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An Integrated Test Platform for Power Transformer Testing

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Abstract

Quality testing of transformers is an important aspect of the transformer manufacturing process. Ensuring standard functioning of transformer decreases the chance of failure and provides good lifespan. The process of testing every single aspect of the transformer is long and tedious when performed manually. Automating the testing process using a software platform LabVIEW will be advantageous, thus saving time and capital. The test platform is designed to perform High Voltage Test and No-Load Voltage Test. The manufacturing process leading up to quality testing of the power transformer is discussed.

Keywords: Quality testing; Automating; High voltage test; No-Load voltage test; Power transformer

Introduction

The transformer is the main part of an electrical distribution system. Failure of transformer can be due to electrical-overvoltage conditions, lighting, switching surges, partial discharge or static electrification or mechanical-deformation of windings of the transformer resulting in abrasions or rupturing of the paper insulation or thermal-when paper insulation loses its physical strength to a point where it can no longer withstand the mechanical movement or overloading the transformer beyond its design capabilities for a long time.

Other reasons include meeting customer requirement, improve accuracy of operation, faster troubleshooting and reduce overall risk of failure.

This makes it essential to let the transformer through numerous testing procedures.

Manual testing of the transformer consumes time, labour and capital in a mass-producing industry. Automating the testing process will thus be advantageous [1].

Literature Review

PCB mountable toroidal transformer

The testing methods for power transformer depends on the type of transformer. The testing methods for PCB mountable toroidal type power transformer is discussed in this paper. The parts of PCB mountable toroidal transformer are as follows.

CRGO Core: The magnetic and electrical properties of iron is found to improve significantly with the addition of silicon in iron in right proportions along with the help of certain manufacturing process. This is now known as silicon steel. This combination of metals not only reduced the eddy current losses but also significantly improved the magnetic permeability of the steel. This discovery led to the production of high- grade steel known as Cold Rolled Grain Oriented (CRGO) steel[1]. This steel mainly finds application as core material for power transformers and distribution transformers.

Toroidal Core: Tape toroidal core are constructed similar to tape C cores, by winding the magnetic material around a mandrel, in the form of a pre- slit tape. This tape material comes in all of the iron alloys and the amorphous materials. The tape toroid is offered in two configurations, cased and encapsulated. The cased toroid offers superior electrical properties and stress protection against winding. The encapsulated cores are used when not all of the fine magnetic properties are important to the design, as in power transformers [1].

Windings: In power transformers, copper windings are preferred over aluminium windings as they are capable of carrying almost twice the current capacity of aluminium and have high short circuit withstanding capacity. These windings are stationary with varying flux, thus causing an induced emf on the secondary windings. The grade of copper winding differs for different transformers.

Manufacturing Of PCB toroidal transformer

The quality testing of power transformer is integrated in to the manufacturing process as a final step. Therefore, understanding the entire manufacturing process is essential. The process of power transformer manufacturing begins with the selection of core (encapsulated), along with insulation. Next, the primary windings are wound, followed by the secondary windings separated by insulation. The PCB toroidal transformer may contain more than one secondary winding. The windings are wound one after the other separated by insulation. The case is fixed over the completed windings. The partially complete power transformer goes into intermediate testing. The intermediate test is also called as before potting test. Once the transformer passes the intermediate test, it is potted. Potting is the process of filling a complete electronic assembly with a solid or gelatinous compound for high voltage assemblies by excluding gaseous phenomenon such as corona discharge.

Potting is done to ensure the device’s ability to resist shock, vibration, exclude water, moisture and/or corrosive agents. A potted PCB toroidal transformer is looks as shown in Figure 1.

Figure 1: A potted PCB toroidal transformer.

The before potting test is carried out before potting because it is difficult to rework on the transformer, in case it fails the intermediate test. After potting, the transformer is subjected to screen print marking and visual inspection. Next, the final test, called Final Quality Control (FQC) is performed on the transformer. The FQC is not as intensive as the intermediate test. Finally, the tested transformers are sent for packaging.

Testing Methods

The type of intermediate test performed varies according to the type of transformer. For the PCB mountable toroidal transformer, two tests are carried out. The High Voltage (HV) test and the No load voltage test.

High Voltage Test: Electrical equipment must be capable of withstanding over voltages during operation. This test is also known as the dielectric withstand test. It is the opposite of continuity test, in the sense that, it will make sure no current flows from one point to the other. The High Voltage test is carried out by subjecting the primary windings of the transformer to very high voltage, say, 500 V and the output voltage across the secondary winding is measured. The high voltage ensures proper insulation between the windings, which, in turn, ensures that the application of a large voltage difference between two conductors separated by the insulator would result in the flow of a very small current. Although this negligible current is acceptable, no breakdown of the insulation must occur. The entire high voltage test takes place in less than a minute in accordance to the safety standard.

No load voltage Test: The no load voltage is measured to determine the no load current. In this test, the rated voltage is applied to the primary windings of the transformer while the secondary windings are at the no-load state. As a result, the current flows only to the primary side of the transformer. Yet, this current excites the core and causes iron loss of the core. For this, the parameters such as input voltage, voltage across the secondary windings, the total output voltage and the no load current at different input voltages are noted.

Hardware

Automating and implementing the above-mentioned testing methods for PCB mountable toroidal transformer requires the integration of various hardware components with the testing platform created using LabVIEW software. A brief account of hardware components is listed.

- The High Voltage (HV) tester is used for carrying out the High Voltage Test. The Chroma Hipot Tester 19050 series is a suggested choice.
- The digital multimeter is needed to measure and record the voltage and current flowing through the transformer during the tests. A separate multimeter for voltage and current measurement is recommended.
- 230 V AC power source is required to energies the primary windings of the transformer to test the output voltage of the secondary windings. This type of power source is provided by the IRDC CF-500 programmable power source. This is fully digitized with digital sampling measurement capability.
- To run an application continuously for a long period of time, powerful and efficient computer is required The Lenovo ThinkCentre Tiny desktop packs a powerful enterprise performance that is energy efficient and easy to manage.
- Convertor wires are used for transfer of data from HV Tester and digital multimeter to PC. The USB to serial convertor operates as a bridge between one USB port and standard RS -232 serial ports.
- The relays used in the quality testing are programmed using Arduino Mega. It is programmed using the Arduino Software IDE.
- The driver IC is needed to drive high current loads using digital logic circuits. The Arduino I/ O cannot supply the required power. ULN 2003 motor driver IC can be used. This is used to drive the relay modules.
- Relays are switches that operate electromechanically or electronically. They are generally used to switch currents in a control circuit. The relays are used to switch the point of contact between tests.

Software

The power transformer requires several tests to be performed in order to determine its quality. Testing each of the parameters separately consumes time and capital. The solution to this is to develop an integrated testing setup that makes use of the available hardware instruments and a software application that helps in developing a continuous testing process that determines the various parameters of power transformer. LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform anddevelopment environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platform.

Selection page: The selection page is the first screen that appears when the application is opened. It should have the different types of power transformers to be tested. From this the operator can select the type of transformers that is to be tested. The selection panel designed using LabVIEW is shown in Figure 2 Selection Page. In the figure, two types of transformers are provided for selecting from. One is the PCB mountable power transformer and the other is the panel mount transformer.

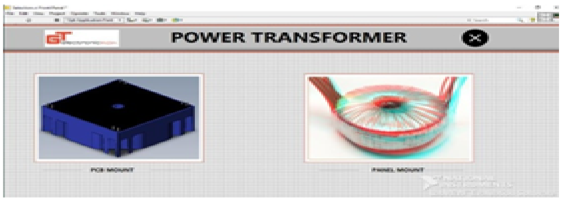

Figure 2: Selection Page.

Home page: The home page of the testing application should contain options such as start, create and edit.

The start option opens the testing platform to perform testing for the selected type of power transformer.

The create option is used to input standard data if any new power transformer is tested.

The edit option is used to edit the standard values if needed.

The home page created using the LabVIEW software is shown in Figure 3.

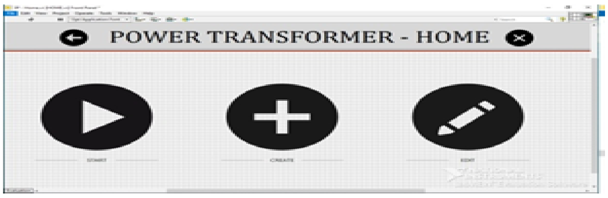

Figure 3: Home Page.

Test page: The testing page, as shown in Figure 4 where is all the tests are performed and quality of the power transformer is determined. Once the transformer to be tested is placed on the fixture, the operator has to press READY TO TEST, and the testing has to begin. If the measured values lie within the specified range, the testing result is published as PASS. If any one of the parameters deviates from the range, then the result is published as FAIL.

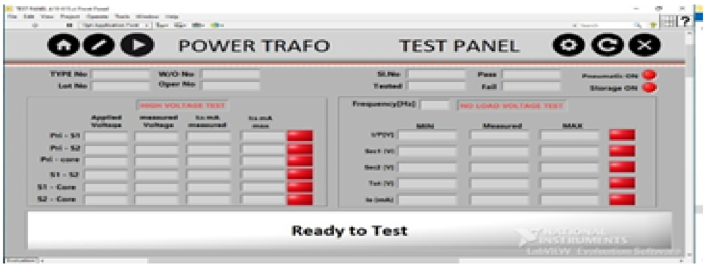

Figure 4: Test Panel.

Program: LabVIEW follows a dataflow model for running VIs. When a node completes execution, it supplies data to its output terminals and passes the output data to the next node in the dataflow path. For this application we are making use of case structures.

Case Structure has one or more sub diagrams, or cases, exactly one of which executes when the structure executes.

The value wired to the selector terminal determines which case to execute and can be Boolean, string, integer, or enumerated type. Right-clicking the structure border to add or delete cases.

The Labeling tool can be used to enter value(s) in the case selector label and configure the value(s) handled by each case.

The testing panel is programmed using LabVIEW software. This program is loaded on to the destination PC where the testing process takes place.

The reason being, data acquisition becomes easier with LabVIEW when compared to other programming platforms. The test panel contains several Sub VIs. A few of them are shown in Figures 5-7.

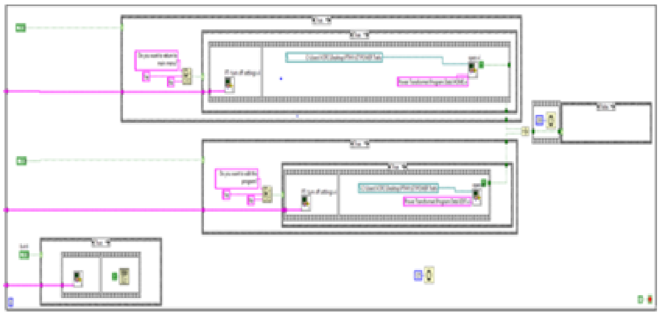

Figure 5: LabVIEW block diagram for testing primary voltage.

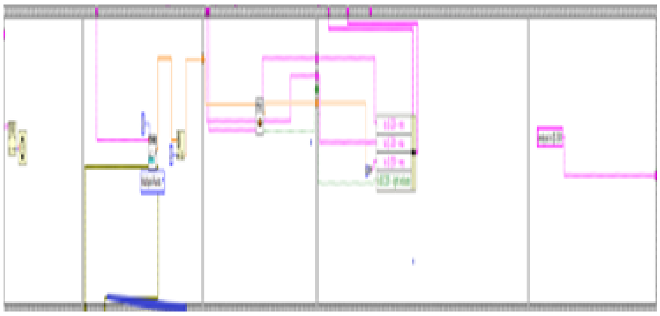

Figure 6: LabVIEW Block Diagram for no load test.

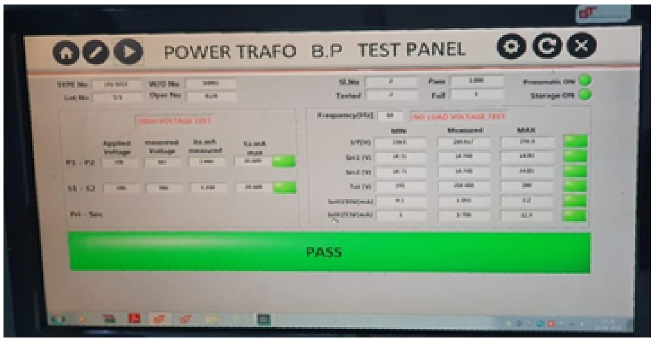

Figure 7: Test results.

The results observed for all the products are stored in the form of an excel sheet. This sheet contains all the values measured under different parameters and whether the product has passed the quality testing or not. A sample excel sheet is shown in Figure 8.

1	DATE	Order-No.	Lot No	Inspector	Result	f [Hz]	Ip meas [\	s1 meas. [	s2 meas. [	tot meas.	Io@230V	Io@253V	p1-p2 [V]	p1-p2 [mA	s1-s2 [V]	s1-s2 [mA
2	12-03-202	34991	1/2	4360	PASS	50	230.144	14.749	14.749	259.533	1.104	4.068	500	2.46	500	0.15
3	12-03-202	34991	1/2	4360	FAIL	50	230.093	13.68	0	0	0	0	500	2.48	500	0.14
4	12-03-202	34991	1/2	4360	PASS	50	230.094	14.749	14.75	259.536	1.086	3.658	500	2.49	500	0.14
5	12-03-202	34991	1/2	4360	PASS	50	230.101	14.749	14.749	259.535	1.14	5.052	500	2.46	500	0.14
6	12-03-202	34991	1/2	4360	PASS	50	230.092	14.749	14.749	259.537	1.138	4.195	500	2.53	500	0.15
7	12-03-202	34991	1/2	4360	PASS	50	230.104	14.75	14.75	259.544	1.075	4.106	500	2.4	500	0.15
8	12-03-202	34991	1/2	4360	PASS	50	230.102	14.749	14.749	259.538	1.192	4.657	500	2.69	500	0.15
9	12-03-202	34991	1/2	4360	PASS	50	230.101	14.75	14.75	259.545	1.111	3.757	500	2.66	500	0.15
10	12-03-202	34991	1/2	4360	PASS	50	230.095	14.75	14.75	259.543	1.078	3.745	500	2.67	500	0.15
11	12-03-202	34991	1/2	4360	PASS	50	230.101	14.749	14.75	259.538	1.099	3.863	500	2.55	500	0.15
12	12-03-202	34991	1/2	4360	PASS	50	230.103	14.75	14.75	259.54	1.137	4.093	500	2.67	500	0.15
13	12-03-202	34991	1/2	4360	PASS	50	230.095	14.748	14.749	259.538	1.215	4.312	500	2.71	500	0.15
14	12-03-202	34991	1/2	4360	FAIL	50	230.104	7.288	0	0	0	0	500	2.46	500	0.14
15	12-03-202	34991	1/2	4360	FAIL	50	230.096	14.749	14.749	56.98	1.179	4.612	500	2.46	500	0.14
16	12-03-202	34991	1/2	4360	PASS	50	230.034	14.749	14.749	259.531	1.18	4.611	500	2.48	500	0.15
17	12-03-202	34991	1/2	4360	PASS	50	230.085	14.749	14.749	259.463	1.12	4.64	500	2.46	500	0.14
18	12-03-202	34991	1/2	4360	PASS	50	230.09	14.745	14.745	259.455	1.102	4.599	500	2.48	500	0.14
19	12-03-202	34991	1/2	4360	PASS	50	230.03	14.745	14.745	259.467	1.121	4.186	500	2.67	500	0.14
20	12-03-202	34991	1/2	4360	FAIL	50	230.033	7.278	0	0	0	0	500	2.48	500	0.14
21	12-03-202	34991	1/2	4360	PASS	50	230.049	14.749	14.749	259.534	1.128	4.46	500	2.49	500	0.14
22	12-03-202	34991	1/2	4360	FAIL	50	230.092	7.2	0	0	0	0	500	2.42	500	0.15
23	12-03-202	34991	1/2	4360	PASS	50	230.095	14.75	14.75	259.541	1.097	3.561	500	2.42	500	0.14

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Figure 8: Results of HV test and No-load voltage test.

Conclusion

The results obtained by testing a PCB mountable encapsulated Power transformer before potting is shown in. The figure shows the test panel with measurements obtained for the various parameters. It can be observed that each of the parameter lies between the specified standard ranges. Hence, the transformer is declared.

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