IOP Conf. Series: Earth and Environmental Science **100** (2017) 012018 doi:10.1088/1755-1315/100/1/012018

Research on the Cascading Tripping Risk of Wind Turbine Generators Caused by Transient Overvoltage and Its Countermeasures

Haiyang Yu[1, a]), Meilun Zhang[1, b]) , Guangxin Zu[1, c])

[1]Heilongjiang Electric Power Research Institute, Harbin 150030, China

Abstract. At present, China's electricity utility develops rapidly, however, the wind power consumption ability has been unable to meet the actual demand of consumption. Therefore, it is necessary to send wind power across the region. The commutation failure in the operation will lead to the cascading tripping of wind turbines. In order to solve the above problems, this paper will analyze the causes of such problems, analyze the basic principles of wind power cascading trips and analyze the specific solutions, hoping to give some reference for relevant people.

1. Introduction

In the process of DC commutation, the reactive power should be consumed. In order to solve this problem, it is necessary to install an AC filter bank, which can achieve centralized fixed compensation. In practical application, if commutation fails, the overvoltage will occur.

2. Analysis of Specific Situations of Cascading Trips

2.1 Transient Voltage Rise Problem

In this paper, ultra high voltage direct current(UHVDC) is taken as the case. The rated capacity is 8000 MW. In operation, if DC commutation fails, for example, there is the locking problem at startup, the active power will be interrupted instantaneously. At this point, the reactive power loss will change greatly, and the former reactive power balance will be broken, resulting in a large number of surplus problems in the local reactive power in the system, and the voltage near the converter station will begin to rise. Combined with the actual test, and through the data analysis, the technical personnel found that the amplitude of voltage rise is directly related to the system short-circuit capacity, surplus reactive power and so on. The calculation formula is: $\Delta U \approx \Delta Q/Sc$. In this formula, ΔU is the AC voltage rise of the converter station; Sc is the short-circuit capacity of the converter station; ΔQ is the reactive power change of converter station and system exchange. If the commutation failure occurs, the response at the sending and receiving end is different. The following is mainly to study the problem of sending end over-voltage. Through the in-depth analysis, when the commutation failure occurs, the AC voltage at the sending end will rise first, and then decrease, and the transient voltage rise will occur during the commutation failure recovery period. At this point, the voltage on the inverter side will resume in time, while the pressure difference between the two sides of the DC line will begin to become smaller and even become negative, resulting in a sharp reduction in current. When the DC current is reduced to zero, the reactive power consumed on the DC rectifier side will be greatly reduced[1].

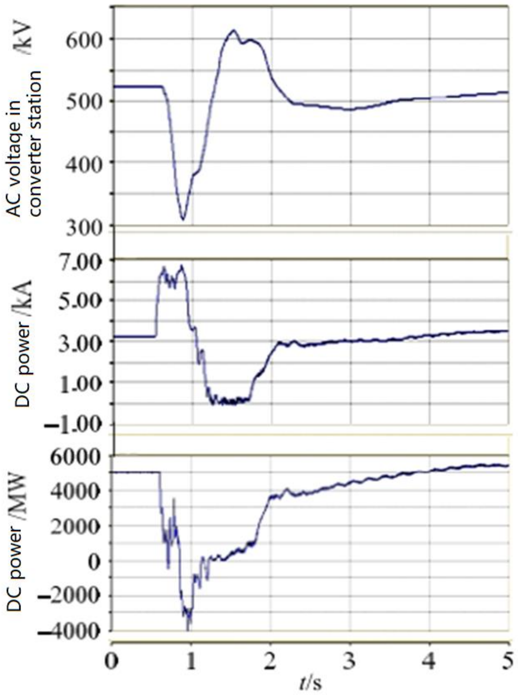

Figure 1. The situation of voltage, current and power after commutation failure

2.2 Transient Overvoltage Caused by DC Bipolar Locking

When the commutation failure occurs, there will be some disturbances in the second start-up, and if the DC bipolar locking operation is carried out, it will lead to the transient overvoltage problem. When the DC locking operation is carried out, the active power is zero in the shortest time and the AC filter group switching off time starts to lag. At this time, even if the staff use the fast switching off method, the lag time will reach more than 200ms. In this process, the AC filter will send a large amount of reactive power to the system, resulting in a large rise in voltage in a short time. You can refer to figure 2 for analysis.

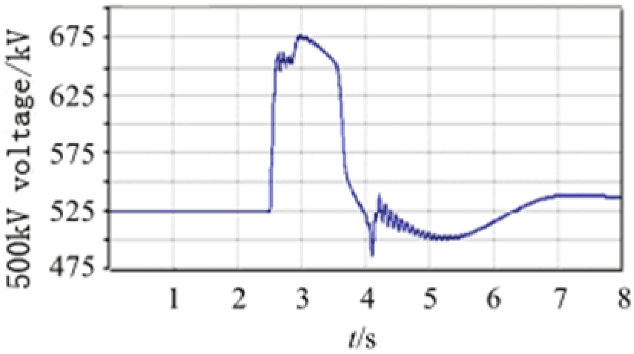

Figure 2. Transient overvoltage problem of extreme high voltage in a city

3. Analysis of the Basic Principle of Wind Power Cascading Trips

There are a lot of wind power surplus in many lines, so in order to solve this problem, related technical personnel carry out in-depth research, and finally, the large-scale wind power collection technology is selected. It mainly deals with the surplus electric energy through the DC trans-regional transmission mode, and the results show that this method is effective. If a large number of wind farms are connected to the terminal, it is necessary to carefully analyze the adverse effects of transient overvoltage on the overall distribution network. When the DC disturbance occurs, the transient overvoltage will appear in the distribution network. This voltage will be transmitted directly to the nearest power grid, leading to a failure in the nearby wind turbine. In view of this problem, technicians have made a careful analysis, and found that the voltage rise is closely related to the short-circuit capacity and the electrical distance. For the equipment in the line and the main transformer, they generally have 1.3 times the per-unit value and short time withstand voltage capacity of 1s. Compared with the conventional AC equipment, it is found that the wind power has low short time withstand voltage ability. From the specific configuration, if the overvoltage in distribution network is more than 1.1 times, there will be wind turbine tripping situation. Therefore, when selecting the equipment, the relevant parameters should be selected according to the actual needs[2].

4. Analysis of Specific Circumstances of Wind Turbine Tripping

4.1 Analysis of Specific Simulation Content

Taking a UHV as an example, the above situation is analyzed, and we can refer to the following figure for understanding. BPA program is used in the analysis, and this UHV zone is divided into four stations, namely A, B, C and D. Each station is connected to a large amount of wind power.

In this project, A station and D station are closest to the converter station, and the distance between them is about 70 km. The distance between C station and converter station is the farthest, which can reach 700km. For the A station and the D station, the connected wind power installation can reach 6 million kW, and for the B station, the connected wind power can reach 6 million kW. In the actual operation, 10 thermal power units are connected to the converter station, and the power can reach 6.6 million kW. According to this situation, relevant researchers calculate and analyze it. 8 thermal power units are opened, and the DC transmission mode is adopted. After the DC commutation failure or bipolar locking, if the trip-off accidents of wind power are not taken into consideration, the converter station is closest to the DC electric, and the voltage rise can reach 0.18pu. Combined with the electrical distance, it is known that the voltage rise of 750 kV A station, D station and B station can respectively reach 0.16pu, 0.15pu and 0.10pu. Combined with the current wind power voltage endurance capability, when the voltage reaches 1.15 Pu, it is easy to cause the trip-off accidents of wind power. For the wind power situation in station A and station D, the passing rate is 60%. Through analysis, it is found that after the tripping of A station and B station, the voltage in the near area is increased. If this situation can not be improved, the transient overvoltage issues will continue to transmit to the B station, resulting in the increase of the voltage of B station. The test results show that its voltage is higher than 1.1pu, and eventually it will lead to tripping problem of the B station. If large-scale tripping situations occur, the problem of steady-state overvoltage will occur[3].

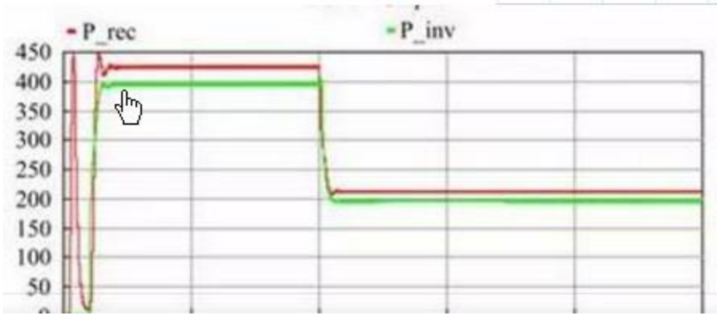

Figure 3. Transient voltage after bipolar locking occurred in distribution network

4.2 Practical Operation Analysis

In 2016, the unipolar locking problem occurred in UHVDC, and the power loss could reach 2 million kW. This period belongs to the small wind period of the grid, and the wind power output is only 400 thousand kW. In order to solve the fault in time, the basic situation of the converter is tested. It is found that the initial voltage of the 750 kV bus is 765 kV, the highest transient voltage is 897 kV, and the transient voltage of A station and B station also starts to rise, reaching 0.14 Pu and 0.10pu respectively. This paper summarizes the related situation and finds that the closer the electrical distance is, the higher the transient voltage rise is. In addition, in the actual case analysis, it is also found that the voltage endurance capability is not uniform, and the tripping has a certain disorder.

5. Analysis of Collective Prevention Strategies

5.1 The DC Output Power is Strictly Controlled

Through in-depth analysis, it is found that the short-circuit capacity and DC transmission power have a great impact on the transient overvoltage level. When the short-circuit capacity is not up to the standard value, in order to ensure that it is in the range of pressure resistance, it is necessary to control the DC transmission power to avoid disturbance to DC during operation, and avoid the problem of cascading tripping of wind turbines.

5.2 The DC Control Effect is Optimized

The DC control effect is optimized to avoid the occurrence of related risks. Technicians can reduce the probability of DC commutation failure and improve the speed of recovery after failure. On this basis, the speed of switching off the AC filter after DC bipolar locking is improved. Through these two measures, the probability of transient overvoltage can be effectively reduced, and the maintenance time can be reduced to ensure the safety of the wind turbine and the whole power grid.

5.3 Its Actual Voltage Endurance Capability is Improved

For the DC near area wind turbine, its role is very important. When its voltage endurance capacity does not meet the standard, and the cascading tripping risk of wind turbines caused by transient overvoltage occurs, it can not withstand voltage operation, and then there is a fault. The wind turbines in this position are faced with great risk of high voltage. In order to avoid the faults, it is necessary to do a good job of handling the high voltage. The researchers found that through the calculation, the use of related equipment can effectively improve the stability of the work, and the equipment can also be operated under the limit of 1.15 pu~1.3 Pu, which can effectively reduce the probability of the occurrence of such risks and ensure the normal working condition[4].

5.4 The Wind Power Access Method is Scientifically Set Up

When the DC disturbance occurs, if the transient overvoltage occurs in the power grid, it must be caused by the reactive power of the AC filter reverse delivery system. In addition, when the distance from the AC bus is closer, the transient voltage starts to rise. Combined with the actual situation, in the construction process, the staff should make scientific planning for wind power access mode and the wind power collection line cannot be directly connected to the converter station. In addition, the technicians can also configure dynamic reactive power compensation equipment or configure conventional units in the wind power collection area. By doing these two points in practice, the voltage can be controlled to avoid the continued increase in voltage, curb relevant influence and ensure the stability of the operation[5].

6. Conclusion

Through the research on the cascading tripping risk of wind turbine generators caused by transient overvoltage and its countermeasures, we find that this problem is very serious. Combined with the simulation operation and actual case analysis, the concrete treatment methods are summarized, including control of DC output power, effective DC control effect, improvement of the voltage endurance capability, scientific setting of wind power access capability, etc.

References

[1] HE Jingbo,ZHUANG Wei,XU Tao,HUO Chao,JIANG Weiyong.Study on Cascading Tripping Risk of Wind Turbines Caused by Transient Overvoltage and Its Countermeasures[J]. Power System Technology,2016(06):1839-1844(in Chinese).

[2] Liu Zhenya, Zhang Qiping, Dong Cun, et al. Study on the development mode of national power grid of China[J]. Proceedings of the CSEE, 2013, 33(7): 1-10(in Chinese).

[3] He Jingbo, Wan Lei, Huo Chao, et al. Abnormal over-voltage risk analysis of HVDC transmission on atypical conditions[J]. Power System Technology, 2014, 38(12): 3459-3463(in Chinese).

[4] He Jingbo, Li Mingjie, Yi Jun, et al. Research on dynamic characteristics and countermeasures of AC-DC hybrid power system with large scale HVDC transmission[C]//2014 International Conference on Power System Technology (POWERCON). Chongqing: IEEE Power Engineering Society, 2014: 799-805.

[5] Sun Huadong, Zhang Zhenyu, Lin Weifang, et al. Analysis on serious wind turbine generators tripping accident in Northwest China Power Grid in 2011 and its lessons[J]. Power System Technology, 2012, 36(10): 76-80 (in Chinese).