Advanced wound-rotor machine model with saturation and high-frequency effects

ABSTRACT

Nowadays, the doubly-fed induction generator (DFIG) is perhaps the most common type of generator used in onshore wind turbines. With the thriving development of wind energy, there is a high demand for precisely predicting the dynamic performance of the DFIG. Due to the involvement of power electronics, massive high-frequency harmonics are injected into the machine leading to high-frequency effects such as parasitic currents. As the core of DFIGs, the wound-rotor induction machine must be well modeled to capture these significant phenomena in the operation of wind turbines. However, the T-equivalent model, which is currently the most widely used model in machine dynamic studies and controller designs, is incapable to simulate machine behaviors in the high-frequency range.

The aim of this research is to develop a novel model of a wound-rotor induction machine, which incorporates magnetic saturation of the main flux path and high-frequency effects. The model's experimental parameterization procedure is described in detail. This consists of standstill frequency response tests, and a test for determining the machine's magnetizing characteristic and turns ratio. Time-domain simulations are used to highlight the capabilities of the proposed model, and to compare its predictions with those of a classical model at both transient and steady states. The results show that the proposed model can better capture the dynamic performance with the consideration of magnetic saturation. What is more, the high-frequency current ripples, which are caused by common-mode ground currents, can also be simulated in the proposed model.