Power system reliability analysis

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Abstract. Electric power development is the key factor of economic development, but also an important guarantee of industrial modernization. At present, with the improvement of people's quality of life, electricity has become an indispensable part of ensuring people's lives. Therefore, the stable and reliable development of power system has an important impact on economic development, industrial modernization and people's lives. With the continuous maturity of the reliability theory, the power system and its combination have evolved into an important application subject called the reliability evaluation of the power system, which has penetrated into the whole industrial chain of the power system, which is a reliable guarantee for the industrial chain to gain economic and social benefits. Based on the analysis of the operation reliability of power system, this paper puts forward the main measures to improve the operation reliability of power system in order to meet the operation requirements.

1. Introduction

System reliability is an important guarantee for the performance of large-scale equipment, which is not only related to the reliability of each component, but also related to the connection form between the components. With the rapid development of China's social economy, it is gradually moving towards the direction of high-level and high-capacity Internet. With the continuous development of the process, problems also appear. The most obvious is the reliability and security of power system. Often a large-scale power failure accident may lead to power failure in many places, and then bring loss to people's daily production and life. Therefore, emphasizing the stability and security of power grid operation can enhance the cognitive height of power system operation reliability, and directly enhance the reliability of power grid operation to the level of national security strategy, which can also realize the in-depth study of power grid operation.

2. Explanation of power system operation reliability

At the initial stage, for the understanding of reliability, people will take it as a symbol to measure the quality of products, but the concept of reliability applied to power system operation is mainly to express the reliability of power system operation. The most basic function of the power system is to provide electric energy with the quality up to the standard. The reliability of power system operation needs to realize the protection of part of equipment management in the process of power system
operation in advance. The reliability here refers to the completion of the most basic functions of equipment, components or system under predetermined time and specified conditions.

2.1. Definition
Power system reliability is an applied science combining theory (reliability principle and method) with practice (practical power system engineering problems). It includes two aspects: one is power system reliability engineering technology, the other is power industry reliability management.

2.2. Essence
The essence of power system reliability is to take economic and reasonable technical means and management methods to give full play to the maximum potential of power supply system, to continuously deliver stable power energy to all users, so as to realize the goal of total quality management and comprehensive safety management for the whole power system. Generally speaking, improving the health level of power supply equipment, extending the service life of the system, improving the safe operation environment of the system and other activities to improve the level of power system reliability belong to the scope of power industry reliability work.

2.3. Main tasks
The main task of power system operation reliability is: in the historical operation process, accumulate the data generated by power components, and accumulate the data after the reliability test of components. Through the analysis of this part of data, the reliability of components can be solved. At the same time, considering the expected load changes of the power model and the reliability model of the power system, the corresponding analysis and simulation processing can be done. This kind of simulation can not complete the predetermined function in the power system within the specified time. After the simulation, we also need to do the corresponding calculation, so that we can get the most effective data, and do a targeted analysis. Then, on the basis of opportunity system investment and reliability coordination, comprehensive evaluation can be carried out for the operation and control of power system, and auxiliary decision-making can be carried out. The purpose is to find the key to limit reliability and organize relevant departments to realize it.

3. Reliability testing

3.1. Purpose of testing
According to the experience of power system reliability detection, first of all, in the power system planning and design, the whole system reliability quantitative system should be used to detect and analyze the possible faults of the system, and corresponding technical measures should be taken to reduce the impact of faults on the normal operation of the system. Compared with the cost investment and the economic benefits brought by system operation, the comprehensive evaluation of reliability is guaranteed and the comprehensive benefits of power system operation are maintained in the best state for a long time. For the evaluation of power system reliability, we determine the purpose of detection, then we can develop the corresponding detection technology, so as to determine the type of fault, and effectively make professional evaluation and judgment on the severity of the fault.

In order to make the reliability of power system reach our expected level, ensuring the adequacy and security of power system is the primary evaluation property. The corresponding measures are taken to avoid the influence of power load reduction on system components in case of sudden fault. At the same time, the integrity of the system should also be paid attention to, so that the main units of the system can be controlled and separated. It is necessary to prevent secondary system damage caused by fault spreading and expansion, and avoid system entering shock state. Measures should be taken in time to restore the normal operation of the power system after power failure.
3.2. Planning and design stage
The design of power system should first assess how to minimize the impact of damage in case of exceeding the design requirements. The system should have enough capacity to withstand different degrees of disturbance, so as to avoid the consequences and increase the blackout range. At the same time, it creates a safe working condition for the operators to protect the equipment from damage. The operation reliability evaluation of power system reduces the controllable risk and carries out various operation modes. The reserve capacity and maintenance plan of the system are designed and determined, the output and input power data values are determined, and the output and input electric energy of interconnected system is determined.

3.3. Reliability criteria
The numerical parameters meeting the specified reliability evaluation purpose, or the on-line criterion of unreliability. In order to determine the performance test criteria, firstly, the transmission and transmission interconnected system should be able to effectively undertake the conditions of power generation system and system sudden outage. The combination of different faults should include the disturbance itself and the operation of the system before the disturbance. Considering the loss of one element in the system with multiple components, the system should be kept in the operation state of continuous power supply. Therefore, the N-1 principle is adopted in the transmission and transmission interconnection systems of various countries. In order to avoid the reduction of power consumption caused by sudden failure, this criterion has certain reliability and stability, and its concept is indirect and clear. It is widely used in the evaluation and appraisal of power system reliability.

3.4. Basic connotation
According to the quality and quantity standards stipulated by the power system, the power supply operation can be carried out all day without any difference. Through the power generation system, we can comprehensively observe whether the power generation is sufficient and whether the system has faults. Once the fault occurs, the power generation system will send out the signal of insufficient power, and the load point can not receive the power transmitted by the transmission and distribution system. Conversely, power will be transmitted smoothly to any load point. The reliability of power generation system is the key factor of normal power generation.

3.5. Technical assessment
The second is to establish the reliability information management system. According to the operation state of the system on site, the observation record is made, and then the data processing is carried out with the advantage of computer, which makes it become the basis of reliability evaluation.

Finally, it is necessary to establish a detection device for major accidents, install disturbance detection equipment in the system operation status, and detect the disturbance information and fault judgment of the transmission and transmission interconnected system, which is helpful for us to judge the behavior of system components, analyze the cause of disturbance nature, and improve the reliability modeling.

4. Measures for reliable operation of power system
The analysis of power system reliability mainly considers the accumulation of data, reasonable analysis and key fulcrum search, so as to improve the overall level of reliability, as shown in Figure 1. After mastering the contents in Figure 1, we can carry out the subsequent analysis after screening reasonably.
Figure 1. Main work of power system engineering reliability

4.1. Operation protection of the system

4.1.1. Operation of relay protection system. Power system itself belongs to the network which is connected with each other. Once a link has problems in operation, it will affect the whole system and even directly make the system collapse. Among them, the most important link is the relay protection system. Therefore, the research on the reliability of relay protection system mainly needs to consider: firstly, when the power system fails, it is generally necessary to consider whether the relay protection has refused to act, and secondly, whether there are wrong actions. The relay protection system device itself has a certain degree of automation, and it has a certain defense function, which can meet the needs of stable operation of the power system. In the operation of the power system, it is necessary to find the obstacles in the system through relay protection, which can be targeted to solve the problem and avoid further impact on the power system. So, how can we do a good job in the construction of relay protection system reliability? Through reasonable analysis, it needs to be carried out from the following aspects:

The reliability of relay protection system itself needs comprehensive supervision, which can start from the production of relay protection device to the link of supervision and use

(1) Establish a system with high reliability, improve the relevant laws and regulations; regularly carry out staff training, so as to ensure that the corresponding solutions can be done in case of sudden problems. Through good technical foundation, the requirements of reliability of relay protection system can be met, and the overall operation reliability of the system can be finally met.

(2) For the relay protection system, can also be adjusted, once the operation of the power system can not grasp the situation, this is mainly because of the environmental impact of the relay protection system, can not play its performance. One of the most critical points is that the sealing of relay protection itself needs to be focused on, and corresponding adjustment should be made for indoor
problems. Generally speaking, it is necessary to adjust the operation environment of relay protection system appropriately, so as to meet the demand of reliability.

4.1.2. DC power supply of power system

(1) Do a good job in design, selection and procurement, in contrast, the traditional power supply is difficult to meet the requirements of all aspects, so it can not guarantee its reliability. Therefore, people will generally use high-frequency switching power supply. This power supply can not only meet the requirements of weight, but also has low pollution and high power. While meeting the reliability requirements, it can also ensure the ability to resist electromagnetic interference.

(2) Reasonable selection and management of batteries. Through the use of sealed lead-acid battery, with its own advantages, it can meet the requirements of power system reliability. Valve regulated sealed lead-acid battery, because of its own structure is sealed, there will be no leakage or acid mist. In addition, its sealing degree is high, and it can also protect and isolate the positive and negative plates. In this way, there will be no material falling off easily, and its service life can be greatly improved. After the battery is selected, it is necessary to repair and maintain the battery, so as to find the shortage of the battery and meet the requirements of reliability. At the same time, it can meet the requirements of the correctness of the charging mode, and the battery test is needed every year, so as to meet the subsequent use needs. In addition, in the power system operation, the normal use of the battery can not be ignored. Therefore, it is necessary to make effective control of selection and maintenance.

4.1.3. Remote operation of power system. For power system operation equipment, it can carry out automation scheduling, and then meet the needs of remote control. This kind of automatic scheduling needs to be considered in unattended guarding. Therefore, in order to meet the requirements of normal operation of the power system, it is necessary to maintain the smooth transmission of power data, which is very important for the operation of the power system itself. In order to improve the reliability of power system operation equipment, we should also ensure the reliability of its channel operation. Before using the transmission channel, it is necessary to test all aspects of the parameters. However, only such operation is not enough. In order to meet the requirements of smooth channel, it is necessary to conduct line detection regularly, and use the bit error rate and signal-to-noise ratio, so that the inspection can be completed.

4.2. Failure caused by human factors

Due to the misoperation of technical operators, the power grid may collapse, which is caused by human factors. Therefore, the reliability of human factors is analyzed:

When there is a fault in the power grid, it is necessary to identify the cause of the fault in a short period of time, and then formulate effective measures. Human operation will directly affect the recovery of system failure. For example, when the signal of "three-phase position inconsistency" exists in the single-phase operation circuit breaker, it is necessary to comprehensively check the actual position of the three-phase circuit breaker, and manually remove the fault. In the operation of non full phase, there will be positive sequence, zero sequence and negative sequence voltage and current. Therefore, there should be no open phase operation for a long time, and the fault should be eliminated within 1.5 s.

Due to the differences of operators themselves, there are differences in their knowledge, experience and psychological quality. Therefore, there will be some operational reliability differences. For example, a certain operator's knowledge and experience have similar problem handling experience. However, another operator can only operate according to the specified requirements because of his / her experience. Specifically, er-hra is used for reasonable analysis. See Table 1 for details.
Table 1. ER—HRA parameter value

| Operator | $\alpha$ | $\beta$ | $\gamma$ | $K_1$ | $K_2$ | $K_3$ | $K_{FP}$ |
|----------|---------|--------|---------|-------|-------|-------|--------|
| A        | 0.407   | 1.2    | 0.8     | -0.22 | 0.00  | -0.22 | 0.055  |
| B        | 0.601   | 0.9    | 0.6     | 0.28  | 0.28  | -0.22 | 0.239  |

Generally speaking, this operation can be completed in 0.8s. The probability of error can be directly calculated by using the following consensus.

$$P(t)=\exp[-\left(\frac{t}{\alpha}\right)^\gamma]$$

Where,
- $\alpha$ — scale parameters of cognitive model;
- $\beta$ — shape parameter;
- $T$ — allowable operation time;
- $T_{1/2}$ — median time.

$$T_{1/2}=T_{1/2n}(1+k_1)(1+k_2)(1+k_3)$$

Where, $T_{1/2n}$ — operation in general takes time;
- $k_1, k_2, k_3$ — training time, personnel mentality and human-computer interface level, etc.

According to the data presented in Table 1, the error rate of the former is 0.055, and that of the latter is 0.239. In the face of failure, we can clearly understand that whether it is the operation time, experience and skills, or the mentality of the operator itself, will affect the reliability of operation, so it is very important to do a good job of training in the daily work.

5. Conclusion

With the further development of China’s economy, people use more electrical products in their daily life. As the main driving force of the country's development, the reliability of the power system itself directly affects the development of social economy and the quality of life of the people. This puts forward more strict requirements for the reliability of power system. For the power system, the most basic requirement lies in the guarantee of the national power supply. Although the use of advanced power equipment and safety control devices can meet the requirements of the power system, it is impossible to be foolproof. Once the power system failure, it will affect people's life and production, and will also affect the development of the national economy. Therefore, the reliability of power system is not the demand of the power industry itself, but also the core guarantee for the orderly development of people’s life and production.

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