European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality
(ICREPQ'10)
Granada (Spain), 23rd to 25th March, 2010

CUSUM based Fault Detection of Stator Winding Short Circuits in Doubly-Fed Induction Generator based Wind Energy Conversion Systems

Jawwad Zafar, Johan Gyselinck

Department of Electrical Engineering

Université Libre de Bruxelles (ULB)

CP165/52, 50 Av. F.D. Roosevelt, 1050 Brussels, Belgium.

Phone: +32 2 650 2660, Fax: +32 2 650 2653, e-mail: Jawwad.Zafar@ulb.ac.be

Abstract. This paper investigates the detection of short-circuit faults in the stator winding of a Wind Energy Conversion System (WECS) based on a Doubly-Fed Induction Generator (DFIG). Simulation results are presented for a 15 kW system operated, under a power control strategy, at rated conditions.

Condition monitoring and fault detection in WECS are becoming increasingly important as the penetration of this renewable energy source is set to increase further in the power system. This leads to concerns as the availability of WECS along with the prevention of extensive and costly damage resulting from delays in detecting an incipient fault. The popularity of DFIG based WECS makes it an obvious choice for such an investigation.

Stator winding short-circuit faults account for around 40% of all machine faults. This fault has the potential to quickly develop into a system failure with damage to the generator core. To be able to simulate the short circuits the generator is modeled using the winding-functions approach. Fault location and severity can be changed to observe the effect on the detection method.

In this paper, fault detection is based on the change in the magnitude of the negative-sequence stator current. It is therefore called as the residual. Since system unbalances such as grid voltage unbalance, transducer gain difference, load unbalance and construction asymmetry also cause negative-sequence current, it is therefore necessary to take these into account. In this paper the fault detection method is tested for its robustness against grid voltage unbalance quantified by a Voltage Unbalance Factor (VUF) of 6 %.

A change-detection algorithm known as the Cumulative Sum (CUSUM) algorithm is used to detect the change in the value of the residual. The test function is compared, to a carefully selected, threshold to generate an alarm in case of a fault and to avoid false alarms. It allows rapid detection within two cycles of fundamental frequency. This is in contrast to the fault detection methods found in literature which are based on Current Signature Analysis (CSA) and it is not shown how rapidly the fault is detected.

Another important aspect of the investigation is the inclusion of the response of the control system to such a fault and its consequences on the detection. This is important since the way the fault manifests itself in the currents may be modified by the control system. The control system implemented is the power control strategy which controls the active power to the reference value and maintains a unity power at the point of common coupling. At the occurrence of a fault the positive-sequence current magnitude and phase remain the same due to the presence of control while the negative-sequence current magnitude increases significantly and therefore used as the residual.

The results show that the faults are detected correctly and rapidly while the detection system is robust to grid voltage unbalance within acceptable limits of 5 % as defined in NEMA guidelines for motors. It is however necessary to consider different operating points to select proper threshold for alarm generation.