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Signal Processing Techniques for Diagnosis Rotor Faults in Small Wind Turbine Motor

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Abstract
The core objective of this paper was to diagnosis and detect the expected rotor faults in small wind turbine SWT utilize signal processing technique. This aim was achieved by acquired and analyzed the current signal of SWT motor and employed the motor current signature analysis MCSA to detect the sudden changes can have occurred during SWT operation. LabVIEW program as a virtual instrument and (NI USB 6259) DAQ were take advantage of current measurement and data processing.

Keywords: Motor current signature analysis, fault diagnosis, signal processing, LabVIEW.

تقنيات معالجة الإشارات لتشخيص أعطال الدوار في محركات توربينات الرياح الصغيرة

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الخلاصة
ان الهدف الاساسي من هذا البحث هو تشخيص وكشف خلل الدوار المتوقع في توربين رياح صغير باستخدام تقنية معالجة الاشارة. تم انجاز الغرض من خلال جمع وتحليل اشارة التيار لموتور توربين رياح صغير وتوظيف تحليل اشارة تيار الموتور لكشف التغير المفاجيء الممكن حصوله خلال تشغيل توربين الرياح الصغير. فوائد برنامج LabVIEW كأداة افتراضيه و جامع البيانات (NI USB 6259) استثمرت لقياس التيار ومعالجة البيانات.

Introduction
Many signal processing techniques used as a compatible technique with non-destructive technique (NDT) to diagnosis the faults, such as power cepstrum, adaptive noise cancellation (ANC), and Fast Fourier Transformation (FFT) [1, 2]. Data are acquired, analyzed, and recorded utilizing sensors and data acquisition (DAQ). Data processed by signal processing techniques and monitored the abnormalities depending on ISO information to predict the faults and help to choose the appropriate maintenance strategy. Rotor faults is one of the most failure may be occurred in small wind turbine (SWT). The induction motor participates in an important manner to breakdown the wind turbine and subsequently to operation and maintenance (O&M). Many studies were presented for the detection and diagnosis of the broken rotor bar (BRB) [3, 4]. Several techniques were utilized for detection the faults in rotor bar [5, 6, 7].

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Motor current signature analysis is the best option from several conditions monitoring system (CMS) that is attainable for diagnosis rotor faults in SWT Motor [8]. MCSA interest is that it can be used online [9, 10]. Current spectra explanation is significance in order that components of spectral can appear from both normal operating conditions as well as faulty ones [11].Rotor faults can be detected by MCSA; current transducer is required for measuring the current. FFT algorithm used to compute a discrete Fourier Transform (DFT). FFT calculation is utilized for the conversion of the digital signal from time domain into one in the frequency domain [12]. The preference of frequency domain analysis over time domain analysis is its competence to recognize and isolation specific frequency components of interest [13]. It operates by decomposing an N point time domain signal into N time domain signals each composed of a signal point. The second step is to calculate the N frequency spectra corresponding to these N time domain signals. Lastly, the N spectra are synthesized into a single frequency spectrum [14]. BRB represent serious secondary effects lead to motor failure because of hitting the rotor bar to the end winding or stator core of a high voltage motor at a high velocity. This can cause serious mechanical damage to the insulation and a consequential winding failure may follow, resulting in a costly repair and lost production. Twice slip frequency side bands occur at $(1\mp 2s)$ f1, both side of the supply frequency. The lower sideband and upper side bands are specifically due to the broken bar and consequent speed oscillation occur at $f_b = (1\mp 2ks) f_1$,Where: k=1,2,3,etc., f1: fundamental frequency, and s: slip.

Laboratory Testing

In order to diagnose the fault of SWT induction motor with high accuracy, a lab test bench was built. The test bench show in Figure-1. The test bench consists of variable frequency device (VFD) to control the speed of DC motor which is connected with the SWT by coupling. A national Instrument NI USB DAQ, 32 channel, 16 bit was used to acquire the signals and PC with LabVIEW program (virtual instrument) tested all data process.

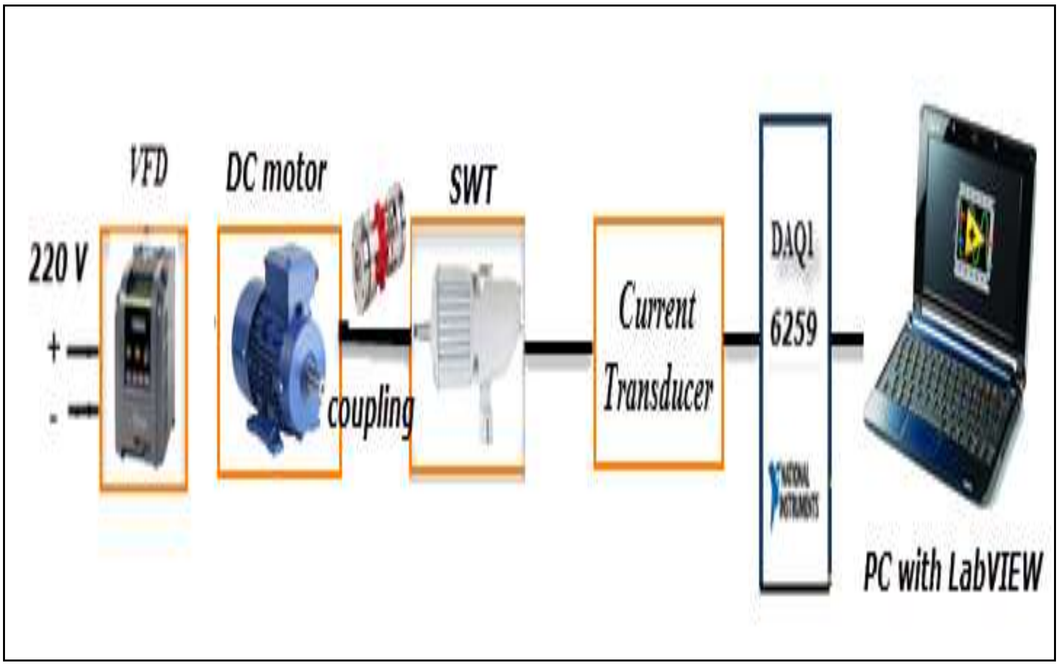

Figure 1- The test bench

The software design is a primary step in the signal process. There are no programs specialized in wind turbine monitoring field given free on the web, also the licenced software for this kind of applications is very expensive. Thus a program is used for solving this problem. Figure-2 show the processing of current signal.

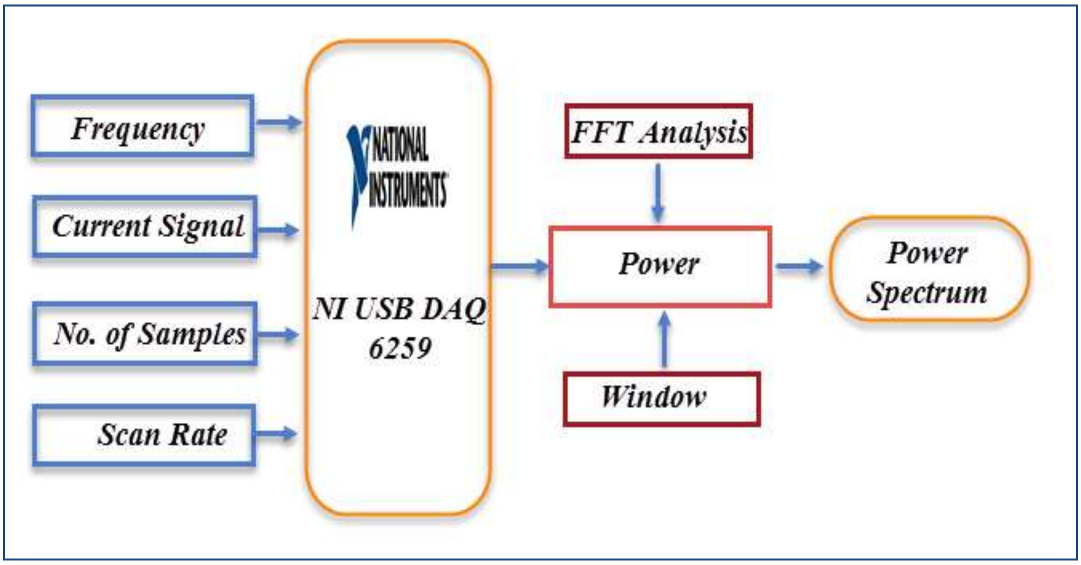

Figure 2- Process of signal processing

Test results

Rotor fault analysis can be monitored by investigating the compatibility of advanced signal processing technique with computerized data acquisition and processing by use of spectral analysis. FFT possibly utilized for diagnosis of rotor fault. Spectral estimation technique is widely adopted in machine diagnosis. The current of healthy motor with different loads condition and without motor fault was monitored and recorded, where it was considered healthy condition. Figures- (3, 4) illustrate the current spectrum of healthy motor with 50% and full load condition respectively.

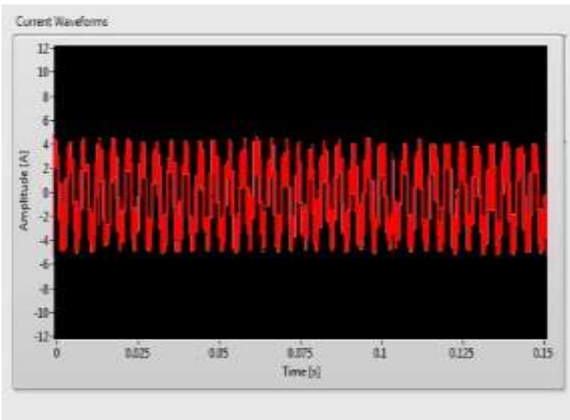

Figure 3- Healthy motor Current with 50 %load condition

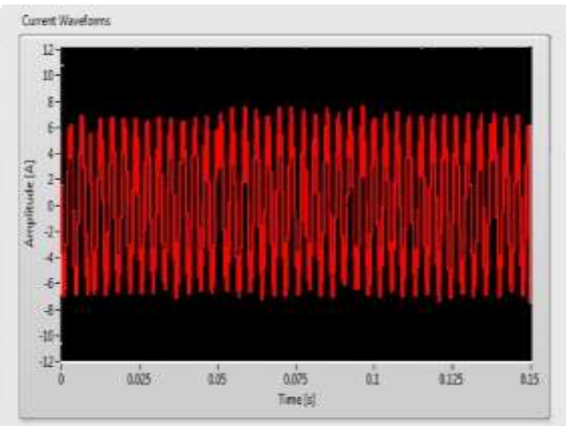

Figure 4- Healthy motor Current with full load condition

Practically, it is impossible to get clear signature with reason effect of inductive load of SWT. In addition of this attendant effect, declared fluctuation line currents observed in rotor fault of motor. The current of faulty motor was observed and recorded at different load condition. Figures- (5, 6) illustrate the current spectrum for faulty motor.

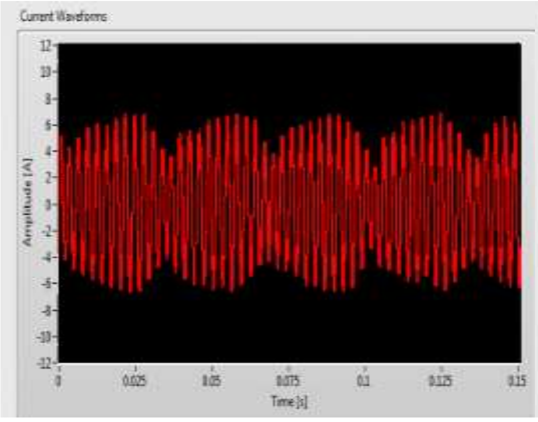

Figure 5- Current of faulty motor with 50% load condition

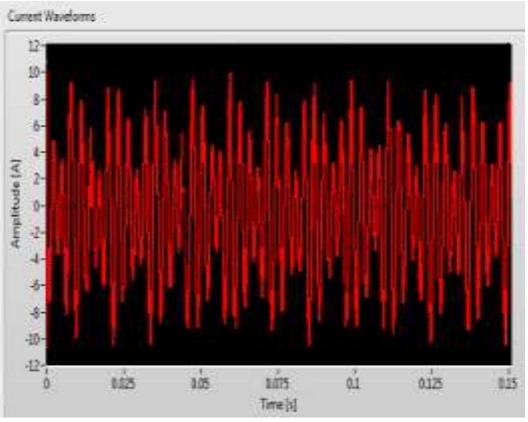

Figure 6- Current of faulty motor with full load condition

From Figure- 7, it can be observed that the magnitude of the currents is compress with the raise of the load. By applying FFT, the power spectrums of currents at four conditions were plotted in decibel.

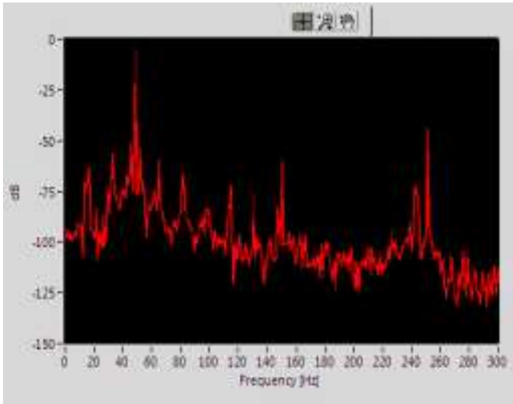

Figure 7- Power spectrum of healthy motor.

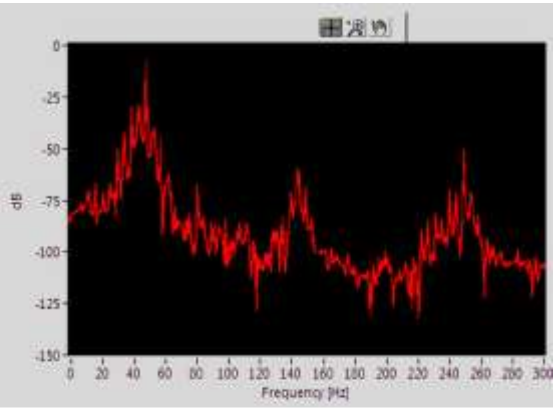

Figure 8-Power spectrum of faulty motor (No load condition)

From Figure-8, it can be observed that the lower sidebands and upper sidebands appear at 48 and 51 Hz respectively, at no load condition.

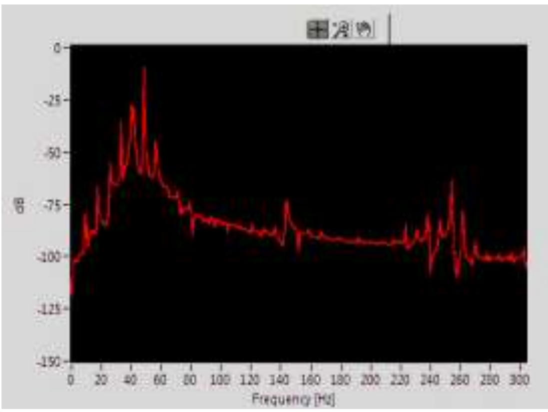

Figure 9- power spectrum of faulty motor with (half load condition)

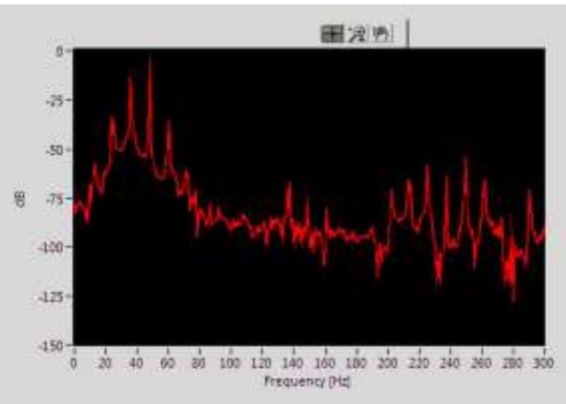

Figure 10-power spectrum of faulty motor with (full load condition)

From Figure-9, the sidebands harmonics in power spectrum were observed due to fault in the rotor and the computed sideband frequencies are 45 and 55 Hz respectively. Figure-10 show the fault frequencies lower sideband at 41 Hz and upper sidebands at 59 Hz in the power spectrum which is an indication of BRB fault.

Conclusion

This paper depicted about utilizing the MCSA for diagnosis rotor fault in SWT motor. This strategy is a very adaptable and demonstrated innovation for condition monitoring and fault analysis of motor. The avail of utilizing MCSA technique can distinguish these issues at a beginning period and in this way maintain a strategic distance from optional harm and finish failure of the motor. As well as,real time monitoring benefits. The real advantages incorporate the avoidance of lost downtime, evasion of real motor maintenance. The utilization of signal processing such as MCSA assures the normal operating and reliable data.

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