SFRA testing on transformers

Introduction

A power transformer is for all intents and purposes a sealed box. While it is, in theory, possible to see what's going on "inside the box" by dismantling the transformer, this is hardly ever a practical option. Yet changes can take place within a transformer that compromise its reliability and/or shorten its service but, in the short term, have no apparent effect on its performance.

Given the enormous direct and consequential costs associated with the failure of power transformers, it is clear that there is a need for some method of reliably detecting these changes. It is to address this requirement that the technique of sweep frequency response analysis (SFRA) testing has been developed. This principle behind this method of testing, which has now been in use by major utilities and service companies for more than a decade, is easy to explain. The SFRA test set applies a test signal to the transformer that sweeps through a range of frequencies, and plots the transformers response as a function of frequency. By comparing the results with a reference or "fingerprint" curve, changes can readily be seen.

The SFRA test technique is capable of detecting a wide range of problems, including winding deformations and displacements, shorted turns and open windings, loosened or broken clamping structures, core connection problems, partial winding collapse, faulty core grounding, core movements and hoop buckling. Note that many of these problems are difficult or even impossible to detect by any other method of testing.

SFRA tests provide the most detailed and accurate information when a good reference curve is available for the transformer under test. Ideally, this should be an SFRA curve produced for the same transformer at an earlier time when it was known to be in good order.

To provide such a reference curve, some manufacturers now carry out SFRA tests on all new transformers before they are despatched to site. In addition, many utilities carry out SFRA testing on new transformers as a matter of course, seeing it as a very worth-while investment, particularly in mission critical applications.

Where previous SFRA results are however, not available for the transformer under test, it is worth noting that it may still be possible to obtain useful information by making comparisons with another transformer of the same type.

So much for the theory of SFRA testing, but what about the practice? The best of modern test sets are readily portable and feature rugged construction, making them ideal for field use. These test sets fall into two distinct categories; those designed for use in conjunction with an external laptop PC, and those that have the PC functionality built in. As might be expected, the former are smaller, handier for transportation and a little lower in price, while the latter may be somewhat more convenient to use. The elimination of the need to carry a separate laptop PC may also be an important factor in its own right, as standard laptops are not particularly well suited for use in difficult environments, such as electrical substations, and on some sites their use is not permitted at all.

Whether or not the test set has an integrated PC, there are some features that are highly desirable for fast accurate testing. Among these is the ability to customise the sweep setting. Traditionally, SFRA test sets have used fixed logarithmic frequency spacing for test points. This means that there are as many test points between 20 Hz and 200 Hz as there are between 200 kHz and 2 MHz.

Transformers however, have few resonances at low frequencies and many more at high frequencies, so the use of fixed logarithmic spacing means that many more test

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points are measured in the low frequency range than are actually needed, which unnecessarily extends the testing time. In contrast, the best modern instruments allow users to specify fewer test points at low frequencies and more at high frequencies. This leads to much faster tests with greater detail in the results where it is most needed.

Another desirable test set feature is the ability to display results not simply as the traditional amplitude versus frequency curves, but also as impedance or admittance versus frequency. These alternative models/views have proved to be powerful aids to analysis certain types of power transformers. Facilities for importing test results directly from other test sets or in the standardised XFRA format, as well as in CSV and TXT files are also invaluable, as they allow accurate comparisons to be made with reference data from other test sets. In addition, where imported data is used in this way, it is very useful to be able to adjust the voltage used by the test set to match that used when the historic data was produced, since the results from an SFRA test are influenced to some extent by the test voltage at the lower frequencies. A further issue that needs to be considered when making SFRA tests is the connections between the test set and the transformer. The more consistent these connections are between tests, the more accurate will be the comparisons between the results obtained. It is particularly important that the connection between the test cable shield and ground should be as near as possible the same for every measurement on a given transformer. With conventional test leads, such consistency is hard to achieve. Some SFRA instruments, however, such as the Megger FRAX99, 101 and 150, are supplied with test leads that are specifically designed to overcome this problem. With these leads, the braid drops down directly from the bushing connection C-clamp, next to the insulating discs, to the ground connection at the base of the bushing. This arrangement called "shortest braid technique", is the recommended practice in SFRA standards and creates near identical conditions every time a connection is made, irrespective of whether the bushing is tall or short.

As already mentioned, dismantling a power transformer to determine its condition is hardly ever a practical possibility. It is, however, possible to accurately assess transformer condition by using proven SFRA test techniques. And, the latest SFRA test sets make these techniques more accessible, more convenient and more dependable that ever.

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DATE: January 2010

KEYWORDS: Sweep frequency response analysis, transformer diagnostics, SFRA.

ABSTRACT: Dismantling a power transformer to determine its condition is hardly ever a practical possibility. By using the latest proven SFRA test techniques, it is possible to accurately assess transformer condition without dismantling it.The latest SFRA test sets make these techniques more accessible, more convenient and more dependable that ever.