Study on Fault Mechanism of Lightning Flashover Based on EMTP - RV in Wind Farm

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Abstract. The particularity of lightning flashover failure of wind farm is analyzed, and it is pointed out that the formation mechanism of lightning overvoltage in wind farm collector system is different from that of power system distribution network. On this basis, the mechanism of lightning flashover failure of wind farm collector system is analyzed. The EMTP-RV software is used to simulate the typical lightning overvoltage formation and propagation process of the wind farm collector system. Results show that the fault mechanism of the lightning flashover fault system is analyzed. Finally, it is pointed out that the design scheme of the insulation system of the wind farm collection system should not directly copy the design scheme of the distribution network of the power system.

1. Introduction

   After wind farm struck, the lightning overvoltage is formed and propagated in the wind farm collector system. If the insulation of the collector system is relative weak, the lightning overvoltage will cause the insulation flashover. This will lead to system trip, which affects the safe and stable operation of the wind farm. In 2015, Shanxi Province, the lightning stroke is mainly in July and August, which leads to more than ten times tripping for the collector system. This makes a huge negative influence for operation of wind farm.

   As lightning stroke is hard to avoid, it is important to design the insulation coordination of collector system. The insulation coordination of collector system should be based on the lightning overvoltage level[1]. In order to design the lightning overvoltage level, the mechanism of lightning flashover needs to be understood.

   By analyzing the mechanism of lightning flashover on collector system and simulating the formation of the lightning overvoltage, this article illustrates the insulation coordination design scheme of wind farm cannot match the scheme of distribution network power system.

2. The mechanism of lightning flashover in wind farm

2.1. Particularity of lightning flashover fault of collector system.

   The insulation coordination design scheme of wind farm is same with scheme of distribution network power system for a long term. The lightning flashover fault of power system includes Direct lightning flashover fault and induced flashover fault. The former one includes react lightning and twist lightning. By using the scheme of distribution network power system, those two faults can be reduced. However, the possibility of faults is still high in some places of wind farm. For example, it is
mentioned that the wind farm in Shanxi province. This wind farm installed the typical scheme of
distribution network power system, which can avoid lightning flashover. After analyzing, engineers
found faults are twist lightning and react lightning. According to IEC-61400[2], the tower is under
protection of the Wind turbine Engineers, so the probability of react lightning is small and the
probability of twist lightning is high. However, twist lightning is usually single-phase fault. Moreover,
the rate of three-phase short-circuit fault and two-phase short-circuit fault are high.

Overall, there is another form of lightning overvoltage existing in wind farm.

2.2. Analysis of lightning flashover fault in wind farm

![Figure 1. The mechanism of lightning flashover fault for collector system](image1)

The height of wind turbine is higher than that of the overhead line of the collector system.
According to IEC61400—24[2], wind turbine generator is more possible to attract lightning stroke as
its height. The potential of box transformer is rising, if lightning struck the wind turbine. When this
potential is high enough to trip Surge arrester, there will be a instantaneous overvoltage occurred on
Surge arrester. Therefore, current will flow in collector system and break the collector system.

That is why the rate of three-phase short-circuit faults and two-phase short-circuit faults are high in
wind farm in Shanxi province. Another wind farm (Yunnan Province) occurred the same fault as that
one.

3. Simulation of typical lightning flashover in wind farm

3.1. Simulation modelling

For verifying theory, the model is built by using EMTP-RV software. It can be seen that the model
is based on two situations including WT1 struck and WT10 fan struck. The simulation shows the value
of overvoltage in different position of collector system. The graph can be seen as below:

![Figure 2. Simulation](image2)

There are 10 wind turbines including Gearbox, synchronous motor, rectifier components and
inverter components respectively. Each of them has same parameters.
3.2 Result of simulation

Fault 1 is set to Wt1 and fault 2 is set to WT 10. Graphs are shown as below:

Figure 3. The voltage curve of WT5 box transformer.

![Figure 3](image3.png)

Figure 4. The voltage curve of WT10 box transformer.

![Figure 4](image4.png)

From figure 3 and figure 4, it can be seen that when WT1 struck, lightning current went through both WT5 and WT10. The amplitude of overvoltage in both turbines are nearly the same. Graph 5 and graph 6 show fault occurred near WT10. Graphs can be seen as below:

Figure 5. The voltage curve of WT1 box transformer.

![Figure 5](image5.png)
Figure 6. The voltage curve of WT10 box transformer.

By analyzing both of graphs, the amplitude of overvoltage in WT1 and WT10 are nearly the same. Therefore, there are two main points. Firstly, when collector system is struck, the overvoltage of collector system is rising. Secondly, there is no relationship with position on collector system (the level of over voltage flashover is relative same, when different position of tower struck.).

4. Conclusion

After wind turbines struck, there is probably lightning overvoltage in collector system. Overvoltage may lead flashover fault. This fault is different from that of distribution network of the power system. It is conclusion that the insulation coordination design scheme of wind farm cannot match the scheme of distribution network power system.

References

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