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Research Article

GRAPHICAL SYSTEM DESIGN PLATFORM FOR MEASUREMENT AND ANALYSIS OF SINGLE PHASE TRANSFORMER PARAMETERS USING LABVIEW

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A R T I C L E I N F O

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A B S T R A C T

The proposed work aims to the performance measurement and analysis for a single phase transformer using user friendly software tool. In existing system, for measuring the voltage, current and other characteristics of transformer digital clamp meter, digital hand held scope meter are used. For analysis, oscilloscope, digital voltmeter, time current curve methods are used. To perform all these measurements human intervention is required and moreover there is more chance for human error that occurs makes the process inefficient. LabVIEW is an integrated development environment designed specifically for engineers and scientist building measurement and control system. Hence it is proposed to measure various parameter of transformer under different testing conditions to analyze the characteristics of transformer using LabVIEW. NI USB 6009 Data Acquisition Card is used as a interfacing hardware between LabVIEW and experimental setup. By sensing the Voltage, Current under various conditions performance and characteristics will be measured and analyzed. And also this proposed method aims for online measurement and continuous monitoring. This helps to improve the system performance and quality. Moreover it gives exact values and it reduces computation difficulties while calculating its required parameters. The graphical view of the machine's performance can be obtained using graphical programming. Hence LabVIEW with Data Acquisition System is used widely in measurement technique and also helps in analysis of various signals. The equivalent circuit parameters of the transformer under open circuit and short circuit test are being measured.

INTRODUCTION

The various transformer testing carried out are two types: tests done at factory and Tests done at site. In factory testing, routine and special tests are carried out for every unit manufactured with customer requirement [1]. Tests did at site include pre-commissioning tests, condition monitoring periodic tests and emergency tests. Pre-commissioning test is to assess the condition of transformer after installation and compare the results with factory reports. Condition monitoring tests is performed for calibration. To measure all parameters human power is required where possibility of human error and data storage is tedious. Field-testing takes time, effort and incurs a cost; but the need for testing is necessary to prevent from damages. Offline methods require disconnecting the transformer from the power network and are mainly used during scheduled inspections or when the transformer is already failure suspicious. There are number of tests such as OC, SC, Polarity test, Routine test available but the values cannot be stored simultaneously. Therefore the tests are being made at periodic measurement and availability of the required values is not available from time to time. Open Circuit (OC) and Short Circuit (SC) test are performed to measure losses in transformer. There are different types of losses such as Core/Iron Loss: Hysteresis loss and Eddy current loss, Copper loss. Copper loss and Iron loss can be determined from OC and SC test respectively. Data Acquisition (DAQ) is the process of measuring an electrical or physical phenomena such as voltage, current, temperature, pressure, or sound with a computer [8],[9]. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible, and cost-effective measurement solution [2],[7].

Motivation

To identify unsatisfactory conditions that may shorten the unit's useful life or to confirm that a transformer is in suitable condition for service many field testing and experiments are carried out. Human interventions in this process lead to inefficient testing and possibility of human errors. In this new age era it is mandatory to go with technology to achieve the target more effectively.

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Proposed System

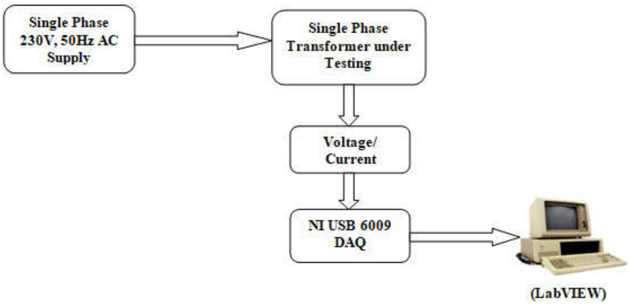


Fig 1 Structure of the proposed system

The block diagram of the proposed system is shown in the Fig. 1. The 230V 1Φ supply is given to the single phase transformer under OC and SC testing. A 1kVA 2:1 power transformer with 440V high voltage and 230V low voltage is used for testing [3]. Potential Transformer and Current Transformer will be used to sense the Voltage and Current in the primary and secondary winding of the transformer. The 230V/ 5V step down potential transformer has been used as a voltage sensor [6]. The current transformer of 5A/50mA is used as a current sensor. The sensed signal is given to the analog input of the interfacing device (NI 6009). The I/O characteristics of the sensors are shown in the Fig. 2 for various input values and the linear relationship is found satisfactory for this proposed system [5].

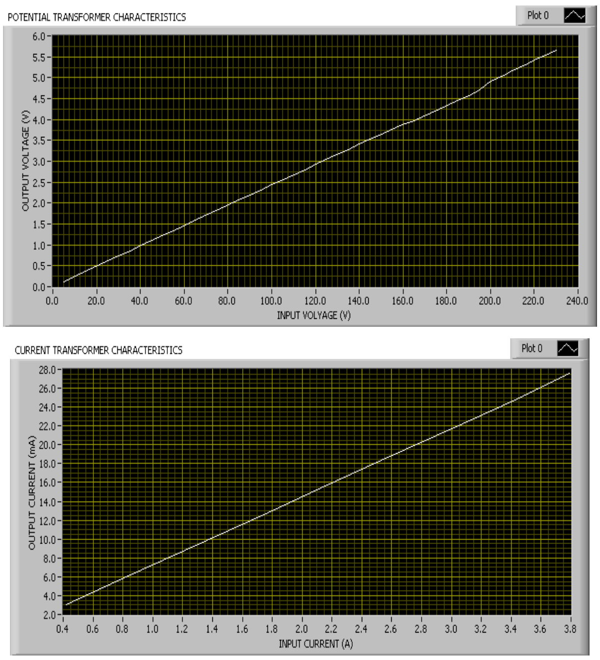
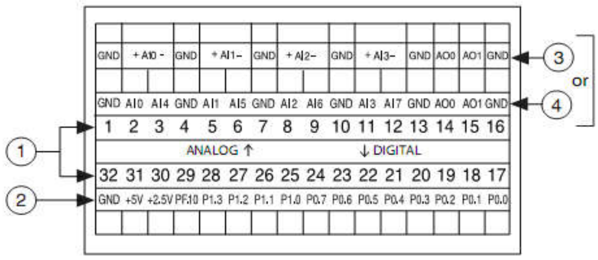


Fig 2 Characteristics of sensors

The USB port has been used as a communication medium which transfers the signal from DAQ to personal computer. NI USB 6009 DAQ card is a combination of powerful hardware and software running on real time processor and it brings even better flexibility for virtual instrumentation in personal computer platform.

Realization of NI USB 6009

Data acquisition (DAQ) systems using NI USB 6009 are becoming increasingly practical for analysis and monitoring due to large flexibility in software and hardware. The architectural diagram of the DAQ NI 6009 is shown in the Fig. 3. It offers 8 analog input (AI0 – AI7) and 2 analog output signals (AO1 & AO2). In this proposed work only two inputs has been used for voltage and current respectively. It has 14 bits differential and 13 bits single ended input resolution with maximum samples of 48kS/s. The input ranges from ±10V and 50mA current [9]. The voltage and current sensors will provide the input signal to the DAQ, it converts the given analog input signal into digital signal and given to the personal computer through USB port. Fig. 3 shows the pin configuration of the DAQ.



1. Terminal Number Labels
2. Digital I/O Label
3. Differential Signal
4. Single-Ended Signal

Fig 3 Pin Diagram

Design of Virtual Instrumentation for Oc and SC Test

Implementation of OC Test

The purpose of conducting OC test is to determine the shunt branch parameters of the equivalent circuit of transformer. Low voltage side winding is connected to supply at rated voltage, while the high voltage side winding is kept open circuited. This test is conducted to determine the iron losses (or core losses) and parameters R_0 and X_0 of the transformer. In this test the rated voltage is applied to LV side while the HV side is left open circuited. The applied primary voltage V_1 is measured by the voltage sensor, the no load current I_0 by current sensor and no load input power W_0 by EPM Power Tool [4]. As the normal rated voltage is applied to the primary, normal iron losses will occur in the transformer core. Hence wattmeter will record the iron losses and small copper losses in the primary winding.

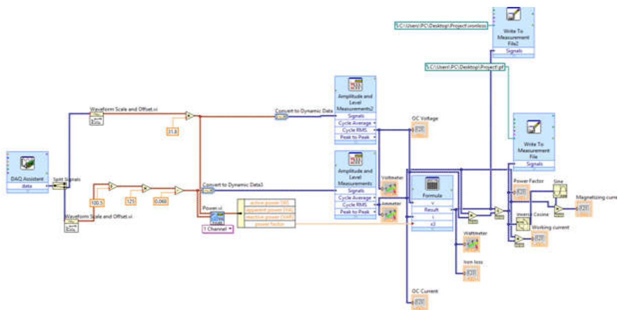


Fig 4 Block Diagram for OC Test

Formulae Used

$$\cos\varphi_0 = \frac{W_0}{V_0 \times I_0} \quad (1)$$

$$I_M = I_0 \sin\varphi_0 \quad (2)$$

$$I_W = I_0 \cos\varphi_0 \quad (3)$$

$$R_0 = X_0 = \frac{V_0}{I_0} \quad (4)$$

In the above shown formula's, equation (1) is used to calculate Power factor. The equation (2), (3) and (4) are used to calculate Magnetizing Current, Working Current and Resistance/Reactance respectively.

Implementation of SC Test

The purpose of conducting SC test is to determine the series branch parameters of the equivalent circuit of transformer. High voltage side winding is connected to supply voltage, while the low voltage side winding is kept short circuited.

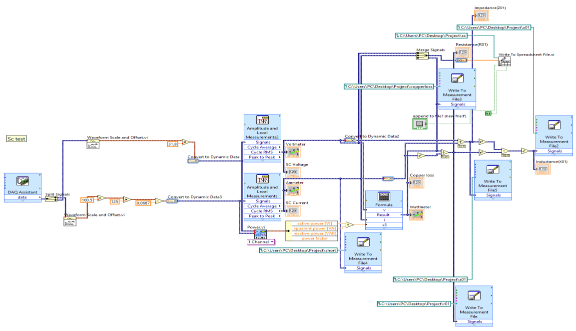


Fig 5 Block Diagram for SC Test

This test is conducted to determine Primary Resistance (R_{01}) and Primary Reactance (X_{01}) and full load copper losses of the transformer. In this test the secondary is short circuited by a thick conductor and variable low voltage is applied to the primary. The low input voltage is gradually raised till voltage V_{sc}, full load current I_1 flows in the primary. Then I_2 in the secondary also has full load value since $I_1/I_2=N_2/N_1$. Under such conditions, the copper loss in the windings is same as that on full load.

Formulae Used

$$R_{01} = \frac{W_{SC}}{I_{SC}^2} \quad (5)$$

$$Z_{01} = \frac{V_{SC}}{I_{SC}} \quad (6)$$

$$X_{01} = \sqrt{Z_{01}^2 - R_{01}^2} \quad (7)$$

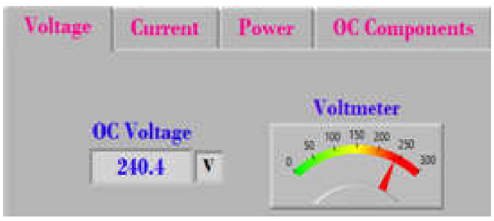
$$P_{OUT} = 1000 \times X \times PF \quad (8)$$

$$P_{IN} = P_{OUT} + (X^2 \times W_{SC}) + W_{OC} \quad (9)$$

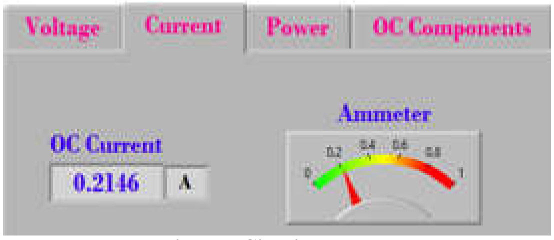
Table I Results Obtained with Proposed Experimental Setup

Open Circuit Test

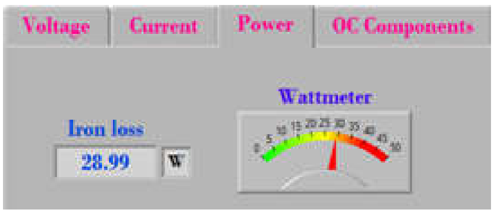
Open Circuit Voltage



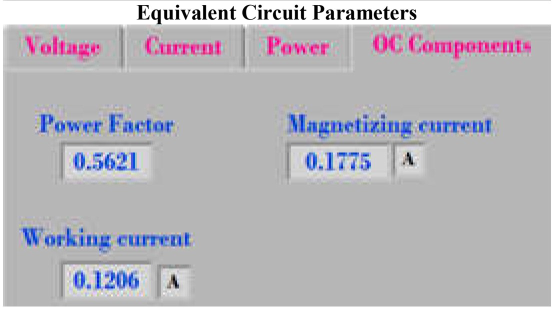
Open Circuit Current



Open Circuit Power

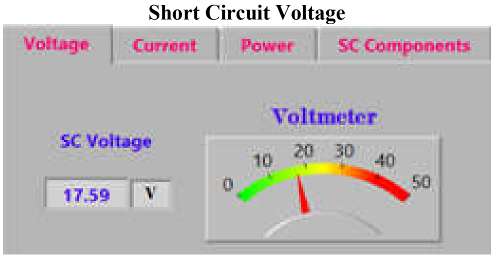


Equivalent Circuit Parameters

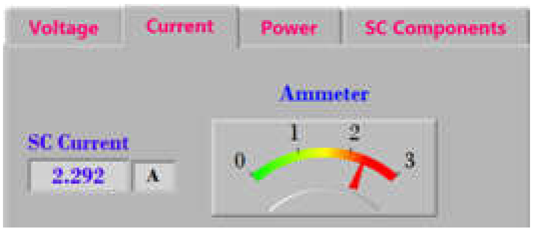


Short Circuit Test

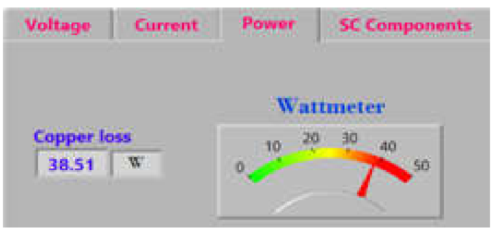
Short Circuit Voltage



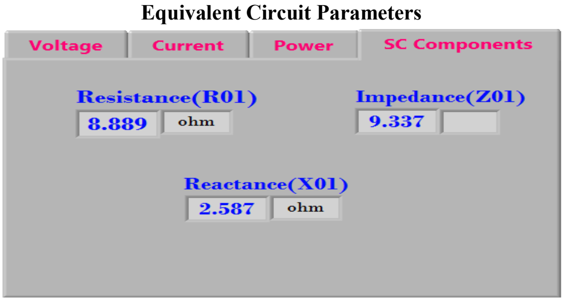
Short Circuit Current



Short Circuit Power



Equivalent Circuit Parameters



In the above shown formula's, equation (5) is used to calculate Resistance with respect to primary side. The equation (6) and (7) are used to calculate Impedance and Reactance with respect to primary side respectively. The equation (8) and (9) are used to calculate Output Power and Input Power respectively.

EXPERIMENTAL RESULTS

The experimental result has been taken under Open Circuit and Short Circuit conditions. The obtained result has been compared with the traditionally measured quantities taken with same experimental setup. In the following Table I, the graphical representation of results obtained under OC and SC test is shown. From the shown figures, for OC test at rated Voltage 240V, the corresponding Current in low voltage side is 0.214A, the Power consumed is (Iron loss) 28.99W. Also the obtained power factor is 0.5621, magnetizing current (I_m) is 0.1775A and working current (I_w) is 0.1206A. In OC test, the obtained power indicates iron loss in transformer which is more when compared to Copper loss. Hence copper loss is negligible. For SC test at rated current 2.27A, the Short circuit voltage is 17.59V, the Power consumed (Copper loss) is 38.51W, Resistance (R_{01}) is 6.341Ω, Impedance(Z_{01}) is 6.639Ω and Reactance(X_{01}) is 1.967Ω. In SC test obtained power indicates Copper loss in transformer which is more when compared to Iron loss. Hence Iron loss is negligible under full load condition.

Comparison between Proposed and Existing Techniques

Parameters	Proposed Method	Conventional Method	Difference
Open Circuit Test			
Voltage(V)	240.4V	240V	0.4V
Current(A)	0.214A	0.22A	0.006A
Power(W)	28.99W	30W	1.11W
Power Factor	0.56	0.5	0.06
Magnetizing Current (A)	0.1775A	0.1699A	0.0076A
Working Current(A)	0.1206A	0.1309A	0.0103A
Short Circuit Test			
Voltage(V)	17.59V	18V	0.41V
Current(A)	2.292A	2.025A	0.267A
Power(W)	38.51W	40W	1.49W
Resistance (ohm)	8.889Ω	9.07 Ω	0.181 Ω
Impedance(ohm)	9.337Ω	9.55 Ω	0.213 Ω
Reactance(ohm)	2.857Ω	3.23 Ω	0.373 Ω

Photography of the Developed Model

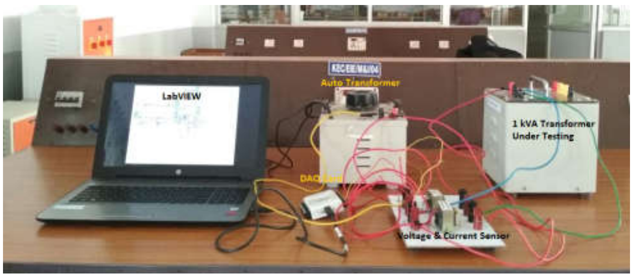


Fig 5 Photography of Developed Model

CONCLUSION

In this paper, a platform for performance analysis and measurement of the single phase transformer is successfully developed on a Virtual Instrument using LabVIEW and also tested extensively using experimental setup. The virtual instrument being economic, highly flexible, user-friendly and easily upgradable comes up as a revolutionary tool with its improved performance and more reliability than the traditional manual methodologies which themselves may be tedious to carry out, inaccurate and time consuming. The results of this proposed system proves it as a modern tool with Web enabled feature with remote accessibility of DAQ cards in Advanced Control and Instrumentation field.

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