PhD Public Defence

Title: Condition Monitoring of Capacitors for DC-link Application in Power Electronic Converters

Location: Pontoppidanstræde 111, auditorium

Time: Monday 3 July 2017 at 13.00

PhD defendant: Hammam Abdelaal Hammam Soliman

Supervisor: Professor Frede Blaabjerg

Moderator: Associate Professor Xiongfei Wang

Opponents: Associate Professor Deszo Sera, Dept. of Energy Technology, Aalborg University (Chairman)
Dr. J.J Liu, Xian Jiaotong University, China
Dr. Suresh Perinpanayagam, University of Cranfield, UK

All are welcome. The defence will be in English.

After the defence there will be an informal reception in Pontoppidanstræde 111 (coffee room).
Abstract:

Power electronic circuits are used in a variety of applications ranging from small power supplies in computers to more specialized applications such as satellite, airplane, medical equipment and different war-machines. In all of these applications, static power converters are an essential subsystem whose failure leads to the imminent and total stoppage of the equipment. DC-link capacitor is commonly used in all of these equipment as smoothening energy element of the converters. As a fact, in power electronics conversion systems, a single capacitor or a capacitor bank is usually used as dc-link filter. The system may be malfunction if one or more capacitor reaches end-of-life. Since failure of a single element may lead to collapse of the entire system, it is needed to develop some kind of mechanism, which will alert the operator in advance for predictive maintenance before failure, such mechanism is known as "Condition Monitoring".

Recently, the condition monitoring of dc-link capacitors to estimate their health status have been attracted by the academic research. Industry applications require more reliable power electronics products with preventive maintenance. Therefore, an in-depth analysis of prior-art condition monitoring methods (advantages, shortcomings) have been done from the following aspects: a) end-of-life indicator (e.g. C, ESR); b) how to estimate the indicator (e.g. sense current, voltage); c) algorithm to obtain the value of the indicator (online or offline); d) accuracy study and sensitivity analysis; e) hardware and software realization (reliability, cost, and complexity of the additional software algorithm and hardware circuits).

From analyzing the prior-art methods it was found that, the existing capacitor condition monitoring methods suffer from either increased hardware cost or low estimation accuracy, being the challenges to be adopted in industry applications. Therefore, new development in condition monitoring technology with software solutions without extra hardware will reduce the cost, and therefore could be more promising for industry applications.

This project develops new method using an Artificial Neural Network (ANN) algorithm in order to monitor the change of the electrical parameters of electrolytic capacitors for dc-link application under stressed conditions. The application of the method is condition monitoring of capacitors under field operation in power electronic systems in order to apply predictive maintenance. The software based method is proposed in order to solve the existing issues of the prior-art research.

The ANN method estimates the end-of-life indicator (e.g. capacitance) using only the input terminal and output terminal information of the power converter, which are readily available from the feedback signals of existing digital controller. The trained ANN is implemented with the Digital Signal Processor (DSP) which normally exists for control purposes. In order to investigate the proposed method under different conditions, the ANN condition monitoring method is applied on dc-link capacitor in a Front-End diode bridge converter. Moreover, the impact of training data quality and amount on the ANN accuracy are studied. An error analysis under different dc-link capacitance values, different level of capacitance reduction with respect to the initial value under different loading conditions is also given.