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Static VAR compensation of a fixed speed stall control wind turbine during start-up

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ABSTRACT

An installed 900 kW fixed speed stall controlled soft-started wind turbine connected to a weak distribution grid was modeled under start-up conditions. Generator and soft-start control and design parameters were not available, so a modeling process independent of this information was developed. Field measured transients were closely reproduced in simulation using a full-order generator model with generic parameters and a thyristor-based graduated interconnection to the grid. A Static VAR Compensator model was then added to the wind turbine model to explore a method of reducing start-up transients. It was found that for the specific transients modeled, a 300 kVAR SVC supplied sufficient reactive power to limit line voltage variations to within 3% of steady state values. Model details and simulation output are presented in this paper.

1. Introduction

Fixed speed stall controlled wind turbine generators are connected to the electric power grid in many locations worldwide due to their robust and simple design, long life, and low cost [1,2]. Some of these installations are at distribution level voltages along feeder lines remote from a substation or transformer where turbine initiated grid disturbances can have an impact on power quality. Although most fixed speed wind turbines have a soft-start mechanism to limit start-up transients, it may not be sufficient in some cases and adds complexity to the modeling process due to injected switching harmonics and their interaction with higher order characteristics of the induction motor.

Start-up transients recorded from a 900 kW fixed speed stall controlled soft-started wind turbine connected to a 12.5 kV distribution feeder were reproduced in PSCAD/EMTDC without knowing the turbine manufacturer's control and design parameters [3]. Details of the model development process have been discussed in [4]. A Static VAR Compensator (SVC) model was added to the wind turbine model to simulate one method of reducing start-up transients, and the results are reported here.

A brief description of the original wind turbine model is given in Section 2, followed by details of the SVC model in Section 3. Simulation results of the SVC addition are presented in Section 4, and concluding remarks are given Section 5.

2. Turbine model prior to addition of the SVC

A fixed speed stall controlled, soft-started wind turbine connected to a rural distribution grid is illustrated in Fig. 1. Model components include the wind energy and resultant torque derived from the wind by the turbine rotor (hub and blades), an induction generator, soft-start power electronics and controls, a 600 V/12.5 kV transformer and the electric power distribution grid to which the turbine is connected.

The relationship between wind speed and power derived from the wind is usually given by the turbine manufacturer. For modeling purposes the wind speed and the power captured by the turbine rotor are assumed constant during the simulation interval over which the generator is connected to the grid. Typically there will be very little variation in these quantities for periods of time less than 10 s [1]. The wind turbine generator under study is of the pole-changing type. At low wind speeds a smaller 200 kW generator is utilized for increased efficiency in capturing the power in the wind, and under high wind conditions a 900 kW generator is employed.

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