MULTIPLE TESTS ON TRANSFORMER WITH THE HELP OF MATLAB SIMULINK

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Abstract - *Transformers are widely in the transmission network to either step up or step down the voltage. In order to get efficient performance, these transformers should be tested periodically over the period of time, whether the transformer is working in proper condition or not. For testing of the power transformers. There are various tests are conducted such as ratio test, vector group test, core balance test, no load test, short circuit test as well as load test. To perform each test there are large numbers of instruments and equipment are used. From which, each reading should be noted manually, which wastes more amount of time. To avoid those problems and to reduce human efforts, this paper represents a MATLAB SIMULINK model which can be used to perform several tests where the results are obtained in a simpler manner.*

*Key Words***: Transformers, MATLAB SIMULINK, Tests, Performance, Accuracy**

1. INTRODUCTION

Transformer, device that transfers electric energy from one alternating-current circuit to one or more other circuits, either increasing i.e., stepping up or reducing i.e., stepping down the voltage supplied to it. Transformers are employed for widely varying purposes; e.g., to reduce the voltage of the conventional power circuits, to operate the low-voltage devices such as doorbells and toy electric trains, to raise the voltage from electric generators so that electric power can be transmitted over long distances etc. Coming to this wide range of applications of transformers, transformer is also required to be monitored over the period of time for the satisfactory operations. In order to get this, we perform various performance tests on the transformers. These tests are time consuming as well as can cause various errors such as connection error, calculation error, testing error, etc. So, to avoid this, we can perform these tests on MATLAB.

2. LITERATURE REVIEW

A.   NY Dahlan, 2017 IEEE 9th International Conference on Engineering Education, Transformer Interactive Learning Tool Based on MATLAB Simulink and GUI.

This paper presents transformer interactive learning tool which is developed in MATLAB Simulink and Graphical interface i.e., GUI. This tool is developed to improve student's interest and understanding on transformer subject and practical. The tool consists of three sections which are nothing but the transformer performance, open-circuit test and short circuit test. Using this tool, the transformer electrical behavior can be understood and also the effect of parameter variation of transformer is observed because it is repeated several times. The output of this tool has been verified and compared with the manual calculation in lab. The developed tool is additionally tested for various readings.

B.   Amangaldi Koochaki, Indian Journal of Science and Technology, Teaching Calculation of Transformer Equivalent Circuit Parameters using MATLAB/Simulink.

This paper presents MATLAB/Simulink implementation of transformer tests namely dc test, open-circuit test and short-circuit tests performed to identify the equivalent circuit parameters and to study effective transformer modeling and reinforcement of the theoretical concepts. The proposed method has been successfully integrated into electric machinery courses at Author University with encouraging results. The results show that relative errors are negligible, and the proposed simulation models can accurately predict equivalent circuit parameters. Also, this method will be very helpful for students when they carry out hardware laboratory experiments in practice.

C.   Prof. J. H. Patil, IJIRST –International Journal for Innovative Research in Science & Technology Transformer Testing and Analysis using MATLAB/Simuink.

This research paper gives information about a MATLAB based program which utilizes a Graphical User Interface (GUI) to calculate the circuit parameters and efficiency of single-phase ac transformer. The project has been designed and developed with the help of MATLAB SIMULINK. The GUI developed can be used in the form of simulation for an electrical software application in lab session for better understanding. This paper has presented a virtual instrument of AC transformer with the help of MATLAB & SIMULINK. It is a user-friendly application in which a user just needs to give a desired data for processing stage and output performance result. Also, the MATLAB & SIMULINK result have been verified and compared with manual calculation in order to ensure that the correct and reliable solutions are obtained.

D.   Mr. M. Subramani, International Journal of Advanced Science and Engineering Research, Investigations of Power Transformer Parameters Using Core Balance and Vector Group Test.

Power transformers are used in the high voltage transmission network to step up or step down the voltage as per our requirement. These transformers should be tested periodically in order to check whether the transformer is working in optimum conditions or not. This paper provides a computer-based solution for these tests. To perform each test there are large numbers of meters and equipment are required. Also, each reading of measurement should be noted manually which wastes more amount of time. To avoid these problems testing kit is used where the readings are in digital format and communication is also enabled.

3.   OBJECTIVES

In order to reduce human efforts as well as to get increased accuracy, set of tests such as, load test, open circuit test, short circuit tests are performed on transformer in MATLAB SIMULINK model.

4.   MATLAB in Performance tests

A.   Use of MATLAB in Transformer Testing

Over the years, we use several sets of equipment's for the measurement of performance tests in MATLAB. In recent years, various research paper is being produced to avoid complexity and perform these tests on MATLAB. Our research paper also helps in performing these tests with higher accuracy and easier solutions. Although these conventional techniques are good for conceptual understanding but it requires human efforts. In order to get those required parameters to be calculated automatically, this paper helps in providing MATLAB solution over here.

B.   Specifications / Software versions.

In order to perform the internal parameter calculations, MATLAB R2020a is used. To get electrical components in MATLAB, MATLAB Simulink as well as Simscape libraries are used.

C.   Abbreviations and Acronyms.

R_1: Internal resistance of Transformer from primary side. R_2: Internal resistance of Transformer from secondary side.

L_1: Inductance of primary side. L_2: Inductance of secondary side.

Rm: Magnetization resistance   Lm: magnetization inductance.

P_{oc}: Open circuit power. V_{oc}: Open circuit voltage.

I_{oc}: Open circuit current. Φ_{oc}: Open circuit power factor angle.

R_{oc}: Open circuit resistance. Z_{oc}: Open circuit impedance.

X_{oc}: Open circuit reactance. $I\mu$: Magnetizing current component.

$I\omega$: Core loss component. P_{sc}= Short circuit power.

V_{sc}= Short circuit voltage. I_{sc}= Short circuit current.

Φ_{sc}= Short circuit power factor angle. R_{sc}= Short circuit resistance.

Z_{sc}= Short circuit impedance. X_{sc}= Short circuit reactance.

D.   Units

Resistance in Ohms   Inductance in mH,100 Hz

Power in VA   Voltage in volts

Current in amperes   Reactance in ohms
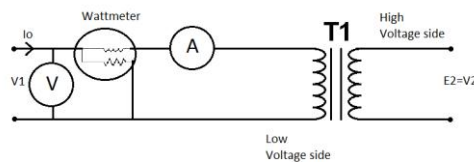
E.   Equations

1.   Open circuit test

Fig. 1 Open circuit test circuit

Relating to fig.1, defining the equations.

$P_{oc}=V_{oc}\times I_{oc}\times Cos\Phi_{oc}$ $Cos\Phi_{oc}= P_{oc}/ V_{oc}\times I_{oc}$

$I_{\mu}= I_{oc}\times Sin\Phi_{oc}$ $I_{\omega} =I_{oc}\times Cos\Phi_{oc}$

$R_{oc}= V_{oc} / I_{oc}\times Cos\Phi_{oc} = R/I_{\omega}$ $X_{oc}=V_{oc}/I_{\mu}$

2.   Short circuit test
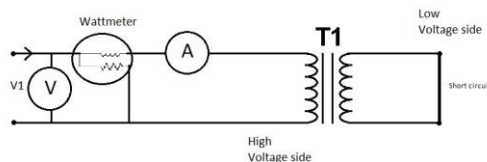
Fig. 2 Short circuit test circuit

Relating to Fig. 2,

$P_{sc}=V_{sc}\times I_{sc}\times Cos\Phi_{sc}$ $Cos\Phi_{sc}= P_{sc}/ V_{sc}\times I_{sc}$

Zsc=Vsc/Isc $Xsc=((Zsc)^2-(Xsc)^2)^{1/2}$
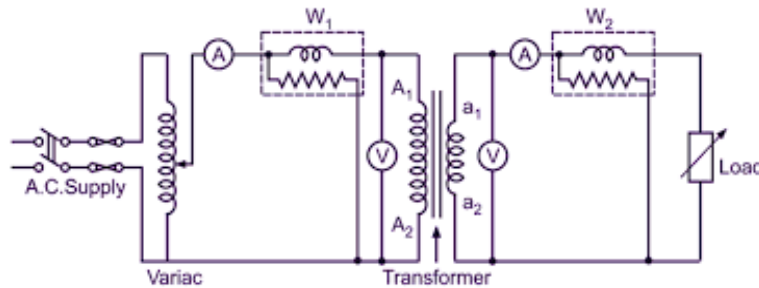
3. Load test

Fig. 3 Load test circuit

Relating to fig.3,

% η = (W_2/W_1) × 100   % R=$(V_{NL}-V_{FL}/V_{FL})$ × 100

5. MEASURMENTS FOR THE TESTS

Measuring current transformer has a general purpose as well as a specific purpose. It should be according to the power system measurement in engineering application as well as in the measurement system of the practical need of the type of current transformer. In practice this could be applied on higher rating of the transformer. We performed the tests based on the research paper data as well as the data that obtained in our laboratory calculations, in this research paper measurements are carried out on 230V/115V, 1 KVA, 50 Hz current transformer with the help of manual test.

Readings obtained are as follows: With R load (Rheostat of the value R=270 0hm and I=1.2 A)

V_1 = 215 V V_2 = 110.6 V

I_1 = 0.218 A I_2 = 0.016 A

R_1= 2 Ohm R_2=1.1 Ohm

L_1=1.325 H for 100 Hz, SER

L_2=490 mH for 100 Hz, SER

O.C. Test in lab:

P_{oc}=40 W V_{oc}=115 V

I_{oc}=0.4 A $Cos\Phi_{oc}$ =0.869.

R_{oc}=330.635 X_{oc}=581.10

$I\mu$=0.1979 A $I\omega$=0.3476 A

S.C. Test in Lab:

P_{sc}= 95 W V_{sc}=27 V

I_{sc}= 4.30 A $Cos\Phi_{sc}$=0.85

R_{sc}=15.13 Ohm

Z_{sc}= 6.04 Ohm

X_{sc}= 3.26 Ohm

Load test:

Efficiency= 94%   Regulation=1.86%

6.   MATLAB CIRCUIT DESIGN

A.   Load circuit design

MATLAB circuit is designed with the help Simulink and Simscape libraries. An AC Voltage source of value 230 V is connected on primary side and then on secondary series resistive load is connected. For voltage, current and power measurements, scopes are used. Following figure 2 shows the MATLAB circuit design.
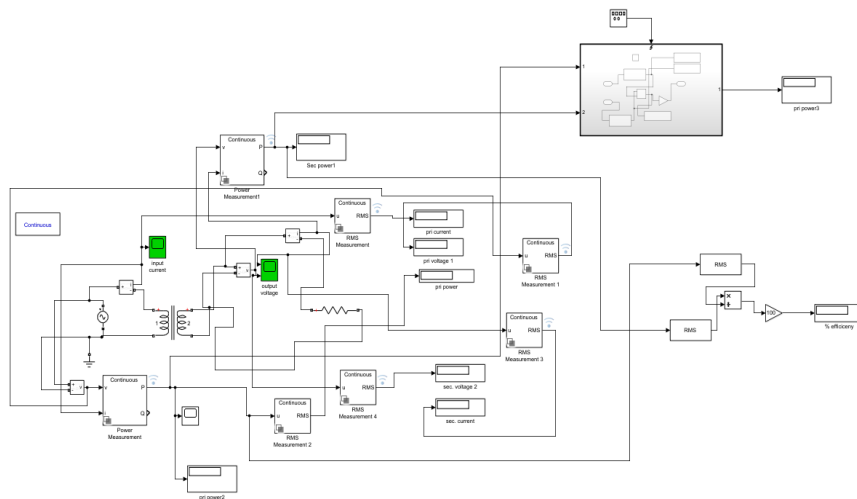

Fig. 4 Load test circuit MATLAB design

With the help of application of parameter estimation in MATLAB Simulink, Circuit is tuned for the calculated values of voltage and current. In parameter estimation, calculated values of input and output voltages and current are provided. Here, calculated the values of internal resistance and inductance of the primary and secondary winding. Also, sensitivity analysis is performed that helps in that helps in accuracy of the results. With the help of multiple values, percentage efficiency and percentage voltage regulation are calculated.
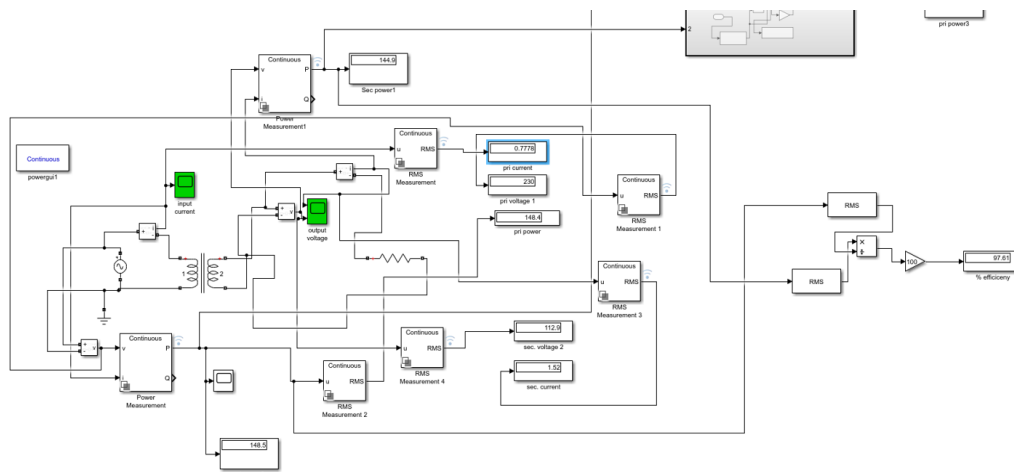

Fig. 5 Load test MATLAB Simulation results.

B.   Open circuit test

The open-circuit test, or no-load test, is one of the methods used in electrical engineering to determine the no load impedance in the excitation branch of a transformer. The no load is represented by the open circuit, which is represented on the right side of the figure as the incomplete part of the circuit. The secondary of the transformer is left open-circuited. A wattmeter is connected to the primary. An ammeter is connected in series with the primary winding. A voltmeter is optional since the applied voltage is the same as the voltmeter reading. Rated voltage is applied at primary.
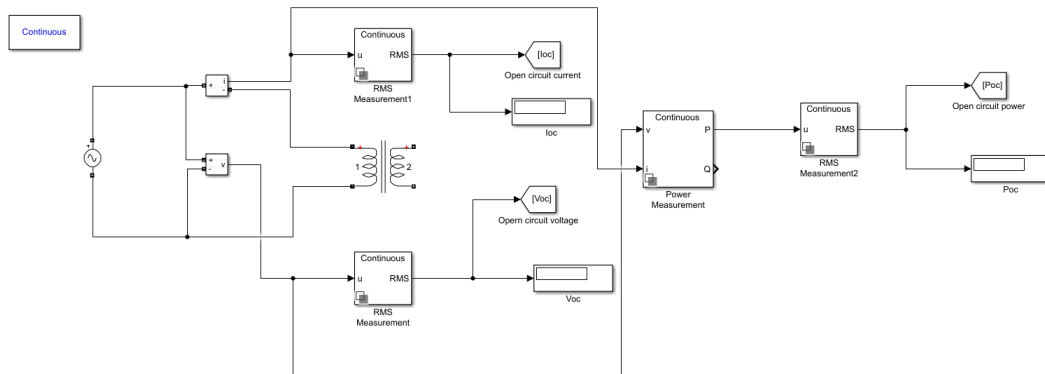

Fig. 6 Open test circuit MATLAB design

A power measurement scope is connected to the primary. A current measurement scope is connected in series with the primary winding. Rated voltage is applied at primary.
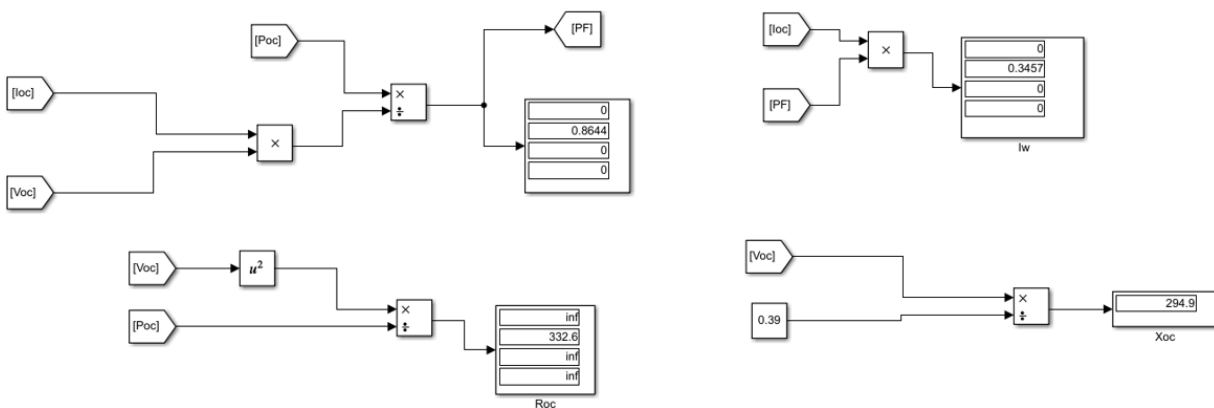

Fig. 7 OC test parameter results
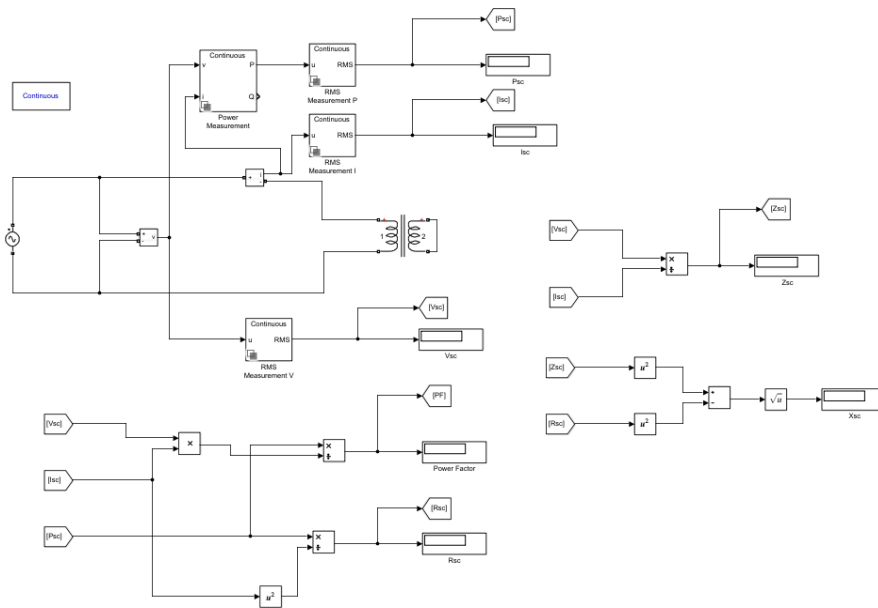
C.   Short circuit test

Fig. 8 Short circuit test MATLAB circuit

The purpose of a short-circuit test is to determine the series branch parameters of the equivalent circuit of a transformer.

This test is conducted on the high-voltage (HV) side of the transformer when the low-voltage (LV) side (or the secondary) is short-circuited. A wattmeter is connected to the primary side, an ammeter is connected in series with the primary winding. With the help of a variac, the applied voltage is slowly increased until the ammeter gives a reading equal to the rated current of the HV side. After reaching the rated current of the HV side, all three instruments reading (Voltmeter, Ammeter, and wattmeter readings) are recorded. The ammeters reading gives the primary equivalent of full load current IL. As the voltage applied for full load current in short circuit test on transformer is quite small compared to the rated primary voltage of the transformer, the iron losses in the transformer can be taken as negligible here.
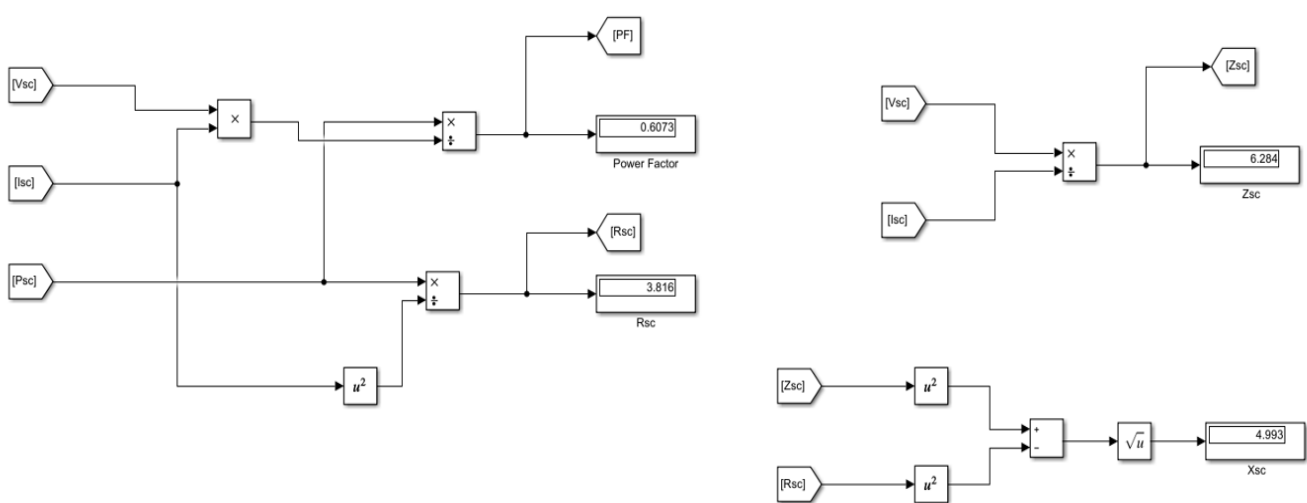

Fig. 9 SC test parameter results

7. CONCLUSIONS

This paper presents a user-friendly and education-oriented transformer learning tool and is successfully developed using MATLAB Simulink. This tool is intended to make transformer testing teaching in more effective and easy way. The interface of MATLAB is a button-driven program provides which is a convenient tool so that user can run this tool repeatedly to observe the transformer behavior with parameter variation. By using this tool, user can also reduce manual calculation time.

8. FUTURE SCOPES

Future work will be focused on developing a more complete learning tool that consist of all transformer tests together. Also, the MATLAB circuit tests design for other electrical machine devices such as induction machine, synchronous machine and DC machine.

9. REFERENCES

1. NY Dahlan, 2017 IEEE 9th International Conference on Engineering Education, Transformer Interactive Learning Tool Based on MATLAB Simulink and GUI.

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3. Prof. J. H. Patil, IJIRST –International Journal for Innovative Research in Science & Technology Transformer Testing and Analysis using MATLAB/Simuink.

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