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Minimum DC link Voltages for the Generator Bridge Converter of a SCIG Based Variable Speed Wind Turbine with Fully Rated Converters

U.I. Dayaratne, S.B. Tennakoon, J.S. Knight and N.Y.A. Shammas

Faculty of Computing, Engineering and Technology
Staffordshire University
Beaconside – Stafford, ST18 0AD (United Kingdom)
Phone number: +44 1785 353488,
e-mail: u.i.dayaratne@staffs.ac.uk, s.b.tennakoon@staffs.ac.uk, n.y.a.shammas@staffs.ac.uk

Abstract. Squirrel Cage Induction Generator (SCIG) based variable speed wind turbine with Fully Rated Converters (FRC) is a popular choice in the industry for the modern multi mega-watt wind turbines. Typical FRC system uses a fixed DC link voltage that allows operation in all steady state and dynamic operating conditions while allowing the modulation index of the PWM scheme to vary. However, the analysis made in this paper shows that at steady state, in the maximum power point tracking region where the turbine is operated at variable speeds with generator controlled using Rotor Flux Oriented Control (R-FOC), it is possible to operate the Generator Bridge (GB) converter with significantly lower DC link voltages than the fixed value used, by maintaining maximum modulation index in the PWM scheme. This paper presents a methodology of determining the minimum DC link voltages for such a system supported by simulation results showing the successful operation of a GB converter with minimum DC link voltages in the maximum power point tracking region.

Key words

DC link voltage, Modulation Index, IGBT, Generator Bridge Converter, SCIG

1. Introduction

Variable speed wind turbines with Squirrel Cage Induction Generators (SCIG) and Fully Rated Converters (FRC) are used by some leading manufacturers in the industry for modern large wind turbines of multi-megawatt capacity. Power converter manufacturers strive for continuous improvement of products and systems, and achieving higher inherent reliability is one of the areas of research.

Typically, the FRC consists of back to back pulse width modulated voltage source converters based on Insulated Gate Bipolar Transistor (IGBT) modules, interconnected through DC link capacitors [1]-[5]. Authors' previous work [1] presented minimum DC link voltage operation of the network bridge converter that covered first part of the overall objective of operating the FRC system with variable DC link voltages optimised at minimum values. This paper presents the theoretical and quantitative analysis on determining the minimum DC link voltages required for the Generator Bridge (GB) converter of an FRC system with SCIG controlled with Rotor-Flux Oriented Control (R-FOC). The quantitative analysis is based on data of a commercial multi-megawatt FRC system. Supporting simulation results are presented based on MatLab/Simulink simulation model.

2. Minimum DC Link Voltages for Generator Bridge Converter

The schematic diagram of the GB side used for the analysis is shown in Fig. 1. The GB converter is controlled with R-FOC in synchronous d-q reference frame with rotor flux linkage aligned with d axis having rated rotor flux linkage. The controller feeds the magnitude of the space vector $V_{s,gen}$* of the voltages to be generated at GB converter terminals and its angle θ_{gen} to the PWM reference signal generator.

The methodology of determining the minimum DC link voltage for the above GB converter system is as follows.