Safety Technology Analysis of Relay Protection in Traction Power Supply System

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Abstract: If the economy allows, a traction substation can be built to supply power to it. If the economy does not allow, the rails of the depot are isolated from the rails of other main lines, and the grounding part is connected to the negative end of the nearest substation through cables. Compared with the traction network, the failure rate of the traction network is much higher than that of the power system due to the way that the EMU is in sliding contact with the contact line through the pantograph and mechanical vibration. For transformers, China's high-speed railways use transformers with special wiring, and their capacity and voltage level are greatly improved compared with ordinary-speed railways. The main substation is suitable for centralized power supply. The function of power supply switching station is to receive urban medium voltage power supply and transfer medium voltage power supply for traction substation and step-down substation. Power supply switching station is generally built together with station traction or step-down substation. Conventional protection cannot operate correctly in some serious cases, which will lead to serious accidents such as burning loss or even burnout of traction network and long-term interruption of train power supply. Meet all aspects required by the operation of electric locomotive, and ensure the safe operation of power supply system and its equipment when the traction power supply system cannot work normally and is damaged. With the development of metro system of urban rail transit, DC traction power supply system has been paid more and more attention and widely used. The research on high-performance, reliable and stable DC protection has become a very urgent task. This paper mainly analyzes the relay safety through the traction power supply system.

1. Introduction

The main function of the traction power supply system is to provide continuous and reliable electrical energy to the electric locomotive. Under normal working conditions, the traction power supply system should be able to ensure safe and uninterrupted power supply to the traction load [1]. If the economy permits, a separate traction substation can be constructed to supply power to it. If the economy does not permit, the rails of the depot are isolated from the rails of other main lines, and the grounding part is connected to the negative terminal of the nearest substation through cables [2]]. For the traction network, the failure rate of the traction network is much higher than that of the electric power system due to the way of taking current through the sliding contact between the pantograph and the contact line and the mechanical vibration. Compared with the traction network, the failure rate of the traction network is much higher than that of the power system due to the way that the EMU is in sliding contact with the contact line through the pantograph and the mechanical vibration [3]. Comparing the field test data with the characteristic curve of protection principle, the adjustment method of protection parameter matching is put forward, which provides reference for the protection adjustment of DC traction system [4]. As for transformers, China's high-speed railways adopt transformers with special wiring, and their capacity and voltage level are greatly improved compared with those of general-speed railways.

Traction power supply system is an important part of electrified railway. Whether the traction power supply system can work stably and efficiently is related to the safe and reliable operation of the railway. The main substation is suitable for centralized power supply [5]. The function of the power switch station is to accept the urban medium voltage power supply and transfer it to the

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traction substation and the step-down substation. Generally, the power switch station is jointly built with the station traction substation or step-down substation. In some serious cases, the conventional protection can't act correctly, which will lead to serious accidents such as traction network burning or even burning out, train power supply interruption for a long time [6]. In order to enable the traction power supply system to supply power reliably and safely, relay protection plays an important role. It meets all aspects required for the operation of electric locomotives, and can ensure the safe operation of the power supply system and its equipment when the traction power supply system fails to work normally and is damaged. However, the disadvantage of using fixed filtering is that it can only compensate harmonics of one or several frequencies [8]. With the development of the urban rail transit subway system, the DC traction power supply system has received more and more attention and more and more extensive applications, and the research on high-performance, reliable and stable DC protection has also become a very urgent task [9] .

2. Protection principle of traction power supply system

2.1. Working principle of traction system protection

The safe and reliable operation of the DC traction power supply system is guaranteed by the DC power supply control and protection device. In order to completely remove the electrical phase separation of the partition and better improve the energy quality problems such as harmonics, negative sequence and reactive power, on the basis of the in-phase power supply, a through-type power supply based on AC-DC-AC transformation is considered. Because the traction load is a single-phase load, in order to evenly distribute the single-phase load to the three phases of the power system as much as possible, the traction transformer often chooses a special wiring transformer [10]. Under this power supply mode, the feeding voltage is high, the power supply capacity is strong, and the number of traction substations can be reduced, thereby saving investment. The current in the contact line and the positive feeder is approximately equal in size and opposite in direction, so the traction current has little impact on the communication line. In addition, in order to make the pantograph sliding plate wear evenly, the contact line forms an intersection angle with the pantograph center line and is arranged in a zigzag shape. The pressure brought by the high-speed movement of EMU makes the contact wire often in vibration state, and the probability of mechanical failure of traction network increases. This can reduce the unit impedance of traction network, reduce voltage loss and improve power supply quality. Among them, the control and protection system plays an important role in ensuring the safe and reliable operation of rail transit.

2.2. DC feeder protection

The high-current tripping protection is the main protection of the near-end protection of the catenary, which is realized by the tripper set in the circuit breaker, allowing the current to pass through the coil of an electromagnet, and the electromagnet is connected to the tripping mechanism. With the continuous promotion and use of high-power EMUs and the increasing density of trains, the load current of the traction network is increasing, and the load impedance is decreasing. The sensitivity of the traction network relay protection is getting smaller and smaller, and the probability of refusal and misoperation increases. Under this power supply mode, the load current of locomotive will have multiple power supply circuits due to the existence of parallel branches, which reduces the resistance value of traction network and increases the power supply capacity of traction network. In the same phase power supply device, the converter can use either two single-phase 'back-to-back' converters or three-phase four leg converters. There are also many power supply modes of traction network, and different combination modes can realize a variety of in-phase power supply system schemes. In the process of on-site waveform analysis, the maintenance personnel considered that it was caused by the abnormal action characteristics of the protection device body, and replaced the dpu96 protection device. Therefore, the high current tripping protection is very sensitive, especially the near end short circuit with very fast current rise, which often acts before the current rise rate and current increment protection.

3. Relay protection research

3.1. Research on line protection

Due to the need of full-line quick-action, the lines with voltage levels above 220kV in the power system generally adopt the line current differential protection with optical fiber as the communication channel as the main protection. Faults on the line can be removed by feeder protection. If the short-circuit point is very close to the outlet of the substation, the short-circuit current is very large, and the busbar voltage at the outlet of the substation will not be able to maintain the operation of the converter. At this time, the pulse must be completely blocked to make it out of operation. When the power supply line is long and the short circuit occurs at the middle and far ends of the line, the short circuit current may be very small, even lower than the starting current of the train or the impulse current when the train passes through the catenary section. At this time, the high current tripping protection will lose its protection against short-circuit fault. Firstly, the overall design of the software is carried out, and then the design of each program module is carried out. Each module includes initialization, timer initialization, LCD initialization, a \ D sampling program, keyboard control program, etc. As shown in Figure 1.

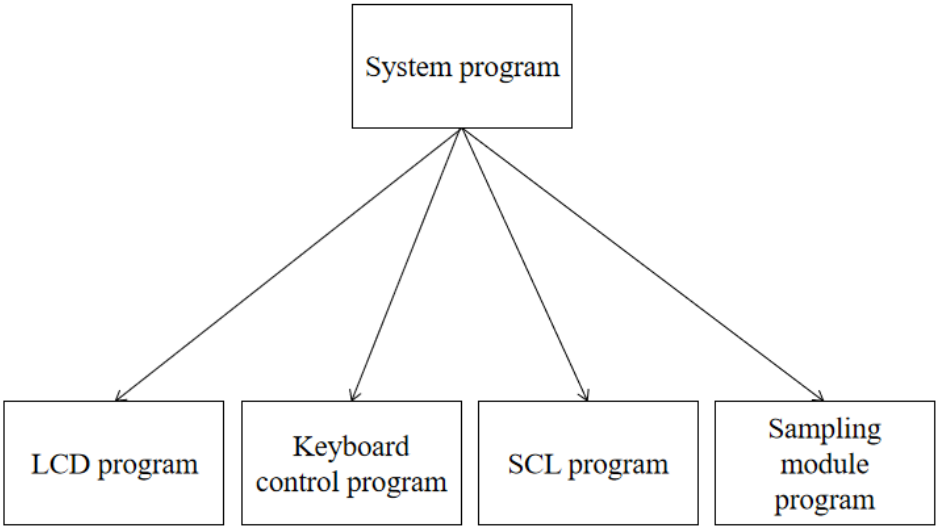

Figure 1 System software structure diagram

For special wiring transformers, due to the phase rotation of the voltage and current on the high and low voltage sides, the conventional phase-to-phase impedance and phase-to-ground impedance cannot correctly reflect the total impedance from the protection installation to the fault point. However, once these measures are taken, the performance of differential protection will be deteriorated, and the complexity of protection and the probability of refusal will be increased. Therefore, differential protection should not be directly used in traction network. The development of computer technology and communication technology promotes the progress of relay protection technology, so that relay protection can adopt more complex and refined algorithms.

3.2. Research on transformer protection

The most important equipment in the power supply of the system is the transformer, and its relay protection can directly affect whether the power supply is normal and whether the equipment is safe. If the transformer is overloaded for a long time, the insulation aging of the transformer will be accelerated, which will affect its life. The converters are equipped with overcurrent protection. Once the line has a short-circuit fault, the short-circuit current provided by the substation will be greater than the maximum current value it can withstand. Conversely, if the current falls below the fixed value, the protection will return. The thread is used to read the serial port data. Before using the serial port, it must be opened and initialized. The process flow of serial port initialization is shown in Figure 2. The process of terminating the serial port read thread is shown in Figure 3.

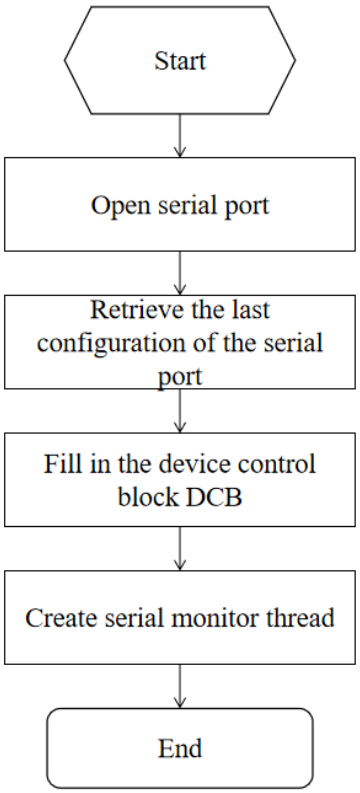

Figure 2 Flow chart of serial port initialization

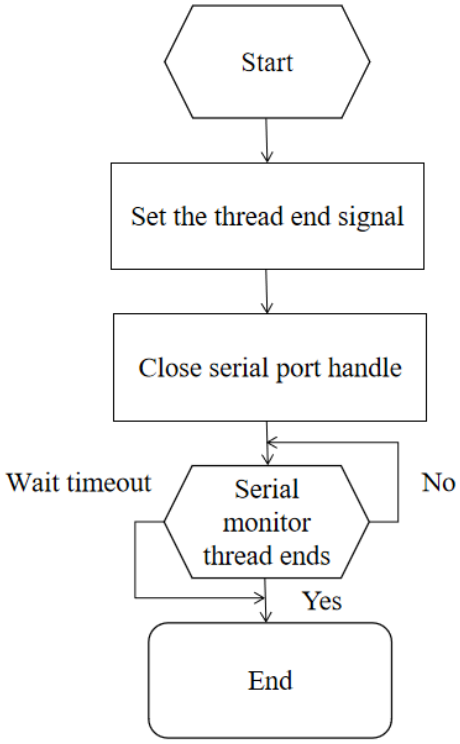

Figure 3 Flow chart of terminating serial port thread

For some short-circuit faults with very small currents, if the settings of the current rise rate and the current increment protection are unreasonable, it may lead to failure to trip, and it is necessary to rely on backup protection. To sum up, when the line fails, the converter may directly exit operation or operate in current limiting mode. High-speed railway traction power supply system requires large traction power, coupled with high-speed railway traffic density, the traction transformer is often in a short-term overload state. The switching action waveform recorded by the

fault recording of the protection device is significantly different from that under the condition of short circuit fault. At present, the research on transformer backup protection mainly includes two categories: one is to improve the existing overcurrent protection. The other is to adopt other protection principles.

4. Conclusions

All high-speed railways in China use electric traction, and the role of the traction power supply system as the source power is even more important. However, China's high-speed railway has a short development time and rapid development speed. The relay protection principle and protection configuration ideas mainly follow the experience of ordinary-speed electrified railways. Through adjustment, the action parameters of the protection device are matched with the load current characteristics of the vehicle, and the reliability of the system operation is improved. On this basis, the short-circuit simulation analysis of the multi-vehicle DC traction power supply system of urban rail transit, the design of the relay protection detection circuit of the DC traction power supply system, and the design of the relay protection control system of the DC traction power supply system are carried out. When different types of failures occur throughout the traction network. At least one of the joint tripping protection elements on the fault power supply arm acts reliably and correctly and trips other protections on the same power supply arm in parallel to isolate the fault power supply arm, but all the protections on the non fault power supply arm do not act reliably. Compared with in-phase power supply, in-phase through power supply can not only solve the power quality problems such as negative sequence, harmonic and reactive power in traction power supply system. And it can fundamentally cancel the over-current phase separation link of traction power supply system. Therefore, the continuous and in-depth research on the relay protection of high-speed railway traction power supply system not only responds to the actual needs of the site, but also has important social and economic value.

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