Grid Frequency Support By Coordinated Rotor Speed And Pitch Angle Control Of Wind Turbines

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Motivation

In recent years there has been a significant penetration of Variable speed Wind Turbines(VSWTs) into the power systems. VSWTs do not participate in frequency control due to the fact that they are connected to the grid through a power electronic converter which decouples the generator speed from the grid frequency.

Problem Statement

Also, VSWTs are normally operated in Maximum Power Point Tracking (MPPT) mode, therefore they do not have power reserves. In power systems, conventional power plants are synchronously connected to the grid frequency, consequently their power output increases or decreases as the load demand varies. The rapid penetration of VSWTs mostly dominated by Doubly-Fed Induction Generators (DFIGs) and Permanent Magnet Synchronous Generator (PMSGs), will result in fewer conventional synchronous generators on the network. This will lead to reduced inertia and power reserves on the network.

Methodology

A reduction in the total system inertia will result in an increased rate of change of frequency and deeper frequency excursions, which may lead to frequency instability resulting into blackouts. An additional control loop can be added in the converter to enable VSWTs to participate in frequency control by using synthetic inertial and power reserve control. This inertial control utilizes the kinetic energy stored in the rotating masses of the wind turbine. And power reserve control can be achieved by operating the VSWT at a sub-optimal power coefficient. To operate the VSWTs at sub-optimal power coefficient, there has to be coordination between the Rotor Speed Control (RSC) and Pitch Angle Control (PAC) at different wind speeds i.e. low, medium and high wind speed. The objective of this research is to develop coordinated control strategies for geared and gear-less PMSG-based wind energy systems for frequency support of the grid.

Results

The geared PMSG-based system has a high speed machine compared to the gearless, direct-drive PMSG system, which has a low speed machine. The amount of kinetic energy that each of these systems including the DFIG can release without exceeding the current and voltage limits will be critically evaluated.

Conclusions

Furthermore, the power reserve when the VSWT is operated at sub-optimal power coefficient will be investigated by means of the coordination of the RSC and PAC.