finally to the low frequency, and this can be created because of the parameters and its coils, which power transformer consists of, so this makes the response not to be identical at any frequency. However, all figures shown below tell that the transformer is operating well, but with a little change at mid 5KHz – 50KHz and high 50KHz – 2MHz frequencies.

Fig.5.1 One SFRA of a 440/55V 3-phase transformer (Frequency and magnitude).

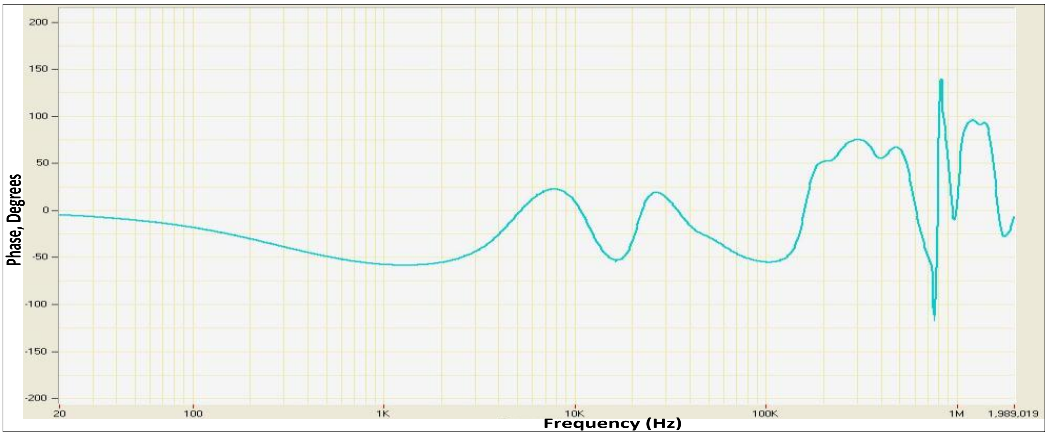

Fig.5.2 One SFRA of a 440/55V 3-phase transformer (Frequency and phase).

Fig.5.3 One SFRA of a 440/55V 3-phase transformer (Frequency and impedance).

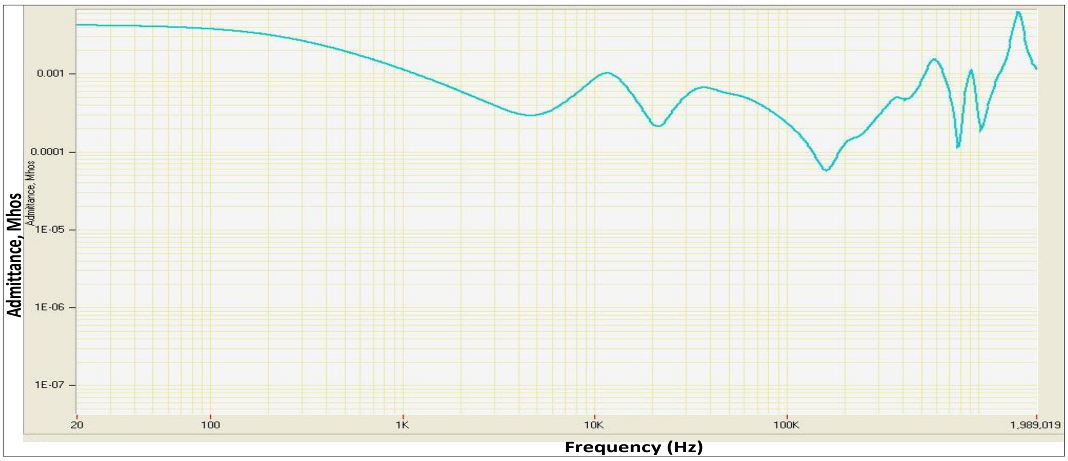

Fig.5.4 One SFRA of a 440/55V 3-phase transformer (Frequency and admittance).

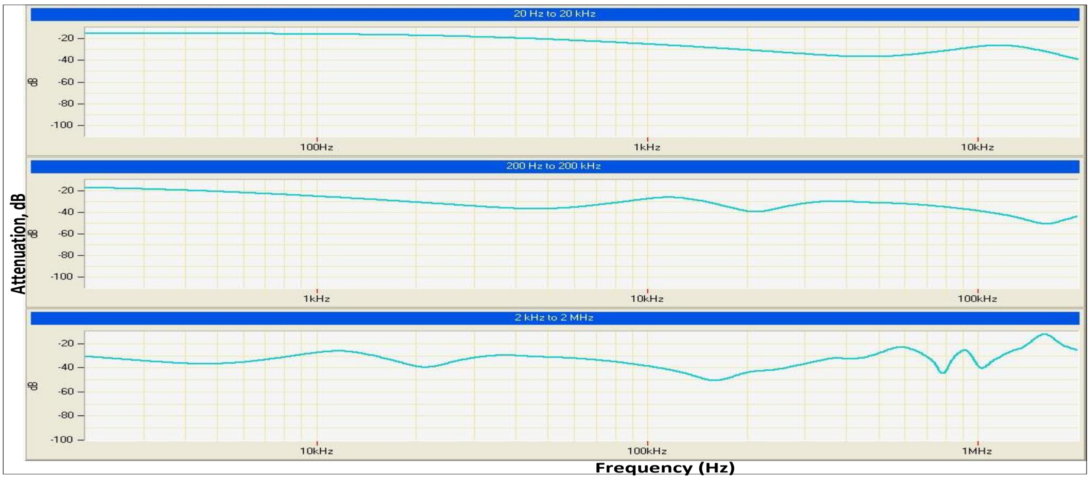

Fig.5.5 One SFRA of a 440/55V 3-phase transformer (Frequency and attenuation).

Case 2. Two SFRA measurements measured on a 440/55V 3-ph transformer

The following figures show SFRA results measured on the three-phase transformer. It can be observed that the SFRA in power transformer can create very similar results, so repeating the experiment many times, the result will vary but in this results there is big variation in the windings, therefore this means that the windings have been affected by a capacitor used as a fault to get different result, so the figures below show the relation between the frequency and Amplitude, impedance, admittance, and phase angle). It is very clear from the result, which the relation between frequency and magnitude, so there has been changes in response, and the windings are tested under different conditions (changed conditions), the change happened at all frequencies due to changing the terminals of the transformer which connected to FRA device. The relation between phase and frequency as shown in figure (6.2) is not important but it is useful to identify whether the measurement is more inductive or more capacitive.

Fig.6.1 Two SFRA measurement of a 440/55V 3-phase transformer (Frequency and Magnitude).

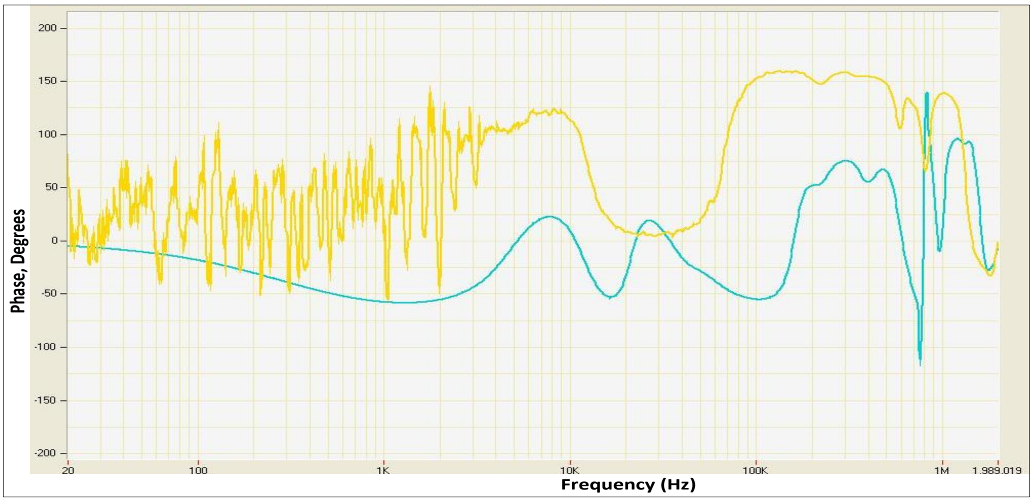

Fig.6.2 Two SFRA of a 440/55V 3-phase transformer (Frequency and phase).

Fig.6.3 Two SFRA of a 440/55V 3-phase transformer (Frequency and impedance).

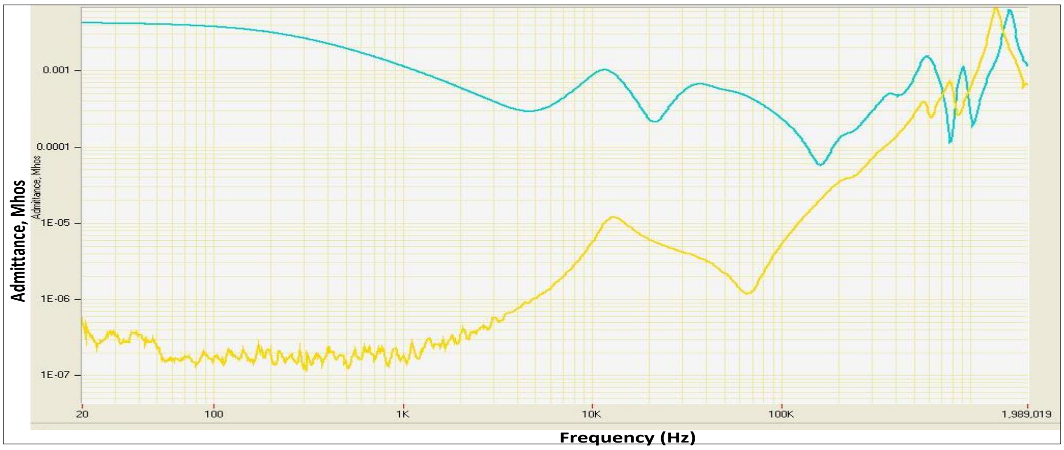

Fig.6.4 Two SFRA of a 440/55V 3-phase transformer (Frequency and admittance).

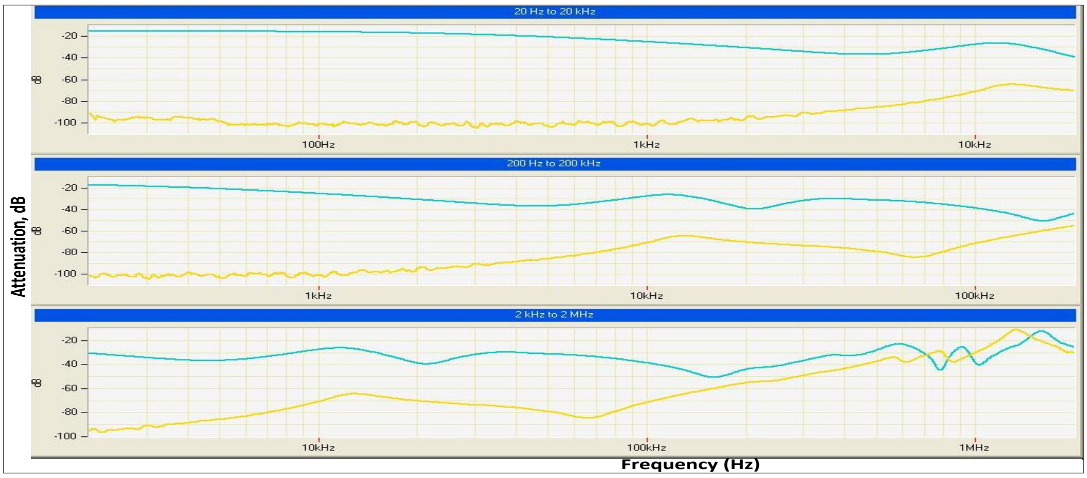

Fig.6.5 Two SFRA of a 440/55V 3-phase transformer (Frequency and attenuation).

Case 3: Three SFRA measurements measured on a 440/55V 3-ph transformer

The graph (7.2) shown below explain the effects of windings compressive failure on SFRA measurements. It is mutual reason, which can affect the transformer. SFRA response shows clear shift to high frequencies to the phase.

Basically, it can be observed from figures (7.1 & 7.3 – 7.5) that there is change in response in high and mid-frequencies show. It can be observed also that the SFRA in power transformer can create very similar results, so repeating the experiment many times, the result will vary but, in these results, there is variation in the traces, so this means that the windings have move or deformed, so the figures below show the relationship between the frequency and Amplitude, impedance, admittance, and phase angle. It is very clear from the result that there has been changes in response in high and mid-frequencies, and the windings are tested under different conditions (changed conditions), and there have been significant changes happened at high frequency due to switching the transformer off, and the response is changed in the high and mid-frequencies. However, all figures shown below tell that the transformer is operating well, but with a little change at mid 7KHz – 50KHz and high 60KHz – 2MHz frequencies.

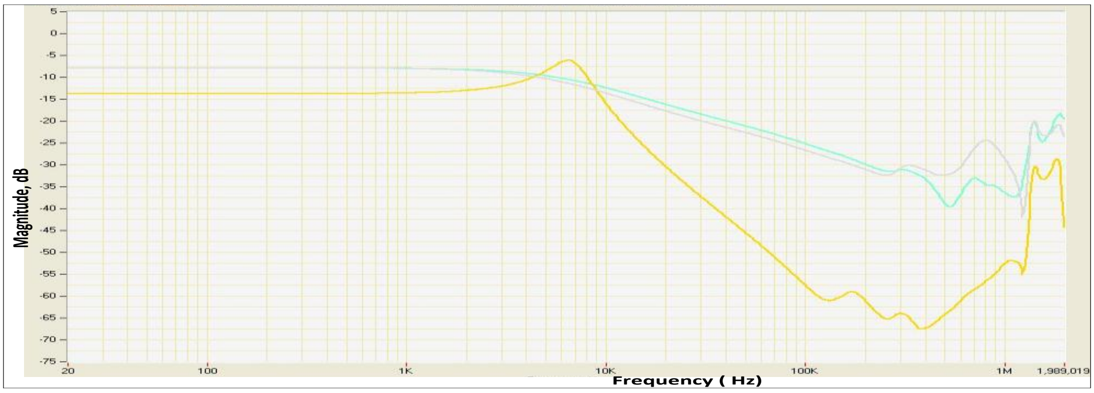

Fig.7.1 Three SFRA measurement of a 440/55V 3-ph transformer (Frequency and magnitude)

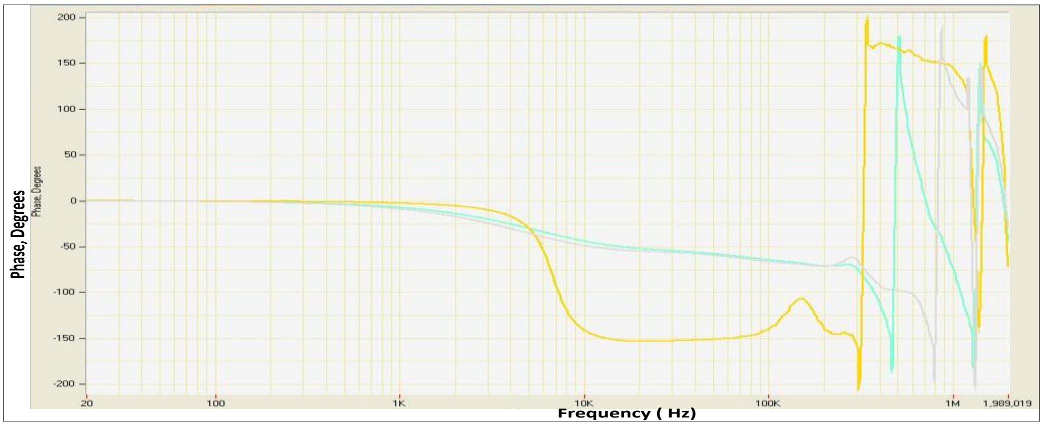

Fig.7.2 Three SFRA measurement of a 440/55V 3-ph transformer (Frequency and Phase).

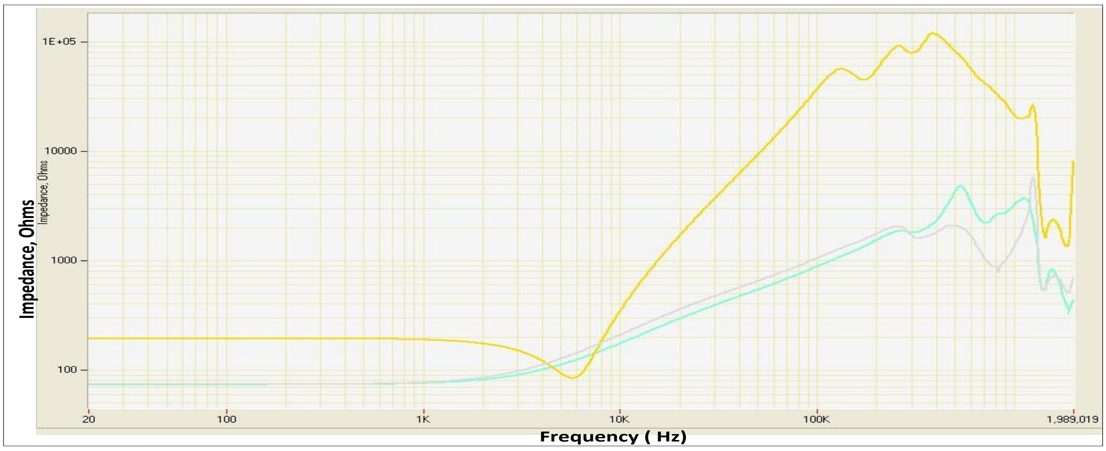

Fig.7.3 Three SFRA measurement of a 440/55V 3-ph transformer (Frequency and impedance).

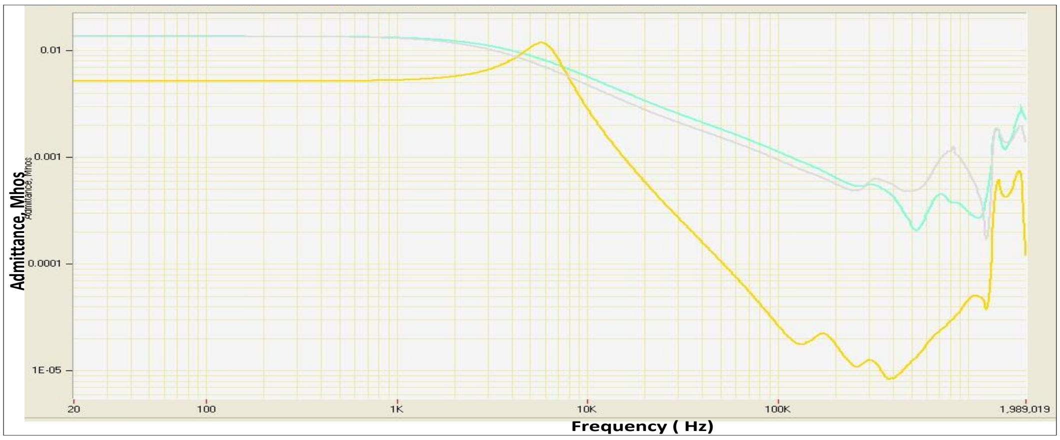

Fig.7.4 Three SFRA measurement of a 440/55V 3-ph transformer (Frequency and admittance).

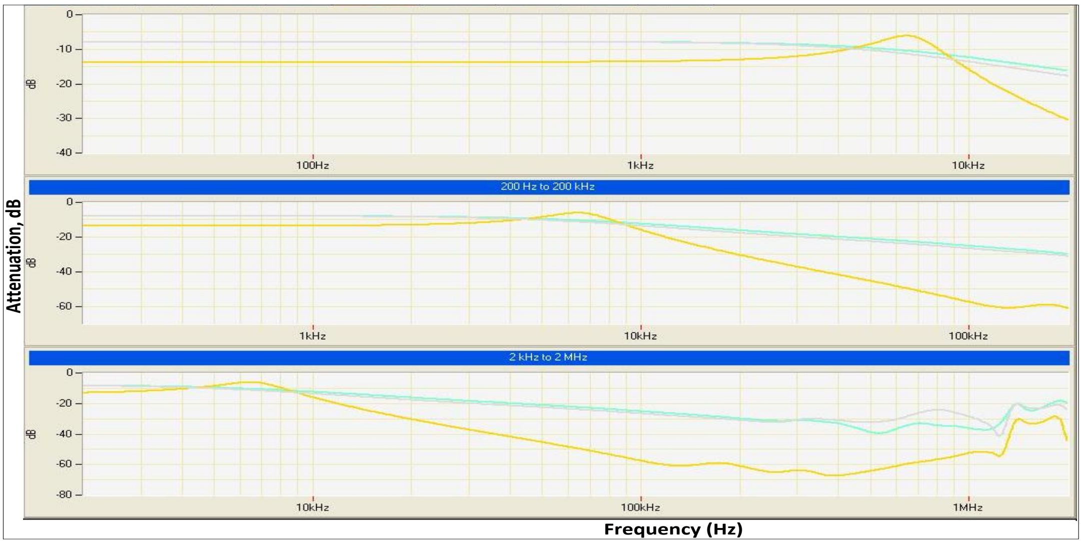

Fig.7.5 Three FRA measurement of a 440/55V 3-ph transformer (Frequency and attenuation).

5. Conclusion

This project has successfully introduced a new technique for identifying the characteristic of a 440/55V 3-ph transformer. Basically, most of changing of transformer windings characteristic is due to experiencing the transformer by adding capacitor to its windings, hence this leads transformer to be tested the way it should be. Moreover, the characteristic of the used transformer such as magnitude, phase, impedance and attenuation have graphically been identified. The transformer model was applied to the SFRA data from 440V/55V 3-ph voltage transformer. The results in both phase and magnitude through frequencies up to 1MHz were varied.

6. References

[1] T. Sano, and K. Miyagi, "Influence of measurement parameters on FRA characteristics of power transformers," Proceedings of 2008 International Conference on Condition Monitoring and Diagnosis (CMD), pp. 968-973, 2008.

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[3] Megger, "Frequency response analysis of power transformer", pp.32, 2009.