STUDY OF FAULT DETECTION IN POWER TRANSFORMER USING SWEEP FREQUENCY RESPONSE ANALYSIS

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***Abstract*— Due to transformer failure power system subjected to great loss and damage to the assets and reliability. This paper presents technical details regarding Sweep Frequency Response Analysis (SFRA) and the role it plays in transformer test and maintenance. SFRA is an electrical test that provides information relating to transformer mechanical integrity. Changes in frequency response as measured by SFRA techniques may indicate a physical change inside the transformer, the cause of which then needs to be identified and investigated.**

***Index Terms*—Sweep Frequency Response Analysis (SFRA), Power Transformer, High Voltage (HV), Low Voltage (LV).**

I. INTRODUCTION

Electric power in one circuit can be transferred to another circuit while kipping the frequency can be done by using transformer a static (or stationary) device. [1] One of the most costly equipment in electrical power system are the high voltage power transformer (HVPT). The failure of large power transformer, caused by winding movement and core deformation, are due to the effects of short circuit tresses and mechanical tresses caused by shifting of transformer from manufacturing site to the installation area. The short circuit tresses comprise about 12-15% of total failure [2].

SFRA (Sweep Frequency Response Analysis) is a tool that can be used to give an indication of winding and core deformation in the transformer. The transformer is a complex network of RLC components. These RLC components changes due to any kind of physical damage to the transformer. These small changes in the RLC network due to damage to the transformer are used to employ frequency response. For various frequencies transformer RLC component offer various impedance paths. This can be used to highlight the area of fault to be subjected [3].

II. FAULTS IN TRANSFORMER

Though there is absence of the moving parts the power transformers are subjected to sever faults due to over current and over voltage, insulation determination, transformer transportation from manufacturing unit to the installation place. Winding deformation is mainly due to mechanical and electrical faults, in which Mechanical faults are mostly occurs in the form of displaced winding, hoop buckling, winding movement, deformation and damaged winding.

Following are the most occurred faults in the transformer:

1. Core Displacement
   During transportation of the transformer from the manufacturing site to the installation point displacement of the core can occur due to vibrations, pressure loss and also too much mechanical force in the period of a short circuit fault happen close by to the transformer.
2. Winding Displacement and Deformation
   The winding movement can happen due to stresses induced by electrical faults such as an inerturn's short circuit as a result of lightning strikes.
3. Faulty core ground
4. Partial winding collapse
5. Hoop Buckling
   During the over current situation, around the winding turns a radial electromagnetic forces create a considerable compressive stress. This can cause conductors of the turns to buckle inwards between the two or three adjacent sets of supporting sticks causing stretching in the rest of the turn. Further buckling due to stretching and radial reaction can cause the change in the leakage reactance.
6. Brocken or Loosen Clamping Structure
7. Shorted Turns or Open Winding

In large power transformer it is often cumbersome and time consuming and costly process to find these faults by visual inspection due to its bulkiness and large oil content in the transformer. These faults can be found by the routine test, type test and some special purpose test on the power transformer, each technique has its advantage and disadvantage, in which SFRA (Sweep Frequency Response Analysis) is one of the most powerful and accurate tool find these faults without losing time as well as money. In this paper we explained the SFRA test and how it is performed. [4,5,6]

III. SFRA (SWEEP FREQUENCY RESPONSE ANALYSIS)

Several techniques such as thermal monitoring, partial discharge measurements, dissolved gas analysis (DGA), and tan-delta and capacitance measurements etc. are available for condition assessment of the transformer. However, each one of these methods is applicable for the identification of a specific type of problem and none of these methods is suitable for detecting winding displacement or deformation. As far as we know this technique was developed by Dick and Erven [4]. FRA is may be part of a routine condition assessment program. Alternatively FRA may be used to obtain information to inform decision making if a transformer is suspected of being damaged. The comparison of results made by plotting a graph of the modulus (or gain) of the impedance against frequency of both sets of measurement. Examine the curves for any significant differences. Significant differences are usually understood to be:

- Change to the overall shape of the curve
- The creation of new resonant frequencies or the elimination of existing resonant frequencies.
- Large shifts in existing resonant frequencies.

Figure one shows the typical response from a healthy transformer.

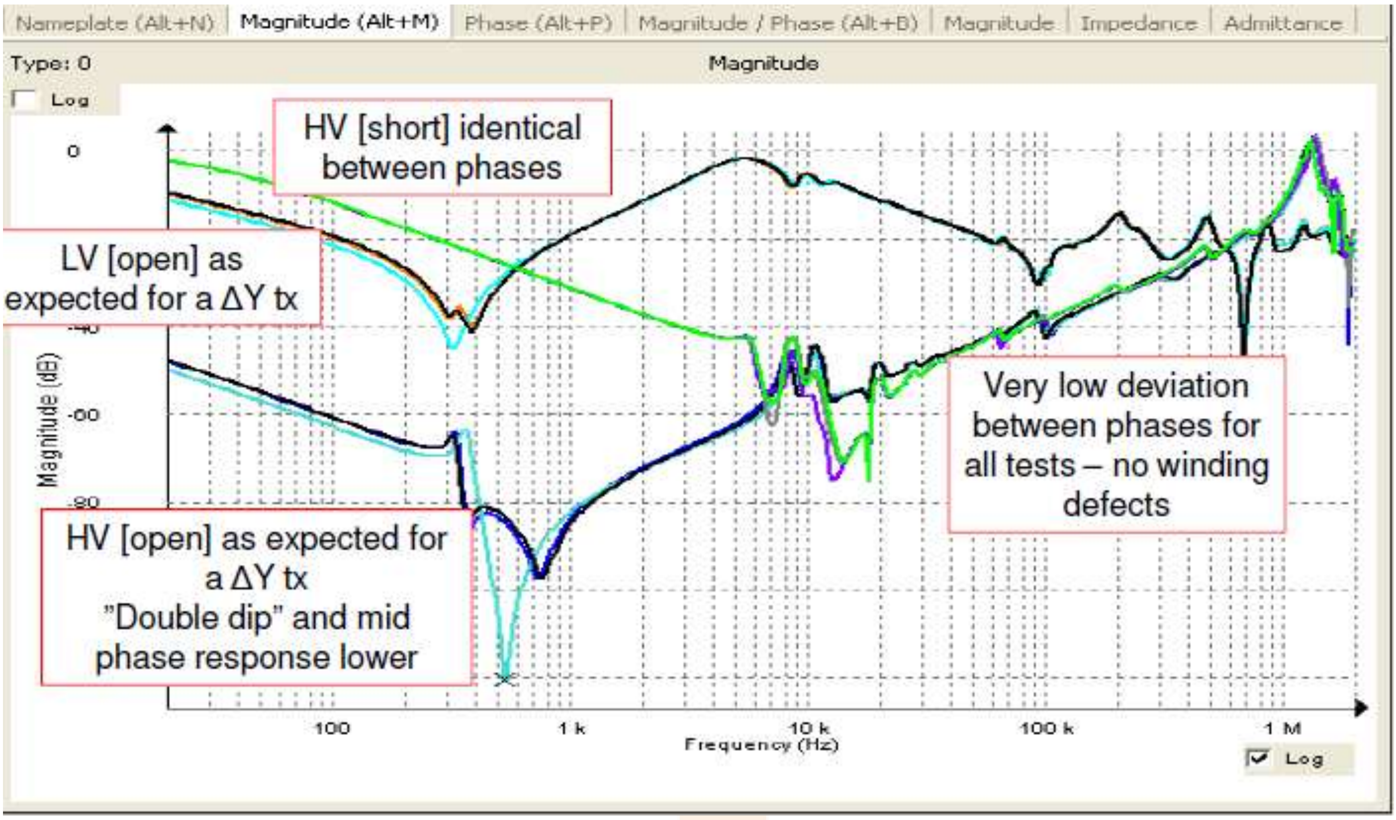

Fig. 1. Typical Sweep Frequency Response (SFRA) of a Healthy Transformer

Figure 2 gives an example where SFRA has diagnosed a shorted turn in a generator step up transformer. The Sweep Frequency Response (SFRA) results for all the phases (Phase R, phase Y and Phase B) of the transformer are plotted as DB responses against frequency. In this case, the change in response of one phase from the other two denotes a shorted turn. It is important to get good resolution in results such as this to give clear and unmistakable traces at low frequencies.

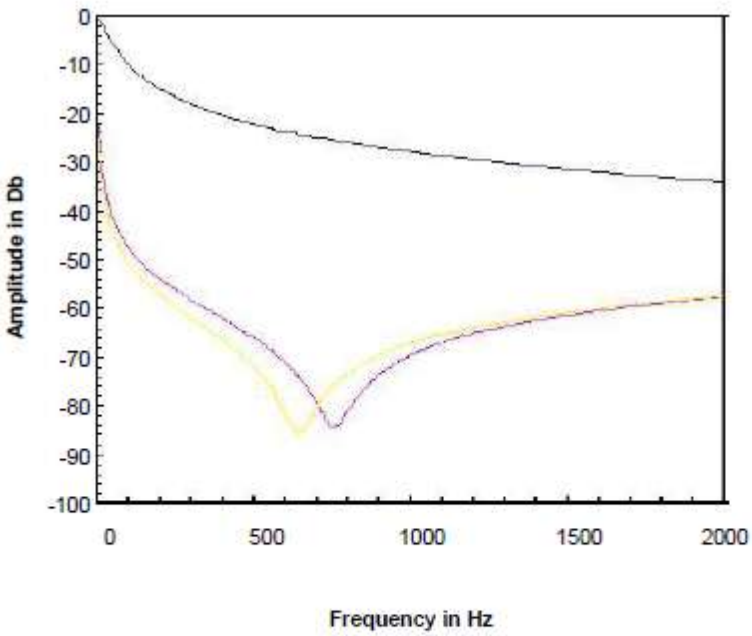

Fig.2 Generator Transformer HV Tap 9 Shorted Turn on one Phase

IV. METHODOLOGY

Figure 2 shows the typical test connection for the testing of transformer by using SFRA tool kit. Four different test configurations are normally used for making FRA measurements. These are:

i) End-to-End open circuit test;

This test is performed on one winding (LV or HV). The input signal is connected to one terminal of the winding while the output signal is measured from the other end of the winding. This concept can be applied for the both star as well as delta type of connection. The secondary winding of the same phase

ii) End-to-End Short circuit Test;

This is also conducted on the one winding in the similar fashion. However, the two terminals of the secondary winding are connected together for the short circuit test.

iii) Capacitive inter-winding test;

In the capacitive inter-winding test, the input signal is applied at one terminal of the primary winding and the output signal is measured t one terminal of the secondary winding while all other terminals are left open.

iv) Inductive inter-winding test;

The inductive inter-winding test is similar to the capacitive test discussed above, except that the open terminals of the primary and secondary measured windings are connected to ground. In this test, the input signal should be supplied at the HV terminal and measured at the LV terminal.[10]

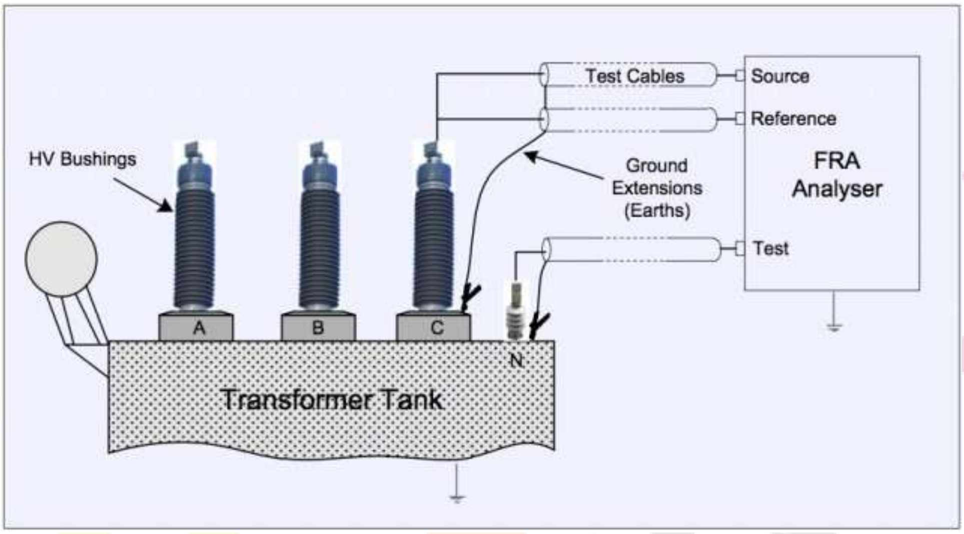

Fig. 3 General Test Connections for SFRA Testing

Transformer testing can be done with oil as well as without oil, only a small difference will be there due to removal of the oil reduce the capacitance of the transformer, by changing the key dielectric from oil to air. Figure 3 shows results from a 30MVA transformer tested with oil ("H3-H1 OIL") and without oil ("H3-H1 No").

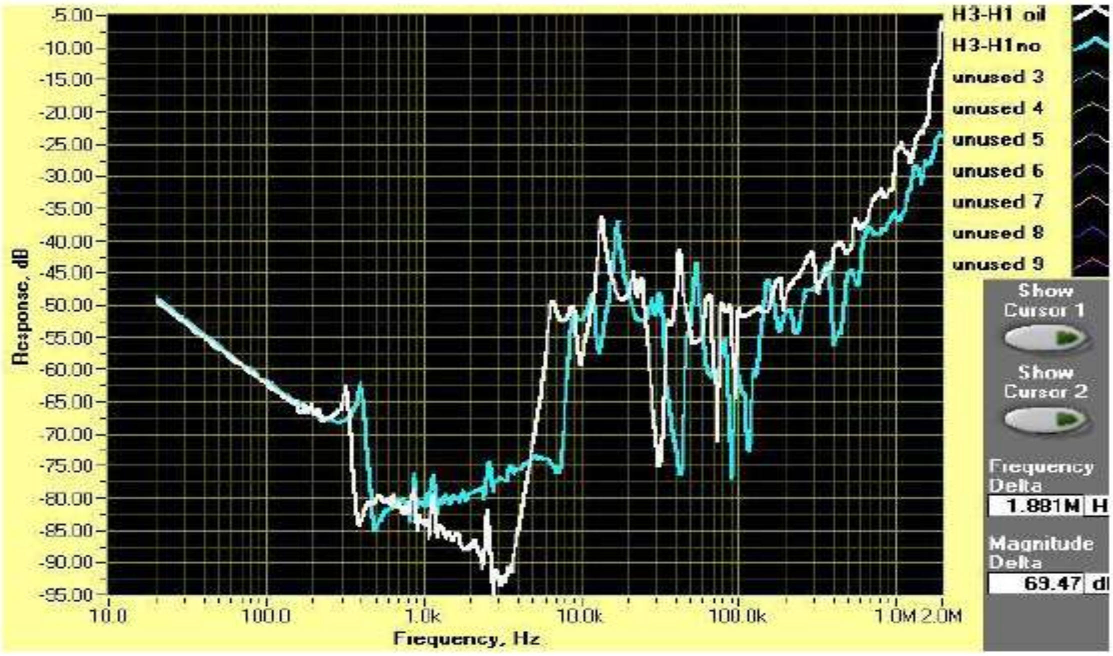

Fig. 4 SFRA Response for with Oil and Without Oil

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VI. CONCLUSION

Thus, in SFRA Testing methodology every transformer winding has a unique signature that is sensitive to change in the parameters of the winding, namely resistance, inductance and capacitance. Frequency spectrum of transformer is very sensitive to any deformation or displacement of the winding. Frequency response analysis is a very effective tool for diagnosing transformer condition. It is particularly useful in detecting any fault that is due to mechanical damage to the winding. Also this technic is very reliable for detecting any short circuit to the winding. Results from a measurement can be analyzed through several techniques via graphical presentation. However reference is needed for better interpretation. The reference can be either from historical deta of the same transformer or from sister transformer unit.

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