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A Summary of Relay Protection-based Simulation for Dynamic Performance and Reliability Assessment

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Abstract

As technology advances, electricity has become an essential aspect of both national security and daily life. Ensuring the safety of the power grid is thus of utmost importance. However, in China, research on relay protection models for dynamic simulation of power systems is still in its early stages. Due to this, the control laws of relay protection elements have not been well understood, leading to inadequate handling of system failures. To ensure the safe operation of power systems, it is crucial to first strengthen the grid structure of the power system. This can be achieved through the improvement of elasticity coefficient, reasonable distribution of reserve capacity, and the reinforcement of the adjustment ability of the tie line between major power grids. Additionally, improving the stable reserve of the power grid is essential. To improve the authenticity and reliability of dynamic simulation, it is necessary to establish a set of relay protection models that are consistent with actual relay protection. By doing so, the stability problem in the power system can be accurately analyzed, leading to improved reliability. In this study, a relay protection model was established that reduces the complexity of modeling and can accurately reflect the dynamic characteristics of the power system following interference. This model is significant to the analysis and research of power systems, as it can enhance the understanding of control laws for relay protection elements, leading to improved management of system failures and better overall reliability.

Keywords: Relay Protection, Reliability, Dynamic Performance

1. Introduction

Relay protection systems are critical components of power systems, providing protection against power system failures and ensuring the reliability of electricity supply. The dynamic performance and reliability of these systems can be evaluated through simulation [1]. The simulation of relay protection systems is a complex process that involves modeling various components and accounting for their interactions. Additionally, virtual relays are used to accurately model the logical judgments made during the protection process. While these simulations can provide valuable insight into the performance of relay protection systems, there is a need for a comprehensive summary of the available simulation methods to ensure their accuracy and reliability [2].

One key challenge in the simulation of relay protection systems is the need to model multiple components with different hierarchical levels. Each component has a well-established protection principle and operates quickly, ensuring that the system is reliable [3]. However, simplifying these components during the simulation process can be difficult, and it is important to ensure that their interactions are accurately modeled. To address this challenge, a

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hierarchical approach to modeling the components can be used, with each component modeled separately and then integrated into a system-level simulation [4].

Another challenge in the simulation of relay protection systems is the need to account for the unique features of different power system structures and operational practices. Each power system has a different grid structure and operating practices, which can affect the behavior of the relay protection system. To ensure the accuracy of the simulation, it is important to accurately model these factors and account for their impact on the performance of the relay protection system [5].

A third challenge in the simulation of relay protection systems is the need to accurately model the logical judgments made during the protection process. While virtual relays can be used to model these judgments, it is important to ensure that they are accurately represented in the simulation [6]. This requires a clear understanding of the protection principles of each component and their interactions during the protection process.

Despite these challenges, the simulation of relay protection systems is a critical tool for assessing the dynamic performance and reliability of power systems. It can help to identify potential issues and inform the design of more robust protection systems. However, there is a need for a comprehensive summary of the available simulation methods and best practices to ensure that these simulations are accurate and reliable [6]. This summary can guide the development of new simulation methods and help to ensure the continued reliability of power systems.

In a relay protection system, there are multiple relay protection devices arranged in a clear hierarchy. This makes it easier to model each component than the relay protection system as a whole. The protection principle of each relay protection component is well-established, and the time it takes to take protection measures is very short, which leads to high reliability [7]. When implementing a relay dynamic simulation, it is appropriately simplified to ensure accuracy while avoiding complexity. For example, the main protection can be simulated by the circuit breaker according to the set time, ensuring the accuracy of the simulation.

However, in actual situations, the power grid structure of the system can vary, and operational habits can differ. To provide a more accurate description of the protection system, each process can be better described by logical judgment. Each logical judgment process can be regarded as a relay, although these relays are not real and are called virtual relays. Using virtual relays can help better simulate the protection system and provide a more accurate description of the relay protection system's behavior [8].

The current relay is a simple relay that can realize the protection of the current. Its working principle is straightforward - if the input current is greater than the action current, the current relay will automatically close the contact. Once its contact is closed, it will only reopen when the current decreases and becomes less than the return current. The reference source of the current relay is either the action or return current. The working principle of other relays is the same as the current relay. On the other hand, virtual relays function in the same way as conventional relays, with contacts divided into two types - open and closed. When the input is greater than the reference source, the contact is closed, and when the input is less than the reference source, the contact is disconnected.

In summary, the reliability and dynamic performance simulation based on relay protection requires proper simplification to avoid complexity while ensuring accuracy. By using virtual relays and logical judgment, a more accurate representation of the relay protection system can be achieved. Additionally, the use of current and other types of relays can protect against current-related issues and provide a reliable protection system.

2. Literature Review

Misoperation and abnormal operation of the power grid are inevitable. The key is that the power grid will not cause large area power outages and huge economic losses in the event of any accident, which requires strengthening the ability of the power grid itself to resist accidents:

2.1. Improved treatment of relay protection staff

The field of power system protection is vital to ensure the safe and reliable operation of electrical networks. Relay protection staff plays a critical role in the operation and maintenance of power system protection. Their expertise and experience in relay protection are essential for identifying and resolving faults in the system [4,9]. However, the increased complexity of modern power systems has put a significant strain on relay protection staff, leading to an increased risk of human error and system failures. Therefore, it is essential to provide improved treatment to relay protection staff to ensure their efficiency and effectiveness in the field.

One aspect of improved treatment for relay protection staff is providing adequate training and resources. The increased complexity of modern power systems demands that relay protection staff continuously upgrade their knowledge and skills to keep up with the latest developments in the field [10]. Training programs that offer comprehensive knowledge on relay protection principles, techniques, and new technologies should be provided to the staff. Additionally, the staff should be given access to modern tools and resources that can aid them in their work. Such resources include sophisticated software tools for analyzing and diagnosing system faults.

Another aspect of improved treatment for relay protection staff is providing a conducive work environment. Working in the field of power system protection can be stressful and demanding, and it is essential to provide a supportive and motivating work environment. This includes ensuring that the staff has access to adequate rest and leisure facilities, as well as offering appropriate compensation and benefits packages. It is also crucial to provide a work culture that promotes teamwork, communication, and a positive attitude towards problem-solving [11].

The provision of modern and up-to-date equipment and tools is also crucial to improve the treatment of relay protection staff. Inadequate or outdated equipment can lead to inefficiencies and errors in the operation of the protection system [12]. The use of modern equipment and tools, such as digital relays and advanced protective devices, can help to enhance the performance of relay protection staff and reduce the risk of system failures.

Effective communication and collaboration between relay protection staff and other power system professionals are also essential for improved treatment. Relay protection staff must work closely with other professionals in the power system, such as system operators and engineers, to ensure the safe and reliable operation of the network. Effective communication and collaboration help to facilitate the identification and resolution of system faults and failures, reducing the risk of prolonged outages and costly repairs [13].

The field of power system protection relies heavily on the expertise and skills of relay protection staff. Therefore, it is essential to provide improved treatment to these professionals to ensure their efficiency and effectiveness in the field. Adequate training and resources, a supportive work environment, modern equipment and tools, and effective communication and collaboration are crucial aspects of improved treatment for relay protection staff [14]. By implementing these measures, power system operators can ensure the safe and reliable operation of their networks, reducing the risk of system failures and improving customer satisfaction.

2.2. Reasonably determine the elastic coefficient of electric power development

Electric power development is crucial for economic growth and social welfare. However, it is essential to determine the optimal elastic coefficient of electric power development to ensure sustainable development. The elastic coefficient is defined as the change in power demand in response to a change in price [15]. It is a vital factor in the development of the electric power industry because it helps to determine the market demand for electricity and the corresponding investment in generation and transmission facilities.

The elastic coefficient of electric power development is influenced by various factors, including economic growth, energy prices, environmental regulations, and technological advancements. These factors can lead to changes in the demand for electricity, making it crucial to understand their effects on the elasticity of demand. Additionally, the

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elasticity of demand can vary by region and sector, making it important to tailor policies and investment strategies to specific circumstances [16].

To determine the optimal elastic coefficient of electric power development, various methods can be used. These include statistical analysis of historical data, econometric models, and simulations. These methods help to understand the relationship between price and demand and provide insights into how changes in external factors can affect the elasticity of demand [17]. Additionally, the use of these methods helps to identify trends and patterns in electricity consumption and market behavior, which can inform investment decisions.

It is also essential to consider the potential impact of policy measures on the elasticity of electric power demand. Policies that promote energy efficiency, renewable energy, and carbon pricing can influence the elasticity of demand and affect the optimal level of investment in generation and transmission facilities. Therefore, policymakers must carefully assess the impact of policy measures on the elasticity of demand and take them into account when determining the optimal elastic coefficient of electric power development.

Determining the optimal elastic coefficient of electric power development is critical for ensuring sustainable development in the electric power industry. Understanding the factors that influence the elasticity of demand, using appropriate analytical methods, and considering the impact of policy measures can help to identify the optimal level of investment in generation and transmission facilities. This approach will enable the industry to meet the growing demand for electricity while also promoting economic growth, social welfare, and environmental sustainability.

2.3. Setting of relevant indicators

Indicators are used to measure and evaluate the performance, progress, and effectiveness of various systems, processes, and strategies. The setting of relevant indicators is an essential component of performance management, monitoring, and evaluation. It involves selecting and defining the criteria and measures that will be used to assess the performance and impact of a system, process, or strategy [13,18]. The indicators should be relevant, reliable, valid, and feasible to collect and analyze.

The process of setting relevant indicators typically involves a combination of qualitative and quantitative methods. The relevant stakeholders are usually involved in identifying and selecting the indicators. These stakeholders can include policymakers, program managers, technical experts, and beneficiaries [19]. The indicators are selected based on the objectives and goals of the system, process, or strategy being evaluated. They should be able to provide meaningful information on the progress and impact of the system, process, or strategy.

The selection and setting of relevant indicators should be guided by certain principles. The indicators should be aligned with the overall goals and objectives of the system, process, or strategy. They should be specific, measurable, achievable, relevant, and time-bound. The indicators should also be reliable and valid, meaning that they should be accurate and reflect what they are intended to measure. Additionally, the indicators should be responsive to change and adaptable to different contexts.

The setting of relevant indicators is crucial for effective performance management, monitoring, and evaluation. It allows stakeholders to track progress, identify areas for improvement, and make informed decisions. The indicators can also be used to compare performance across different systems, processes, or strategies, and to benchmark against industry standards or best practices. However, it is important to recognize that the selection and setting of indicators is not a one-time event but rather an ongoing process that requires regular review and refinement.

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system, process, or strategy. The indicators should be relevant, reliable, valid, and feasible to collect and analyze. The process of setting relevant indicators should be guided by certain principles, and it requires the involvement of relevant stakeholders. Regular review and refinement of the indicators are necessary to ensure their ongoing relevance and effectiveness.

2.4. Strengthening the backbone grid

Strengthening the backbone grid refers to the process of improving and enhancing the reliability, stability, and efficiency of the transmission system. The backbone grid is the primary power transmission network that connects power generation facilities to distribution centers, and it is critical for the smooth operation of the power system. The backbone grid is subject to various factors such as natural disasters, cyber-attacks, and equipment failures that can result in widespread power outages. Therefore, it is essential to strengthen the backbone grid to ensure uninterrupted power supply [20].

One of the key strategies for strengthening the backbone grid is to upgrade and modernize the existing transmission infrastructure. This involves replacing outdated equipment with modern, more efficient equipment that can better withstand extreme weather conditions, reduce transmission losses, and improve overall system performance. Upgrading the transmission system also involves increasing its capacity, which can be achieved by constructing new transmission lines, installing advanced technologies like Flexible AC Transmission Systems (FACTS), and using innovative solutions like High Voltage Direct Current (HVDC) transmission [21].

Another approach to strengthening the backbone grid is to improve the monitoring and control of the transmission system. This involves deploying advanced monitoring technologies, such as synchrophasors and phasor measurement units (PMUs), to provide real-time information about the status of the system. By improving situational awareness, grid operators can identify potential problems and take corrective actions to prevent power outages. Additionally, control systems can be enhanced to enable automatic load shedding and restoration in case of emergencies.

Moreover, integrating renewable energy sources into the grid is another way to strengthen the backbone grid. Renewable energy sources such as wind and solar are often located far from population centers, making it necessary to expand the transmission infrastructure. Integrating renewable energy sources into the grid can help reduce the reliance on fossil fuels and increase energy security. However, integrating intermittent renewable sources into the grid also poses challenges, such as variability and unpredictability. Therefore, proper planning and grid integration strategies are required to ensure a reliable and stable power supply.

Finally, strengthening the backbone grid also requires collaboration between various stakeholders, including utilities, regulators, policymakers, and consumers. This includes developing and implementing policies and regulations that incentivize investment in grid modernization and encouraging consumers to adopt energy-efficient practices. Additionally, stakeholders need to work together to develop contingency plans for emergencies and improve communication to ensure a coordinated response in case of disruptions to the power system.

Strengthening the backbone grid is critical to ensuring a reliable, stable, and efficient power supply. Upgrading the transmission infrastructure, improving monitoring and control, integrating renewable energy sources, and fostering collaboration between stakeholders are key strategies for achieving this goal. By taking these steps, we can create a more resilient power system that can withstand various challenges and provide uninterrupted power supply to consumers.

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Table 1. Strengthening related operation of power grid to withstand accidents

Strengthening related operation of power grid to withstand accidents	Improved treatment of relay protection staff
	Reasonably determine the elastic coefficient of electric power development
	Setting of relevant indicators
	Strengthening the backbone grid

2.5. The basic operation of system relay protection

Relay protection is a crucial component of power systems and is designed to detect and isolate faults in the system to prevent further damage. The basic operation of relay protection involves detecting changes in the electrical characteristics of the power system and activating a protective response to prevent damage to equipment or harm to personnel. In essence, relay protection systems monitor the state of power systems and respond to changes in a matter of milliseconds. Relay protection systems consist of relays, which are electrical devices that detect changes in the electrical characteristics of a power system. A relay can be described as an electrically controlled switch that is designed to activate when certain conditions are met. Relays are typically installed at strategic points in the power system, such as substations, where they can detect changes in current, voltage, and frequency.

The basic operation of a relay involves two states: normal and fault. In the normal state, the relay is not activated and the power system is functioning as intended. However, in the event of a fault, such as a short circuit or an overload, the relay is activated and triggers a protective response. This response may involve opening a circuit breaker to isolate the fault or initiating a shutdown of the power system. Relay protection systems operate on the principle of selective coordination, which ensures that only the affected part of the power system is shut down in the event of a fault. This is achieved by dividing the power system into zones and ensuring that the relays in each zone are set to activate at different levels of fault current. This ensures that the relay closest to the fault will activate first, isolating the fault and preventing further damage.

Relay protection is a critical component of power systems and plays a crucial role in ensuring the safe and reliable operation of these systems. The basic operation of relay protection involves the detection of changes in the electrical characteristics of the power system and the activation of a protective response to prevent damage to equipment or harm to personnel. Selective coordination is key to the effective operation of relay protection systems, and this is achieved by dividing the power system into zones and ensuring that relays in each zone are set to activate at different levels of fault current.

2.6. Innovation in digital technology

Digital technology is rapidly changing the world we live in, and innovation in this area is crucial for driving progress and growth. Digital technology refers to the use of computers, software, and other digital tools to process, store, and share information. Innovation in digital technology has led to numerous advances in fields such as healthcare, education, finance, and entertainment. In recent years, the rise of mobile devices, cloud computing, and the Internet of Things (IoT) has further accelerated the pace of innovation in this field.

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One key aspect of innovation in digital technology is the development of new software applications and platforms. Companies and entrepreneurs are constantly pushing the boundaries of what is possible in terms of software design, creating new tools and applications that allow individuals and organizations to accomplish tasks more efficiently and effectively. For example, the rise of cloud-based software platforms has made it possible for businesses to easily manage their operations from anywhere in the world, while social media and messaging apps have revolutionized communication and networking.

Another important area of innovation in digital technology is hardware design. As computing power continues to increase and devices become smaller and more powerful, hardware designers are constantly exploring new ways to improve the performance and functionality of digital devices. From smartphones and laptops to wearables and smart home devices, there is a vast array of innovative hardware products that are changing the way we interact with technology.

Innovation in digital technology also has significant implications for society as a whole. For example, the rise of automation and artificial intelligence (AI) is leading to significant changes in the job market, as machines take over many routine tasks and humans focus on higher-level thinking and problem-solving. At the same time, digital technology is also making it possible to improve access to education, healthcare, and other essential services, particularly in developing countries where traditional infrastructure may be lacking.

Overall, innovation in digital technology is a key driver of progress and growth in the modern world. As technology continues to evolve and new applications and platforms emerge, it is likely that we will continue to see major shifts in the way we live and work, as well as new opportunities for entrepreneurship and innovation.

Figure 1. Digital relay protection device

3. Methodology

There are several methods available for calculating the reliability index of the relay protection system, and these methods can be broadly classified into two categories: analytical and simulation-based methods. Analytical methods involve the use of mathematical models and formulas to calculate the reliability index, while simulation-based methods use computer simulations to assess the reliability of the system.

One of the commonly used analytical methods for calculating the reliability index of the relay protection system is the Markov model. This method involves modeling the state transitions of the system as a Markov chain and using the steady-state probabilities of the chain to calculate the reliability index. The Markov model has been widely used in power system analysis and is suitable for systems with a large number of states and complex configurations.

Another analytical method that has been used for calculating the reliability index of the relay protection system is the Monte Carlo method. This method involves generating random samples of the system parameters and using these samples to simulate the behavior of the system under various operating conditions. The reliability index is then calculated based on the simulation results.

Simulation-based methods for calculating the reliability index of the relay protection system include the use of various software tools such as ETAP, PSCAD, and DIgSILENT. These tools provide a comprehensive platform for simulating the behavior of the power system and assessing the reliability of the relay protection system. These tools have advanced features such as fault analysis, protection coordination, and dynamic simulation, which enable accurate and reliable assessment of the reliability index.

The calculation of the reliability index of the relay protection system is a critical task in power system analysis and planning. Various analytical and simulation-based methods are available for calculating the reliability index, and each method has its advantages and limitations. The selection of the appropriate method depends on the system configuration, operating conditions, and the required level of accuracy. The accurate assessment of the reliability index can provide valuable insights into the performance of the relay protection system and help in the design of more reliable and robust systems.

For a continuous production of machinery and equipment, set Q as the production capacity per unit time of the equipment, Q_n for the production capacity of the equipment within the time t, then

$$Q_n = Q_t \tag{1}$$

The failure rate of the equipment can be expressed as economic loss

$$\Delta Q = Q \sum_{i=1} \Delta t_i \tag{2}$$

The relay protection device is an essential component of the power system that is continuously operational. It can be analyzed using a specific method, but its uniqueness lies in its production capacity, which is directly proportional to the economic loss avoided by its reliable action to eliminate a fault. Consequently, only when a fault occurs, does the relay protection device produce results and create economic benefits. On the other hand, incorrect relay protection may cause economic losses equivalent to the shutdown of machinery and equipment. Thus, the failure rate of relay protection is the ratio of the economic loss of power systems and users caused by incorrect actions to the economic loss avoided by each correct action, denoted as FR. Therefore, the reliability index of relay protection, R, is defined as (1-Fp) x 100, where Fp is the probability of failure. It is a ratio of the economic benefit created by the relay protection device when it performs correctly to the absolute reliability of its work. This index can be useful for the relay protection workers to analyze the severity of the consequences caused by each protective device's incorrect action and pay particular attention to devices that may lead to significant economic losses. Thus, this index can directly reflect the safety and economy of power system operation.

The calculation of the reliability index of relay protection is critical in determining the effectiveness of the protection system. The range of power outages and direct and indirect economic losses caused by each relay protection device's incorrect operation can be estimated, making it possible to calculate the reliability index accurately. This index can be useful in identifying the protective devices that may cause significant economic losses and devising strategies to mitigate their effects. Moreover, the index can also be helpful in analyzing the effectiveness of the protection system and improving it where necessary.

The reliability index calculation of relay protection can be beneficial in ensuring the safe and economical operation of the power system. The index can be used to determine the effectiveness of the protection system and the overall performance of the relay protection device. Moreover, the index can be useful in assessing the reliability of each protective device, identifying those that are prone to incorrect actions, and devising strategies to improve their reliability. With this index, relay protection workers can pay particular attention to the protection devices that are likely to cause significant economic losses and take measures to mitigate the impact.

In conclusion, the calculation of the reliability index of relay protection is crucial in ensuring the safety and economic efficiency of the power system. The index provides a useful tool for analyzing the effectiveness of the protection system and improving it where necessary. The range of power outages and economic losses caused by incorrect operation of each protective device can be estimated, making it possible to calculate the reliability index accurately. With this index, relay protection workers can identify the protective devices that may cause significant economic losses and devise strategies to mitigate their effects, improving the safety and efficiency of the power system.

4. Result and Discussion

For example, the system voltage U variable is established by creating the new variable and setting the variable type. The detailed variables of the system are shown in Table 2.

Table 2. Variable address allocation table

Number	Variable name	Explanatory note	Type
1	IL1	Current lamp	Memory discrete
2	IL2	Current lamp	Memory discrete
3	IL3	Current lamp	Memory discrete
4	VL1	Voltage lamp	Memory discrete
5	VL2	Voltage lamp	Memory discrete

In the startup interface system login management, this is the initial window after the system runs, mainly including the management of system permissions. The management of system user group is realized by user configuration, including: permission level, user group, system password and so on. In the startup interface, the system login and close the system by calling the system function, and judging the system permission implementation script as follows:

Log0ff()；LogOn()；if($ Access Authority <=200) else{ShowPicture；ClosePicture;}

The running interface for relay protection device testing comprises several components, including the system simulation script, data display, data input, button script, indicator lamp, and calculating scripts. The calculation script is added using the calculation button and operates through page properties. While relay protection devices undergo theoretical analysis, simulation research, and laboratory performance tests, it is challenging to simulate real electromagnetic processes when they fail at high voltage and current. To ensure the protection device functions reliably under any fault condition, repeated testing is necessary using a large number of on-site fault recording data under various faults. However, this testing is costly and cannot be performed during the research and development stage. Therefore, there is a need to develop relay protection dynamic performance simulation software for repeated

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testing with various fault recording data in the field. Various relay protection device dynamic performance simulation software has emerged in the market, but there is a need to establish a standard, open, and universal simulation software system as a test means for protection development and identification. The system should have a large number of standard component libraries for drawing relay protection logic block diagrams, and the component library and its interface should be open and transparent. This will enable protection manufacturers to test their own protection devices with the system in advance without revealing their technical secrets. The protection test software can also be used as a development tool for protection manufacturers as the software developer can generate the required code by connecting each component and even download it directly to the protection. Tianjin University and the Relay Protection Office of Huazhong Electric Power Group Company have developed the dynamic performance simulation software of the relay protection device. The software has compiled all kinds of protection elements and various logic elements, enabling the user to draw the protection logic block diagram and set the value of each element in the block diagram. The field recording data of the Comtrade format is inputted for simulation testing, and the element's action is displayed in the diagram with a red label. The software enables the user to see the internal action process and logical coordination relationship in the fault transient process, facilitating the identification of incorrect action links and causes and conducting accident analysis. Compared to the previous simulation system, the open relay protection device dynamic performance simulation system has more flexibility and openness as it can simulate several commonly used protection principles and action characteristics and any custom protection principles and action characteristics.

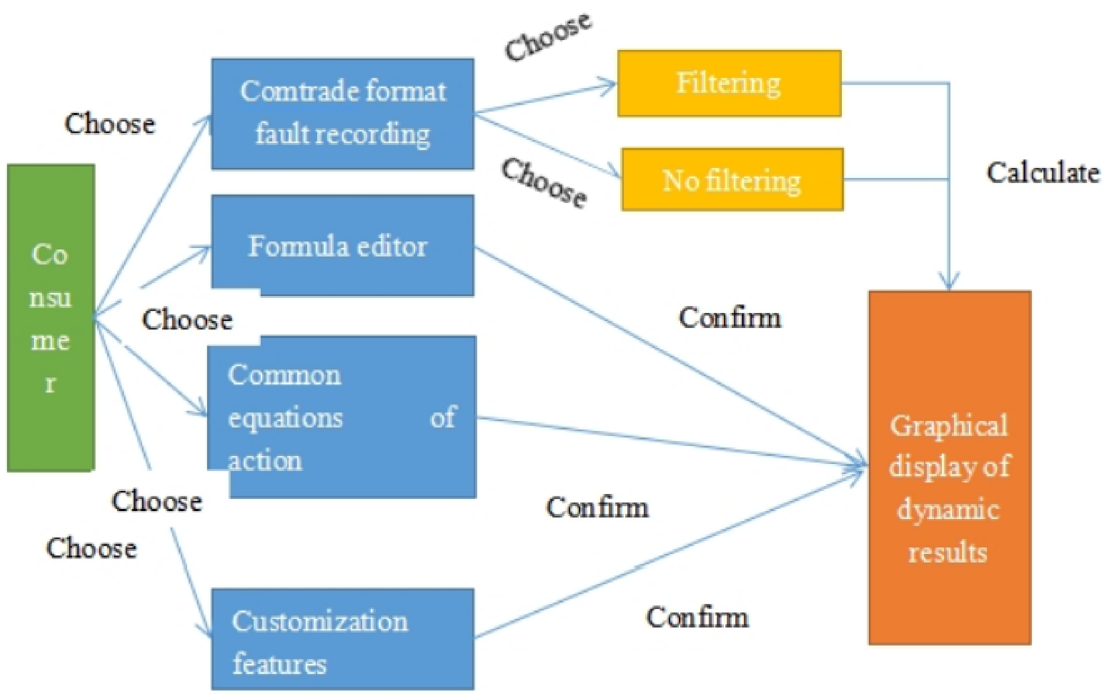

Figure 2. Block diagram of dynamic performance simulation system for open relay protection device

To use the system, fault data in Comtrade format from the field admission should be chosen, and then the data format is converted to any filtering algorithm. The filtered data is then sent to the action equation module, where the algorithm can solve the differential equation or sampling value directly. A commonly used protected action equation can be chosen by the user, which is then sent to the action equation module for verification with field recording data. Alternatively, the user can edit a customized action equation using the "formula editor" and verify it with field recording data. The selected action characteristics of the protection, such as circle characteristics or quadrilateral characteristics, are sent to the action characteristic module. The action equation module and action characteristic

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module are calculated and then sent to the graphics display module. The protection measurement value is compared with the action characteristic in the graphic display module. This process helps to observe the change process of measuring impedance in system oscillation, from load state to fault removal to overlap permanent fault to secondary resection. This simulation analysis can carry out a large number of repeated tests to the protective device easily and effectively.

In the past, the test center of the power department could only give two conclusions: correct action or wrong action through dynamic mode test or protection tester to test the hardware and software of the relay protection device. For false action, neither the tester nor the developer could clearly identify which module or logic in the device, hardware, and software led to the wrong action of protection. It was not possible to test the device with a large amount of field recording data. Hence, it is suggested that the test center of the power sector establish a standard, open and universal simulation software system as a test means for protection development and identification. This system should have a large number of standard component library for drawing relay protection logic block diagram, and the component library and its interface should be open, open, and transparent. The protection manufacturer can test his own protection device with this system in advance without revealing its technical secrets.

The simulation software system is advantageous in that it can verify the protection device with field recording data, and it can easily identify the faulty modules and logic in the device, hardware, and software. This system has an open and transparent interface, allowing protection manufacturers to test their protection devices without revealing technical secrets. It is cost-effective as it carries out a large number of repeated tests to the protective device, which would have been difficult to do with hardware and software testing. The graphic display module is advantageous in that it provides a clear and intuitive view of the process of measuring impedance from load impedance to action area, and the change process of measuring impedance in system oscillation.

However, there may be some challenges in establishing this simulation software system, such as the need for highly skilled personnel to manage the system and analyze the test results. The establishment of the standard component library may require a lot of time and resources, and there may be a need to continually update the system to keep up with the changing technology. Additionally, the simulation software system may not be able to simulate all scenarios accurately, and there may be a need to conduct some field testing to validate the simulation results.

In conclusion, the calculation method of the reliability index of relay protection involves choosing fault data, selecting a filtering algorithm, sending the filtered data to the action equation module, choosing action characteristics of protection, and sending the results to the graphics display module. The establishment of a standard, open, and universal simulation software system for protection development and identification can be a cost-effective way of testing protection devices. This simulation software system can easily identify the faulty modules and logic in the device, hardware, and software, and can verify the protection device with field recording data. However, there may be some challenges in establishing this system, such as the need for highly skilled personnel, time and resource requirements,

5. Conclusion

In this article, the focus is on the relay protection model in dynamic simulation of power systems. The author briefly describes the ideas and methods of modeling, and emphasizes the importance of a dynamic performance simulation system for relay protection. The author proposes the development of a standard "relay protection dynamic performance simulation system" by the protection test center of power department. This simulation system should be open and transparent to manufacturers in terms of its modules and interfaces. This would allow each manufacturer to test the standard simulation system in advance or use it as a research and development tool. Such a system would be able to truly reflect the actual situation of the power system, and provide effective protection against sudden accidents. Additionally, the causes of such accidents can be reasonably analyzed, and corresponding measures can be taken to prevent them from occurring again, thus having practical significance.

In particular, the simulation calculation of relay protection is discussed, which provides a useful reference for expanding and supplementing the existing models. The proposed simulation system will be able to effectively protect the power system, and provide valuable insights for future research and development in the field of power systems.

Overall, the article highlights the need for a reliable and efficient dynamic performance simulation system for relay protection in power systems. The development of such a system can help prevent sudden accidents, and ensure the continued safe operation of the power system. The proposed standard simulation system will provide manufacturers with a valuable tool for testing and development, and will also serve as a useful reference for expanding and supplementing existing models. By taking into account the actual situation of the power system, the proposed simulation system will provide a more accurate and effective means of protection against sudden accidents.

The article concludes by emphasizing the practical significance of the proposed simulation system, which will be able to help protect the power system and prevent sudden accidents. The proposed standard simulation system will provide valuable insights for manufacturers, and will also serve as a useful reference for further research and development in the field of power systems. In this way, the reliability and safety of power systems can be ensured, and the smooth and stable operation of the power grid can be guaranteed.

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