International Journal of Advances in Engineering and Management (IJAEM)
Volume 4, Issue 5 May 2022, pp: 2576-2581 www.ijaem.net ISSN: 2395-5252

# Power Transformers Measurement and Maintenance Analysis

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Submitted: 20-05-2022 Revised: 28-05-2022 Accepted: 30-05-2022

**ABSTRACT**: Transformer is an important component in electric power system. The function of the transformer is to adjust the current and voltage values so that it can be used according to usage needs. In the operation of electric power distribution, the transformer is the heart of transmission and distribution. Therefore, the transformer is expected to operate optimally, so that the continuity and quality of electrical energy can be maintained. As with other electrical power equipment, transformers are required to always work in maximum conditions. For this reason, it is necessary to maintain and monitor the condition of the transformer on a regular basis.
Some tests that are important to monitor the condition of the transformer are winding insulation resistance testing, voltage ratio testing, SFRA testing, tangent delta testing, and testing the quality of insulating oil. To test the quality of the insulating oil, six kinds of tests were carried out, namely color testing, breakdown voltage, water content, acid content, interfacial tension, and sediment content in the oil.
**Key words** : Transformer maintenance, winding insulation resistance test, voltage ratio test, SFRA, tangent delta test, transformer oil characteristic test

## I. INTRODUCTION

With the development of science and technology, the public as users of electrical energy today, begin to think critically, so that one day they can demand reliability problems in the supply of electricity, so this needs to be considered. quality problems or quality of voltage or continuity of service. This is evidenced by the complaints of electrical disturbances from the electricity consumer community, in the form of voltage drops, voltage flickers, or frequent blackouts. This causes the voltage quality and service continuity to decrease. In the field, there were also cases of problematic transformers, both from the beginning of planning, maintenance procedures and even poor maintenance so that the performance of the transformer itself could not be optimal. Therefore, planning and procedures for the performance of a 60 MVA transformer in a medium voltage network must be considered and more importantly, before the transformer is used, it should be tested first in order to ensure that the transformer to be used is really good and has the right transformation value.

Maintenance of power transformers is very important to maintain the effectiveness and durability of electrical power system equipment, so that the continuity and quality of electricity generated is maintained.
The purpose of this study was to determine the working principle of power transformers, understand power transformer maintenance guidelines and analyze the condition of power transformers based on testing according to power transformer maintenance guidelines.

## II. METHOD

In the process of compiling this research, the authors obtained the data through several methods, namely:
1. Observation Method (Observation)
With the observation technique, the authors conducted a direct observation of all the equipment that was done. With this method the compiler can know for sure about the equipment.
2. Literature Method (Library)
This method is done by reading literature books that are used as references to obtain data. Thus the author becomes more aware and clear about the equipment or equipment installed on the transformer in the 60 MVA network
3. Testing
The tests to be carried out are winding insulation resistance testing, voltage ratio testing, SFRA testing, tangent delta testing, and oil quality testing.

## III. TESTING

### 1 Winding Insulation Resistance Test

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This test uses a megger gauge to obtain the value of the insulation resistance of the transformer windings between the live parts (phase) to ground and between the primary, secondary, and tertiary windings. This test is carried out to determine the amount of leakage current (leakage current) in the insulation of the primary, secondary, or tertiary windings.

The polarization index test is carried out to test the insulation resistance of the transformer.

$$\text{Indeks Polarisasi (IP)} = \frac{R_{10}}{R_1} \times 100\ \%$$

where :
R10 = tenth minute measurement insulation resistance value (Ω)
R1 = the value of the insulation resistance of the first minute measurement (Ω)

Table 1. Data on winding insulation resistance test results

| **DESCRIPTION OF ACTIVITIES** | | **INITIAL CONDITION** | | |
|---|---|---|---|---|
| **AFTER TRANSFORM OFF** temperature : ° C | | 1 Mnt | 10 Mnt | **Ip** |
| 1 | Primery - Soil (MΩ) | 514 | 740 | 1,44 |
| 2 | Secondary - Soil (MΩ) | 334 | 510 | 1,53 |
| 3 | Tertier - Soil (MΩ) | 319 | 555 | 1,74 |
| 4 | Primery-Secondary (MΩ) | 441 | 705 | 1,60 |
| 5 | Primery - Tertiery (MΩ) | 813 | 1140 | 1,40 |
| 6 | Secondary - Tertiery (MΩ) | 435 | 605 | 1,39 |

Table 2. Classification of conditions test results polarization index value

| **Condition** | **Index Polarisasi** |
|---|---|
| Dangerous | < 1,0 |
| Bad | 1,0 – 1,1 |
| Questioned | 1,1 – 1,25 |
| Well | 1,25 – 2,0 |
| Very good | > 2,0 |

From the data above, it can be concluded that the leakage current is still within reasonable limits so that the transformer is safe to be given a voltage and avoids insulation failure. This is because the value of the polarization index (IP) of the insulation resistance of the transformer windings is still in good condition, which is above 1.25.

**2. SFRA Test**

Sweep Frequency Response Analyzer is a tool that can provide an indication of changes in parameters of changes in the core and windings of the transformer without disassembling the inside of the transformer, through a series of tests so that it can be seen how a winding responds to signals in various frequency variations.

The interpretation of the SFRA test results can be done by 3 methods, namely:
1. Comparing Test Results and Initial Data The examiner compares the graph of the test results with the initial data (base line). Initial data, ideally is data when the transformer has just been assembled and has not been relocated.
2. Comparing Test Results and Sister Unit
Sister unit is a transformer with the same specifications and assembled by the same company. Ideally, the sister units used are in new condition and have not been relocated.
3. Comparing Inter-Phase Test Results
This method is taken if the transformer does not have a base line and there is no similar transformer that can be used as a sister unit.

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The test results included in the maintenance report are 2 graphs, namely the magnitude graph and the phase graph. In the maintenance of the transformer at the 150/20 kV Sayung Substation, the following test results were obtained:

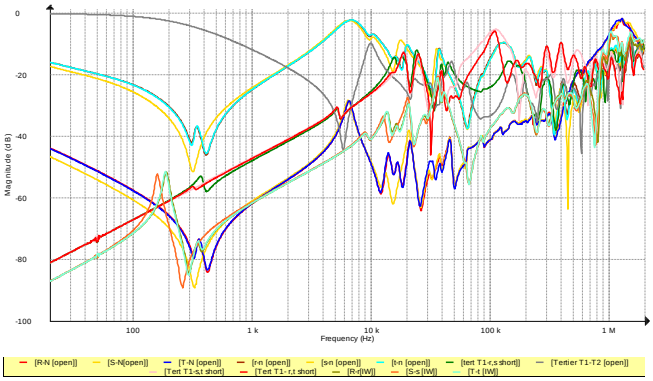


Figure 1. Magnitude graph transformer 30 MVA GI Sayung

This report diagnoses primary coils by phase comparison method. From graph 1, the primary coil graph must be separated first.

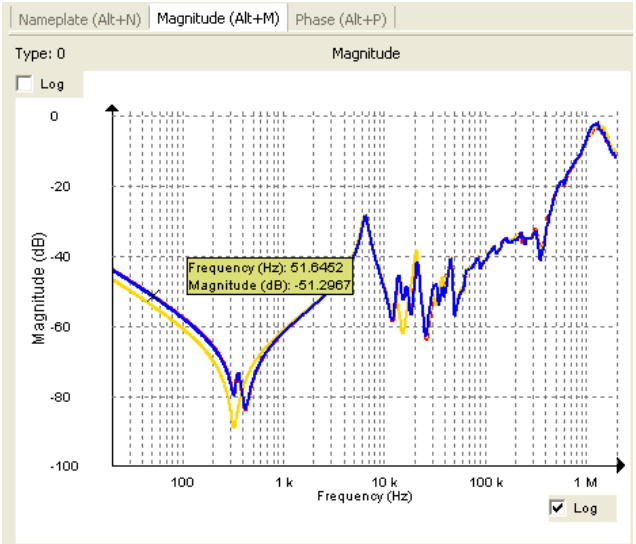


Figure 2. Primary R-S-T magnitude graph

A good transformer, on the graph of the primary coil, the R phase coincides with the T phase, while the S phase is slightly below it, with almost the same pattern and curve as the other phases. From the graph above, it can be seen that the graphs of the R and T phases coincide. Initial diagnosis, the primary coil of this transformer is generally good. Phase comparison method is done by comparing 2 phases-2 phases.Fasa R – T

From the graph of the SFRA test results above, the magnitude graph for the primary R – T phase is obtained as follows:

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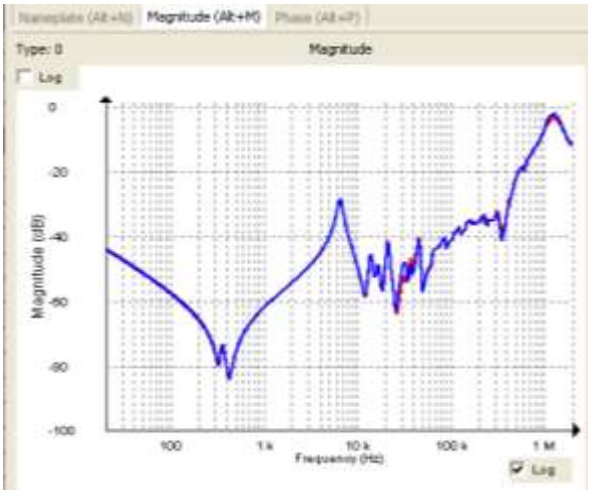


Figure 3. Primary R-T magnitude graph

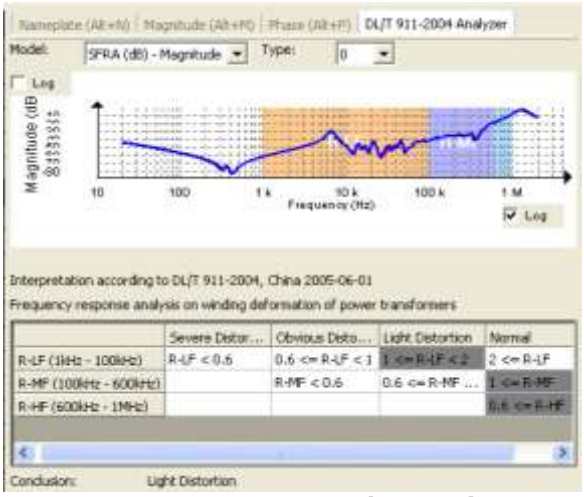


Figure 4. Primary R-T analysis results

a. R – S . phase
From the graph of the SFRA test results above, the magnitude graph for the primary R

– S phase is obtained as follows:

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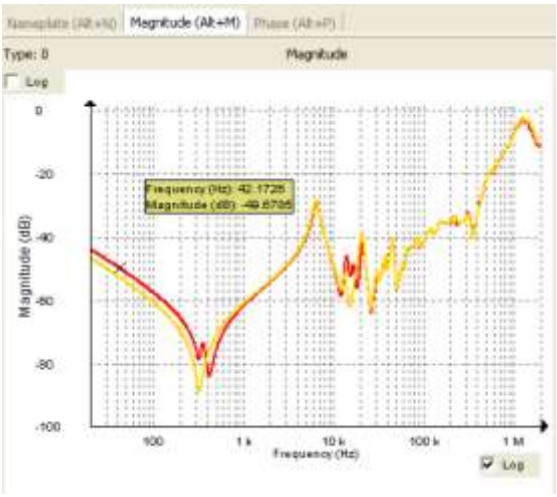


Figure 5. Primary R-S magnitude graph

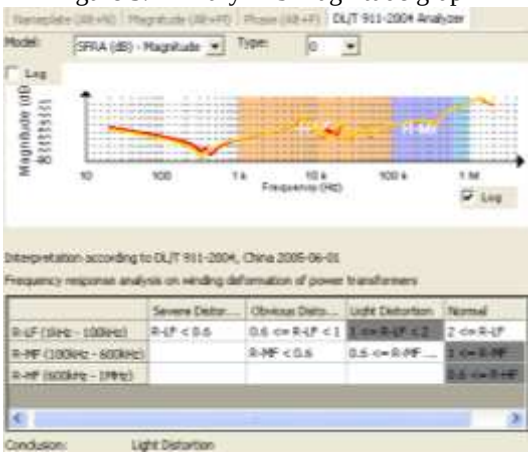

Figure 6. Primary R-S analysis results

b. S – T . phase

From the graph of the SFRA test results above, the magnitude graph for the primary S – T phase is obtained as follows:

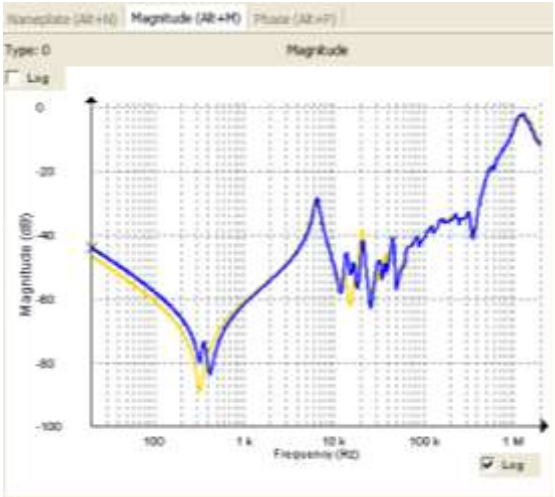


Figure 7. Primary S-T magnitude graph

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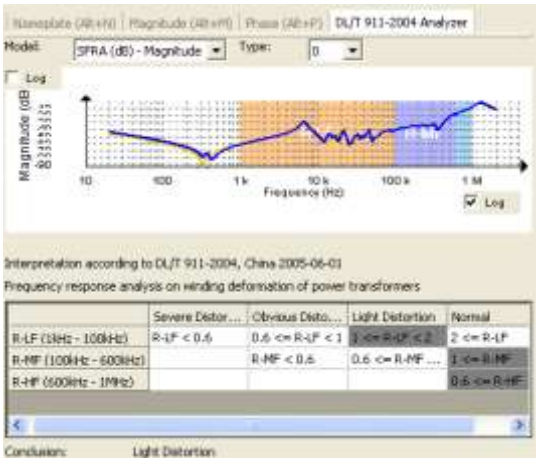

Figure 8. Primary S-T analysis results

From the three phase comparisons above, with the DL/T 911-2004 Analyzer, the following results are obtained:

Table 3. Comparison of results between phases

| **Phases** | **Condition** | **Range Freakuensi** |
|---|---|---|
| R – T | Light Distortion | 1 – 100 kHz |
| R – S | Light Distortion | 1 – 100 kHz |
| S – T | Light Distortion | 1 – 100 kHz |

Table 3. states that there are symptoms of mild distortion in the primary coil in all phase ratios. Symptoms occur in the frequency range 1 – 100 kHz. Possible minor damage that occurs to the transformer primary coil is deformation of the core, coil deformation, or deformation of the tap winding.

## IV. CONCLUSION

The results of the winding insulation resistance test, obtained the value of the Polarization Index 1.25 in all tests. With this measured IP value, the leakage current is still within the tolerance limit so that the transformer is safe to operate, the results of the SFRA test, there is a slight distortion on the primary side of the transformer. Symptoms that may occur are deformation of the core, deformation of the coil, or deformation of the tap winding.

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