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Droop Characteristics of Doubly Fed Induction Generator Energy Storage Systems within Micro Grids

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ABSTRACT

This article presents the operation of DFIG Doubly fed induction generator and a component energy storage (ES) within micro grids (MG). The aim of this proposal is to control voltage and frequency of wind farm micro grid shared by the Doubly fed induction generator (DFIG) through droop characteristics. This paper is mainly concerned with the operation of islanded micro grids. The proposed control methods are pretend by using Matlab/simulink.

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1. INTRODUCTION

In renewable energy resources, wind is an important source for human being as the renewable energy of penetration increases, the problems which are mainly caused by the intermittent nature of renewable energy. To achieve this, each component must react to local information such as voltage and frequency to correctly change its operation point. It is also desirable to ensure that no component (e.g., a master controller) is critical for microgrid operation. An effective way to achieve local control without fast-centralized communication is to control active and reactive power injection to/from each component utilizing frequency and voltage droops respectively. Due to this problem, the system may lose their stability. That's why, the system required an energy back-up to improve the stability of the system and also reduce grid losses [1]. The microgrids are an integrated energy delivery system. The microgrid consists of unified DG (distributed generators) and controllable loads. It operates in parallel with the main power grid. Microgrids can are useful to customers by provides uninterruptible power, improving reliability, reducing the losses of transmission and sustaining local voltage and frequency [2]. To obtain this each DG must react to local information such as voltage and frequency to properly change its operating point. A helpful way to attain local control without fast centralized communication is to control active and reactive power injection to/from each DG by utilizing frequency and voltage droops correspondingly.

Wind energy change with time and difficult to determine. Elucidation for the intermittency and the short term changeable nature associated with wind energy generation can be compensated partially by using Energy storage (ES) systems. The combination of the ES system into wind energy generation can be very useful to the power system in many ways: such as smoothing the wind power fluctuations through captivating its fluctuations and provides active power balancing, In order to support the local grid frequency control by providing spinning reserve, and the low voltage ride through capability by serving as a power sink during low system voltage [3-6].

2. CONTROL OF DFIG

The Doubly fed induction generator's (DFIGs) control is typically by field orientation of the grid voltage. This control method is called direct stator flux orientation (DSFO). DFIGs can neither be simply integrated within micro-grids nor be connected to weak grids, as they cannot control the grid voltage and frequency. When the wind energy penetration level is high, it may be essential for wind generations to have control grid functions regularly associated with usual power generation units. This problem becomes more critical in an isolated power system like that of a remote area which has poor ability of power regulation. A new wind park using DFIGs may in future be required to give advanced grid support for the control of active power frequency and reactive power and voltage. The reactive power voltage support can be achieve and/or by controlling the q-axis current of the grid-side converter. The grid frequency is maintain in a DSFO direct stator flux orientation controlled DFIG through a reserve active power available by operating below the maximum power point, commonly referred to as "deloading"[7]. It is done by pitches control and/or torque control (i.e., inertial energy storage). Apart from the fact that these methods need a non maximum power point operation, the degree of frequency support is limited. It is also possible to maintain the grid frequency through using the energy stored in an external ES, in all these methods, however, an external voltage and frequency source is still required as the DFIGs use field orientation of the voltage source.

Another control method for DFIGs is called indirect stator flux orientation (ISFO). This control the stator flux is no longer determined by the grid voltage but by the rotor excitation current the stator flux angle is set through free running integration of the reference stator voltage frequency Fs^{*}. The stator voltage is controlled through regulating the rotor d-axis current i_{rd}. DFIG appears like a voltage and frequency source in the power system by the ISFO-controlled. By the load itself, now the power delivered is determined and is efficiently user defined. There is no direct electrical torque T_e control of the DFIG. This is a quality of ISFO control because the q-component of stator current i_{sq} is set by the load. It is actuality to maintain the field orientation of the DFIG the q-component of rotor current i_{rq} proportional to $i_{sq.}$ The main challenge in micro grid (MG) is associated with islanded operation. When the micro grids are connected to main grid, the reference voltage and frequency are fixed by grid. In the case of islanded operation, especially for high wind energy penetration, the local grid voltage and frequency control is quite difficult as Figure 1.

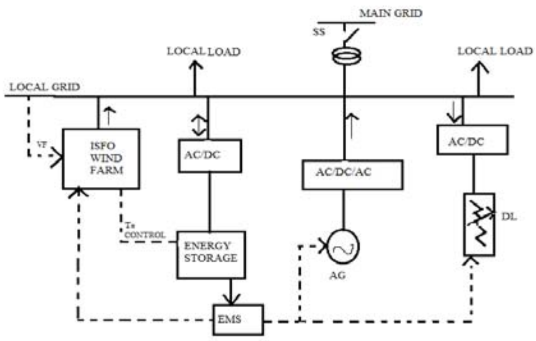

Figure 1. A study on Micro grid configuration

2.a. Droop Control of Generators

The droop method is the most well-known method for load sharing in microgrids. Droop control of generators is necessary for real and reactive powers sharing demanded between several generator sources as Figure 2. In microgrids, there has been much research addressing system stability and performance reliability under harmonic and unbalanced conditions. In the case of intermittent renewable sources. Very little work has been for the case of droop control in which each DG source output is variable and, in general, independent of one another. The rating of power and energy an ES for a wind farm employing droop control is discussed in which real wind profile and PSCAD simulation. Further an alternative droop control in which the droop slope reflects the transmitted shaft power. A various Dfig systems operated with droop control also discussed [4-5].

2.b. Variable Droop Control

Droop control is developed for various DFIGs. The DFIGs frequency and output power of DFIGs is inversely proportional. The input power to the droop control is no longer a mutual component of the load power but is partial by the presented wind and ES power. Where as in a standard droop control.

2.c. Standard Droop Control

The f-P droop gain is set as m=Δf/P_{nom} (Δf is the maximum frequency deviation which is kept equal for all generators and P_{nom} is the rating of the generator). As a result, the demand shared is proportion to the generator rating. But it may not be the finest sharing method for an intermittent generation like wind energy. To explain this, consider a situation, in which the extractable wind power in one of the DFIG (e.g., DFIG2) drops below the contribution required. By the action of its droop controller, this reduction causes the operational frequency to increase from $f_{op}$to f^{1}op. Due to this, the other DFIG powers is reduced to comply with the new operational frequency (i.e., f^{1}op). This operational deficiency is feasible only if the system has an alternative power source (the AG in this case) to take over the power irrespective of the wind power available to the other DFIGs [5].

One of the main solutions for this difficulty is to make the droop coefficients reflect the available wind power. Output power of Dfigs can stay same or it may increase (it is subject to the wind power accessibility) following the wind power reduction in the DFIG2. This can be achieved if the droop coefficients change as a cubic function of ω_r,i.e.,m=Δf/$k_{opt}\omega_r^3$, where k_{opt} is a given constant for maximum power tracking of wind power. The main advantage of the variable droop gain is that the power required from the AG significantly decreases since the DFIGs with the variable droop characteristics can compensate for the differential power.

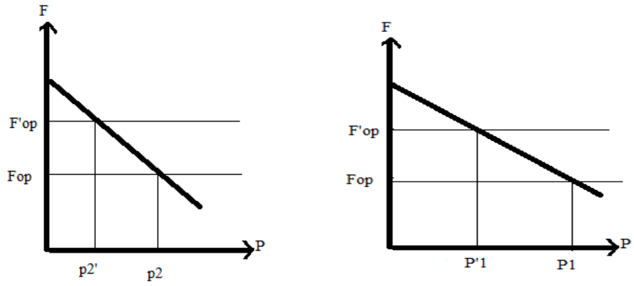

Figure 2. F-P drooping characteristics of DFIGs

3. RESULTS AND CONCLUSIONS

This paper mainly concentrates on islanded microgrid application. The sharing of power in a wind farm is alone optimal by providing the Dfigs through the droop characteristics. To adjust the DFIGs output power according to the wind power, a variable droop and standard droop characteristic are needed methods as Figure 3. Therefore, the DFIGs can compensate for each other which results in significant reduction in power demanded from AG. This paper compares the performance with the variable and standard droop characteristics of Dfigs. The system stability may be affected by the use of the variable droop method.

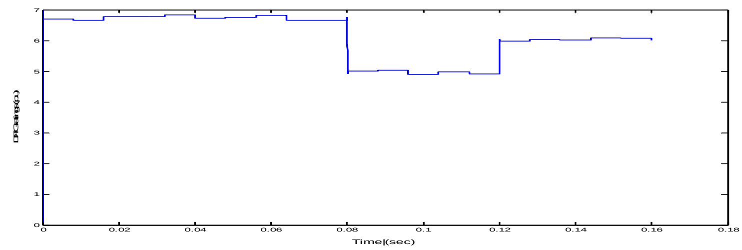

Figure (a)

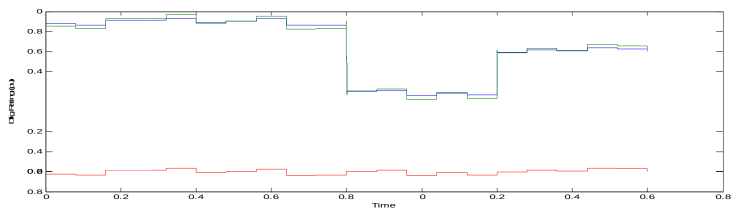

Figure (b)

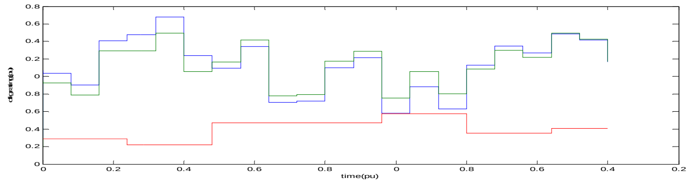

Figure (c)

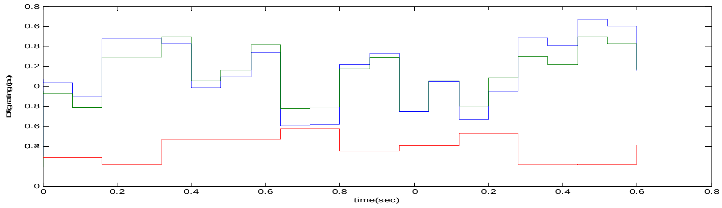

Figure (d)

Figure 3. The comparisons of droop characteristics performances DFIGs reduce the speed of wind.

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