ANALYSIS OF THREE-PHASE RECTIFIERS WITH AC-SIDE SWITCHES AND INTERLEAVED THREE-PHASE VOLTAGE-SOURCE CONVERTERS

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ABSTRACT

Of all the alternative and renewable energy sources, wind power is the fastest growing alternative energy source with a total worldwide capacity of over 93 GW as of the end of 2007. However, making wind energy a sustainable and reliable source of electricity doesn't come without its set of challenges. As the wind turbines increase in size and turbine technology moves towards off-shore wind farms and direct drive transmission, the need for a reliable and efficient power electronics interface to convert the variable-frequency variable-magnitude output of the wind turbine's generator into the fixed-frequency fixed-magnitude voltage of the utility grid is critical.

This dissertation investigates a power electronics interface envisioned to operate with an induction generator-based variable-speed wind turbine. The research conclusions and the interface itself are applicable to a variety of applications, including uninterruptible power supplies, industrial drives, and power quality applications, among others. The three-phase PWM rectifiers with ac-side bidirectional switches are proposed as the rectification stage of the power electronics interface. Modulation strategies are proposed for the rectifiers and the operation of the rectifiers in conjunction with an induction generator is demonstrated. The viability of using these rectifiers in place of the standard three-phase voltage-source converter is analyzed by comparing losses and common-mode voltage generation of the two topologies.

Parallel three-phase voltage-source converter modules operated in an interleaved fashion are proposed for the inversion stage of the power electronics interface. The interleaved three-phase voltage-source converters are analyzed by deriving analytical models for the common-mode voltage, ac phase current, and dc-link current to reveal their spectra and the harmonic cancellation effects of interleaving. The practical problem of low frequency circulating current in parallel voltage-source converters is also analyzed. The low frequency circulating current characteristics of *abc*, *dq*, and nonlinear average current control are determined and experimental results for the nonlinear average current control are presented.