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Based on the Research and Application of a Digital Low-voltage Circuit Breaker in New Infrastructure Field

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Abstract

With the in-depth development of power distribution automation and new infrastructure fields such as modern new energy vehicles, wind energy and rechargeable photovoltaic cells, traditional circuit breakers have been unable to meet the development needs of new infrastructure fields. In this regard, the paper proposes a digital low-voltage circuit breaker. The circuit breaker mainly uses silicon carbide mos pipe instead of IGBT to achieve circuit state switching, which greatly improves the breaking speed of the circuit breaker, in addition, the circuit breaker also has fault detection and self-protection functions, laying a good foundation for the large-scale application of the circuit breaker.

Keywords

Low-Voltage Circuit Breaker; Current Fingerprint; Silicon Carbide; RCD; MOV.

1. Introduction

With the in-depth development of power grid distribution automation and modern new energy vehicles, photovoltaic wind power and charging piles and other new infrastructure fields, the cut-off times of circuit breakers are required to have a longer service life, with microsecond level breaking capacity, can quickly eliminate the fault current in the circuit and prevent the expansion of the fault; It can remotely monitor the electrical system and implement intelligent shutdown to achieve the goal of energy saving and efficiency improvement and reduce the operating costs of photovoltaic wind power and charging pile industries. But the traditional mechanical circuit breaker can not be real-time, flexible, continuous and fast action, easy to enlarge the accident, destroy the stability of the system; There is often an arc when breaking the load, the contact is easy to burn, long breaking time; In the process of operation, there is noise, machinery, electrical life is limited, it is difficult to meet the complex application scenarios of renewable energy electrification. Therefore, the traditional circuit breaker has become more and more difficult to meet the reliability, accuracy and real-time of power system.

At present, using DC circuit breaker is one of the main schemes to realize DC fault breaking. Dc circuit breakers can be divided into mechanical, solid and hybrid types. The mechanical DC circuit breaker will take a long time to break due to the existence of its own inherent action time and arc when breaking, reaching tens of milliseconds or even longer, too long breaking time will make electronic power equipment out of work, reduce the stability and reliability of the power grid. Solid-state DC circuit breaker adopts semiconductor power device as the main switching element, which has the advantages of no arc and fast breaking, but its cost is high, the on-state loss is large, and it often needs to cooperate with control strategy, short-circuit current detection and other modules, which improves the complexity of the system. Hybrid DC circuit breaker is composed of mechanical switch branch, solid state switch, buffer absorption circuit and current limiting circuit, which can realize controllable switching and low on-state loss, but its mechanism is complicated and it is difficult to cooperate with mechanical and electrical. Breaking speed is limited by mechanical switch.

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Based on the advantages and disadvantages of the circuit breakers, this paper proposes a kind of digital low-voltage circuit breaker, which realizes the fast breaking and self-detection of the circuit breaker through the current fingerprint technology, silicon carbide fast breaking technology and self-protection technology.

2. The Background and Significance of the Project

The global electrification level based on renewable energy will develop irretrievably, while the traditional mechanical circuit breaker is difficult to meet the development demand, digital low-voltage circuit breaker to replace the traditional mechanical circuit breaker has become an inevitable trend. With the further development of power system distribution automation and modern new energy vehicles, photovoltaic wind power and charging pile industries, the circuit breaker shutdown times longer service life, with microsecond level breaking ability, can quickly remove the fault part of the system, prevent further expansion; can remote monitoring of electrical system, and implement intelligent shutdown, achieve the goal of energy saving and efficiency, reduce the operating cost of photovoltaic wind power and charging pile industry.However, the traditional mechanical circuit breaker cannot operate in real time, flexibly, continuously and fast, which is easy to expand accidents and destroy the arc of the system stability, easy burning of contact and long opening time; During operation, mechanical and electrical life is limited, so it is difficult to meet the complex application scenarios of renewable energy electrification.Therefore, the traditional circuit breaker has become more and more difficult to meet the requirements of the reliability, accuracy and real-time of the power system.Digital AI circuit breaker / solid state digital circuit breaker to the traditional mechanical circuit breaker replacement has become an inevitable trend.Digital low-voltage circuit breaker will become a new starting point of the digital revolution of distribution market and an inevitable requirement to build the highest standard for the next generation electric power application in the digital era.

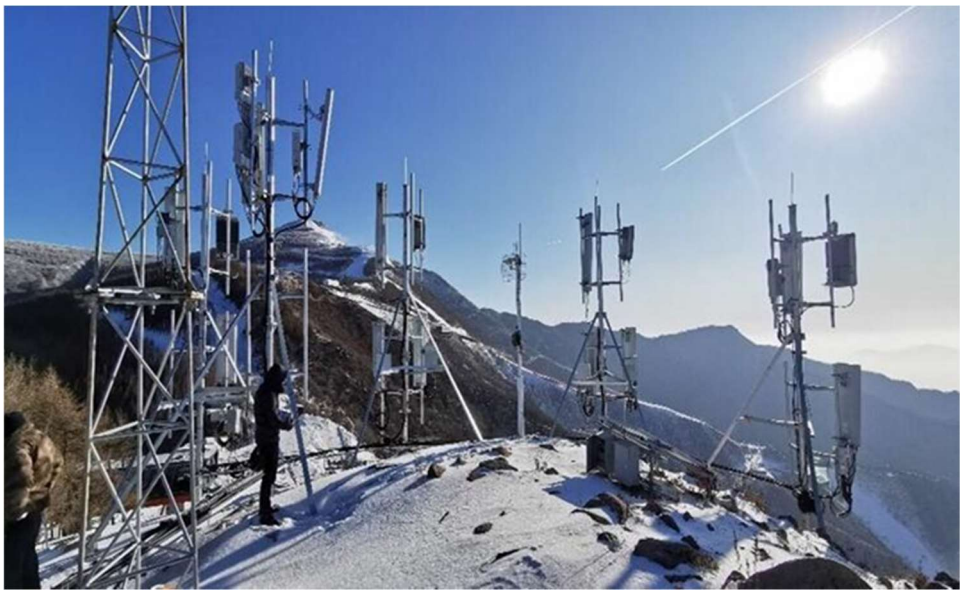

Figure 1. A 5G base station

3. Current Fingerprint Technology

Current fingerprint is a fault identification technology which combines wavelet denoising algorithm with RBM-BP neural network algorithm. Based on wavelet transform algorithm to complete implementation of the original signal wavelet transform through the electrical data dimensionality of feature extraction, at the same time of current waveform after denoising and nearly consistent

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standard voltage under the current waveform, relative noise signal denoising, significantly reduced, to provide an effective digital low voltage circuit breaker to cut off the provides the basis. The neural network analyzes the signal features and identifies the fault types. Current fingerprint technology breaks through the technical difficulty of feature signal extraction, solves the problem of data difference caused by different environments, reduces interference signals, and realizes the rapid and accurate identification of fault current signals. Breaking through the technical difficulties of fault identification in new infrastructure field.

4. Silicon Carbide Rapid Breaking Technology

Silicon carbide itself has high temperature resistance, high critical breakdown characteristics of the electric field, high electron saturation drift velocity, can fast breaking capacity, MOS tube, given a significant boost in circuit breaker breaking capacity, compression capability, the breaker points off the time of fault current, in the case of short circuit fault, can carry on the current limit protection in milliseconds, prevent fault further, Achieve new breakthroughs in the industry. It solves the problem that the new infrastructure is prone to small current failure and can not be broken quickly.

5. Self-protection Technique

Circuit breaker breaking ability refers to the ability of the circuit breaker to cut off the fault current safely, which is an important index to measure and judge the circuit breaker.The faster the break, the shorter the short circuit current, and the less damage.When an electrical short circuit fault occurs, there will be hundreds or even thousands of amps of current generated in a very short time, making the electrical line quickly heat up, and the short circuit point will produce dangerous sparks, thus causing a fire.In order to effectively avoid the fire caused by the short-circuit failure, the key measure is to achieve a fast flow restriction, that is, the system should have a rapid response capability.When the electrical circuit short circuit failure, the system monitors the short circuit current over several times the rated current, and in a very short time quickly realize the current limit break, make the short circuit current no longer surge, so the wire no longer heat, short circuit point will not eruption dangerous sparks and metal particles, so as to reduce the possibility of fire. Traditional mechanical circuit breaker, restricted by its own physical structure, not only moves by noise and arc light, but also has a long opening time, so it is difficult to reach the rapid dynamic requirement of microsecond open current. Therefore, how to make the circuit breaker have the microsecond level opening speed, and can quickly cut off the current has become one of the difficult problems of the circuit breaker research.

In order to protect the digital low voltage circuit breaker from the transient impact of short circuit fault, it is very important to design an effective and economical buffer. Traditional discharge suppressor buffers are widely used because of their good voltage clamping ability and short fault clearing time, while metal oxide rheostat can also be a suitable solution because of its nonlinear voltammetric characteristics. RCD buffer circuit has the advantages of clamping overvoltage and overcurrent, while MOV device is single and cheap, the combination of the two can achieve the separation of overvoltage clamping and energy absorption. Avoid permanent damage to the sensitive semiconductor components inside the circuit breaker when the circuit breaker is disconnected from the faulty circuit, and improve the circuit breaker opening life. It solves the need for frequent cuts in new infrastructure.

6. High-precision Fault Perception Technology

Traditional circuit fault sensing technology is susceptible to complex electromagnetic environment.Based on the traditional Hall sensor for innovation and improvement, the high-precision circuit fault signal sensing technology is developed.Through the innovative use of Poo alloy material and the design of half air gap iron core structure, the Hall sensor can stably measure the micro characteristic signal, and the antimagnetic interference ability is stronger, which greatly reduces the

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interference of the environmental magnetic field to the Hall element.It solves the problem that the traditional Hall sensor is susceptible to electromagnetic environment interference and has a weak perception of microcharacteristic signal.

7. Conclusion

Based on the research and application of a digital low-voltage circuit breaker in the field of new infrastructure construction, this paper proposes a new breakthrough in the field of new infrastructure circuit breaker through current fingerprint technology, silicon carbide rapid breaking technology and circuit breaker self-protection technology.

Acknowledgments

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