International
Journal
Of Advanced Research in Engineering & Management (IJAREM)
ISSN: 2456-2033 || PP. 01-06

Comparison Of Interturn and Turn to turn fault in Transformer By SFRA Method

[1]Prajakta Vinchurkar
M.Tech Integrated Power System Student,Abha Gaikwad Patil College of Engineering, Nagpur. (India)

[2]Prof Bushra Khan
Assistant Professor, Abha Gaikwad Patil College of Engineering, Nagpur. (India)

Abstract: Any failures in the equipments like Power Transformer directly reduce network reliability and increase maintenance costs. Consequently, the preventive maintenance techniques are increasingly developed. Various faults occur in transformer winding. This paper is related to the displacement of windings that occurs due to turn to turn and interturn fault. The thermal, electrical and mechanical stresses exerts radial and axial forces on the transformer windings. In this regard, frequency response analysis is an appropriate method in order to diagnose any change which occurs in transformer physical construction. This contribution has been concentrated on fault diagnosis by use of Frequency Response Analysis (FRA). The sweep frequency response analysis can detect the fault occurring in transformer by comparing the reference set and the fault condition. The results are very worthwhile to better understand how behave transformer frequency responses due to various faults. These obtained results can be very interesting and usable for maintenance engineers to find the occurred fault

Keywords: Sweep frequency response analysis, FRA, LVI, Hv, DGA, PD

I. Introduction

Power transformer is the most important device for reliable electrical power system. While working with it, many faults may occur. Diagnosis of these faults can be done with different techniques [1]. However, they do suffer from internal winding faults principally due to insulation failure; these faults must be quickly and accurately detected and the appropriate action should be taken to isolate the faulty transformer from the rest of the power system [4]. Windings of power transformers should be designed to avoid various mechanical or thermal stresses caused by short-circuit currents occurring in operation.[3]**.** The FRA is a powerful method in detecting transformer mechanical damages, which are difficult to detect by conventional measurements. When a failure occurs in the transformer construction, the values of these parameters are altered and hence the frequency response from the winding will also change accordingly.

In SFRA technique we can detect that deformation easily by applying sweep frequency applied to the winding. If SFRA results are not similar like when transformer is in healthy condition, then it indicates the abnormal condition.

II. Short Circuit Forces

The effect of system short circuit will produce over currents, magnitude of which are dependent on the system MVA, feeding the fault or the voltage, which has been short circuited and on the impedance of the circuit up to the fault. Short circuit may cause winding movement and shorted turns. Short circuits near transformers usually cause currents of high amplitudes. This leads to extreme mechanical stress of core and coil assembly. Electrical and mechanical failure in transformer generates the force resulting from short circuits which may damage the transformers. Due to these mechanical forces, transformer winding deforms radially and axially. Short circuit symmetrical current is 6 to 7 times that of rated current and sometimes is high up to 15 to 18 times the rated current at peak time. The formula for force acting on current carrying conductor during short circuit condition is,

$F = BIL$ Newton

where, B – Flux density in Tesla
I – Current in Ampere.

L- Length of conductor in meters

So the resulting forces are very high because they will be increasing in square of current. These forces extend the current carrying conductor radially as well as axially. Due to this mechanical changes occur in winding and so impedance value changes.

III. Fault Detection Technique

If the transformer has been switched off by protective equipment, there is a need to determine whether the transformer can be safely re-energized. Visual inspections require dismantling of the transformer, removing of the transformer oil and are time consuming. Hence effective detection techniques are required.. There are so many fault detection technique available for transformer of which some are costly ,some are cheap and some having limitations. So, we are discussing about what are different fault detection technique available for smooth working of transformer.

A. Dissolved gas Analysis(DGA)

DGA is the study of dissolved gases in transformer oil. The breakdown of insulating materials within transformers and electrical equipment liberate gases within the unit The distribution of these gases can be related to the type of electrical fault and the rate of gas generation can indicate the severity of fault. The types of fault depend on what type of gas is generated from transformer oil and ratio of these gases. From dissolved gas analysis of transformer Oil **or** DGA of transformer oil, one can predict the actual condition of internal health of a transformer.

B. Winding resistance method

when transformer designed by manufacturer they measure the total winding resistance. In faulty condition like radial deformation change in total length of winding occur.. From that change in resistance we can easily conclude that condition of faulty case. In this method we can measure total resistance for three different phases. The configuration may be star or delta the measurements are normally made phase to phase and comparisons are made to design.

C. Tan Deilta Method

The Tan Delta test works on the principle that any insulation in its pure state acts as a capacitor. A very low frequency test voltage is applied across the equipment whose insulation is to be tested. At the time of starting normal voltage is applied. A loss angle analyzer is connected to compare the tan delta values at normal and higher voltages.

The current which flows through the insulation will also have a resistive component. This will cause the angle of the current to be less than 90 degrees. This difference in the angle is known as the loss angle. The tangent of the angle which is Ir/Ic (opposite/adjacent) gives us an indication of the condition of the insulation. A higher value for the loss angle indicates a high degree of contamination of the insulation.

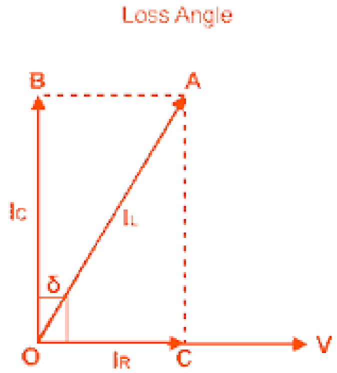

Fig.1 Tan delta method

D. Partial discharge method

Due to improper manufacturing process in insulation design of transformer micro voids are formed during the years of service of transformer. Micro void grows to a big cavity as time passes. Due to electromechanical stress potential difference appears across void. This treeing effect occur on the opposite electrodes leads to developing of partial discharge (PD) means conducting path is formed on insulating material surface which causes weak insulation. It is the case of insulation failure condition. PD can occur in a gaseous, liquid or solid insulating medium. It often starts within gas voids. void grows to a big cavity with time passes due to improper manufacturing process. There are number of methods which can detect the actual PD location like UHF light emission, chemical method and acoustic emission techniques.

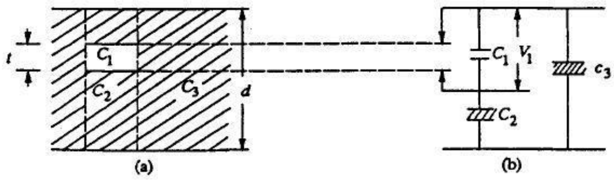

Fig.2 Partial discharge in cavity and its equivalent circuit

E. Sweep Frequency Response Analysis (SRFA)

The SFRA is a powerful method in detecting transformer mechanical damages, which are difficult to detect by conventional measurements. It relies on the fact that transformer winding can be modeled as a network of capacitances, resistances and inductances. When a failure occurs in the transformer construction, the values of these parameters are altered and hence the frequency response from the winding will also change accordingly. SFRA is a simple and low cost method. Also, with this method, it might be able to recognize the type and location of fault, which is not possible with most other methods, involving terminal measurements.

The SFRA method injects sinusoidal low voltage signals of varying frequencies into one side of the winding and measures the output signals as they exit the winding in order to obtain the winding transfer function. Treating a power transformer, undergoing SFRA, as a two-port network, the transfer function of the network is defined as the quotient of the output to input frequency responses when the initial conditions of the network are zero.

With the SFRA method input and output signals are measured at one frequency a time, within a frequency range. How the input signal (*x*) is affected by the specimen's characteristics will depend upon, what is mathematically described as, the transfer function

$H(s) = Y(s)/X(s)$

(where s is a frequency dependent parameter, which for continuous sinusoids equals to $j\omega$). The transfer function will affect how the response will differ from the input.

It is possible by SFRA to detect:-

• a deformation of winding and its movements or a partial breakdown of winding
• a short-circuited turn or opened winding
• a loose and a damaged switching system
• a core connection problem and a core movement or its wrong grounding.

IV. How SFRA Works?

This method can give the proper information about an indication of core movement and winding deformation. In this method measurement are performed at frequency ranges varied from 20 Hz to 20 MHz. Deformation in winding can be easily detect on discrete frequency ranges.

This method can be done in four steps:

1) Measurement in healthy transformer.
2) Again Measurement in faulty case of sister transformer of similar rating.
3) Signature curve of both conditions means healthy and faulty compared.
4) If any difference between both cases found means fault occurred.

V. Matlab/Simulink

The Sweep frequency response analysis method is simulated under MATLAB / Simulink environment. The results found from the same for different cases are explained in this section. These cases are explained below. A 10 section equivalent circuit of the transformer winding is used for simulation purpose

Results

In this case 10 winding model of 16 MVA, 33KV/11KV transformer developed.

CASE I: No Fault Condition

It is case of no fault condition every turns of winding is similar as per manufacturing design. The transformer model for sweep frequency response analysis is developed in MATLAB/Simulink. For no fault condition of above rating transformer impedance parameter value taken from the reference paper [1].

Rs=0.01942 Ω ,
Ls=0.3655 mh,
Cs=0.914 pF
Cg=0.011 nF
Where Rs= series resistance in ohm
Ls=series Inductance in henry
Cs= series Capacitance in farad
Cg= ground capacitance in farad

The following figure 3 shows the transformer model for healthy condition. From this model plot for Normal condition is found which is shown in figure 4 below.

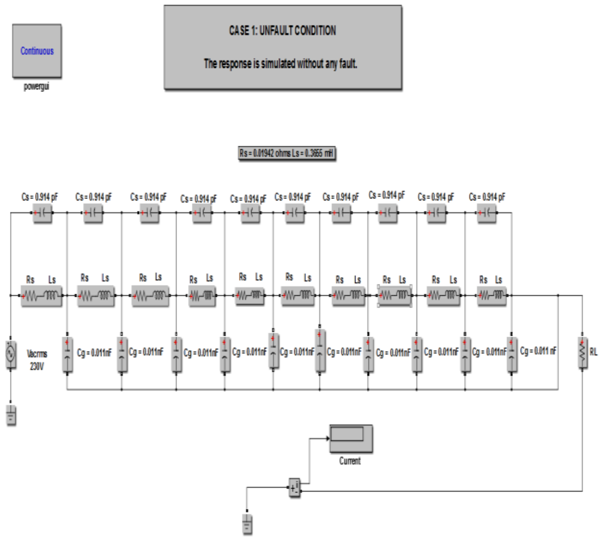

Fig.3 No Fault Condition

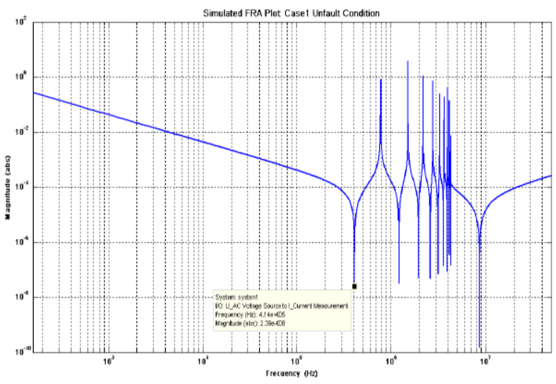

Fig.4 Simulation result of healthy transformer

ISSN: 2456-2033 || PP. 01-06

CASE II: Turn to Turn Fault Condition

The transformer model for turn to turn fault is shown below in figure 5. Here the fault is created between turns 3rd and 4th turn of transformer winding. The plot obtained from this model for turn to turn fault is shown in figure 6

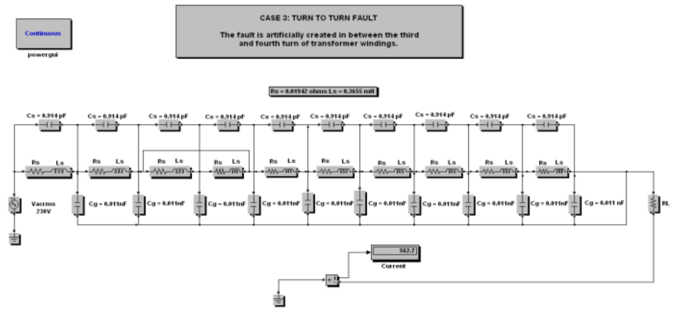

Figure 5. Turn to turn fault condition

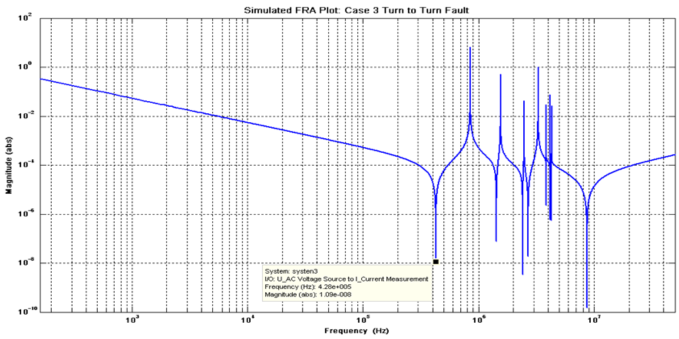

Figure 6: Simulation result of turn to turn fault

CASE III: Inter Turn fault

The following figure 7 shows the transformer model for inter turn fault condition. The fault is created in 4th turn of transformer winding. The plot found from this model is shown in figure 8 below

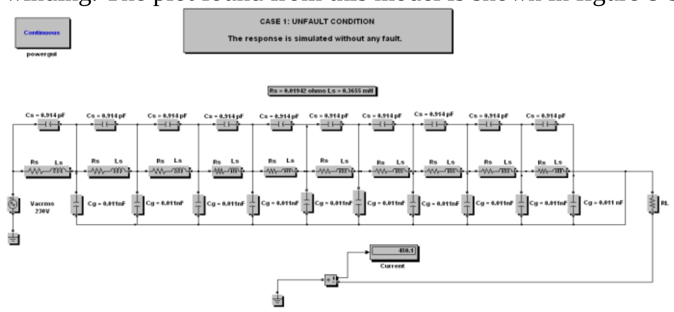

Figure 7. Inter turn fault condition

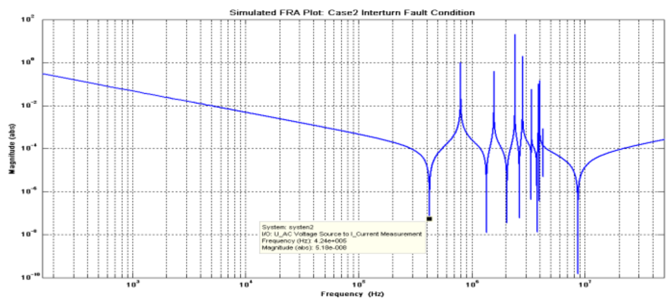

Figure 8. Simulation result of interturn fault.

VI. Conclusions

SFRA testing method represents one of the most effective alternative diagnostic methods compared to visual check. The transformer is considered as a heart of power transmission system. During its duties it can undergo some faults like inter turn fault, turn to turn fault, winding deformation, etc. Every transformer winding has its own signature and it is very sensitive as it changes winding parameters. This paper presents simulation of transformer winding fault detection using sweep frequency response analysis. The two faults cases like inter turn fault and turn to turn fault are simulated and are compared with reference to unfault condition.

On comparing faulty condition with healthy condition, we notice the change in current value due to change in impedance value of complex network. So this change in current value can detect or diagnose the fault in the transformer winding. Using the parameters values and applying SFRA, fingerprint graph for the healthy winding is obtained. This is taken as reference plot for comparison with the unhealthy response corresponding to axial and radial deformation and various faults like inter turn fault and turn to turn fault Hence different fault could be simulated in MATLAB by SFRA method.

VII. References

[1]. M. Gutten and M. Brandt, "SFRA Method - Frequency Analysis of Transformers," Proceedings of the 7th International Conference, Smolenice, Slovakia, 2009

[2]. Vahid Behjat and Abolfazl Vahed," Sweep frequency response analysis for diagnosis of low level short circuit faults on the windings of power transformers" Electrical Power and Energy Systems Elsevier Ltd, 2012

[3]. Dr.P.M. Joshi, Mrs. Pradnya R.Jadhav, "Study of Transformer Winding Parameters as Deformation Diagnostics Techniques Using FRA Measurement", *ACCT 2011, pp 373-376.*

[4]. Akshay Parekh and B.R. Parekh , "Interpretation of SFRA traces for open circuitand short circuit winding fault damages of power transformer"Energy power and Energy system, 2014

[5]. Ilampoornan.M.K, Vikash.M "Transformer fault detection by frequency response analysis" IOSR Journal of Electrical and Electronics Engineering (IOSRJEEE) ISSN: 2278-1676 Volume 1, Issue 4 July-Aug. 2012