Maximum Peak Power Tracking-Based Control Algorithms with Stall Regulation for Optimal Wind Energy Capture

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This paper presents three alternative maximum peak power tracking-based control algorithms with stall regulation for optimal wind energy capture: torque reference- based MPPT algorithm, searching-based MPPT algorithm and fuzzy-based MPPT algorithm.

The first algorithm uses a reference torque trajectory in the below rated wind speed region. The torque reference can be mathematically written as a function of torque and rotational speed or it can be stored as a look up table which is easy to be programmed in a microcontroller or a DSC board. Figures 1(a) and (b) show the reference torque trajectory and corresponding output power in the below and above rated wind speed, respectively.

The second method searches an optimal operating point from the slope of the power-rotational speed curve. This algorithm brings the operating point toward the maximum power at each wind speed as shown in Fig. 1(b) by increasing or decreasing the rotational speed step by step in the above rated wind speed region. The advantages of the algorithms are that a machine model, turbine characteristic curves, wind speed sensors and pitch control are not required. With self tuning step size of perturbation, the peak current can be reduced.

The last one achieves the control objective using a developed fuzzy logic control (FLC). The FLC is superior to conventional controllers when the operating point of the wind turbine moves from the below to above rated wind speed or vise versa. The FLC uses the aerodynamic torque that can be obtained indirectly by an observer whose inputs are the generator torque and rotational speed. The salient features of the FLC over conventional controllers are that it can efficiently solve the nonlinearity problem of the connection between both regions and therefore is able to reduce variation of the generator torque. In addition, it can work with imprecise inputs and does not need accurate mathematical models.

The three MPPT-based control algorithms were implemented on a low cost DSC board and tested with a developed wind turbine simulator. The advantages of the simulators are that various wind profiles and wind turbines and it includes the data acquisition to verify the control algorithms. It can be concluded from the experimental results that the MPPT with torque reference offers fastest tracking time in the below rated wind speed. Although the second method has the slowest tracking time and the highest rotational speed fluctuation, it is attractive for a small amount of computational resource and therefore low cost for implementation. The MPPT with fuzzy logic is favored in terms of power and torque fluctuation, and tracking time in both operating regions.

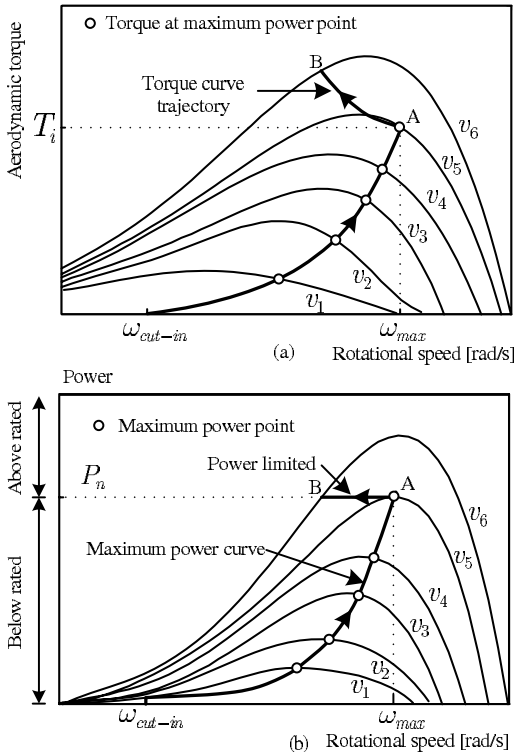

Fig. 1. (a) Optimum torque trajectory and (b) optimal power trajectory