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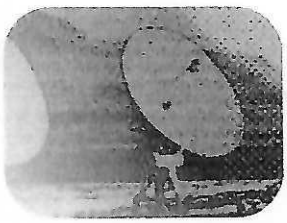

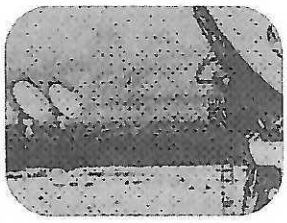
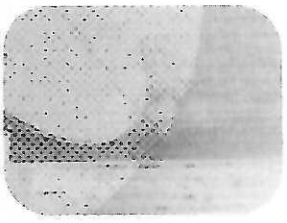

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Automation of Power and Distribution Transformer Tests

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THE CHALLENGE

Automation of measurements and test report generation in test field of power transformer manufacturer.

THE SOLUTION

LabVIEW applications that guide test engineer step by step through standardized tests of power and distribution transformers, simplify the configuration, control and monitoring of measurements, display test results graphically and numerically, simplify the analysis and storage of test data, and drastically reduce time of customized test report generation.

ABSTRACT

Three LabVIEW applications are developed. AMPA (Automated Measurements with Power Analyser) is software for measurements with PC-controlled PA (Power Analyser) trough GPIB communication system. Measurements of three-phase transformer load losses, no-load losses, no-load current harmonics, and zero impedance are automated. AMPA guides the operator, processes test data, and generates customized test reports. ATRT (Automated Temperature-Rise Test) is software for automation of the most complex and time-consuming factory test of power transformers. ATRT integrate up to four digital multimeters, multichanel digital thermometer, PA, and PC in the measuring system. ATRT guides, measures, displays, archives test data and creates final test reports. TRTR (Temperature-Rise Test Report creation) is program for easy test reports creation of temperature-rise tests made on classical way, or with ATRT.

AUTOMATED MEASUREMENTS WITH POWER ANALYZER

During the test of no-load losses of three-phase transformer, three rectified mean voltages, three root mean square voltages, three r.m.s. currents, and three active powers at rated voltage, or more voltages are measured. For simultaneous readings of analogue instruments and writing of data manually on a form, at least two technicians are necessary. After that no-load losses and currents are calculated on the basis of instrument transformers nominal ratio, instrument readings and constants. Besides, according to IEC 60076-1, measured no-load losses are corrected to sinusoidal voltage. Calculated data are then manually transcribed in test report form. Similar processes are those for three-phase transformer load losses, no-load current harmonics, and zero impedance measurements. Probability of errors and mistakes is high.

New digital instrument called power analyser (PA) integrate functions of voltmeters, ammeters, wattmeters, and more.

With LabVIEW tools, we made the program "Automated Measurements with Power Analyser" (AMPA) for measurements with PC-controlled PA trough GPIB communication system. AMPA is a program for automated measurements of three-phase transformer load losses, no-load current harmonics and zero impedance – all in accordance with IEC 60076-1: 1993. It guides the user trough measurement process, allows him to configure the PA, to run tests via an intuitive Windows interface, to process test data automatically, store them, and generate customized test reports.

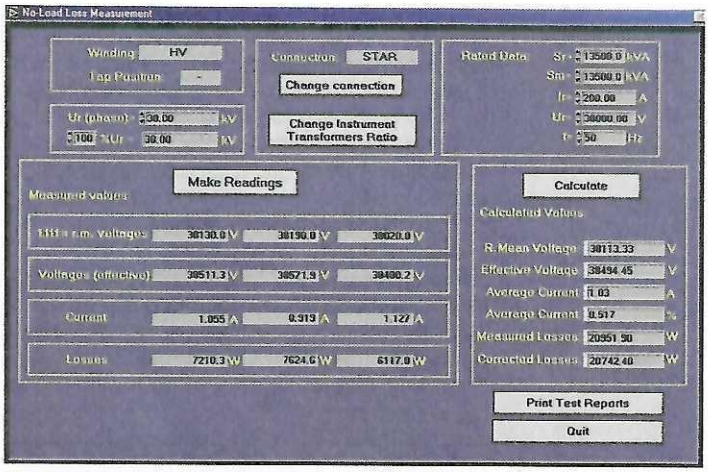

Figure 1. Man-program interface for no-load loss measurement

AUTOMATED TEMPERATURE-RISE TEST

Temperature-rise test (TRT) is the most complex and time-consuming factory test of oil-immersed power transformers. It proves transformer's power rating. During the test, oil and windings steady-state temperature-rises are determined. It is a process consisting of four sequential parts: the reference measurement of winding(s) DC resistances at a known temperature, heating with constant total losses and simultaneously measuring oil and external cooling medium temperatures, heating with constant current and simultaneous temperature measurements, and measurements of winding(s) resistances during cooling after shutdown. Temperature-rises of windings are determined by means of windings resistance increase method. Typical TRT lasts from 12 to 24 hours. At the end the test engineers compute oil and windings steady-state temperature-rises using extensive data processing of several thousands measurement results.

Measurements before automation was as follows. Winding resistance is measured using the voltmeter-ammeter method by means of stand-alone digital multimeters (system DMMs). Temperatures are measured with thermocouples by means of multichannel digital thermometer (system DTM). Three phase AC voltages, currents and frequency are measured with analogue instruments or DMMs connected to instrument transformers, and active powers (losses) are measured with three analogue wattmeters, or with system PA. The number of test engineers at winding(s) resistance measurements is from 2 to 4, depending on the number of simultaneously measured winding(s) resistances (1 to 3). During transformer heating, one test engineer maintains constant

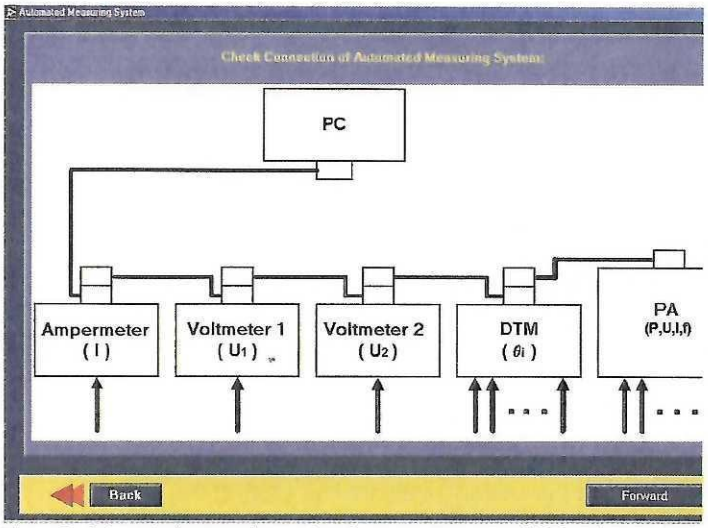

Figure 2. Automated measuring system for measurements of: DC resistances of two windings, temperatures, and AC voltages, currents, powers, and frequency

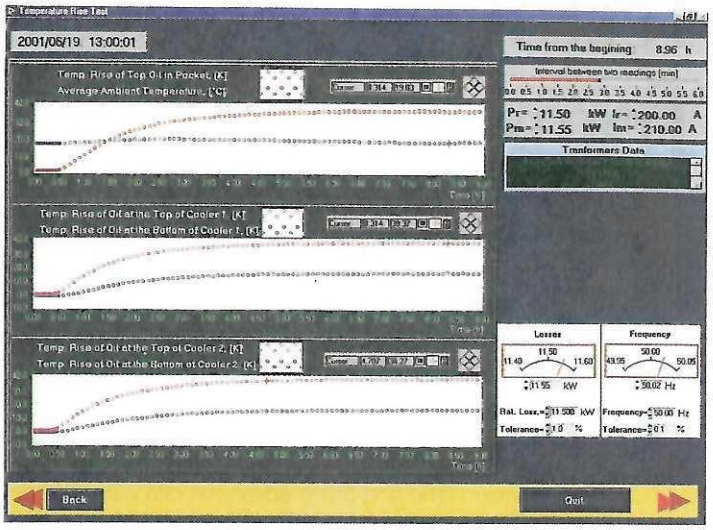

Figure 3. Man-program interface during transformer heating with constant total losses

losses or currents (and records times, voltages, currents and powers), and the other measures temperatures on 6 to 9 points every 15 minutes. Since winding resistance is measured with direct current, and the transformer is heated with alternating current, the windings resistances cannot be measured during the heating. Therefore winding resistances should be measured every 15 seconds during 10 to 15 minutes immediately after shutdown of AC supply, and then they are extrapolated back to the instant of switching off AC supply – using non-linear least squares method. For transition from heating to measuring DC resistances, and for the very measurement of windings resistances, it is necessary to have at least 3 to 5 test engineers. As the time of transition cannot be exactly predicted, the whole test team must be present during the entire test or its major part. Data gathered during the TRT must be transcribed manually and stored in databases for extensive processing of measurement results and creation of test reports.

The management of any factory requires reduction of test cost and increase of test field capacity – with minimum investment. We propose integration of the existing system instruments with LabVIEW tools in automated system (see Fig.2).

So, LabVIEW application ATRT is developed for automation of: test engineer guidance, measurements, displaying, recording, storage, data processing and creation of customized test reports. ATRT makes possible selection of 18 variants of winding connections and phases, two kinds of system DMMs, manual or automatic selection of DMMs ranges, automated or manual reference temperature measurements, 6 combinations of TCs connections, 8 cooling types, 5 criteria for termination of transformer heating and 5 calculation methods of steady-state temperature-rise, 3 options for continuation of the heating, automatic or manual measurements of AC powers, voltages, currents and frequency, and 3 different options for successive resistance measurements during the cooling. During the heating ATRT checks whether the regulated quantities (power or current and frequency) are within the specified limits, and if not, it makes acoustic and visual alarms (see Fig.3).

TEMPERATURE-RISE TEST REPORT CREATION

In practice, requirement arose for processing the TRT afterwards - by a PC independent from the measuring system. Therefore, an additional program called TRTR has been developed. To run this application one needs PC only, with Windows operating system and Excel and LV Run Time. This application makes test reports from databases generated during automated temperature-rise test (databases are transferred into PC). Input of measurement results can be also manual – if TRT has been made in the conventional way. Once entered, data can be processed in accordance with three standards IEC 60076-2: 1993, IEEE Std C57.12.90-1993 and old IEC 76-2:1976. Temperature rise and test reports can be printed out in several languages. The application is suitable for research, analyses, and statistics. In Fig. 4 an example of winding temperature-rise test report is given.

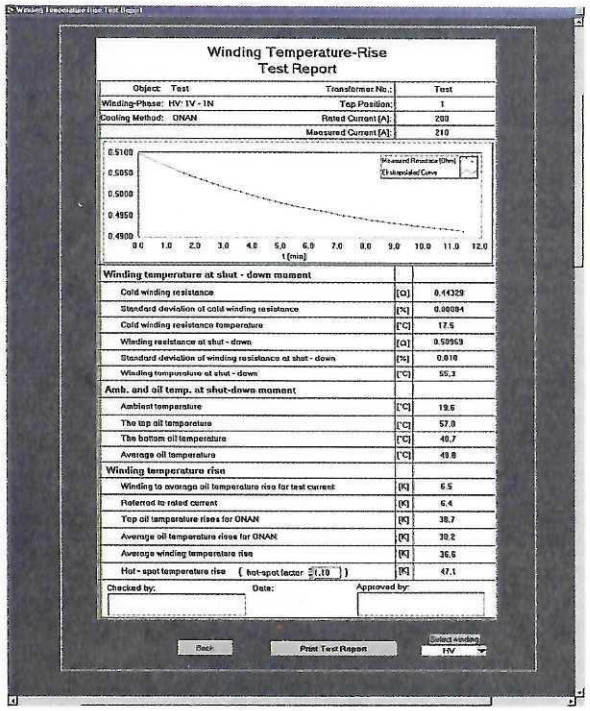

Figure 4. Winding temperature-rise test report

CONCLUSION

Test automation has increased transformer test station capacity, increased accuracy and reliability of measurement results, decreased test costs and made easier the work of test engineers. With LabVIEW it is possible to develop applications for complex measuring processes. LabVIEW simplifies programming and it is fun to work with it.

Products
LabVIEW, GPIB