Research Article

Research on Electrical Automation Monitoring System Model of Power Plant Based on CAN Bus

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Using the traditional manual operation mode to control the electrical equipment of the power plant was not only inefficient and unsafe but also difficult to adapt to the use of new equipment. Therefore, this article puts forward the research on the model of power plant electrical automation monitoring system based on CAN bus, which was of great significance to improve the operation monitoring ability and management efficiency of power plant electrical equipment. Based on the analysis of the design mode and main functions of electrical equipment automation control system in power plant, this article expounded on the characteristics of CAN bus communication mode and its advantages in realizing electrical equipment automation control. According to the hierarchical management and structural characteristics of the electrical automation monitoring system, the real-time database architecture of the monitoring system was established, the real-time data monitoring and processing method of the electrical monitoring system was given, and then the electrical automation monitoring system model of the power plant was proposed. The experimental results showed that the electrical automation monitoring system proposed in this article was effective and feasible for real-time monitoring of the operation of electrical equipment. The model construction method of the electrical automation monitoring system proposed in this article can provide theoretical reference and technical support for improving the control mode of electrical equipment in power plants.

1. Introduction

With the continuous development of electronic information technology and artificial intelligence technology, the traditional manual operation mode for electrical manual control has been difficult to meet the needs of economic and social development. In recent years, the electrical automation monitoring system of the power plant has played an important role in realizing real-time data monitoring, relay protection, and system communication [1, 2]. It can not only greatly improve the work and management efficiency but also save labor costs. The application of electrical automation technology in the production management activities of industrial enterprises can not only effectively improve production efficiency and ensure safe production but also improve the economic benefits of enterprises. At the same time, the rapid development of communication technology makes the electrical control change from the original component control to network control, and the network control based on field-bus technology has gradually replaced the original manual control mode.

With the intellectualization of modern electrical equipment, the requirements of the power plant for automatic operation and management are gradually improved. Electrical monitoring has developed from a one-to-one control mode to a system automation control-based working mode. Field-bus can better serve the electrical power control of the power plant. The electrical automation monitoring system based on field-bus technology is the main mode of system design and management in power plants [3]. Not only is the equipment developing towards intelligence, but also the power plant is developing towards automation and intelligence. In recent years, the electrical monitoring and management requirements of power plants have been continuously improved, and the traditional monitoring system has been difficult to meet the requirements of power
plants in terms of equipment detection, maintenance, and repair. Therefore, establishing an efficient and reliable electrical automation monitoring system of power plants has become one of the issues widely concerned by relevant personnel at home and abroad.

Establishing an efficient power plant electrical automation monitoring system is the key to realizing the modern management of power systems, and the design of an electrical automation monitoring system model is the premise to ensure the effective operation of the system [4]. When building the monitoring system model, it is necessary to adopt a reliable system structure and networking mode, not only to ensure that the system can work normally but also to ensure that the system can accurately collect and effectively process relevant data and information. However, affected by different software and hardware technologies and other factors, the degree of electrical automation of some power plants is not high, and some power plants are still at the level of manual inspection supplemented by automatic monitoring. Therefore, according to the design standards and functional requirements of power plant electrical monitoring system, this article proposes the model research of power plant electrical automation monitoring system based on CAN (Controller Area Network) bus, in order to provide theoretical reference and technical support for the regulation and management of existing power plant electrical facilities.

2. Related Works

The electrical monitoring system mainly adopts field-bus technology, measurement and control technology, and computer and communication technology to realize the automatic operation and management of relevant electrical equipment and its auxiliary facilities [5]. The system is mainly composed of an electrical management workstation and some communication equipment or facilities. It has the functions of real-time monitoring equipment status, fault diagnosis and repair, operation parameter optimization, and so on. Most electrical monitoring systems use fieldbus to connect various electrical equipment, communication facilities, and protection devices to realize various communication and information transmission. Some monitoring systems also realize information interconnection through Ethernet to realize real-time operations such as multitask parallel processing.

The electrical equipment of the power plant is generally distributed in the motor control center and distribution room. Due to the large electrical equipment and large number of components, maintenance is a common problem for the electrical equipment and facilities of the power plant [6]. In order to ensure the stable operation of power plant equipment, the automatic protection device of electrical equipment must have fast response-ability and high reliability to external events. Therefore, the automatic monitoring system should not only maintain normal operation, start, and stop operation but also monitor the operation process of the system in real time. For example, in case of abnormal operation of the system, it is necessary to send an alarm signal in time and display and record the data information about the abnormal state of the equipment. In addition, the automatic monitoring system can timely diagnose the errors and abnormal conditions of electrical equipment or facilities and provide corresponding emergency operation and treatment to ensure the normal operation of the electrical system of the power plant.

In view of how to build an electrical automation monitoring system and use it to provide effective support for the operation and management of power plant electrical systems, scholars at home and abroad have carried out a series of related research work and made some progress. Some people propose to use adaptive detection methods to intelligently monitor the faults of electrical equipment such as coal mills and forced draft fans in power plants based on traditional manual inspection. Due to the gradual improvement of the performance of various new equipment in power plants, the traditional manual operation mode cannot meet the requirements of equipment with data integration ability [7]. Therefore, the electrical automation monitoring system is studied and designed to control the relevant equipment in real time and master the operation status of the electrical equipment through the dynamic analysis of the monitoring data to ensure the normal operation of the electrical system of the power plant.

Compared with other automatic control systems, the electrical automatic control system of power plant not only requires to be able to accurately monitor the field data information but also ensures the smooth operation of electrical equipment in the monitoring process and requires high response sensitivity to equipment working conditions and abnormal events [8]. In addition, the electrical automation monitoring system needs to ensure that one processor has multiple functions. With the expansion of the power plant scale, the objects of electrical control system management increased. In order not to affect the normal production of enterprises, it is necessary to improve the management efficiency and level through the design of electrical automation monitoring system. With the continuous development of electronics, communication, and computer technology, the electrical automation monitoring system of power plants also needs to be improved. How to scientifically design the model of electrical automation monitoring system and ensure its normal operation is the main problem that relevant R&D personnel needs to further solve in the future.

3. Design Mode and Function of Electrical Automation Control System

3.1. Design Mode of Electrical Automation Control System. The common design methods of electrical automation control systems mainly include centralized monitoring, remote monitoring, and field-bus monitoring, as shown in Figure 1:

(1) Centralized monitoring mode, as shown in Figure 1(a): when the centralized monitoring mode is used for electrical automation control of the power plant, the monitoring mode is easy to implement because of its simple design, easy specific operation,
and low requirements for software and hardware conditions of the control station. However, the centralized monitoring mode usually uses one processor to complete all functions of the control system, which not only increases the workload of the processor but also centralizes all functions of the control system. Therefore, one processor needs to monitor all electrical equipment. Since the cables used by various electrical equipment may be different, if all cables are connected to the main control machine, it will not only increase the load of the host but also increase the cost of cables [9]. In addition, the use of this mode for electrical monitoring usually increases the later maintenance tasks due to the complex wiring and inconvenient line inspection. Even during line detection or test, some misoperations may be caused due to the complex wiring.

(2) Remote monitoring mode, as shown in Figure 1(b): the remote monitoring mode mainly adopts the remote-control method for remote automatic control of the electrical system. When designing the remote monitoring mode, the combination of the electrical control system and remote monitoring mode is usually adopted. During the specific implementation of remote monitoring, the transmission signal may be disturbed by the outside world, resulting in the deviation of remote monitoring information [10]. Therefore, when the electrical control system adopts the remote monitoring mode, it generally needs to use the channel compilation technology to convert all received signals into corresponding codes to ensure the accuracy of the electrical control system through the normal transmission of signals. At the same time, the remote monitoring mode is adopted in the electrical control system to transmit the external signal to the electrical control system, then convert it into remote instructions through the system, and use the electrical control system to control the relevant objects, to realize the remote-control function of the electrical automation control system. When the remote monitoring mode is used for electrical automatic control, it can save a lot of cables, labor cost, and site and has the advantages of good reliability and installation flexibility. Because the communication speed of field-bus such as can is low and the communication volume between electrical equipment of power plant is large, although this remote monitoring mode can be applied to the small unit control system of the power plant, it is not suitable for the electrical automation control system of the whole plant.

(3) Field-bus monitoring mode, as shown in Figure 1(c): the design of electrical automation control system using field-bus monitoring mode is the most widely used way at present. This mode has a flexible design...
and good stability and can save a lot of cables, and
the system has a monitoring function [11]. Therefore,
it only needs to install some relevant intelligent
control equipment to connect the monitoring system
with the equipment. This mode uses different in-
telligent devices to realize the remote monitoring of
the system, which can not only improve the work
efficiency of the electrical control system but also
save a lot of costs. At present, many electrical au-
tomation control systems use field-bus monitoring
mode to connect the monitoring system with various
intelligent devices and manipulate and manage the
control object through information transmission,
which can not only effectively control the specific
working process of the object but also enable the
control object to complete various tasks orderly. In
addition, when the field-bus monitoring mode is
adopted, the functions of relevant intelligent devices
are independent of each other, each device is only
connected through the network, and the network
organization form is flexible. Therefore, the reli-
ability of the whole monitoring system is high, and it
only has a certain impact on relevant components in
case of equipment failure. In recent years, field-bus
monitoring mode has been the most widely used
mode of power plant electrical monitoring system.

3.2. Function of Electrical Automation Control System.
The electronic automatic monitoring system generally has
the following five functions:

(1) Data acquisition, monitoring, and transmission
functions: the main task of the on-site measurement
and control unit in the electrical monitoring system
is to collect the on-site data, monitor the relevant
events, equipment operation status or faults, pass the
data rationality test, and preprocess and update the
data in real time. The collected data signals include
analog quantity, pulse signal, and equipment
status. The collected analog signals mainly include
current, power, and voltage. The collected status
signals mainly include relay protection equipment
or instruments and monitoring signals. The col-
lected pulse signals mainly include various electric
energy.

(2) System monitoring, result display, and alarm: two
different terminals in the electrical monitoring sys-
tem use the display to synchronously display the
monitoring information of relevant equipment.
When the analog signal monitored by the system is
out of limit, the alarm device is used to display the
specific name, parameter, number, time, and other
alarm information of the out-of-limit object. At the
same time, by counting the times of exceeding the
limit of the analog signal, it can provide a reference
for the maintenance and fault treatment of relevant
equipment. In addition, in addition to the need to
give an alarm in case of an accident, it is also
necessary to prevent the occurrence of relevant ac-
cidents through an early warning in case of no ac-
cident but a possible accident. For accident alarm
and fault early warning, different warning light
colors and alarm sounds can be used to distinguish.

(3) Event log: when the monitoring system finds that
relevant equipment fails during operation, it can
record the status information of the relay protection
device, circuit breaker, and safety device, including
the name, number, and status of relevant signals.
Then, the event results are generated according to
different time series of fault occurrence, observed
through the display, or stored in the hard disk so as
to provide the basis for further analyzing the cause of
equipment or system fault and judging the protec-
tion equipment.

(4) Manage electrical equipment and handle fault in-
formation: by tracking, protecting, or setting the
status of electrical equipment, establishing equip-
ment accounts and archives, and monitoring in-
formation and other records, the equipment can be
managed online in real time. According to the op-
eration process of the equipment, record its working
status and supplement the operation data of the
equipment through the background management
information system. For equipment faults, the sys-
tem records or analyzes the status and abnormal
event information during operation in real time,
repeats the accident in time, and finds and analyzes
the cause of the accident so as to reduce or avoid the
accident as much as possible.

(5) Automatic control of power generation: through the
preset power generation conditions, the power
generation of the power plant is automatically
controlled to ensure the normal operation and
management of the monitoring system. In the
process of automatic control of power generation, it
is necessary to consider different working conditions
of relevant equipment in the actual operation process
and take into account the unit equipment of the
whole plant to formulate a relevant real-time control
scheme. Therefore, it is necessary to uniformly
manage the number, combination mode, and load
condition of relevant unit equipment in the power
plant so as to make the system working frequency
and set power consistent with the preset value so as
to ensure that the power plant can realize the au-
tomatic regulation of power generation.

4. CAN Bus Communication Mode

4.1. CAN Bus Overview. Fieldbus is called computer LAN in
the application field of automation technology. It can
provide technical support for a distributed system to
complete real-time and reliable data communication. CAN
is a type of fieldbus that can provide serial communication
network technical support for a distributed control system
or real-time control system [12]. As a multimaster local
network, the local area network can connect can controllers of different single-chip computers to the CAN bus. CAN bus has good error detection function and arbitration function, strong antinoise and interference ability, communication rate up to 1 MB/s, and communication distance up to 10 km. Therefore, the CAN bus is more and more widely used in the electrical automation control system.

CAN bus works by a serial data communication protocol. CAN bus communication includes the physical layer and data link layer of CAN protocol, which can process the communication data. CAN protocol uses communication data block coding to replace the traditional address coding method so that the number of network nodes is not limited, and the identification code of the communication data block is generally composed of 11-bit or 29-bit binary numbers. Therefore, 211 or 229 different data blocks can be constructed. Using this data block coding method is conducive to different nodes to receive the same data. Generally, the data length of eight bytes can meet the basic requirements of control commands, working states, and test data in the industrial field. Moreover, the eight-byte data length occupies a short bus time, which can make the communication real time. CAN protocol has the function of error detection and processing, which makes the data communication reliable. Compared with other communication buses, the data communication reliability of the CAN bus is higher, more practical, and flexible [13].

CAN is mainly divided into three different levels: CAN target layer, CAN transmission layer, and physical layer. As shown in Figure 2, the target layer is mainly used to search the sent message, detect the message usage from the transport layer, and connect the port of the relevant application layer. The transport layer is not only used to transmit frame information, detect and calibrate errors, and analyze fault causes but also to determine whether the bus is open for use or whether it receives information immediately. The physical layer is mainly used to transmit information about the electrical characteristics of equipment and different nodes.

4.2. Analysis of Communication Protocol of CAN Bus. When CAN bus is used for data transmission, the transmitter is generally used for message sending tasks. When the CAN bus is idle, the unit is used as a transmitter, and when the bus is not idle and the unit is not a message transmitter, the unit is used as a receiver. Whether it is a message sender or receiver, the message effective time is different. When sending a message, if there is no error at the end of the frame, the sent message is valid. If there is an error in the message sending process, the message is allowed to be resent automatically according to the priority principle. As long as the CAN bus is idle, any message can be transmitted through the bus together with other messages. Similarly, when receiving a message, if there is no error at the end of the frame, the received message is valid.

The transmitted message usually adopts four different frame representation and control modes: the data frame contains relevant data information and is transmitted from the transmitter to the receiver, the remote frame sends the data frame with the same identifier through the bus unit in the form of request, and the error frame can be sent by any unit through the bus, while overload frame is to send the delay information between data frames or remote frames through the bus. In addition, according to the distance between frames, the data detection and remote frame can be distinguished from the current frame.

CAN bus transmits data in the unit of the data frame. Data frame is the main carrier for data or instruction transmission between different nodes on the bus [14]. The data frame usually includes seven parts: frame initial bit, arbitration bit, control bit, data bit, CRC bit, response frame, and frame end bit, as shown in Figure 3.

The data receiver can initialize each source node by transmitting a remote frame. Unlike data frames, remote frames usually consist of six different bits and do not contain data bits. The error frame includes two bits, one for error marking and the other for error judgment. Among them, error markers are divided into error activity markers and error confirmation markers. The error activity marker contains six different dominant bits, while the error confirmation marker contains six different recessive bits. When it is covered by the dominant bits of other nodes, it needs to be relabeled.

Overload frame includes overload mark and overload out of bounds mark. Usually, there are two events causing overload frame transmission in CAN communication protocol: one is the need to delay the reception of the next data frame or remote frame and the other is the occurrence of dominant bits during detection [15]. There are two possibilities for sending overloaded frames: one is the first bit cycle when idle, and the other is the detection of dominant bit signals when idle. The overload frame marker has six hidden bits, while the overload out of bounds marker has eight hidden bits.

Interframe gaps are used to separate data frames, remote frames, and other different frames. There are no interframe gaps before overloaded frames and error detection frames, and there are no interframe gaps before overloaded frames. Interframe space bit includes intermittent bit and bus free bit. When a message error occurs, there is also a pause bit.

Figure 2: Hierarchical model of CAN node.
are composed of four octets. Unit identifiers have the same structural characteristics and entity. For different application service data units, their data in the application layer includes a data unit identifier and a data information service protocols commonly used by different users; for different network applications and specifies the information service protocols commonly used by different users; that is, all protocols that user applications need to belong to the application layer. The application service data unit in the application layer includes a data unit identifier and a data entity. For different application service data units, their data unit identifiers have the same structural characteristics and are composed of four octets.

5. Model Construction of Electrical Automation Monitoring System

5.1. Structure Design of Electrical Monitoring System. The electrical automation monitoring system of the power plant is mainly designed using the distributed architecture mode, and the whole system is organized in a hierarchical manner. Each layer is composed of different equipment or subsystems and has certain functions. The system equipment is mainly located in the station control layer and field protection measurement and control layer, that is, the unit layer, which is composed of different generator set subsystems and common terminal systems [16, 17]. Considering that some equipment protection devices do not contain CAN interface but only have general interface; therefore, CAN and general interface converter are set in relevant monitoring and protection units, and each unit equipment communicates through CAN bus. The station control layer contains various monitoring hosts and other equipment required by the system. Information is transmitted between hosts in the station control layer and between the monitoring host and the unit layer through Ethernet. The electrical monitoring system comprehensively uses the existing electrical automation monitoring technology of power plants and substations and enables the power plant to operate smoothly by effectively monitoring the operation process of the electrical equipment and system of the power plant. As shown in Figure 4, it is the structural diagram of the electrical automation monitoring system.

The power plant electrical automation monitoring and management platform can use the client/server working mode, which is composed of host monitoring center, communication workstation, operation monitoring station, maintenance service station, and other modules. The operating system can use a Windows NT workstation. The collected field data information mainly includes analog quantity, AC quantity, pulse quantity, temperature quantity, and other signals of relevant equipment. Based on data processing, analysis, alarm, protection, report statistics, and other operations, it sends relevant instructions to the field measurement and control unit layer so as to regulate and manage relevant electrical equipment.

The host monitoring center mainly monitors and remotely controls the equipment operation parameters of the lower measurement and control unit. The communication workstation is mainly used for the connection and information sharing of various systems in the power plant so that the mobile terminal and home workstation can access and maintain the electrical automation system in real time. The operation monitoring station is mainly used for real-time monitoring of the operating conditions of the electrical system and equipment and can realize automatic meter reading, fault detection, and equipment management. The maintenance service station is mainly to facilitate the equipment maintenance personnel to maintain and monitor the system background database, electrical equipment terminal, and fault information.

The electrical automation monitoring system can be connected with different workstations through high-speed and reliable CAN bus. For example, the subsystems contained in each unit layer are mainly connected with the communication workstation through the CAN bus. In order to improve the reliability of communication, two-way network interconnection can be adopted between different workstations. When one of the network lines fails, the system can maintain a single network operation and repair the network line in time through alarm so as to ensure that the system is always in operation.

5.2. Real-Time Data Monitoring and Processing Method of Electrical Monitoring System. The electrical monitoring system adopts human-computer interaction to monitor the state of each monitored object. Due to the complexity of the monitored field objects and the large amount of data to be processed in the interaction process between the system and objects, it is necessary to establish a real-time database as the core of data processing, data organization, and management of the electrical monitoring system.
The real-time database management system needs to configure the information of different sites in the real-time database and describe the characteristics and attributes of each site in the database. This is the configuration function of the real-time database and the premise for the system to run. According to the different site information of the configuration database, establish the pending database, event database, rule database, and historical database [18]. Then, according to the different priority sizes of events, the transaction threads to be processed are established, and then the transactions are processed, and the access interface is provided for external applications. As shown in Figure 5, it is the structure diagram of the real-time database of the electrical monitoring system.

In the process of monitoring electrical equipment at all levels, if abnormal data are found, motor protection measures are generally taken to deal with equipment faults. Because temperature is the main factor that directly threatens motor safety, the characteristics of motor damage are generally overheating and burning loss [19]. The calculation formula of equivalent current $I$ of motor overheating protection is as follows:

$$I^2 = k_1I_1^2 + k_2I_2^2,$$

where $k_1$ and $k_2$ are motor overheating protection parameters. $I_1$ and $I_2$ are stator positive sequence current and negative sequence current of motor, respectively.

The equivalent current is used to represent the heating caused by various losses, including stator and rotor copper consumption. The heat source expression is as follows:

$$\Delta T = 3I^2(P_1 + P_1') = 3(k_1I_1^2 + k_2I_2^2)(P_1 + P_1').$$

When the motor is heated and the temperature reaches the alarm critical temperature value, the overheating protection of the motor will send an alarm signal. When the temperature reaches the trip critical temperature value, the overheating protection of the motor will act on the trip. The temperature calculation formula of overheating protection is as follows:

$$T = \frac{\lambda}{I^2 - \theta^2},$$

where the heating temperature $T$ is based on the motor setting current $I$. When $I \leq \theta$, the overheating protection does not act. $\lambda$ is the adjustment parameter, and the value range is $\lambda = 160 \sim 2300$.

Thermal overload is used to prevent motor overheating caused by equipment overload and stator disconnection. It can also play a backup protection role in case of short circuit, long starting time, and other faults of the motor [20]. When the overload is greater than 75%, an alarm signal is sent, and when the overload is greater than 100%, a trip signal is sent. Inverse time limit protection element is adopted for overload protection. The protection action time limit is related to the current in the protected line, and its calculation formula is as follows:

$$t = \frac{\zeta \times T_0}{k_1 \times (I_1/I_0)^2 + k_2 \times (I_2/I_0)^2 - \theta^2},$$

where $\zeta$ is the inverse time coefficient, $T_0$ is the heating time constant of the motor, and $I_0$ is the rated current of the motor.

In the process of monitoring real-time data by the electrical monitoring system, it is necessary to process the information collected at different sites in real time, as shown in Figure 6, which is the real-time data processing flow of the monitoring system.

It can be seen from the figure that after the data collection and processing of the site, the collected values of the site can be compared with the standard values according to the requirements of the electrical equipment work specification. When the real-time acquisition value of the site is greater than 1.1 times the standard value, the system will give an alarm. When the real-time acquisition value is greater than 1.2 times the standard value, the system will automatically trip to ensure that the equipment will not be damaged. Therefore, once the equipment has load fault, overheating fault, short circuit fault and other related faults,
it will automatically send out an alarm. The operator can avoid the automatic tripping of the system by detecting the cause of the fault and eliminating the alarm in time. At this time, the maintenance personnel shall immediately check the equipment fault and eliminate the fault so as to restore the power supply as soon as possible.

6. System Test and Result Analysis

In order to analyze the effectiveness and feasibility of the electrical automation monitoring system proposed in this article, the system test is carried out with the comprehensive measurement and control protection device and data intelligent acquisition unit of the power plant as the object. The comprehensive measurement, control, and protection device of the power plant is designed with a high-performance and reliable chip to ensure the reliable operation of the device.

The device uses the communication port of the CAN bus to monitor the condition of the circuit breaker and control the tripping and closing switch. When the device detects an abnormal condition, it will automatically record the abnormal event and transmit it to the station control layer. At the same time, the protection function will be locked to prevent the device from abnormal action. In addition, the operation interface or other application software provided by the device can be used to monitor the hardware circuit, such as AC input circuit and switching value input or output circuit.

All protective devices used in the test have the cascade function of upper and lower layers. When the protection action of the next level occurs, the output node is automatically provided to lock the upper-level protection device. At the same time, the upper-level protection device receives the signal sent by the next level through the interface. When the cascade locking signal is received, an early warning signal is sent. If the lower switch refuses to operate, the upper protection device will start relevant operation after setting delay. When this signal is not received, the relevant operation will be started immediately.

Transformer protection devices are commonly used to protect large- and medium-sized low-voltage dry-type transformers, in which vacuum switch and F-C circuit are mainly used. Different types of protection actions in transformer protection devices are shown in Table 1. The
motor protection device is commonly used to protect the equipmen
of different measurement and control units, mainly using a vacuum
switch and F-C circuit. Different types of protection actions in motor
protection devices are shown in Table 2.

The electrical automation monitoring system of power
plant needs many types of equipment and wide distribution
and also has a strong correlation between different equip-
ment and high requirements for operating conditions.
Therefore, the electrical automation monitoring system of
the power plant usually needs to set up a master control

| Table 1: Transformer protection control mode. |
|-----------------------------------------------|
| **Protection method** | **Control mode** | **Output result** |
|----------------------|-----------------|-----------------|
| F-C circuit          | Overload protec-
|                      | tion            | Tripping opera-
|                      | Grounding pro-
|                      | tection         | tion            |
|                      | Equipment fault
|                      | alarm           | Alarm signal   |
|                      | Temperature trip|                 |                 |
|                      | Temperature alarm|                |                 |
|                      | Fuse protection |                 |                 |
|                      | Grounding pro-
|                      | tection         | Alarm signal or
|                      | Short circuit pro-
|                      | tection         | trip            |
|                      | Equipment fault
|                      | alarm           | Alarm signal    |
|                      | Temperature trip|                 |                 |
|                      | Temperature alarm|               |                 |
|                      | Overload protec-
|                      | tion            | Tripping opera-
|                      |                | tion            |

| Table 2: Motor protection control mode. |
|----------------------------------------|
| **Protection method** | **Control mode** | **Output result** |
|----------------------|-----------------|-----------------|
| F-C circuit          | Overload protec-
|                      | tion            | Tripping opera-
|                      | Undervoltage pro-
|                      | tection         | tion            |
|                      | Equipment fault
|                      | alarm           | Alarm signal   |
|                      | Locked rotor pro-
|                      | tection         | Tripping opera-
|                      | Fuse protection | tion            |
|                      | Start timeout pro-
|                      | tection         | Tripping opera-
|                      |                 | tion            |
|                      | Locked rotor pro-
|                      | tection         | Tripping opera-
|                      | Short circuit pro-
|                      | tection         | tion            |
|                      | Equipment fault
|                      | alarm           | Alarm signal    |
|                      | Undervoltage pro-
|                      | tection         | Outlet locking
|                      |                | and alarm       |
|                      | Start timeout pro-
|                      | tection         | Tripping opera-
|                      |                 | tion            |

| Table 3: Remote substation and its equipment composition. |
|----------------------------------------------------------|
| **Remote substation** | **Equipment name** | **Equipment code** |
|-----------------------|--------------------|--------------------|
| Transfer station      | Dust catcher       | E1                 |
|                       | Iron separator     | E2                 |
|                       | Belt conveyor      | E3                 |
|                       | Electric tee       | E4                 |
| Coal crushing station | Coal crusher       | E5                 |
|                       | Belt scale         | E6                 |
|                       | Vibrating feeder 1#| E7                 |
|                       | Vibrating feeder 2#| E8                 |
|                       | Belt conveyor      | E9                 |
|                       | Electric tee       | E10                |
| Raw coal bunker station | Coal plough      | E11                |
|                       | Belt conveyor      | E12                |
|                       | Electric tee       | E13                |

In order to verify the effectiveness of the monitoring
system in this article, taking the number of equipment fault
trips and power outage time as comparison parameters, the
working conditions of relevant electrical equipment are
monitored in real time by manual mode and electrical
automation monitoring system, respectively. The compari-
sion results are shown in Figures 7 and 8. Figure 7 shows the
comparison results of fault tripping times of relevant
electrical equipment in 2019 and 2020, and Figure 8 shows the comparison results of fault outage time of relevant electrical equipment in 2019 and 2020. Manual operation mode was adopted in 2019 and automatic electrical monitoring system mode was adopted in 2020.

It can be seen from the comparison results in Figures 7 and 8 that compared with the control of electrical equipment by manual operation in 2019, the fault tripping times and power outage time of each equipment after running the electrical automation monitoring system in 2020 are significantly reduced.

7. Conclusion

With the rapid development of automation technology, communication mode, and artificial intelligence, the electrical automation monitoring system can not only provide a technical guarantee for the normal operation of modern power plants but also improve the work efficiency and economic benefits of enterprises to a great extent. Starting from the control standards and functional requirements of electrical equipment in existing power plants, this article expounded the advantages of CAN bus technology in realizing automatic control and communication of electrical equipment. Combined with the structural design requirements of the electrical automation monitoring system, the real-time data monitoring and processing method of the electrical monitoring system was given, and the electrical automation monitoring system model of the power plant was proposed. Through experimental test and comparative analysis, the results showed that the electrical automation monitoring system proposed in this article can monitor the operation status of electrical equipment in real time and has certain effectiveness and feasibility. The electrical automation monitoring system model proposed in this article can also provide technical support and theoretical reference for further improving the control mode of power plant electrical equipment.
**Data Availability**

The labeled dataset used to support the findings of this study is available from the corresponding author upon request.

**Conflicts of Interest**

The author declares no conflicts of interest.

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