International Journal of Mechanical and Electrical Engineering
ISSN: 3005-9615 (Print), ISSN: 3005-7132 (Online) | Volume 4, Number 1, Year 2024
DOI: https://doi.org/10.62051/ijmee.v4n1.08
Journal homepage: https://wepub.org/index.php/IJMEE/index

Key Technology of Relay Protection and Setting Calculation of Uhv Power Grid

Jinghui Liu [1], Guangze Zhu [2,*], Zhe Yang [1], Zhen Xu [1]

[1] State Grid Zhejiang Electric Power Co., Ltd. Shaoxing Power Supply Company, Shaoxing, China
[2] Zhejiang Electric Transmission and Transformation Engineering Co., Ltd, Hangzhou, China
*Corresponding author: Guangze Zhu (Email: 1109947846@qq.com)

ABSTRACT

As the core component of the modern power transmission system, the stable operation of the UHV power grid is of great significance to ensure the overall safety of the power system. As a key line of defense in the ultra-high voltage power grid, relay protection can detect and isolate faults in time, thus limiting the impact of the accident to the minimum range. Setting calculation is an important basis for relay protection, which involves a series of complex calculation and analysis processes. This paper deeply analyzes the key technology of ultra high voltage power grid relay protection setting calculation, discusses the specific factors of the substation configuration on the setting calculation, carefully analyzes the principles of the setting calculation, comprehensively analyzes the related protection device configuration strategy, and further study the potential problems existing in the setting calculation and its effective countermeasures. Through the in-depth discussion and research of these key technical problems, it provides a set of scientific and reasonable norms and guidance methods for the relevant personnel in the setting and calculation of the relay protection of the ultra-high voltage power grid, so as to effectively guarantee the long-term stable operation and safe power supply of the power system.

KEYWORDS

Ultra-high voltage; Substation; Relay Protection; Setting Calculation.

1. INTRODUCTION

With the rapid progress of science and technology and power demand continues to rise, ultra-high voltage power grid is gradually becoming a key part of modern power transmission system, the improvement of the voltage level, such as the emergence of uhv grid, brought higher transmission efficiency, further transmission distance and lower line loss, for cross-regional allocation and economic and efficient utilization provides a strong support. However, while enjoying the great convenience brought by the UHV power grid, we must also be soberly aware of the severe challenges brought about by its complexity [1-3].

The huge scale and complex structure of the UHV power grid, coupled with the varied operating environment, make it face various fault types and a relatively high probability of failure in the operation process. Once a failure occurs in such a large system, it will have a wide range of effects and rapid chain reaction, which may lead to local power supply interruption, which may cause a systemic collapse. Therefore, in the ultra-high voltage power grid, ensuring the long-term stable operation of the system and the safe and reliable power supply has become a major problem to be solved urgently [4-6].

Figure 1. super grid

To achieve this goal, in addition to the need for advanced equipment, reasonable planning and perfect operation and maintenance, the key link is to rely on the efficient and reliable relay protection system. The relay protection system is like the "security guard" of the power grid, which can quickly and accurately identify the fault and perform the trip operation in the first time when the fault occurs, and remove the fault equipment or fault area, so as to effectively prevent the expansion and spread of the fault.

Therefore, in the construction and development of ultra-high voltage power grid, it is particularly important to deeply study and discuss the configuration optimization of relay protection system and the improvement of setting calculation technology. This is not only related to the safe and stable operation of the power grid, but also directly related to the reliability of the power supply and the normal operation of the society. By continuously optimizing the configuration scheme of the relay protection system and improving the accuracy and efficiency of the setting calculation, we can provide a more solid guarantee for the safe operation of the ultra-high voltage power grid, and contribute to the stable development of social economy and the happiness of people's life.

2. THE IMPORTANCE OF ULTRA-HIGH VOLTAGE POWER GRID RELAY PROTECTION

As the framework of modern power transmission system, the importance of ultra-high voltage power grid is self-evident. It connects power plant and load center and ensures high-speed transmission of power; uHV grid also assumes the responsibility of balancing power generation and load to ensure the stable and reliable power supply. In addition, its strong peak regulating capacity can deal with emergencies and load peak in the grid and guarantee the operation safety of economic transmission and environmental operation, effectively reducing energy loss and environmental pollution.

In this context, the role of relay protection is particularly critical. It is the patron saint of ultra-high voltage power grid security. In the face of complex faults, it can act quickly and accurately, isolate the fault area and control the accident development, gaining time for subsequent maintenance; the protection device can also provide real-time data and fault analysis report to help the operation and maintenance personnel to quickly locate and handle the fault; the preventive protection function can predict potential problems in advance and take measures to avoid serious accidents.

In short, in the complex power grid environment, relay protection is not only a sharp tool to deal with faults, but also the core force to ensure the safe and stable operation of the power grid. We should strengthen the research and application to ensure the continuous, efficient and safe operation of the power grid.

Figure 2. Ultra-high voltage substation relay protection equipment

3. THE INFLUENCE OF SUBSTATION CONFIGURATION ON THE CALCULATION OF RELAY PROTECTION SETTING

3.1. The Wiring Mode of the Substation

The wiring mode of the substation, as a crucial part of the power system, is directly related to the operation stability and safety of the whole power system. Different wiring modes, such as single bus section and double bus section, determine the structural characteristics and fault transmission characteristics of the power grid. For example, a single bus section can improve the reliability of the power supply. When one section of the bus fails, you can quickly switch to another section of the bus to continue the power supply.

In the setting calculation of relay protection, the specific wiring mode of the substation must be closely combined. Because different wiring modes will directly affect the distribution of the fault current, the voltage landing and the action characteristics of the protection device. Differences in wiring patterns may even change the probability and type of failure.

The setting value of the relay protection device is the key parameter, which directly determines whether it can act accurately and timely in the actual operation. Therefore, only by comprehensively considering the substation wiring mode, power grid structure, load characteristics and other factors, can the setting value be reasonably determined. For example, in complex wiring modes, more detailed protection coordination may be required to prevent protection rejection or mis operation.

3.2. Substation Automation Level

In modern power system, the automation level of substation is increasing day by day, this not only significantly reduces the demand of manual operation, makes a lot of tedious, repetitive work to intelligent processing, thus greatly improve the work efficiency and accuracy, but also for relay protection setting calculation has brought many new opportunities and challenges.

A high level of automation means that massive data collection and processing is possible. Through the real-time collection of power grid data, the automation system can more accurately monitor and analyze the operation state of the power grid more accurately, and then provide more rich and accurate

information basis for the setting calculation of relay protection. This is like providing a more accurate "map" for the setting calculation, making the setting value more in line with the actual situation of the grid.

At the same time, the powerful computing power of the high automation system has also brought an unprecedented speed improvement for the setting calculation of the relay protection. Traditional setting calculation often requires a lot of manpower to carry out complex calculation and analysis, but with the support of high automation system, this process can be completed quickly and accurately, greatly shortening the setting cycle.

3.3. The Grounding Mode of the Transformer Neutral Point

The grounding mode of the transformer neutral point plays a key role in the power system. Different grounding methods, such as direct grounding, grounding by arc suppression coil or ungrounding, directly affect the size and direction of the fault current and the electromagnetic environment of the system.

In the setting calculation of relay protection, the grounding mode of transformer neutral point cannot be ignored. Because this directly determines whether the protection device can respond accurately and quickly when the grounding fault occurs. For example, in the direct grounding system, the fault current is large and the direction is clear, so the protection device can be more easily identified and operated. In the ungrounded system, the fault current is small and easy to produce an arc, which requires higher sensitivity and accuracy.

At the same time, the neutral point grounding mode will also affect the system overvoltage level, electromagnetic compatibility and other aspects. In the setting calculation, these factors need to be fully taken into account to ensure that the relay protection device can operate reliably and effectively under various operating conditions.

4. THE MAIN METHOD OF RELAY PROTECTION SETTING CALCULATION

4.1. Setting Method based on Fixed Value

The setting method based on fixed value is a traditional and widely used method. This method first determines the setting value of the protected device according to the characteristics and operation requirements of the protected equipment, and then verifies the validity of these setting values by simulating various fault situations. In practical application, fault component ratio braking differential protection and second harmonic braking principle differential protection are often used for setting calculation.

For example, in the fault component ratio braking differential protection, the action threshold of the differential protection is determined by calculating the component ratio of the fault current and combining with the braking coefficient. This method can better identify the internal faults and the external faults, and give the corresponding protection measures.

4.2. Intelligent Setting Method based on Real-Time Data

With the rapid development of information technology and artificial intelligence, the intelligent setting method based on real-time data has gradually become a research hotspot. This method uses a large amount of power grid data collected in real time, and adjusts the setting value of the protection device in real time through data analysis and machine learning technologies.

4.3. Setting Method based on Model Analysis

The setting method based on model analysis is a method of combining systematic mathematical model and simulation techniques. First, the mathematical model of the power system is established, including the model of the generator, transformer, line and other equipment. Then, the fault characteristics of the system in different operating states are calculated and analyzed by simulation.

4.4. Adaptive Adjustment and Coordination Control Strategy

Adaptive setting and coordination control strategy play an important role in the modern power system. With the continuous development of the power grid and the continuous change of the load, the traditional fixed setting value has been difficult to meet the complex and changeable protection needs.

The core of the adaptive setting technology is to use real-time monitoring data, such as power grid voltage, current, load information, to dynamically adjust the parameters of the protection device. This allows the protection device to flexibly respond to faults according to the actual operating state of the power grid.

The coordinated control strategy refers to the need for effective cooperation between different protection devices and between protection and control systems. In a complex power system, a single protection device is often difficult to deal with all the failure situations. Therefore, the action order and action range between different protection devices need to be reasonably coordinated and controlled.

5. CONFIGURATION STRATEGY OF THE RELAY PROTECTION DEVICE OF THE UHV POWER GRID

5.1. Optimize the Configuration of the Master Protection

Main protection is the most rapid and effective protection level in the uHV power grid. In order to ensure its maximum efficiency, the high-performance current differential protection device should be preferred. By accurately measuring the size and phase difference of the current, such devices can quickly and accurately identify the fault position and realize the rapid resection of the fault.

At the same time, combining advanced distance protection and zero sequence protection technology to form multiple protection mechanism. Distance protection is set for different short-circuit point distances, while zero sequence protection is mainly used to detect grounding faults. The comprehensive application of these technologies provides a full range of protection strategies for primary protection.

In addition, the introduction of optical fiber communication technology and intelligent sensors and other advanced equipment, to improve the information transmission speed and accuracy of the protection system. Optical fiber communication has the characteristics of fast transmission speed and strong anti-interference ability, while intelligent sensors can monitor the state of the power grid in real time and provide reliable data support.

5.2. Perfect Strategy of Reserve Protection

In the case of main protection failure or failure to be timely removed, the role of backup protection is particularly important. Therefore, the perfect reserve protection configuration cannot be ignored.

The setting calculation of the backup protection should fully consider the coordination with the main protection. Ensure that after the main protection action, the backup protection can quickly start and remove the fault part, forming an effective second line of defense.

At the same time, according to different power grid structure and operation characteristics, the types and scope of backup protection should be reasonably configured. For example, in complex network structures, a more refined backup protection configuration may be required to ensure that faults can be located and handled in a timely manner.

In addition, the background monitoring and data analysis capabilities are strengthened to monitor and analyze the action of the backup protection device in real time. By collecting a large amount of running data, the configuration strategy and setting of backup protection are continuously optimized.

5.3. Configuration Consideration of Auxiliary Equipment

Although the auxiliary devices are not directly involved in the fault resection, they provide a strong support for the normal operation of the protection system.

First, a stable power supply is the foundation. Ensure that auxiliary equipment such as circuit breakers, relays can get reliable power supply to avoid power problems affecting the operation of the protection system.

Secondly, choosing high-quality relays and control equipment is crucial. These devices need to respond quickly when they occur, so their performance and quality directly affect the reliability of the protection system.

In addition, the reasonable arrangement of protection devices is also an important factor to be considered in the configuration of auxiliary equipment. By optimizing the arrangement mode, the response speed and accuracy of the protection device can be improved.

6. POTENTIAL PROBLEMS IN THE SETTING CALCULATION AND COUNTERMEASURES

Accuracy problem of data acquisition and processing. In the setting calculation of relay protection, the accuracy and completeness of the data are the crucial basis. Any error or missing data may directly lead to the inaccuracy of the setting values. In order to deal with this problem, the collection and processing of substation data should be strengthened first. High precision sensors and instruments are used to ensure the accuracy and real-time data. At the same time, a sound data verification mechanism is established to find and handle outliers in time through the comparison and verification of the collected data. In addition, advanced technology is used to process and analyze the data. For example, big data analysis and mining techniques are used to extract useful information from the massive data, providing more accurate data support for the setting calculation.

Cooperation problem between the protective devices. In complex power systems, the coordination between different protection devices is crucial. However, due to various factors, such as equipment performance differences, operating environment changes, etc., it may lead to improper coordination between the protection devices. In order to solve this problem, it is necessary to analyze the action characteristics of each protection device in detail and make reasonable configuration according to the actual operation of the power grid. At the same time, the information interaction and coordinated control between different protection devices should be strengthened to ensure that the effective protection force can be formed when the failure occurs. In addition, intelligent methods can also be adopted, such as the collaborative control algorithm based on machine learning, to automatically adjust the setting value and action strategy of different protection devices, so as to achieve more accurate coordination.

The change of the system operation status. With the continuous development of the power grid and the change of the load, the operating state of the system will also change accordingly. This requires that the setting calculation can adapt to this change, and timely adjust the setting value of the protection device. To meet this challenge, dynamic set-up computational models are needed. Through

the real-time monitoring of the operation data of the power grid, the changes of the system status are found in time, and the setting value is adjusted according to the needs. At the same time, strengthen the planning and construction of the power grid, reasonable layout of substations and transmission lines, optimize the power grid structure, and reduce the impact of operation state changes on the protection device. In addition, the advanced prediction technology and methods can also be used to predict the load and development trend of the power grid, so as to provide a more accurate basis for the setting calculation.

7. SUMMARY

In this paper, the key technology of the setting calculation of relay protection in UHV power grid is deeply studied, from the configuration of substation to the principles and methods of the setting calculation of relay protection, to the configuration strategy of protection device and the countermeasures of the potential problems in the setting calculation. As the core part of modern power transmission system, the safety and stability of ultra-high voltage power grid are closely connected with the setting calculation of relay protection. Accurate setting calculation can ensure that the ultra-high voltage power grid can quickly and accurately isolate the fault part in the face of various complex faults, and ensure the normal operation of other parts of the power grid.

By considering the influence of various factors of substation (such as wiring mode, automation level and grounding mode) on the setting calculation, this paper puts forward a more scientific and reasonable setting strategy and method. At the same time, combined with advanced setting technology (such as intelligent setting method based on real-time data) and auxiliary means (such as expert system and artificial neural network technology), the efficiency and accuracy of setting calculation are significantly improved.

Looking into the future, the development of ultra-high voltage power grid will be more rapid and complex. With the large-scale access of new energy, the continuous expansion of the power grid scale and the wide application of power electronics technology, the structure and operation mode of the power grid will undergo profound changes. Therefore, the setting calculation of relay protection also requires continuous technological innovation and theoretical breakthrough.

For example, further develop more intelligent setting algorithm, using big data, cloud computing and other technologies to deeply mine and analyze power grid data, to provide more accurate and comprehensive information support for setting calculation; strengthen the coordination and information sharing between protection devices to form a more powerful protection network; and meanwhile, increase the research and development of new protection principles and equipment to meet the future needs of power grid development.

In short, the research and application of the key technology of relay protection setting calculation of ultra high voltage grid is a process of continuous development and improvement. Only by continuous innovation and progress can we ensure the safe and stable operation of the power grid and meet the needs of social and economic development.

REFERENCES

[1] Hu Yue, Liu Siyuan, Yang Shunfu, et al. Based on the analysis of dangerous points in the main transformer protection and transformation project [C] // Jilin Electrical Engineering Society. Jilin Provincial Electrical Engineering Society2024The winning proceedings of the annual academic conference. State Grid Yanbian Power Supply Company; 2024:5. DOI: 10.26914/c.cnkihy.2024.033664.

[2] Wang Feipeng, Yang Hao. Visual analysis of relay protection faults in the new generation of smart substation [J]. Science, Technology and Innovation,2024, (21):103-105. DOI:10.15913/j.cnki.kjycx.2024.21.031.

[3] Zhou Haoran, Liu Chuang. Research on the application and optimization strategy of relay protection technology in smart substation [J]. Light source and lighting, 2024, (10):177-179.

[4] Zhang Guanglong. Optimization application of Sequential control and error prevention technology in substation operation and maintenance [J]. Industrial innovation research, 2024, (20):124-126.

[5] Zeng Qi. Impact of new energy distributed generation on substation protection and automation [J]. electrical switching,2024,62(05):87-89+94.

[6] Ru Jianhua. Research on fault detection of smart substation relay protection equipment based on improved support vector machine [J]. age of electricity, 2024, (10):76-78.