Insulation Condition Monitoring of Electric Machines Using Time-Frequency Analysis

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1. Introduction

In this project, we discuss condition monitoring of insulation for electric machines. This topic is very important for the Oil/Gas industry because of its aging electric power generators. Specifically, the Oil/Gas industry experiences long stoppages of its power generation units for re-winding, during a time when power is extremely needed. In addition, these fixed-interval scheduled maintenance practices are very costly as on average they cost around US$1 million per 11KV generator. To address these problems, we propose an effective, reliable and automatic technique to monitor the insulation condition of electric machines.

2. Key Features

Due to its significant benefits, condition monitoring (CM) of electric rotating machines is increasingly becoming important asset management tool for the heavy power industry. In particular, monitoring the condition of the stator winding insulation, of an electrical machine, is a vital step towards assessing the condition and reliability of the machine. One of the most popular methods to evaluate the insulation condition for electric machines is the partial discharge (PD) detection method. One can define the PD as small sparks (or impulses) that occur in high-voltage insulation wherever small air pockets exist. These air pockets are formed as a result of deterioration, which can be due to many physical parameters of the insulation properties. Usually, the number of PD impulses that occur in a particular electric machine is a good indication of the machine state. A high increase in the number of these impulses is taken as a warning call by the machine technicians, and an adequate action should follow.

Although PD has been widely used in the power industry, its measurements are very prone to the presence of interferences and noise, which are very common in high voltage equipment such as generators and HV machines. In such situations (i.e., presence of noise), the accuracy and interpretation of the data collected by a PD monitoring system may be seriously affected or even worse misinterpreted. Most of the current methods to de-noise and analyze PD data use classical time or frequency domain methods. In this present project, we propose an alternative modern approach based on time-frequency analysis, as a pre-processing stage, in the analysis and interpretation of PD. This choice stems from the fact that PD signals are non-stationary and, therefore, a natural tool for their analysis is the time-frequency representation. In addition, the ability of a time-frequency representation to localize and detect the various components that may exist in a given signal will be fully exploited in order to extract the impulses which occur in a collected PD signal during a particular time interval.

In the literature, there exist many time-frequency representations (TFRs). The most popular ones are the spectrogram, which is the squared magnitude of the short-time Fourier transform (STFT), and the Wigner-Ville distribution (WVD). The former suffers from the trade-off between the time resolution and the frequency resolution and the latter suffers from the presence of cross-terms. In this project, we will apply a recently developed high-resolution and cross-terms free time-frequency representation. Preliminary results have shown that the new TFR not only outperforms existing classical method but is also superior to the spectrogram and WVD.

3. Conclusions

The ability of the time-frequency representation to display the components temporal localization of a given signal makes it a very powerful tool in the detection and extraction of PD impulses that may occur in electric machine insulation. The preliminary obtained results, using synthetic PD data, are very promising and encouraging in applying the proposed technique to real-life data collected recently.

4. Bibliography

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Author Biographies

B. Barkat received the M.Sc. degree in Control Systems from the University of Colorado, Boulder, USA, in 1988. From 1989 to 1995, he held a Lecturer position at the University of Blida, Algeria. In 1999, he obtained the Ph.D. degree in signal processing from Queensland University of Technology (QUT), Brisbane, Australia. From September 1999 to November 2000 he had been a Postdoctoral Research Fellow, first at QUT and then at Curtin University, Western Australia. From November 2000 to August 2005 he had been an Assistant Professor in the School of Electrical & Electronic Engineering at the Nanyang University of Technology, Singapore. In August 2005 he joined the Electrical Engineering Program at the Petroleum Institute in Abu Dhabi, U.A.E. His research interests include time-frequency analysis, estimation and detection, statistical array processing and signal processing for industrial applications.

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