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# Load Profiling of Electrical Systems Using a Condition Monitoring Platform

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***Abstract* - Calibration is vital for the measurement integrity of every electrical system. For this reason, this paper attempts to introduce a generic test bench for condition monitoring of electrical system. Hence the system is developed on the wooden platform and consists of Devices Under Test (DUTs), measurement and signal generating hardware modules, a Windows-based computer, and the integration of a LabVIEWbased software via a data acquisition (DAQ) to completely define the specific requirements. The developed test bench help the user to test procedure, investigate and display in real – time the characteristics of the DUTs.**

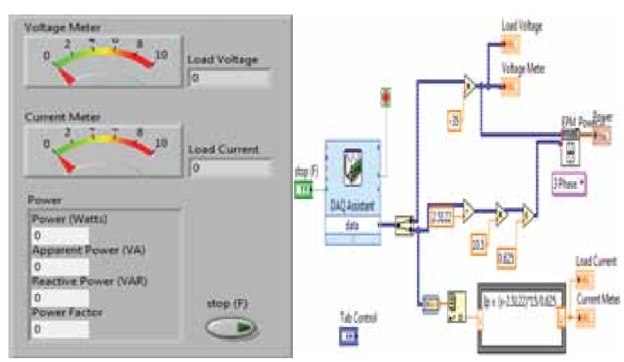
***Keywords :* Electrical Systems, Devices Under Test**

## I. Introduction

There is a technical trend for electrical systems towards ever increasing performance and efficiency. This holds true for industrial loads (e.g. alternating current/induction motors or industrial pumps) as well as domestic loads (e.g. household appliances – electrical kettle etc.). Electrical systems play an important role in the safe and efficient operation of industrial plants as well as the operation of domestic task. They are usually designed for very lengthy years of fault-free lifetime, but most of them fail earlier. Electronic test equipment (sometimes called “bench top”) is used to create signals and capture responses. In this way, the proper operation for fault detection in the device is traced and repaired. Hence, the need for condition monitoring of the electrical systems to significantly reduce the costs of maintenance by allowing the early detection of faults, which could be expensive to repair. A system is designed to carry out different tests on electric systems both for educational and research reasons. Therefore the test bench has to be flexible and yet low cost solution, using general-purpose software and hardware [1].

## II. Design Tool

Traditionally, software test automation tools are centralized on testing only what is visible by human hence requires an easily understandable design method and tool for the designer. Due to this, LABVIEW® tool is used for the design. This tool has user friendly easy to use VIs which makes it suitable to interact between the user and computer, a modular hardware and highly integrated driver software to display real - time results compared to the other data acquisition and analysis software. The programming language used in LabVIEW® is a dataflow programming language usually referred to as G-programming (graphical programming). An important addition to the development cycle of LabVIEW® is the creation of front panels (a user interface panel). LabVIEW® programs are called Vis (virtual instruments). Each VI consists of three basic components: a block diagram, a front panel and a connector panel. The connector panel is used to represent the VI in the block diagrams of other, calling VIs. The front panel can serve as a programmatic interface as well as allow an operator to input data into or extract data from a running VI through the Controls and indicators on the front panel.




**a) LabVIEW® Front Panel b) LabVIEW® Block Diagram**

Fig 1 LabVIEW® front and Block Panels

In Figure 1(a) is the front panel of a LabVIEW® development environment. Using indicators and controls, the front panel show the results in real-time of DUTs for the particular test parameter. In contrast to the front panel, Figure 1(b) shows the block diagram panel which the programmer connects different function-nodes and blocks by drawing wires. Figure 1 can be used to acquire, analysis, process and display in real-time the results DUTs. A key benefit of LabVIEW® over other development environments is the extensive support for accessing instrumentation hardware.

## III. Methodology

The objective of the system is to design a generic test bench for condition monitoring of electrical system. Hence, a system is designed to carry out different tests on electric system both for educational and research reasons. The methodology implies three procedures namely data acquisition, analysis and signal processing, decision making.

The procedure consists of three segments namely the test bench setup, the sensor setup and the data handling setup. The system is mounted on a wooden board with proper wiring and electrical grounding. Six different test parameters are used to test the DUTs. Three sensors namely; Voltage transformer, a LEM 15-NP current transducer and an optical encoder for voltage, current and speed measurement respectively is mounted onto the test bed, while Vibration and temperature monitoring devices a dual axis accelerometer and the LM35 temperature sensor are mounted. The Data Acquisition Module as the heart of the system holds the responsibility to perform signal and information acquisition.

For this system, the National Instruments 6008 DAQ module is used with a USB mode of communication. Thorough investigations is carried out of various devices to understand the effect of the test bench and validate the output. A simple block diagram representation is as detailed in the Fig 2 [2].

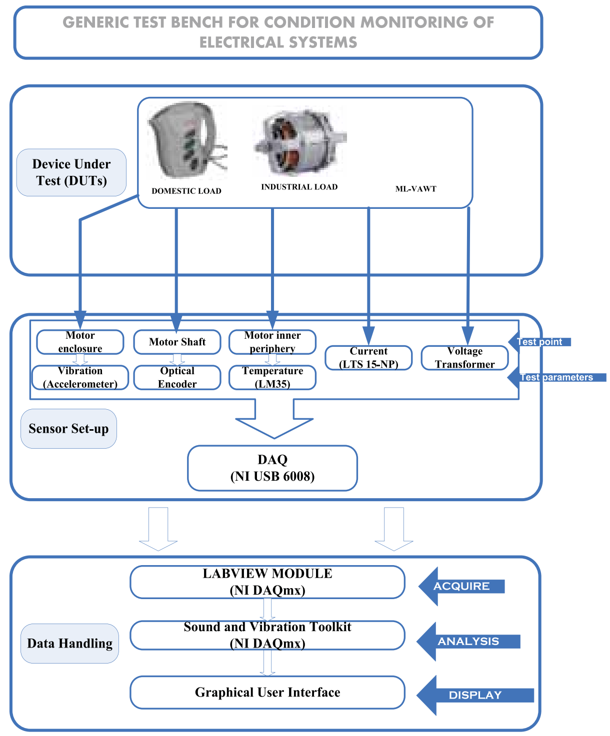



Fig 2 Block Diagram Representation

## IV. System Design

The hardware design incorporated with the paper is a rapid prototype where the materials used correlates to the cost as well. Figure 3 shows the system module setup with the HMI interface panel.

### System Setup

The test bench comprises of a test platform where various devices can be placed for system analysis. NI USB 6800 is used as a hardware interface to the system.

### Sensing Setup

The sensing setup comprises of vibration measurement using accelerometer, the speed measurement using optical encoders and temperature measurement using LM35 a current measurement using LEM 15-NP current transducer and a voltage measurement using a voltage transformer.

### Data Handling

#### a) Data Acquisition

NI USB DAQ is used to communicate the sensor measurements into the LABVIEW® development environment. The USB (NI USB-6008) is a low cost multifunctional data acquisition card (DAQ) which is used for the purpose of acquiring and capturing the test data to disk for analysis. The USB-6008 uses the NI-DAQmx driver software and is compatible with LABVIEW®. A G-programming interface is developed for acquiring the data and the trapped data are then analyzed and calibrated using the LabVIEW® VIs to generate the results.

**b) Data Analysis**

The sensor acquires raw analog voltage signal form the Hardware setup which is then interfaced with a personal computer (Windows OS) via the USB hub using the NI-DAQmx driver software. The data is analysed through precise calibration and fault identification.

**c) Data Presentation**

A Graphical User Interface (GUI) is developed for user understanding and evaluation of the whole system under test. Each GUI includes three measurement parameters place on a multiple Tab Control Container, users are to choose a GUI tab base on the choice of model. Using LABVIEW® guide toolbox, a GUI is developed to present the results obtained from the Fourier analysis of the vibration in a user friendly manner. Figure 4 shows the GUI developed for the Test Bench. The design of the software caters the requirement of the monitoring aspect where all the desired parameters are placed and analyzed.

Fig 3 Various System Module with the HMI

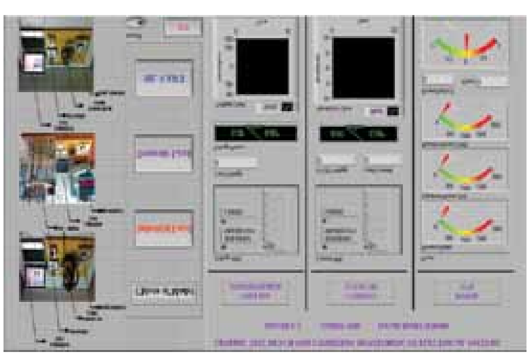


Fig 4 Integrated Graphical System Design

## V. Experimental Investigations

The ability of this test bench to measure and monitor the condition of electrical systems is a major advantage in electronic testing. Several test condition are performed at test points to measure the different devices. Hence, show the rated values and analyze their condition respectively. The data acquired from sensors are recorded by data acquisition module and saved into Microsoft excel file/Origin lab. Using the data, statistical graph are been plotted. Test conditions to be performed are: For this paper, the experimental investigation have been classified into three categories; Industrial Load, Domestic Load, Practical Application.

**a) Industrial Load**

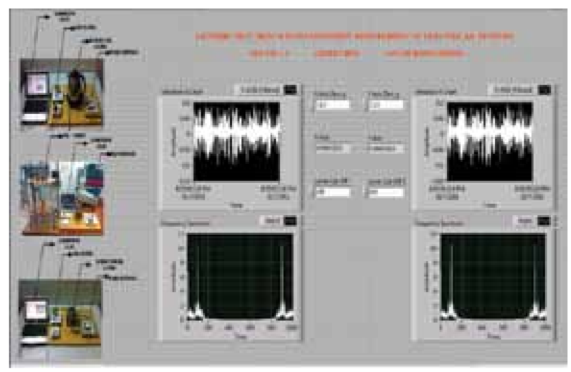
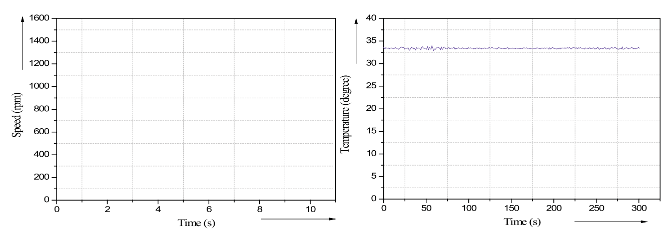
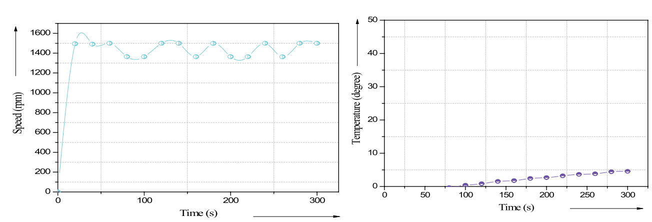


Fig 5 Vibration Pane for Time & Frequency Domains




(A) Speed (B) Temperature

Fig 6 Short Run Test on Industrial Load




(B) Speed (C) Temperature

Fig 7 Long run for industrial Load

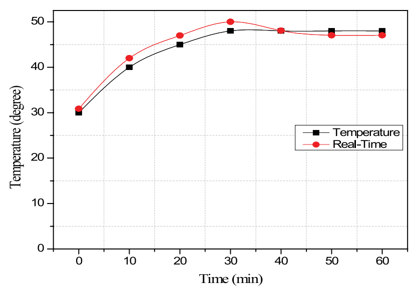



Fig 8: Temperature Chart for Measurement Comparison

### b) Domestic Load

TABLE 1: RESULTS SHOWING ELECTRICAL CHARACTERISTICS OF VARIOUS LOADS

| LabVIEW® Real – time Results | | | | Test Equipment | Rated Values | |
|---|---|---|---|---|---|---|
| Loads | Voltage (V) | Current (A) | Power (W) | Current (A) | Voltage (V) | Power (W) |
| Electric kettle | 230.58 | 7.704 | 1776.38 | 7.7 | 220-240 | 2000 |
| Laptop charger | 230.57 | 0.68549 | 156.788 | - | 220-240 | - |
| Solder gun | 234 | 0.34 | 79.6 | 0.3 | 220-240 | 30-140 |
| Refrigerator | 233.48 | 0.685 | 159.8 | 0.6 | 220-240 | 85 |
| Electric iron I | 230 | 5.68 | 1338.6 | 5.7 | 220-240 | 1200-143 |
| Electric iron II | 233 | 4.11 | 957.63 | 4.0 | 220-240 | 1000 |
| Bread toaster | 228 | 3.04 | 693.12 | 3.0 | 220-240 | 700 |
| Refrigerator | 235 | 0.17 | 39.98 | - | 220-240 | - |

### b) Practical Application

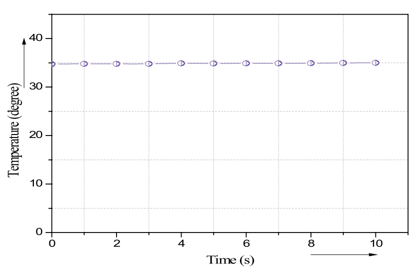
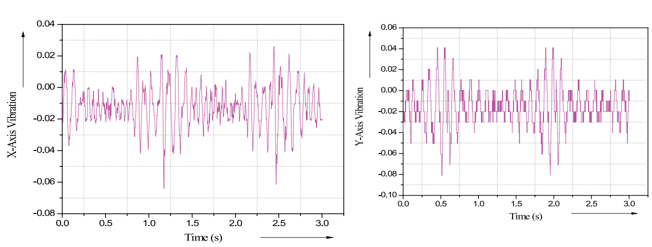



Fig 9 Temperature chart for ML - VAWT




a) X-Axis Vibration b) Y-Axis Vibration

Fig 10 Vibration investigation for ML - VAWT

The experimental investigation show test results of several systems. The outputs from the measurement are voltage signal from the sensors, which are converted to specific physical measuring parameters by unique formulas formed by their manufacturers on the datasheet. An AC fan motor was used as the electrical system for the industrial load investigation, the chart show in time domain and frequency domain (using Fast Fourier Transform) the vibration of the device. the double-sided output DFT method is used in the simulation of the frequency domain. Hence, explains the duplicated harmonic (maximum vibration) at 100Hz and 900Hz [3]. Besides the Vibration, a short-run and long-run has also be perform on the load which includes temperature and speed. Domestic load includes, electric kettle, toaster, solder gun etc. table 1 shows the electrical characteristics of the various loads tested. Finally, the Magnetic Levitated – Vertical Axis Wind Turbine (ML –VAWT) is used as a practical application.

## VI. CONCLUSION

With the help of the method and technology described in this thesis, a test environment was created and in short time at a reasonable cost for electrical systems. With this flexible environment, several experimental investigations not only defined by the users, but also based on newly gained research experience were carried. After the original tests that the bench was designed for, the system was very useful and educational, thanks to the open and flexible architecture of the national instruments hardware and software that was used. The development of the measurement environment took months of thorough research, programming and implementation, less time than the actual hardware testing of the loads.

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