Review on Improving Transient Stability of Grid Connected Squirrel Cage Induction Generator by Using Plugging

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Abstract: In most of the cases, in wind power generation squirrel cage induction generator is widely used. During the fault in the power system, leads to over speed and voltage instability of induction generator. For stability improvement, unique property of the induction machines which is the possibility of reversing the direction of the rotating flux is employed. After clearing the fault, operating mode of the induction machine is changed from the generating to the plugging mode for a short duration of time. This show that the proposed method can be effective in enhancing the transient stability.

1. Introduction

An induction generator is the type of AC electrical generator, works on the principles of induction motors to produce power. An induction generator produces electrical power when its rotor is turned faster than synchronous speed. Induction generator operates by mechanically which turns the rotor in generator mode which gives negative slip. Induction generator is not a self-excited machine. Therefore, when running as a generator, the machine consumes reactive power from the AC line connected to the grid or external source\cite{1}. Reactive power is needed for producing rotating magnetic field. When faults occur on the transmission line that lead to voltage instability and over speed of generator. After fault clearance and voltage recovery, rotor speed of IG is so high that it does not come back to the stable value\cite{2}. To overcome this problem in\cite{2} and\cite{3} Plugging is one of the electrical braking technique applicable in induction machine. The principle of traditional plug braking, is that changing the direction of revolving magnetic field to oppose the direction of former magnetic field by changing the phase sequence of three-phase voltages supply to the stator windings, and then deceleration of rotor speed in short time causing ac voltage to increase and therefore, voltage and rotor Stability will be improve.

1.1. Transient stability Improvement Methods of Induction Generator

There are four methods to improve the induction generator stability.

1) flexible AC transmission system (FACTS) devices
2) Rotor circuit control
3) Breaking resistor
4) Plugging

There are various FACTS devices have been used for improve transient and dynamic stability of induction generator. In \cite{4} It is shown that static var compensator (SVC) and Static reactive compensator (STATCOM) based on voltage source convertor (VSC) PWM technique to stabilize the grid connected squirrel Cage wind generator system. Also in, the rotor speed stability and voltage ride through of Induction Generator By using unified power flow controller(UPFC) are analyzed. But solution based on this facts devices have been recognized as expensive methods. In\cite{5}, by using rotor circuit control base solution is presented. One possibility is to employ an electronically controlled external resistance connected to the rotor windings \cite{8}. Another one is to control the voltage applied to the rotor through a static converter in doubly fed IGs \cite{8}. However, this method is only applicable to the wound rotor IGs and in the case of squirrel-cage IG, there is no access to the rotor winding and increasing the rotor resistance is impossible; therefore, the mentioned method is not applicable.

In \cite{7}, using the braking resistor is introduced as a solution for improving transient stability of IGs. The braking resistor decreases the rotor speed and hence improves transient stability by absorbing electrical power during the fault. However, the operation of an IG is significantly different from that of a synchronous generator and the braking resistor is less effective for improving the IG’s stability than synchronous generators stability.

all the three methods mentioned previously (FACTS devices, rotor circuit control, and braking resistor) need additional equipment such as SVC,
STATCOM, UPFC, extension resistor, and braking resistor.

In [2] and [6], a new and simple method is proposed to mitigate the transient stability of squirrel cage induction generator without any additional equipment. In the proposed method, the possibility of altering the induction machine’s operating mode is employed. After clearing the fault, by just interchanging any two of the stator leads, the operating mode is changed from the generating mode into the plugging mode. In the plugging mode, the rotor speed of the induction machine is decreased as the kinetic energy of the shaft is conducted through the rotor winding and dissipated in the form of heat. Therefore, the deceleration of the rotor speed leads to reduction in reactive power absorbed by the machine, causing ac voltage to increase, and therefore, voltage and rotor speed stability will be improved.

2. Stability analysis of Induction Generator.

Basically, operation of IG is different from synchronous generator because of its asynchronous nature. The equal area criterion develop of IG is not a suitable method for evaluating the transient stability. IG’s stability can be analyzed using the torque–slip and reactive power–slip curves as shown in Fig. 1.

2.1. Electrical torque in the plugging mode

After the fault clearance for transient stability improvement, the successful solutions are those that can amplify electrical torque versus mechanical torque. In [2], proposed method involves changing the operation mode of the machine from the generating mode to plugging mode. Electromagnetic torque of the machine in the plugging mode as backward field and its generating mode as forward field. According to this Fig. 2, the electromagnetic torque in both forward field (generating mode) and backward field (plugging mode) are negative. Equation (1) confirms that it would lead to decrease in the rotor speed after the fault clearance.

\[ T_m - T_e = j\omega \frac{d\omega}{dt} \]  

(1)

3. Block Diagram Of Simulated System

System studies of induction machine are carried out using MATLAB/SIMULINK. The power system model use in this shown in fig.3. The Squirrel cage induction generator is directly connected through a transmission line to the grid with the help of three phase transformer.
4. Result

After clearing the fault, the operating mode of machine is changed from generating to plugging mode. After plugging interval, the machine is returned to the generating mode again. The successful solutions are those that can amplify electrical torque versus mechanical torque after fault clearance. The solution proposed in this paper involves changing the operating mode of the machine after clearing the fault from the generating mode to the plugging mode. It can be done as simply as by interchanging any two leads of the stator supply. By doing this, the direction of the rotating field is reversed. This causes a breaking effect on the rotor, thus decreasing the rotor speed.

5. Conclusion

In wind energy systems one of the popular types used is squirrel-cage IG due to its simplicity, reliability, low weight, low cost, and low maintenance cost. One of the main disadvantages of the wind farms that equipped with this type of generators is the transient stability problem. In this paper, a simple method was presented for preventing instability of grid connected squirrel-cage IGs, when a fault occurs in the network. In the proposed method, the speed of the generator is controlled by changing the operating mode from generating to plugging, for limited time interval after fault.

6. References