

Research on the Development Trend of Intelligent Circuit Breaker in Building Installation

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Abstract: With the continuous progress of science and technology, intelligent circuit breakers are more and more widely used in building installation. Today, the construction industry on the safety, stability and intelligence of the electrical system requirements continue to improve, intelligent circuit breakers with its advanced technology and superior performance, has become a key equipment in the field of building installation. This paper discusses the development trend of intelligent circuit breaker in building installation. The continuous improvement of the level of intelligence means that it will have more powerful data analysis and autonomous decision-making capabilities, and can monitor the operating status of the building electrical system in real time and predict potential failures in advance. The diversified expansion of functions makes it not only realize the traditional circuit breaker protection, but also integrate power quality monitoring, equipment condition monitoring and other functions. The deep integration with the Internet of Things technology will build an intelligent building energy management system to achieve interconnection and collaborative control between devices. At the same time, the outstanding contribution of intelligent circuit breakers to energy conservation and environmental protection can not be ignored, and reduce energy consumption by optimizing control strategies to help the green development of buildings. The continuous strengthening of safety performance provides a solid guarantee for building electrical safety. Through the analysis of these trends, it points out the direction of the future development of intelligent circuit breakers in the field of building installation, and provides useful reference and guidance.

Keywords: Building Installation; Intelligent Circuit Breaker; Development Trend.

1. Introduction

In modern building installations, the safety and stability of electrical systems are of Paramount importance. Nowadays, the demand for electric energy in all fields of people's life and production is growing day by day, and the demand for power quality is also increasing. In this context, the construction of smart grid has become the mainstream trend of current power grid development. [1] Smart grid has the characteristics of high efficiency, reliability and intelligence, which can better meet the demand for electricity in modern society.

As the key equipment of smart grid, intelligent circuit breaker plays an important role. Its performance and function directly affect the safety of electricity consumption and energy management efficiency of buildings. On the one hand, it can quickly cut off the power supply when the circuit fails to protect the safety of electrical equipment and personnel; On the other hand, through intelligent control and monitoring, efficient management of energy can be achieved and energy consumption can be reduced.

With the rapid development of intelligent technology, the application of intelligent circuit breakers in building installation continues to expand and deepen. It not only plays a role in traditional power distribution and protection, but also shows a series of new development trends, such as a higher level of intelligence, deep integration with the Internet of Things, and diversified expansion of functions. These trends will further enhance the performance and value of intelligent circuit breakers, providing a strong guarantee for the safe and stable operation of building electrical systems and the efficient management of energy.

2. The Characteristics and Advantages of Intelligent Circuit Breakers

(1) Intelligent control

Automatic monitoring and diagnosis: It can monitor the current, voltage, power and other parameters in the circuit in real time, and fully control the operating status of the electrical system. Through the analysis of these parameters, we can find the potential trouble, such as overload, short circuit, leakage and so on. With the self-diagnosis function, when the hardware or software problems are detected, the alarm can be issued in time to remind the maintenance personnel to overhaul, improving the reliability and stability of the system. In the intelligent circuit breaker, the remote control technology allows users or managers to remotely monitor, configure and control the circuit breaker through the Internet, mobile network or other communication methods, and comprehensively improve the management efficiency and response speed of the power system.[2]

Intelligent control and regulation: According to the preset logic and algorithm, the automatic adjustment of the circuit breaker opening and closing state, to achieve intelligent control of the circuit. For example, when the load changes, the protection parameters can be automatically adjusted to ensure the safe operation of the circuit. Support remote control, through the network connection can realize the remote operation of the circuit breaker, convenient management and maintenance of users. At the same time, it can also be linked with other intelligent devices to achieve more intelligent electrical system control. In order to realize the remote control function, the intelligent circuit breaker needs to follow a certain remote control protocol, which specifies the communication format, instruction set and

response mode between the host computer and the circuit breaker, so as to ensure that the two sides can accurately carry out data interaction and operation control. [3]

(2) Precise protection

Rapid response to failures: Advanced sensors and detection technology can detect failures within milliseconds and react quickly to cut off faulty circuits and protect electrical equipment and personnel. Compared with traditional circuit breakers, intelligent circuit breakers have a faster response speed and can effectively reduce the impact of faults on the system. For different types of faults, such as short circuit, overload, leakage, etc., it can accurately identify and take corresponding protective measures to improve the pertinacity and effectiveness of protection.

Multiple protection functions: In addition to the basic short circuit protection and overload protection, intelligent circuit breakers also have a variety of protection functions such as leakage protection, overvoltage protection, undervoltage protection, etc., to provide a full range of protection for the electrical system. These protection functions can be flexibly configured based on actual requirements to meet the requirements of different application scenarios.

(3) High efficiency and energy saving

Optimize energy management: real-time monitoring and analysis of energy consumption in the circuit can help users understand the use of energy, find energy waste links, so as to take corresponding energy-saving measures. For example, the power supply mode is automatically adjusted according to the load situation to achieve reasonable distribution and utilization of energy. Support intelligent energy scheduling, and cooperate with other intelligent devices to achieve optimal energy management, improve energy efficiency, and reduce energy costs.

Reduce loss: The use of advanced electronic technology and materials to reduce their own power consumption and energy loss. Compared with traditional circuit breakers, smart circuit breakers generate less heat during operation, reducing the impact on the environment, while also extending the service life of the equipment.

(4) Safe and reliable

Strengthen safety protection: with strict safety certification and protective measures, such as fire, explosion-proof, waterproof, etc., can operate safely in a variety of harsh environments. At the same time, encrypted communication technology is also used to ensure the safety and reliability of data transmission, prevent illegal intrusion and control. For possible misoperation, such as misclosing, misopening, etc., there is an effective prevention mechanism to avoid safety accidents caused by human operation errors.

Improve system stability: Through intelligent control and accurate protection, the probability of failure of the electrical system can be effectively reduced, and the stability and reliability of the system can be improved. After the fault occurs, the power supply can be quickly restored, the power failure time is reduced, and the normal production and life are guaranteed.

(5) Convenient and easy to use

Friendly man-machine interface: equipped with intuitive display and operation interface, users can easily view the circuit breaker status information, parameter Settings, etc. The operation is easy to understand and requires no professional knowledge to operate and maintain. Supports a variety of communication modes, such as Bluetooth, Wi-Fi, RS485, etc., users can remotely monitor and operate through

mobile devices such as mobile phones and tablets, improving the convenience of use.

Easy to install and maintain: standardized design and interface, easy to install, no complex wiring and debugging. At the same time, the maintenance of the intelligent circuit breaker is also relatively simple, through remote diagnosis and online upgrade and other functions, you can solve the problem of the equipment in time, reducing the maintenance cost.

3. The Development Trend of Intelligent Circuit Breakers

(1) a higher level of intelligence

The intelligent circuit breaker of the future will show remarkable intelligent control functions. It can achieve self-learning, like a wise brain, accumulating experience in the process of continuous operation. At the same time, with adaptive control ability, through the in-depth analysis of the operation mode of the electrical equipment, the intelligent circuit breaker can automatically adjust the protection parameters according to the actual situation, thus greatly improving the accuracy and reliability of the protection, and providing a solid guarantee for the safety of electricity.

(2) Diversification of functions

The development prospect of intelligent circuit breaker is very broad. In addition to the traditional short-circuit, overload and leakage protection functions, it will continue to expand new functional areas. For example, the integrated power quality monitoring function can know the stability of the power supply in real time; With electrical fire warning function, can detect fire hazards in advance; Coupled with equipment condition monitoring, keep abreast of the operation of electrical equipment. The integration of these functions will make the intelligent circuit breaker become a comprehensive management platform for the building electrical system, providing a strong guarantee for the safe and stable operation of the building

(3) Deep integration with Internet of Things technology

With the continuous progress of Internet of Things technology, the integration of intelligent circuit breakers and the Internet of Things will become increasingly close. This deep integration enables devices to interconnect with each other. With the Internet of Things platform, users can efficiently and centrally manage and control all intelligent circuit breakers in the building. Not only that, but also remote diagnosis can be realized to find potential problems in time; Fault warning to ensure the safety of electricity use; And carry out energy optimization management, improve energy utilization efficiency, and provide strong support for the intelligent development of buildings.

(4) Energy conservation and environmental protection

Intelligent circuit breakers will pay more attention to energy conservation and environmental protection, and reduce energy consumption by optimizing control strategies and adopting energy-saving technologies. For example, automatic adjustment of operating modes under low load conditions to reduce unnecessary energy consumption; At the same time, intelligent circuit breakers can also be coordinated with renewable energy systems to improve energy efficiency. Power companies can cooperate with manufacturers of smart home appliances and smart home systems to jointly promote energy-saving products, and provide real-time use for users through intelligent circuit breaker remote control technology,

Electrical feedback and energy-saving suggestions to help users make better use of smart devices to achieve energy saving and consumption reduction. [4]

(5) Continuous enhancement of safety performance

Safety is always the core requirement of intelligent circuit breakers. Future intelligent circuit breakers will use more advanced security technologies, such as encrypted communication, identity authentication, etc., to prevent illegal intrusion and operation. At the same time, the intelligent circuit breaker will also strengthen the prevention and control of electrical fires and improve the fire safety level of buildings.

4. The Challenges Facing the Development of Intelligent Circuit Breakers

(1) Technical level

Compatibility problems: Intelligent circuit breakers produced by different manufacturers have differences in communication protocols and interface standards, resulting in poor compatibility between devices. This makes it difficult to realize the interconnection and collaborative work of different brands of devices when building smart grid systems, increasing the difficulty and cost of system integration. The realization of intelligent functions often depends on a specific software platform and hardware architecture, and the products of different manufacturers also have incompatibility in terms of software upgrade and function expansion, which limits the scalability and adaptability of the equipment.

Reliability problems: Intelligent circuit breakers integrate a large number of electronic components and sensors, and their reliability is affected by factors such as the life of electronic components and electromagnetic interference. In a complex electromagnetic environment, electronic components may appear misoperation, failure or even damage, affecting the normal operation of the circuit breaker. The stability of software systems is also a key issue. The realization of intelligent functions needs to rely on complex software algorithms and control systems. Loopholes and errors in software may cause circuit breakers to misoperate or fail to work normally, which brings potential risks to the safe operation of power grids.

Data security and privacy issues: Intelligent circuit breakers can collect and transmit a large number of power grid operation data in real time, which contains sensitive power system information and user electricity information. If the data is not adequately protected during transmission, it may be hacked or stolen, resulting in data leakage and privacy violations. Malicious attackers may destroy the normal operation of the power grid by tampering with the control instructions or data of the circuit breaker, and even cause serious consequences such as a large-scale power outage. Therefore, ensuring data security and privacy is an important challenge for the development of intelligent circuit breakers.

(2) Cost level

High research and development costs: intelligent circuit breaker research and development needs to invest a lot of capital and human resources. The research and development process involves the research and development of advanced sensor technology, communication technology, artificial intelligence algorithms and other fields, which require high research and development costs. In order to ensure the quality and reliability of the product, it is also necessary to carry out

rigorous testing and verification, which also increases the cost of research and development. High research and development costs make the price of intelligent circuit breakers relatively high, limiting its promotion and application in the market.

High production costs: The production process of intelligent circuit breakers is relatively complex, and high-precision production equipment and processes are required. For example, the production of sensors requires high-precision manufacturing techniques and strict quality control, which increases production costs. The realization of intelligent functions requires the integration of a large number of electronic components and software systems, which are also expensive to purchase. In addition, in order to ensure the quality and performance of the product, it is also necessary to conduct strict quality testing and certification, which also increases the production cost.

(3) Market level

Lack of user awareness: Although intelligent circuit breakers have many advantages, the awareness of users on the market is still relatively low. Many users do not know enough about the function and value of intelligent circuit breakers, and there are doubts about their safety and reliability. Some users may think that the price of intelligent circuit breakers is high and are not willing to invest. Therefore, to improve the user's awareness and acceptance of intelligent circuit breakers is the key to promote the application.

Fierce market competition: With the development of intelligent technology, more and more enterprises enter the intelligent circuit breaker market, and the market competition is becoming increasingly fierce. In the fierce market competition, enterprises need to continuously improve the quality and performance of products, reduce costs, in order to improve market competitiveness. Some enterprises may compete for market share by lowering prices, which may lead to a decline in product quality and affect the healthy development of the entire industry.

(4) Standards and norms

Imperfect standards: At present, the relevant standards and specifications of intelligent circuit breakers are not perfect enough. There are differences in the standards of different countries and regions, which brings difficulties to the international trade and cross-regional application of intelligent circuit breakers. The standards and specifications of intelligent functions are also constantly developing and improving, such as data communication protocols, fault diagnosis standards, and so on. The lack of unified standards and norms makes enterprises lack guidance in the product development and production process, which affects the quality and performance of products.

Supervision is difficult: The intelligent function of intelligent circuit breaker makes its supervision relatively difficult. The regulatory authorities need to strictly supervise the safety, reliability and data security of products, but due to the complexity of intelligent technology, the regulatory authorities may lack the corresponding technical means and professional knowledge. With the continuous development and application of intelligent circuit breakers, regulatory authorities need to constantly update regulatory means and methods to meet the development needs of new technologies.

Technical standards are not uniform: at present, the technical standards of intelligent circuit breakers have not been completely unified, and there are differences in communication protocols and interface specifications of different manufacturers' products, which brings difficulties to

system integration and interconnection.

High cost: The research and development and production costs of intelligent circuit breakers are relatively high, which limits their wide application in building installation to a certain extent.

Lack of user awareness: some users do not know enough about the functions and advantages of intelligent circuit breakers, and there are doubts about their investment value, which also affects the marketing of intelligent circuit breakers.

5. The Development of Intelligent Circuit Breaker Core Strategy

(1) Technological innovation

Sensor technology upgrade: In today's power grid system, sensor technology upgrade is imperative. We are committed to developing high-precision, high-reliability current, voltage, temperature and other sensors in order to accurately monitor the operation of the power grid in real time. For example, the active use of new magnetic sensor technology, in-depth research and innovation of its materials and structures, thereby greatly improving the accuracy and stability of current measurement. This will provide a reliable data basis for the precise control of intelligent circuit breakers, ensuring that the power grid can operate safely and stably in a variety of complex environments. At the same time, the development of multi-functional sensor integration module is also a key initiative. Through advanced integration technology, the detection of various parameters is integrated in one module, which not only reduces the volume of the equipment, but also improves the convenience of installation and maintenance, reduces the cost and time consumption, and provides strong support for the intelligent development of the power grid.

Intelligent control algorithm optimization: The optimization of intelligent control algorithm is of great significance in improving the performance of power grid. We deeply study advanced artificial intelligence algorithms, such as deep learning and fuzzy logic, and actively apply them in the field of fault diagnosis and prediction. By deep mining and learning from massive historical data, intelligent circuit breakers can keenly identify potential failure risks in advance. Once the risk is found, corresponding preventive measures can be taken quickly, which greatly improves the reliability of the power grid. At the same time, the control strategy is optimized constantly to realize the precise control of the circuit breaker. According to different power grid operating conditions, the automatic and flexible adjustment of the circuit breaker operating parameters, such as opening and closing speed, time, etc., to ensure that the protection requirements can be accurately met in a variety of complex situations, provide a solid guarantee for the stable operation of the power grid, and promote the development of the power grid to a more intelligent direction.

Communication technology integration: The integration of communication technology plays a key role in the construction of smart grid. The use of high-speed, stable communication technologies, such as 5G and industrial Ethernet, can build a bridge for real-time communication between intelligent circuit breakers and other devices. In this way, the circuit breaker can quickly sense and respond to various changes in the system. When there is an abnormal situation in the power grid, it can work together with other protection equipment in time to jointly ensure the safe and stable operation of the power grid, thus greatly improving the

overall protection performance of the power grid. In addition, the development of a unified communication protocol and interface standards is also crucial. This will promote the interconnection between smart circuit breakers of different manufacturers and other smart devices, and break the barriers between devices. The integrated management of smart grid helps to improve the management efficiency and intelligence level of the power grid, provide users with more reliable and efficient power services, and promote the construction of smart grid to a new height.

In order to achieve the deep integration of smart circuit breakers and smart grids, it is necessary to start from multiple levels. At the hardware level, research and development is more

Intelligent, integrated circuit breaker equipment, so that it can better adapt to the needs of smart grid; At the software level, the API developed to achieve seamless docking and data sharing between smart circuit breakers and smart grids; At the management level, a perfect equipment management system is established to realize remote monitoring, configuration and fault diagnosis of intelligent circuit breakers. [5]

(2) Product design optimization

Modular design: Modular design brings many advantages to intelligent circuit breakers. Adhering to the modular design concept, it is divided into control module, protection module, communication module and other different functional modules. In this way, it can be flexibly combined and configured according to different application requirements, which greatly improves the adaptability and scalability of the product. Excellent performance in maintenance and upgrade, when a module fails, it can be quickly replaced, effectively reducing equipment downtime and reducing the loss caused by failure. Moreover, as technology continues to advance, individual modules can be easily upgraded without the need to replace the entire equipment, thus extending the service life of the product and reducing the cost.

Reliability design: The selection of high-quality materials and components to ensure that the intelligent circuit breaker can operate stably in a variety of harsh environments. For example, the use of high temperature, corrosion resistant materials to make the shell, improve the protection level of the product. Carry out strict reliability testing, including high and low temperature test, vibration test, electromagnetic compatibility test, etc., to ensure that products can operate reliably under various working conditions. At the same time, a perfect quality control system is established to strictly monitor the production process to ensure the consistency of product quality.

3. Industrial coordination and cooperation

Industry-university-research cooperation: Enterprises actively strengthen cooperation with universities and scientific research institutions, and jointly commit to the technology research and development of intelligent circuit breakers. With rich scientific research resources and strong talent advantages, universities and research institutions continue to provide cutting-edge technical support and innovative ideas for enterprises. The enterprises will timely feedback the problems encountered in practical application to universities and scientific research institutions, so as to promote the transformation and application of scientific research results more efficiently. This benign interaction not only enhances the technical level and product competitiveness of enterprises, but also promotes the

scientific research and innovation of universities and scientific research institutions, and injects strong impetus into the development of the intelligent circuit breaker industry.

Industrial chain integration: Industrial chain integration is crucial to the development of intelligent circuit breakers. We should strengthen close cooperation with upstream and downstream enterprises and fully integrate industrial chain resources. Actively cooperate with sensor manufacturers to ensure that high-precision and high-reliability sensors provide accurate data for intelligent circuit breakers; Cooperate with communication equipment manufacturers to realize real-time communication with advanced communication technology; Collaborate with software developers to develop efficient control software. Through the establishment of close cooperation with these enterprises, we can jointly create a complete industrial chain of intelligent circuit breakers. Under the collaborative innovation of the industrial chain, it can give full play to the advantages of all parties and improve the overall performance and competitiveness of products. At the same time, the integration of the industrial chain can also reduce costs, making intelligent circuit breakers more advantageous in price, thus promoting their wide application in various fields.

(4) Policy support and standard formulation

Policy support: Policy support plays a key role in promoting the development of intelligent circuit breakers. The government should actively introduce relevant policies and vigorously encourage enterprises to increase investment in research and development of intelligent circuit breakers. For example, provide generous research and development subsidies, give tax incentives and other policy support, so as to effectively stimulate the innovation momentum of enterprises. At the same time, the government is fully promoting the construction of smart grid, which undoubtedly opens up a broad market space for the application of smart circuit breakers. In addition, the government can further increase investment in smart grid projects, give full play to the guiding role, promote the power industry to accelerate the pace of intelligent upgrading, and create a good policy environment and market conditions for the development of smart circuit breakers.

Standard formulation: Unified technical standards and specifications for intelligent circuit breakers should be developed to strictly ensure product quality and performance. With the standard, it can effectively promote the orderly competition in the market and avoid the adverse consequences of disorderly competition. At the same time, improve product compatibility and interoperability, and facilitate the collaborative use of products from different manufacturers. In addition, we should actively participate in the formulation of international standards to enhance our country's discourse power and influence in the field of intelligent circuit breakers. By promoting China's intelligent circuit breaker technology and international standards, to lay a solid foundation for expanding the international market, so that China's intelligent circuit breaker occupies an important position in the global market.

6. Conclusion

The application of intelligent circuit breaker in building installation has broad development prospects. In today's era, intelligent technology and Internet of Things technology are developing at an amazing speed and are widely used in various fields. For building installation, intelligent circuit breakers conform to this trend and will continue to move to new heights. With the continuous progress of intelligent technology, the intelligent level of intelligent circuit breakers will continue to improve, and can more accurately monitor and analyze the operating status of the building electrical system to achieve more efficient fault diagnosis and early warning. Functions will also be diversified, in addition to the basic break protection, will also cover power quality monitoring, electrical fire warning and other practical functions. The deep integration with the Internet of Things will make the intelligent circuit breaker a core part of the building energy management system to achieve intelligent linkage and remote control between devices. At the same time, the characteristics of energy conservation and environmental protection will be more prominent, and energy consumption will be reduced by optimizing control strategies, contributing to green buildings. Safety features will also continue to be enhanced to ensure the stability and safety of the building's electrical system. However, the development process is not smooth sailing, facing challenges such as inconsistent technical standards, high costs, and insufficient user awareness. However, we can overcome these difficulties through the government to promote the unified development of technical standards, enterprises to increase research and development to reduce costs, strengthen publicity to improve user awareness and other coping strategies. In order to promote the wide application of intelligent circuit breakers in the field of building installation, provide a strong guarantee for the safe, stable and efficient operation of buildings, and help the construction industry to move towards a new era of intelligence.

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