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Characteristic Performance Analysis of Electrical Machine with Faults via Wavelet Transforms

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Abstract- This paper presents a novel approach to electrical machine current signature analysis based on wavelet transform of the stator current by using labview programming. The novelty of the proposed method lies in the fact that by using WT method the inherent non stationary nature of stator current can be accurately considered. The key characteristics of the proposed method are its ability to provide feature representations of multiple frequency resolutions for faulty modes, ability to clearly differentiate between healthy and faulty conditions, and its applicability to non-stationary signals. Successful implementation of the system for rotor bar breakage is demonstrated here .The condition monitoring of the electrical machines can significantly reduce the costs of maintenance by allowing the early detection of faults, which could be expensive to repair. The applied method is the wavelet transform which utilizes the results of the stator current.

Keyword-Electrical machine, Mechanical fault, Wavelet transform, NI USB

I. INTRODUCTION

Labview is a graphical programming language that is suitable for developing DAQ systems using the PC plug in DAQ boards. It is an effective application for engineering in DAQ, analysis, and presentation [1], [2].To prepares the software for measuring systems to be used for the measurements in real and virtual circuits. LabVIEW environment is a complex program enabling the designing and modeling of simple circuits as well as monitoring of complex manufacturing processes by means of graphical programming languages [3]. The designing and building of virtual devices used in computer aided measuring systems is also possible in LabVIEW environment [3], [4]. Thanks to special equipment (e.g. data acquisition device), the construction of the instrument panel required for testing of the real system under test is also possible [5]. The NI USB-6008 (National Instruments) data acquisition device was used to record real diagnostic signals originating from the instrument panel installed at the laboratory [6].

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II. DATA ACQUISITION DEVICES

This research will perform DAQ to obtain the online stator phase currents of 3-phase induction motor by the processes. The current from the motor will be acquired by the signal conditioning device. NI-6008 (USB) DAQ board will interface those signal to PC and LabVIEW will play the role on signal processing and display graphs in its front panel. To develop a proposed LabVIEW interfaced module, DAQ interface board is necessary. The DAQ interface boards will interface PC to real world analogue signals. Selecting a DAQ interface board can be based on several DAQ options featuring different form factors, characteristics, and specifications of target. In this research, NI-6008 (USB) DAQ board will play on this role. From the comparison of the waveform obtained from the front panel of the LabVIEW and wavelet simulation result, the front panel of the LabVIEW shows approximately similar result which was obtained from the wavelet analysis in terms of, amplitude and spectrum of currents. Because of its overall versatility as an engineering tool, the software package LabVIEW is chosen in most of the engineering problems. It is a graphical programming language that allows engineers and scientists to develop their own virtual instrument, which is flexible, modular and economical. Furthermore, the software meets most of the software selection criteria, and it not only does the data manipulation, analysis, and control, but also has some multimedia authoring capabilities with the help of the add-on tools. The LabVIEW software allows for the creating of application-specific templates (sub-virtual instruments) to reduce the production time for the identical subjects. Many useful functions can be incorporated with the LabVIEW programs to perform very useful tasks in a laboratory virtual instrumentation system design. The NI USB-6008 data acquisition device is shown in Figure 1. This data acquisition device is provided with 8 single analogue inputs (or 4 differential programmable analogue inputs), 2 analogue outputs, and 12 programmable digital I/O systems. The information received from the input or output control signals are sent to the control unit a PC by a USB connection. The signal transmitted between the data acquisition device and t he PC conforms to full-speed USB standards [7].

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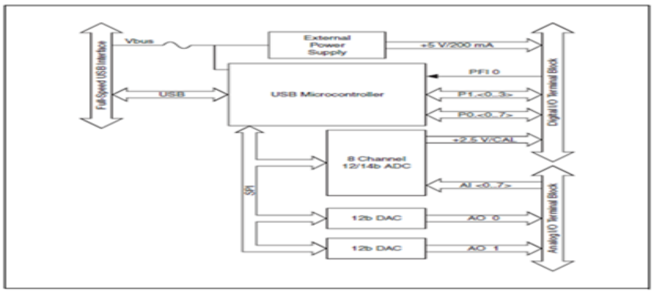


Figure 1. NI data acquisition device

The present study involves the development block diagram of Lab VIEW modules for DAQ and analysis of an AC motor test bench by using wavelet transform. The block diagram of the created virtual instrument panel analogical to the instrument panel installed with the three-phase squirrel cage induction motor in experimental condition [8]. In order to improve the circuit diagram transparency, some of its elements were combined into subprograms containing a part of input or output elements, the configuration of the data acquisition device ports, the configuration performing the conversions required to adapt the input signal parameters into the ranges of indicators, and warning lamps [9]. In figure 2 the block diagram of the created virtual instrument panel analogical to the instrument panel installed with the three-phase squirrel cage induction motor in experimental condition [8].

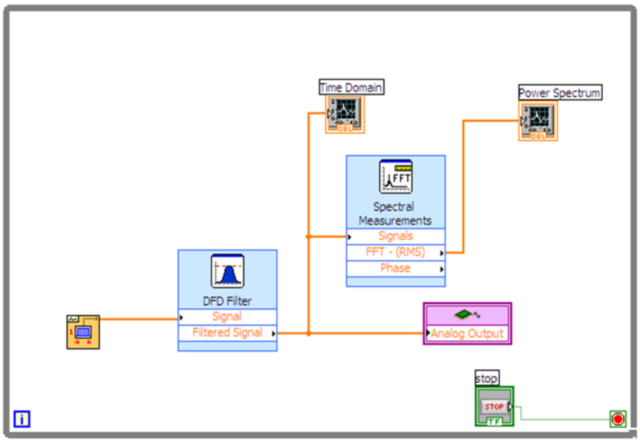


Figure 2. Block diagram of the created virtual instrument panel analogical

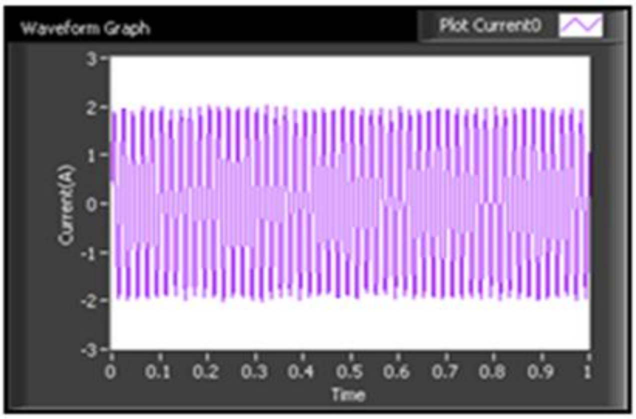
III. STATOR CURRENT AND WAVELET TRANSFORM

To detect the broken rotor bar fault, a system for fault detection was designed based on MCA. The stators current is first sampled in the time domain and in the sequence frequency domain the current spectrum are calculated and analyzed aiming to detect specific frequency components related to incipient faults. For each rotor fault, there is an associated frequency that can be identified in the spectrum [10]. The faults are detected comparing the amplitude of specific frequencies with that for the same motor considered as healthy. Based on the amplitude it is also possible to determine the degree of faulty condition. In the described system, data acquisition card was used to acquire the current samples from the motor operating under different load conditions [11].

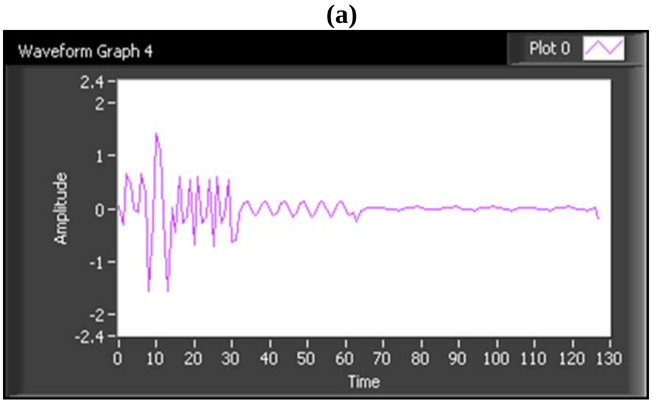
For the motor test, it is to apply the proposed LabVIEW interfaced module to motor to ensure its performances in real life motor at healthy and faulty condition [12]. The line current, of the motor is measured by the proposed LabVIEW interfaced module, the results already are compared

IV. OBSERVATIONS ON RESULTS USING WAVELET TRANSFORM

It is clear from the results obtained from the experiments that FFT is significantly dependent on the loading conditions of induction motors. At light load, it is difficult to distinguish between healthy and faulty rotors because the characteristic broken rotor bar fault frequencies are very close to the fundamental component and their amplitudes are small in comparison. As a result, detection of the fault and classification of the fault severity under light load is almost impossible. To overcome this problem, Wavelet Transform may be applied with light load. However, analyzing the wavelet time amplitude decomposition Figure 3 will show that the amplitude value follows the change of the amplitude in the fault harmonic over time, eventually achieving a value higher than when load is applied. The implemented and tested methods by labview technique showed their efficiency in fault diagnosis and condition monitoring of induction motor. The results obtained present a high degree of reliability, which enables the proposed methods as monitoring tools for diagnosis of broken rotor bars fault of similar motors.



(a)



(b)

Figure 3. Current waveform and wavelet transform in healthy state

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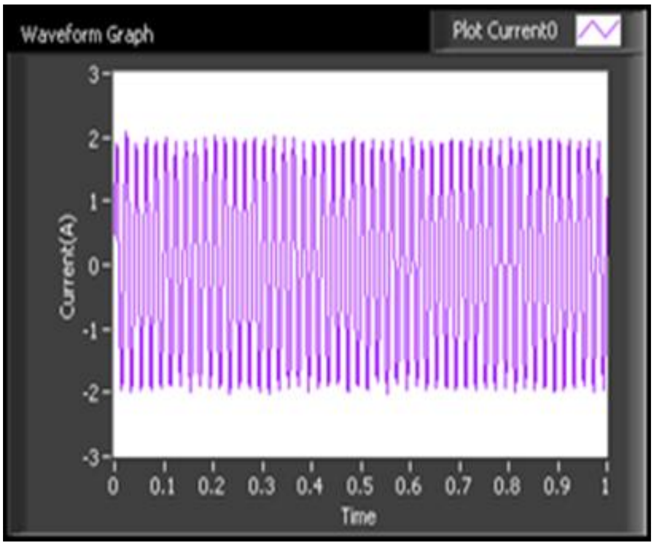
Several virtual instruments (VIs) were built up in LabVIEW. These VIs were used both for controlling the test measurements and data acquisition, and for the data processing. When motor running at no-load condition the active power is low because the power losses for motor is low in this case the result of power factor of motor is 0.53 percentage, while when the motor running at load condition the active power is higher because the power losses for motor increases this lead to improve the of power factor of motor to 0.90 percentage. Promising results are obtained using wavelet transforms and evaluating the proper signal evolution during acquisition time. Figure3 and figure4 shows the advantage of the use of wavelets under load. Comparing the FFT decomposition and the WT proves how using the Fourier decomposition will reveal low amplitude for the spectrum sideband. However, analyzing the wavelet time amplitude decomposition will show that the amplitude value follows the change of the amplitude in the fault harmonic over time, eventually achieving a value higher than when load is applied.



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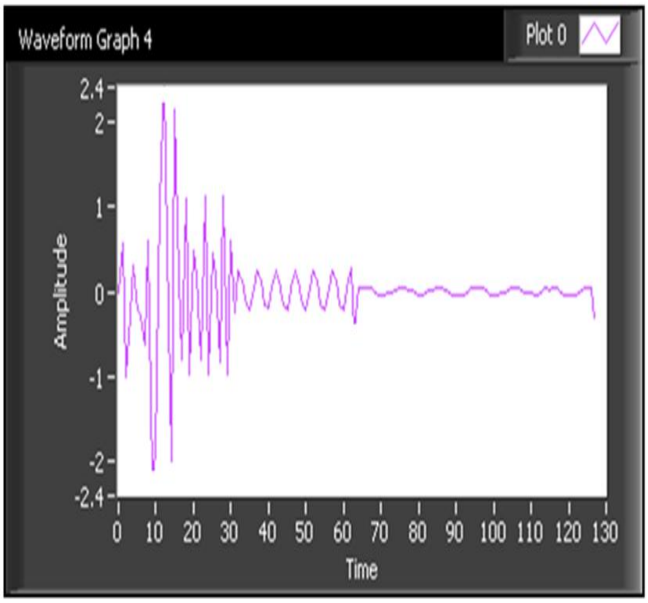
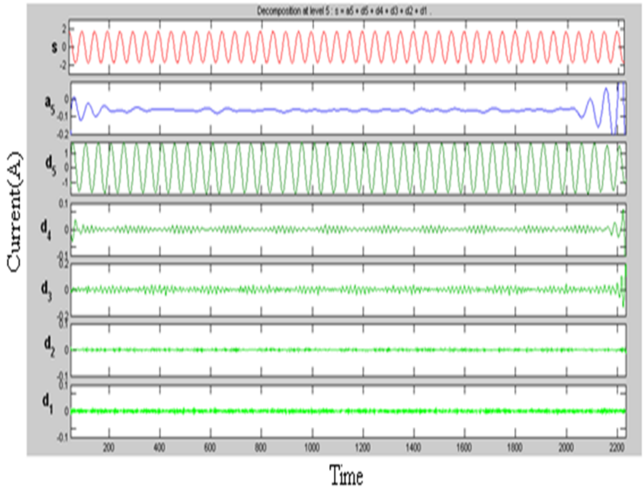


(b)

Figure 4. Stator current waveform and wavelet transform in faulty state

Tests were carried out for different loads with the healthy motor, and with similar motors having up to broken rotor bars. A it can be seen from the Figures respectively showed the amplitude and waveform graph of the stator current and current spectrum frequency at no-load (and also at loads) .The most eloquent results were obtained at great loads, especially near the rated load. The Discrete Approximation of Wavelet Transform (WT) has been already applied to the stator current in steady state condition for broken bar detection in induction motors by Matlab programming and apply actual current signal as shown in Figure5 corresponds with simulation results in detail comparison for different frequency band of the main harmonic between healthy and faulty motor.



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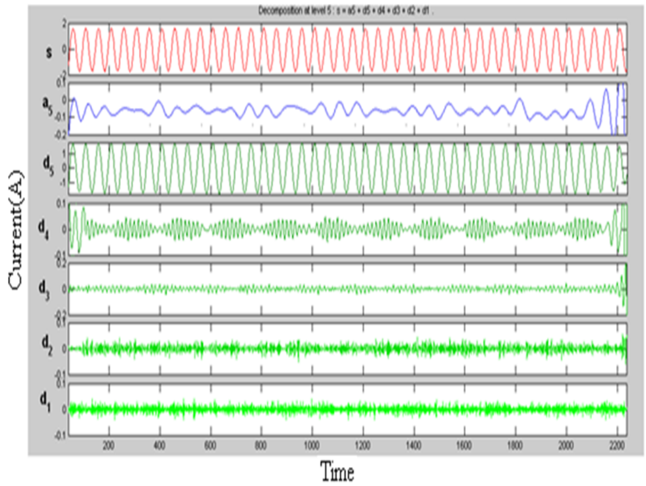

(b)

Figure 5. Decomposition of stator current in matlab

(a) Healthy motor (b) Faulty motor

V. CONCLUSION

Figures and Tables Analyzing the wavelet time amplitude decomposition will show that the amplitude value follows the change of the amplitude in the fault harmonic over time, eventually achieving a value higher than when load is applied. The present results shows that many factors affect the diagnosis of a broken bar fault.

The determining factor however, is the number of the broken bars, which are determined precisely by experimentally testing using wavelet transform. The distribution of the broken bars over the poles of the motor also reduces the amplitude of the harmonic components caused by the fault. In this experiment, the stator current frequency of a faulted induction motor was obtained for three imaginable cases.

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