

SFRA, Detect of Winding Deformation in Power Transformer



B. Gopinath, C. Shankar, C. Jaya Meenakshi, P. Meena, K. Sudha

Abstract: The sweep frequency response analysis is extensively used technique for detect hidden fault and condition monitoring of power transformer. The operation is administered by supply a coffee voltage signal of varying frequencies to the transformer windings and measuring both the input and output signals. These two signals give the specified response of the ratio is named the transfer function of the transformer from which both the magnitude and phase are often obtained. Frequency response is change as measured by SFRA techniques may indicate a phase transition inside the transformer, then causes of fault identified and investigation is required for root cause analysis.

Keywords: Sweep Frequency Response Analyzer Doble M5100, SFRA, Winding Deformation, Power Transformer, SFRA Traces.

I. INTRODUCTION

This work proposes to detect short-circuit faults between two turns during a winding of a transformer & mechanical displacement. The transformer is taken into account to be a posh network of RLC components. Any sort of physical damage to the transformer leads to the changes of this RLC network. These changes are what we are trying to find and use frequency response to spotlight these small changes within the RLC network within the transformer. It is one among essential elements and a failure of transformer can cause serious problems in electric utility operation.

II. SWEEP FREQUENCY RESPONSE ANALYZER

The SFRA contains measurement the resistivity of a electrical device winding over an honest vary of frequencies & scrutiny the results with a reference set. SFRA is non-destructive take a look at, Off-Line testing and it ar usually administered for any voltage rating of Power electrical device. The mensuration of SFRA usually a neighborhood of traditional electrical device maintenance.

The SFRA instrument detects the next fault inside the facility electrical device before break down occur.

1. Displacement of Core
2. Deformation and displacement of winding
3. Faulty core ground

The technique of SFRA could also be a significant advance in electrical device condition analysis. this can be a tested technique for acquire precise and repeatable measurements. The check are often administered,

1. Initial to get initial signature of the electrical device sweep frequency response as a record for the longer term reference comparison.
2. Periodical measure as a maintenance check, once in 2 years.
3. Right away when a significant external shortcuts, particularly for faults electrically nearer to electrical device.
4. Transportation or re-location of electrical device.
5. Earthquakes.
6. Pre-commissioning check

III. SWEEP FREQUENCY RESPONSE TEST

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Revised Manuscript Received on March 30, 2020.

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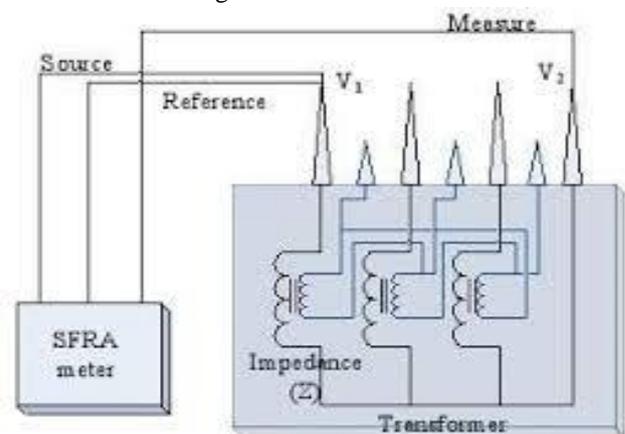


Fig. (1): A typical SFRA test connection

Commercial metal instruments have 3 leads i.e. source, reference and live (Fig. 1). The supply and reference terminals connected to the input finish whereas the measure terminal is connected to the output finish. In typical 3 part transformers, there area unit high voltage (HV), low voltage (LV) and tertiary windings, and therefore various metal connections area unit doable. Major kinds of metal connections area unit mentioned in, that embody end-to-end connections and inter-winding connections. A typical pattern is determined for each check affiliation. check instruments have associate degree alternating voltage supply, capable of activity a sweep frequency inside the vary of twenty cycle per second to 5 megacycle per second, with voltage magnitude between two five to twenty five.

IV. DISCUSSION ON TYPICAL NATURES OF SFRA PLOTS OF VARIED SORTS OF CONNECTION

The end-to-end SFRA affiliation is one amongst the foremost ordinarily used connections of the SFRA check. it's 2 versions, i.e. end-to-end circuit (the secondary winding unbroken open-circuited) and end-to-end short (the secondary winding unbroken short-circuited). The intention of the end-to-end circuit affiliation is specifically to examine core health to boot to health of windings. A typical end-to-end circuit SFRA graph for a star-connected 55 winding is shown in Fig. 2. The low-frequency region (up to ten kHz) has one dominant depression that is due to of resonance between the core-dominated inductance and so the winding capacitance. The initial downward trend is ruled by the inductance whereas the upward trend inside the curve is dominated by the winding capacitance.

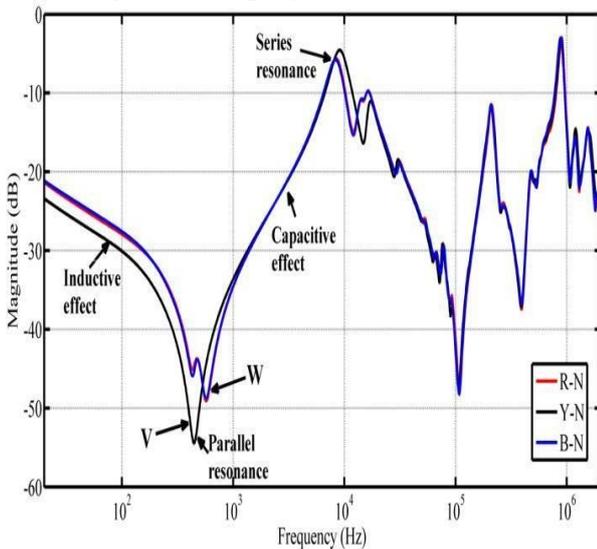


Fig. (2): End-to-end circuit frequency response for a ten MVA transformer

Initially, at low frequencies the quantity of flux is substantial within the core; this is often to blame for higher values of the inductance and therefore the corresponding influence of the core on the curve. because the frequency will increase, the amount of flux inside the core reduces for a similar magnitude of the input voltage. At the resonance purpose the value of the inductive electrical phenomenon becomes up to that of the electrical phenomenon electrical phenomenon, and thenceforth the electrical phenomenon electrical phenomenon becomes dominant. Thus, the position of the first natural depression inside the case of the end-to-

end circuit SFRA affiliation is ready by the size of the core, the amount of excitation and therefore the winding capacitance. the primary natural depression purpose is due to parallel resonance between the core influenced inductance and so the winding capacitance. In mid- and high-frequency regions the curve has several resonance points indicating series similarly as parallel resonances between inductances and capacitances. Peaks square measure due to series resonances whereas natural depression points represent parallel resonances. A downward movement of the curve indicates associate inductive behavior whereas associate upward movement shows a electrical phenomenon behavior..

The patterns of the SFRA curves square measure totally different. 55 windings have smaller bushings (low capacitances) and lesser variety of turns (low inductances) whereas HV windings have larger bushings (high capacitances) and additional variety of turns (higher inductances). This constructional distinction is responsible for larger HV winding ohmic resistance compared to that of the 55 winding. Thus, the 55 winding's SFRA remains higher than that of the H curve. The actual convention for the SFRA curve is: the lower the curve the upper is that the ohmic resistance of the winding. within the case of the end-to-end open-circuit take a look at condition for a star- connected 55 winding, the curve typically starts between -10 decibel to -30 decibel and generally its movement remains between zero to -60 decibel. The designed ohmic resistance of the 55 winding is a smaller amount than that of the HV winding throughout a electrical device. so the drop across the windings, whereas testing, is lower inside the case of the 55 winding. Hence, the 55 winding SFRA curve has higher values of decibel compared to the HV curve winding. The HV winding's SFRA typically ranges from -40 decibel to -60 decibel relying upon the rating associated ohmic resistance of the electrical device For an end-to-end circuit case, a star-connection involves one winding whereas testing it, and thus the curve indicates a true image of the winding as shown in Fig. 2. once the winding is connected in delta and a take a look at signal is applied to a minimum of one in every of the windings.

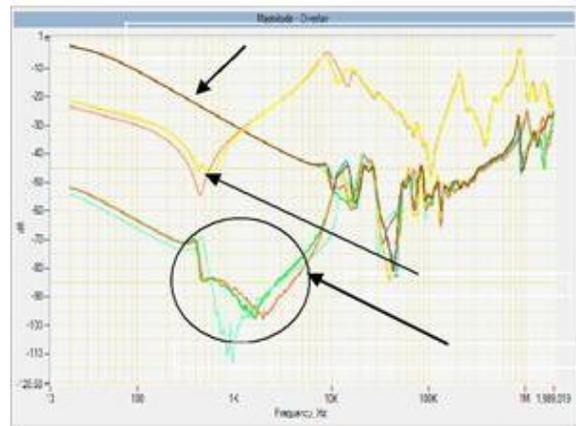


Fig. (3): SFRA of a ten MVA, 66kV/11kV two winding transformer.

windings type a series affiliation internally and thus the mix comes in parallel with the winding underneath check. therefore the shape of the curve is completely different for delta-connected windings, since the check affiliation involves a series-parallel combination of the windings, as shown in Fig. 3. Another vital observation for delta-connected windings among the low frequency region is that a dominant peak is determined (encircled). finish part responses R- and B-phases indicate slightly bumpier responses among the encircled region whereas the center part (Y-phase) is determined to supply a deep natural depression. The probable reason for the development is: the inductances and capacitances of the highest part ar smaller than those of the center part due to their constructional distinction. Thus, the effective impedances for finish phases stay barely but those of the center introduce the encircled region. This conjointly depends on the kind of magnetism hold on on every limb. The end-to-end short association, for a delta-connected HV winding with the fifty-five winding short-circuited (as shown in Fig. 3), the initial vale is missing as a result of the secondary is short-circuited, that eliminates the presence of the core for the check instrument. This association is specifically used to check the discharge inductance on w health. The mid- and high-frequency regions of the curve ought to be rather like those just like the end-to-end circuit association.

V. SFRA OF ON AUTOTRANSFORMER

Generally, terribly massive power transformers square measure automobile transformers. within the case of Associate in Nursing automobile electrical device, the pattern of Associate in Nursing 55 to HV end-to-end metallic element is shown in Fig. 4, wherever each windings square measure star-connected.

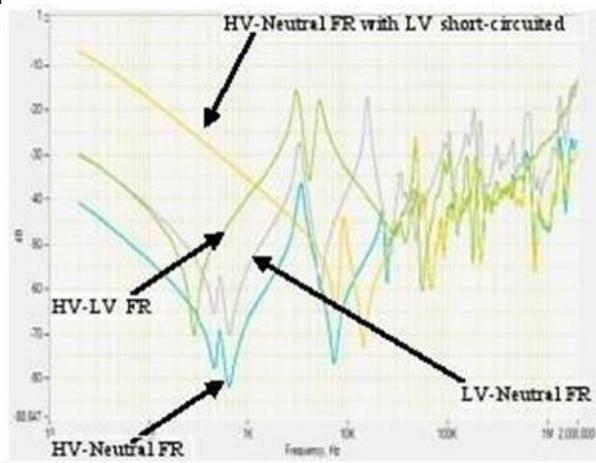


Fig. (4): SFR of B-phase for a 40 MVA auto transformer

In a car electrical device, the run field associated with the fifty-five winding is a smaller amount than that of the HV winding. Its Fr could also be a couple of dBs higher than that of the HV winding, and options an identical form. The end-to-end Fr of the HV winding, with the fifty-five winding unbroken short-circuited can have no initial dominant natural depression thanks to presence the short-circuited winding. The HV-LV Fr options a awfully completely different form compared to that of a two-winding power electrical device, as this affiliation takes the Fr of the series HV winding of the car electrical device, that

is not common between them, and therefore the Fr contains a primary natural depression influenced by the core.

VI. DISCUS WHAT IF THE CURVE IS DEVIATING FROM ITS TYPICAL SHAPE?

A active engineer, United Nations agency has Associate in Nursing experience among the activity of metal curves, usually expects typical shapes relying upon the type of the take a look at affiliation. within the event of any abnormality or fault, the curve can deviate considerably from its typical form. beneath such circumstances, there is not any have to be compelled to compare it with its fingerprint curve, and so the abnormal form is nice enough to suspect abnormality. Fig. five shows such a case which can be a frequency response curve for a five MVA, 66 kV/11.55 kV electrical device for Associate in Nursing fifty-five end-to-end circuit affiliation. the form is appreciably totally different from the one in Fig. 2. Thus, this is often a transparent case of abnormality. once the electrical device was opened, a fault (short-circuit) was discovered between the fifty-five winding and so the core. As explained throughout a previous section, a resistance creates a damping result and tries to flatten the curve. within the mid- and high-frequency regions the curve has shown typical traditional patterns.

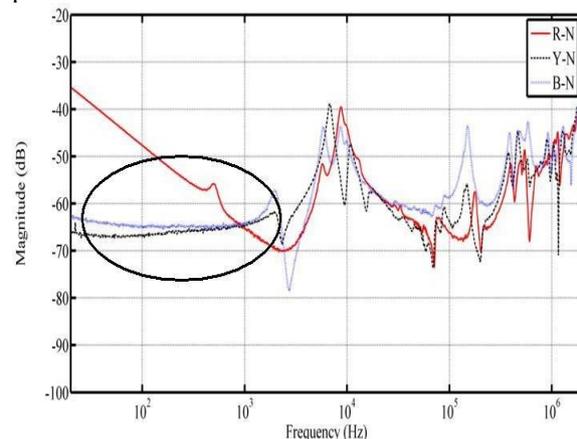


Fig. (5): SFR for transformer with a fault condition

VII. SEQUENCE OF TEST PROCEDURE

Practicing engineers; United Nations agency typically do For measurements, all right apprehend the impact of hold on magnetism within the core within the low-frequency region. The switching-off instant for a electrical device can not be simply controlled and therefore the quantity of hold on magnetism within the core might have totally different completely different} values at different times. Ideally, the SFRA measure ought to be done by permitting the residual magnetism to decay right down to a negligible price. this could need a protracted time, which can not be acceptable in follow. Another different is to get rid of the residual flux by some reasonably short-circuit take a look at, e.g. if the end-to-end contact take a look at is finished initial, it'll wipe out the flux from the core and also the next FRA tests would be free from the impact of hold on magnetism. Secondly, whereas doing variety of maintenance tests like turns quantitative relation tests, low voltage circuit and contact tests, magnetic balance tests,

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and M5100 tests, the SFRA take a look at ought to be done simply once the alternating voltage tests. Tests just like the M5100 take a look at and also the winding resistance take a look at, that invariably need a DC provide, might lead to DC magnetization of the core, which can have an effect on the low-frequency region of the curve.



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IX. RESULT

The graph obtained initially is made as a reference. In future when there is any change any change in mechanical integrity of the transformer, it is detected by the SFRA test momentarily and graph is obtained. Both the graphs which is obtained as reference and present is compared. When there is any deviation in the graph abnormality in the transformer's mechanical part is found.

VIII.CONCLUSION

This paper has made public the essential theory of SFRA. Basic circuit diagram for check association area unit explained the everyday form of finish to finish SFRA connections for associate degree open yet as a brief circuited condition, SFRA trends in H.P. and cardinal windings and in Star-Delta windings and also the nature of the SFRA in automotive vehicle electrical device area unit mentioned. These discussions area unit expected to assist active engineers in doing higher medical specialty.

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