Artificial Neural Networks for Grid Integration of Renewable Energy Sources

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In today’s electric power systems, power electronic converters play an increasingly important role for integration of smart grids, renewable energy resources and energy storage devices. Power converters are key components that physically connect wind power, solar panels, and batteries to the grid. Traditionally, those converters are controlled using standard control mechanisms. However, recent studies indicate that such mechanisms show serious limitations in their applicability to dynamic systems.

In recent years, significant research has been conducted in the area of dynamic programming for optimal control of nonlinear systems. Dynamic programming employs the principle of optimality and is a very useful tool for solving optimization and optimal control problems. This presentation focuses on how to employ dynamic programming technique to develop optimal control method for grid integration of renewable energy resources. The dynamic programming principle is implemented through an artificial neural network. To accomplish the temporal tracking requirements of a dynamic control system, the neural network was trained by using backpropagation through time algorithm, which involves derivative computation throughout the layers of the neural network and over different time sequences.

To enhance performance and stability under disturbance, additional strategies are adopted, including integrals of error signals, predictive signals, and history information as network inputs. The performance of the neural network controller is studied under typical renewable integration conditions and compared against conventional control methods, which demonstrates that the neural network control strategy is effective. Even in dynamic and power converter switching environments, the neural network controller shows strong ability to trace rapidly changing reference commands, tolerate system disturbances, and satisfy control requirements for a faulted power system. The neural network controller demonstrates a special ability for rapid grid synchronization when connecting a renewable source to the grid and an ability to effectively handle a unique control requirement under physical constraints.