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Overview of low voltage crossing technology in DFIG wind power generation system

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ABSTRACT: with the increasing scale of wind power grid connection, the influence of wind farms on the stability of power system becomes more and more significant. The power system has put forward higher requirements on the continuous operation capability of grid-connected wind turbines under voltage sag fault. More and more researches on DFIG instantaneous power grid fault have focused on low-voltage crossing technology. At first, this paper analysis the influence of power grid voltage drop of DFIG operation, puts forward the DFIG wind power system low voltage control objectives through running, summarize and evaluate the DFIG wind power system low voltage through technology, and points out the optimization direction of DFIG wind power system low voltage through technology, show the latest progress and developing trend of the technology, providing a reference for subsequent research and engineering application.

KEYWORDS -DFIG; Grid voltage sag; Low voltage crossing

1. OVERVIEW

At present, the world wind power market develops rapidly, and the installed capacity of wind farms increases year by year. Among various types of wind power generating sets, variable speed constant frequency doubly-fed asynchronous generator occupies most of the market share due to its wide range of speed regulation, independent adjustment of active and reactive power and small capacity of excitation converter.

2. DFIG WIND TURBINE

Doubly-fed Induction Generator through four quadrant converter back-to-back to excitation of rotor winding, thus make the DFIG realize variable speed constant frequency operation. DFIG is equipped with Crowbar protection to ensure the rotor side converter fails. When Crowbar protection detects that the rotor current reaches the set protection fixed value, the rotor winding is short-connected to make DFIG switch to the running state of the asynchronous motor. Meanwhile, the rotor side converter is blocked to control the pulse to make it exit from operation, so as to protect the rotor side converter from overload damage. Although Crowbar protection protects the safety of rotor side converter in the electromagnetic transient process, its action breaks the original torque balance condition of DFIG and triggers the electromechanical transient process. If a new torque balance can be established in the subsequent electromechanical transient process, the DFIG speed can be stable. If the new torque balance cannot be achieved, DFIG still has the risk of overspeed off-grid. With the rapid increase of the capacity of DFIG wind turbines in the power system, the interaction between the generator and the local power grid is also increasing, so the operation control of the wind turbine and the power grid must be implemented as a whole [2]. For this reason, power companies and power grid operators have put forward the grid-connection specification for wind power generation equipment, and from the perspective of maintaining the

stability of the power system, it is required that the wind turbines can maintain the grid operation during the voltage sag of the grid, that is, DFIG wind turbines should have the capability of low voltage crossing .

3. LOW VOLTAGE CROSSING

Low voltage across refers to the fan and node voltage sags, fan can keep parallel operation provide a certain amount of reactive power, even to the grid support grid voltage return to normal, and "through" the low voltage time zones, different countries (and area) of the proposed LVRT requirement is not the same, our country LVRT requirements for electric/wind turbine are shown in figure 1.

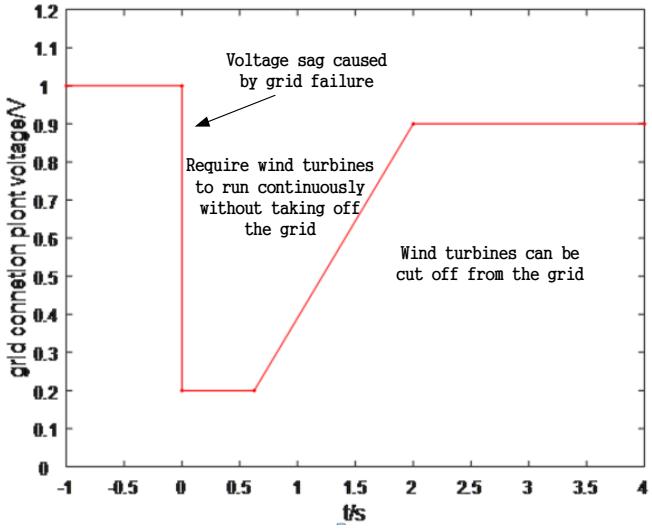

Figure1 LVRT requirements for wind turbines

Off-grid is allowed only when the grid voltage is under the curve shown in the figure in terms of time or value; In the area above the curve, the fan should remain connected to the grid and wait for the power grid to recover. When the voltage drops to 15%-45%, the fan is required to provide reactive power support and should be able to maintain grid connection for at least 625ms. The fan should always be connected to the grid when the voltage drop reaches more than 90%.

4. CHARACTERISTICS OF DFIG IN CASE OF POWER GRID FAILURE

Due to the strong coupling between the stator and rotor, the rotor side also induces outflow and overvoltage. Considering that the high current will lead to the saturation of the motor core and the reduction of reactance, the stator and rotor current will further increase. After the rotor energy flows through the rotor-side converter, part of it is transferred to the grid by the grid-side converter, and the rest is charged to the dc capacity, resulting in a rapid rise in the dc bus voltage [3]. Moreover, the large fluctuation of the stator rotor current will cause the drastic change of DFIG electromagnetic torque, which will have a great impact on the mechanical system of the wind turbine. If protection measures are not taken in time, excessive current and voltage will lead to damage of excitation converter, stator winding insulation and dc busbar capacitance.

5. CONTROL TARGET FOR LVRT OPERATION

According to the analysis of the influence of the above grid voltage sag fault on DFIG wind power generation system, the control objectives of DFIG low-voltage crossing operation can be summarized as:

5.1 ensure that the power grid does not run off-grid during the power grid failure, and prevent the fan from off-grid subsequent failures. It can provide reactive power continuously and stably to restore the power grid voltage and reduce the power grid voltage collapse.

5.2 keep the transient amplitude of electromagnetic torque within the bearing range of the rotating shaft and gear (about 2 ~ 2.5 times the rated torque) [4]. Release residual energy, suppress fault current, protect excitation converter and dc busbar capacitor.

6. THE DEVELOPMENT DIRECTION OF LVRT TECHNOLOGY

Based on the above analysis of DFIG low-voltage crossing technology and the development status of wind power technology in China, it is expected that this technology will be studied in the following aspects in the future:

6.1 establish LVRT technical standard suitable for China's power grid situation, so as to provide wind power equipment manufacturers and wind farm developers with evidence. In areas with strong power grids, LVRT requirements can be relaxed to reduce engineering costs. In areas with weak power grids, strict LVRT standards are required to ensure the safety of power grids and units.

6.2 the operation control of DFIG wind power generation system is essentially the control of excitation converter, so the improved control strategy of DFIG for various grid faults will be the focus of future research on low-voltage crossing technology.

6.3 the existing transient mathematical models of DFIG and excitation converter are not accurate enough to truly reflect the electromagnetic response of DFIG unit under various voltage fault conditions, which affects the accuracy of control strategy and protection device design. Therefore, constructing the transient mathematical model of DFIG system including protection devices (such as Crowbar) will become an important part of LVRT technology research.

6.4 fast detection of grid voltage faults and accurate identification of fault types are the basis of LVRT operation control. Therefore, it is of great importance to study fast phase-lock detection technology under complex grid conditions with positive, negative sequence components and harmonic components, and it is also an important component of LVRT technology.

6.5 the key to the success of low voltage crossing is to develop various protective devices with low cost, high reliability and simple control, so as to ensure the safety of DFIG, especially excitation frequency converter, under severe faults. The various protection devices mentioned above have their own advantages and disadvantages, which can be combined to meet the LVRT technical specification of the local power grid.

7. CONCLUSION

With the increasing installed capacity of large-scale wind power generating units with DFIG as the main body, it is particularly important to improve the LVRT capability of DFIG under power grid failure. This paper proposes LVRT operation control objectives, systematically summarizes and evaluates the research achievements of DFIG wind turbine failure operation control and protection in academic and engineering circles at home and abroad, and predicts the future development trend of LVRT technology, which can provide references for subsequent research and engineering applications.

8. REFERENCES

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