Simulation and Research on Single Machine Infinite Power System Model

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Abstract. With the increasing size of power systems, various failures can pose a threat to the safety of power plants and users and multiple power equipment within power plants. Therefore, time domain simulation is used to verify that the power system is in a certain state. Whether it is stable or not has important theoretical and practical significance. According to the circuit model requirements of the grid power supply system, the dynamic simulation software Simulink is used to build a simulation model of the single-machine infinite power system, which can meet the needs of various faults that the power grid may encounter.

1. Introduction
The power system is a complex dynamic system. On the one hand, it must guarantee reliable power quality at all times. On the other hand, it is in constant disturbance. The time, place, type and severity of the disturbance have a large randomness. When a disturbance occurs, the system may have serious consequences within a few seconds if a stability problem occurs. For a particular stable operating state of the system, and for a particular disturbance, if the system achieves an acceptable stable operating state after the disturbance, the system operation is transiently stable.

2. Power system transient stability analysis
In the event of a short circuit, the power system changes drastically from one state to another, creating complex transient phenomena. In a three-phase system, short circuits that may occur are: three-phase short circuit, two-phase short circuit, two-phase ground short circuit, and single-phase ground short circuit. When the dynamic circuit transitions from a stable state to another stable state, some physical quantities do not change, but take some time. During this time, the circuit will exhibit a special phenomenon different from the steady state, that is, the transition process or transient phenomenon of the circuit. When analyzing the transient phenomenon of the circuit, the differential equation of voltage and current can be established and solved according to the initial.

As shown in Figure 1-2, under normal operating conditions, if the mechanical power input by the prime mover is \( P_m \), the electromagnetic power output by the generator is balanced with the mechanical power input by the prime mover. The working point of the generator should be \( P_1 \). And the intersection of the \( P_m \) line is determined, that is, point a, and the corresponding power angle is \( \delta_0 \). At the moment of short circuit occurrence, since the aperiodic component of the stator circuit is not considered, the power of the periodic component can be abrupt, so that the generator operating point \( P_i \) will suddenly be \( P_{ii} \). And due to the inertia of the mechanical motion of the genset rotor, the power angle \( \delta \) impossible mutation, still \( \delta_0 \). Then the operating point jumps from point a to point b on the power-angle characteristic curve \( P_{ii} \). After reaching point b, the input mechanical power \( P_m \) is greater...
than the output electromagnetic power $P_{IIb}$, and the unbalanced net acceleration power is greater than zero. According to the equation of motion of the rotor, the rotor begins to accelerate, i.e. $\Delta \omega > 0$. Power angle $\delta$ starts to increase, $\Delta \delta > 0$, the operating point will move along the power-angle characteristic curve $p_{ii}$, set a period of time, when the power angle is increased to $\delta_c$, when running at point c, the speed reaches the maximum $\omega_{\text{max}}$.

![Figure 1. Power system transient stability](image1.png)

![Figure 2. Power system transient instability](image2.png)

At point k: $P_{m} = P_{III} - k$, deceleration stops, the speed is minimum $\omega_{\text{min}}$. But due to the mechanical inertia of the rotor, the power angle $\delta$ Will continue to decrease, when the point k is over $P_{m} < P_{iii}$, under the effect of the unbalanced power is positive, the rotor begins to accelerate, and finally reaches the synchronous belt $\omega_N$. Power angle $\delta$ No longer decreasing, at this time the power angle is the minimum $\delta_{\text{min}}$. Then start the second oscillation again, the power angle $\delta$. From small to large, the operating point along the work-angle characteristic $P_{iii}$ crosses the k point and reaches the f point. If there is no damping during the oscillation, the oscillation will continue to oscillate. But in fact, there is always a certain damping effect in the oscillation process, the oscillation is gradually attenuated, and the system will stay at a new operating point k to continue the synchronous operation, that is, the system can maintain transient stability after a large disturbance.

When the short circuit fault is removed later, $\delta$. When c is larger, after the fault is removed, the operating point moves along the power $P_{iii}$ continuously in the direction of increasing power angle. Although the rotor is continuously decelerating, the operating point reaches the curve $P_{III}$. k At the point, the rotor speed is still greater than the synchronous speed. Then the running point will be crossed $k'$ Point, passed $k'$ after the point, the situation reversed. Due to $P_{m} > P_{iii}$, the genset rotor starts to accelerate again, and the acceleration is getting bigger and bigger, the power angle is higher. $\delta$ Infinitely increased, the generator and the system will lose synchronization, and the system transient instability.
3. **Single machine infinity system simulation**

In the stability analysis of power system operation, the commonly used model is single-machine to infinity system. The single-machine infinite system considers power infinity, constant frequency and constant voltage. It is the most commonly used method in engineering, and it is the simplest and most basic of power system simulation. The mode of operation, that is, approximating the reality to simplify the model, is more conducive to drawing conclusions and simplifying the calculation process.

Assuming that the contact impedance is pure inductance, the p of the active power sent by the generator to the infinite system is:

$$P = \frac{E_n}{\sum Z} U \sin \delta$$

In the middle $\sum Z$ representing the total impedance of the generator electromotive force, including the generator impedance, to the busbar of the infinite system; $\delta$ indicates the power angle. The use of matlab to simulate the system is mainly for the comparison of the generator speed change in the 0.1s resection fault and the 0.55s resection fault. By changing the type of short circuit in the faulty module, the transient stability of the system in the event of various short circuits can be simulated. Similarly, the influence of various parameters on the transient stability of the system can be studied by changing the component parameters in the system. The simulation diagram is as follows:

![Figure 3. Single-machine infinite power system simulation diagram](image-url)
4. Conclusion
A large number of transient stability analyses are required in the planning and design of power systems. Through the transient stability analysis, we can see the effects of various stabilization measures and the performance of stable control. In this paper, the simulation model of single-machine infinite power system is built by using dynamic simulation software, which can meet the needs of various faults that the power grid may encounter.

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