Modelling and Analysis of Doubly Fed Induction Generator Based Wind Energy System for Multimode Operation in Unbalanced Condition

Abstract

Use of Doubly-fed Induction Generator (DFIG) as a distributed resource in grid-connected and islanded mode raises concern over second harmonic oscillations in electromagnetic torque caused by the unbalanced system voltage in distribution network. DFIG operation in unbalanced mode necessitates the consideration of operating limits and implementation of these limits in dynamic control structures. This leads to the question of extent to which control objectives, for reducing the effect of unbalance, are achievable for equipments of certain capacity. A detailed three-phase steady-state model of DFIG (Doubly Fed Induction Generator) is developed in this work with provision for representation of limit infringement and it is effectively utilized to study the effect of violation of limit on voltage stability and maximum loading point of a multi-bus distribution network. The advantage of the proposed strategy for enforcing limits on DFIG internal parameters as well as DFIG operating state at restricted condition, with variation in rotor speed, are effectively represented in obtained results. A novel method for enforcement of limits on sequence components of voltage and current is presented in this thesis while maintaining the actual limit on phase quantities for maximum utilization of available equipment capacity during unbalanced operation. The advantages of this adaptive limiter in cases of low and high voltage unbalance factors at PCC are highlighted. An Islanding Detection Relay (IDR) utilizing perturbation introduced through rotor-side converter of DFIG is proposed by modifying the classical Rate Of Change Of Frequency (ROCOF) IDR, and successfully verified for situations with different operating conditions. A strategy to scale down the magnitude of perturbation in order to achieve detection is also proposed. The dependency of proposed IDR on DFIG control structure is highlighted in this work. DFIG based wind generator is seen to provide frequency regulation and reactive power support on successful detection of island formation by proposed IDR, through appropriate control of rotor and grid-side converters, in islanded mode. The effect of negative sequence control objective, to mitigate torque pulsations, on operation of proposed IDR and island stability is investigated for loads with increasing unbalance.

Keywords: DFIG, islanding detection, operating limits, steady-state model, unbalanced.