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Research on Railway Real-time Online Power Supply Automation Network Communication System

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Abstract. Railway construction has entered a stage of rapid development. The design and construction of high-speed railways are further expanding. In the face of competition from advanced technologies, it is very urgent to study the real-time online power supply automation system for railways. At the same time, network communication problems have become a core issue in the research and development of traction power supply automation systems. In this paper, the communication system is studied. The high-speed railway runs at high speed, the train time interval is short, and the maintenance time is small. Under the premise of considering the safe and reliable operation of the system, the whole data of TPSAS is re-planned according to the principle of management and control diversion flow. The solution for industrial Ethernet of traction substation is proposed, which is distributed switching double-loop fiber self-healing Ethernet. Research shows that TSAS adopts distributed-switched double-loop fiber self-healing Ethernet, which is a better choice for railway network communication systems.

Keywords: Railway; Power supply automation; Industrial ethernet; Communication real-time.

1. Introduction

With the improvement of power supply management standards for high-speed electrified railways and passenger dedicated lines, higher requirements are placed on the safety and reliability of power supply equipment. As far as the current electrified railway electrical equipment management method is concerned, it will cost a lot of operation and maintenance costs to meet its standard requirements. Therefore, necessary equipment monitoring measures must be taken to reduce power system accident hazards, reduce accident probability, and shorten fault finding and overhaul [1]. In order to realize the unmanned duty in the true sense, it is necessary to establish a TPSAS with high reliability, maintainability and real-time control, and manage and control the primary equipment of the entire traction power supply system to ensure efficient and safe traction power supply system [2]. At present, all systems are operated independently, the traffic scheduling and traction power supply scheduling are separated, and PSDS and PSMIS are not connected [3]. The level of automation in traction substations is uneven. Many scholars have proposed various improvements to improve the real-time performance of Ethernet communication [4]. The information flow of the subsystem completes the information flow planning suitable for high-speed railway. TPSAS is proposed to solve the substation, contact network area, power supply dispatching center, power supply vascular center, and bureau comprehensive dispatching center [5].

2. Railway Real-time Online Power Supply Automation Communication System

2.1 Railway Real-time Online Power Supply Equipment

According to the hierarchical distributed configuration requirements, the on-line monitoring system for high-voltage equipment of traction substation consists of background expert diagnosis system, substation communication management unit and local intelligent interval monitoring unit. Each interval monitoring unit is arranged at the field device to complete the device status on the spot. Online measurement and processing of data [6]. The communication management machine in the station communicates with the interval device through industrial Ethernet or serial bus, controls each interval monitoring unit, and receives real-time data measured and uploaded by each interval monitoring unit [7].

The communication management machine can transmit data to the remote maintenance dispatching diagnosis system through the internal LAN to the in-station backstage expert diagnosis system or through the modem according to the specific conditions of the network and communication in the substation [8]. The diagnostic software can be installed in the power supply section maintenance dispatch management department, through the Web. Browse remotely monitor real-time and historical data of each substation, and access the relevant management department of traction power supply to assist professional engineers and relevant leaders to evaluate equipment management and equipment operation status [9]. Remote diagnosis system enables engineers to monitor online through the network anytime and anywhere. Operating parameters of the high-voltage equipment of the traction substation.

2.2 TPSAS Information Flow Analysis

TPSAS is an automatic system that guarantees the normal and reliable operation of the primary equipment of the traction power supply system. It protects, measures, controls, manages and maintains the primary equipment of the traction power supply system. For the operating characteristics of high-speed railways, TPSAS is required to complete the above tasks in real time and reliably. Traction substation, mainly to complete the transformation task. At the same time, the task of power supply for the upper and lower feeders of the high-speed railway has the functions of protection, measurement and control of primary equipment such as transformers, capacitors and feeders [10].

From the perspective of control security, control information and management information should not share channels. A large amount of rich information cannot be transmitted to the required nodes, forming an "automation island." The solution is to divide all the information of the substation according to the two categories of monitoring and maintenance management. Of course, some information is shared. At the time of initial development, research institutions were generally designed to meet the needs of users as much as possible. In fact, by dividing the information flow and actual experience, it was found that some information was redundant. In order to realize the information distribution by function, the vascular communication unit can be added, as shown in Figure 1.

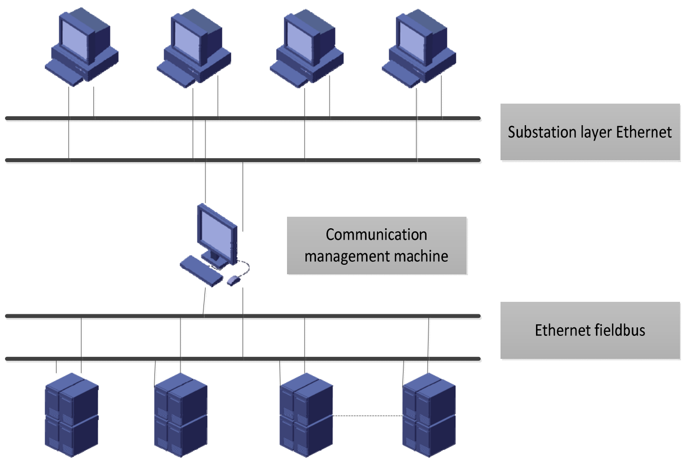

Figure 1. TSAS structure connected to PSMIS

It should be emphasized that the smaller the amount of monitoring data, the better the scale of power supply scheduling will be, and the number of substations to be controlled will be more and more. For the control system, high real-time and reliability are guaranteed. The amount of data required is small. The real-time requirements for maintenance management data are not very high, but the reliability of the data is required to be high. Of course, the corresponding amount of data is large. At the same time, the PSDS channel should be configured in redundancy. The engineer station data such as fault information and fault recording of the substation interval unit is directly transmitted to the maintenance management center instead of the power dispatch center. The maintenance management center can remotely set, diagnose, and even download programs under the authorization of the power dispatching center. This is the latest operating model for high speed railways.

2.3 Information Transmission Network

TSAS is an important part of the traction power supply system. The internal communication network is a structure in which the substation layer is Ethernet, the bay level is a field bus, and the upper and lower layers are connected by a communication management machine. Research and implement a distributed switching function, each IED is a data switch, thus replacing the industrial-grade fiber-optic data switch. In fact, each bay unit in the substation is configured in a redundant manner. The reliability of the system is decomposed into every interval unit, and the reliability is greatly enhanced.

The traction power supply maintenance management system consists of the local area network of the maintenance management center and the wide area network that communicates with the substation, the substation, the opening and closing station, and the contact network area. In the design of the new high-speed railway, the contact network area is recommended to be built together with the substation. The contact network area can be connected to the maintenance management center through the vascular communication unit in the TSAS. That is, TSAS shares a channel with the contact network area.

3. Distributed Switched Ethernet Research

3.1 Distributed Switched Double Loop Fiber Self-Healing Ethernet

The performance of switched Ethernet exceeds that of shared Ethernet, but switched Ethernet also has the same congestion and queuing when sending packets to a node. Whether it is store-and-forward or direct transmission, there is such a problem. The hardware principles of the telecontrol communication unit and the vascular communication unit are the same, but the content of the message transmission is different because the real-time requirements are different.

The telecontrol communication unit adopts the design idea of dual CPU. One CPU is responsible for communication with the intelligent devices inside the substation, one CPU is responsible for communication with the power dispatching center, and is connected with the local monitoring unit via Ethernet, and the two CPUs pass through the double the port RAM communicates.

3.2 Substation Communication Real-time Transmission

The Ethernet MAC controller communicates with the communication CPU in an interrupt mode. After receiving a complete message frame, the Ethernet controller changes the corresponding status register to generate an interrupt. After the CPU responds to the interrupt, the corresponding flag is queried. The FIFO in the network controller has received all the messages into the RAM area of the communication CPU system, and the packets to be forwarded are directly moved into the sending queue according to the priority. When the sending buffer is empty, the packets are put into the sending buffer. Zone, send a command, send directly, and fill the second buffer with a message that needs to be sent. When the received message needs to respond to the confirmation message, it will be processed accordingly.

When a frame is sent, the Ethernet controller will generate a completion interrupt. In the transmission interrupt, the transmission efficiency is nearly doubled because two buffers are sent alternately. The transmission interrupt service time is very short, just send a command and move one frame, up to two frames of messages. Since the communication must process the left and right messages as well as the left and right message transmissions. Therefore, the left input, the right input, the left output, and the right output are arranged in order, and the interrupt priority is the same. That is, when there is input on the left, the left input is processed first, and after completion, whether the right input, the left output, and the right output are interrupted, and then the left input is processed, and the loop is automatically performed.

4. TSAS Communication Real-time Simulation Analysis

In the simulation, data retransmission, network failure, and multiple data bursts must be considered. In these cases, is it possible to ensure the certainty of data delay? Is it possible to promptly alert and switch channels? In this paper, data retransmission, network failure and, in the worst case, all burst data are used as simulation conditions for the entire Ethernet performance, and the distributed switching Ethernet is simulated. The network communication structure suitable for high-speed railway is discussed from the determinism of the data and the alarm and repair time of the communication system failure.

The purpose of simulating the TSAS communication network is to compare and analyze the performance of the three network structures. It is very important to select appropriate parameters for the simulation. There are many indicators for evaluating the performance of a network, including link utilization, service response time, loss rate, and delay. However, for a specific research object, the performance of the system can often be characterized by certain specific indicators without requiring each an indicator.

Distributed Ethernet has a stable and fast response time during normal operation. This is the fastest and most stable in the network structure. It has been stable without large fluctuations. The distributed switched Ethernet link utilization is shown in Figure 2.

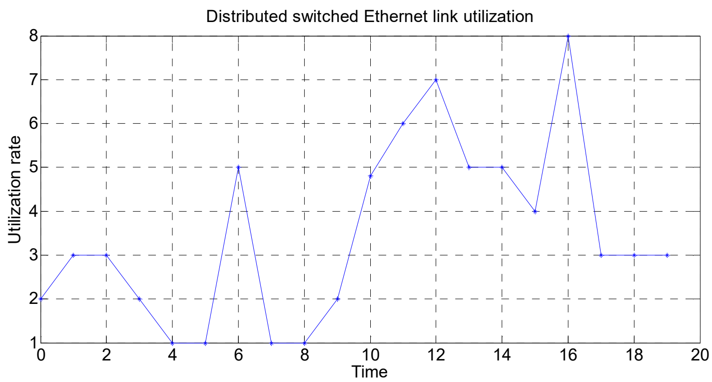

Figure 2. Distribution Switched Ethernet Link Utilization

5. Conclusion

Electric traction is an inevitable choice for high-speed railway. Reliable and efficient traction power supply is an inevitable requirement for high-speed railway operation. The integration of management and control is the basis for ensuring the safe and reliable operation of the entire traction power supply system. To realize the integration of management and control, communication problems must be solved. The communication problem is divided into two aspects, one is the information flow problem, and the other is the reliability and real-time problem of communication. This paper proposes a railway real-time online power supply automation system with integrated management and control, which provides a reliable guarantee for the safe operation of the railway. For the information islands, information flow confusion and other issues, the entire information flow has been studied and planned. Under the premise of considering the security and reliability of the system, according to the principle of management and control diversion, the input and output of each subsystem are specified. In addition, distributed switched double-loop fiber self-healing Ethernet is proposed. If we can further refine the data flow, it will be a future research direction after fully communicating with various design and construction professionals to form a consensus and establish railway information flow standards, network structure standards, and substation communication standards.

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