Application of Intelligent Technology in Electrical Engineering Automation Control

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Abstract. Aiming at the problems of low control precision and complex control process in electrical engineering automation control, this paper proposes a kind of intelligent electrical engineering automation control technology based on DeviceNet. This paper focuses on the development process, communication protocol and object modeling method of DeviceNet universal I/O interface based on microprocessor. At the same time, this paper designs the application layer software, and gives the detailed hardware circuit and software design process. The experimental results show that the method can reduce the complexity of the control process and improve the control accuracy.

Keywords: DeviceNet, Data fusion, Control precision

1. Introduction
With the penetration of network technology into the field of industrial control, the industrial control network has been produced. It is widely used in the control of production and living equipment, and the state detection, monitoring or control of the production process [1]. Technically, it requires a high degree of reliability, real-time and security [2-3]. In addition to conventional microcomputers and workstations, its network nodes are more intelligent electrical equipment and instruments with computing and communication capabilities [4]. Therefore, the main characteristics of intelligent electrical appliances are [5-7]: the products are embedded with microprocessors, have communication interface, can be connected with field bus, and adopt network standardized structure. It not only completes various control tasks on site, but also undertakes the network remote collection, transmission and control functions of all kinds of information, that is to realize the networking of information control and management. With the rapid development of control network structure, the types of protocols increase and the protocol standards are different, resulting in many problems, which begin to affect the further development of control network, and also become the main factor affecting the research and development, production, engineering application and promotion of intelligent electrical appliances. Therefore, as a node in the control network, intelligent electrical appliances are often applied in industrial field. In the current situation of coexistence of various bus systems, the research on interconnection technology of control network and control network specification of intelligent electrical appliances has become the focus of attention of users and manufacturers [8]. At present, system level integration (OPC based system level integration) and device level integration (gateway based device level integration) are mainly used to solve the interconnection problem of
heterogeneous control networks.

2. Control network system structure based on DeviceNet Bus

Intelligent electrical equipment is used to achieve information control and management of the network, is from the analog signal control mode into the field bus network control mode, to achieve network, open, decentralized, fully digital control. The control network system structure based on DeviceNet Bus is shown in Figure 1, which is mainly composed of three parts: DeviceNet Bus, upper computer (master station) and intelligent electrical node (slave station).

![Figure 1 Control network system structure based on DeviceNet Bus](image)

DeviceNet is the device level network of the second class bus in the international standard IEC61158, and also the second type of bus recommended by the international standard IEC62026 controller device interface (CDI) for low voltage switchgear and control equipment ". China has published the national standard GB / T18858.3-2002, which is equivalent to this standard. DeviceNet is a field bus based on CAN bus technology. It inherits the advantages of CAN bus. Due to the small amount of communication data in the intelligent electrical appliance control network system that can be realized by intelligent electrical appliance node itself. Therefore, we can make full use of the characteristics of DeviceNet to configure the communication data well to meet the requirements of real-time, security and reliability.

The upper computer (including DeviceNet interface card) realizes high-speed data exchange between intelligent appliances and host PC, which is mainly responsible for the management and scheduling of the whole intelligent electrical control network system; at the same time, the host can connect to Ethernet through the built-in network card or modem, and exchange data with the subnet composed of other bus lines on the Ethernet. At present, there are commercial DE vicenet bus PC interface cards.

Electrical control process is the most important part of the whole electrical automation operation process. If the automation operation is realized in the electrical control process, in the whole electrical automation operation process, the work efficiency will be greatly improved, and the operation cost and labor cost will be reduced. In the field of electrical automation control, the application of artificial intelligence technology mainly focuses on neural network control, fuzzy control and expert system. In order to analyze the application of artificial intelligence technology in electrical automation control, this paper takes the fuzzy control in electrical automation control as an example. The fuzzy control plays a role in electrical drive mainly through DC and AC drive. Among them, DC drive control mainly includes Sugeno and Mamdani. The main exception is the application of Mamdani in speed control. In AC drive, artificial intelligence is mainly realized by fuzzy controller.

3. Hardware circuit design of DeviceNet general I / O

The hardware circuit mainly includes two parts: DeviceNet Bus and data I/O (sending and receiving of messages), as shown in Figure 2.
3.1. DeviceNet Bus communication interface

(1) Data acquisition and processing function. This function can realize the data acquisition of switching value and analog value of electrical equipment, and can also realize the data processing and storage under certain conditions;

(2) System operation monitoring and time alarm function. This function can not only realize the real-time monitoring of the analog value of the main equipment of the electrical system, but also realize the effective intelligent monitoring of the switching value state of the equipment, which has the function of accident alarm exceeding the limit; it can also alarm the events whose state changes; it can record the events in sequence and deal with the accidents In addition, it has the functions of sound and light, image, telephone alarm, etc;

(3) Operation control function. With the help of keyboard or mouse, the artificial intelligence automatic control of electrical system can control the circuit breaker and electric disconnector to adjust the excitation current. According to the sequence control procedure, the operators of electrical system can realize the synchronous grid connection with load or shutdown operation. In addition, in order to meet the needs of all levels of system operation on duty, the electrical system will also limit the operation authority of operators;

(4) Fault recording function. This function is mainly manifested in analog fault recording, sequence recording, switch displacement and waveform capture..

Figure 2 I/O hardware circuit diagram of DeviceNet Bus

The microprocessor 78E58 is an 8-bit single chip microcomputer with built-in watchdog, which is compatible with 52 single chip microcomputer instructions and supports KeilC51 programming.

The interface circuit is shown in Figure 3. After the normal initialization of the system, when a node on the bus needs to send information to the bus, it first judges whether the bus is in the idle state, and sends the encapsulated information to the bus when it is idle. The node on the bus receives the bus information and carries out the acceptance of the code bit to judge whether it is the information sent to the node, whether to receive or stop receiving. When SJAI000 receives a frame of information, SJAI000 generates an interrupt signal, which causes the external interrupt of 78E58. 78E58 obtains the receiving information from sjai000's receiving buffer, which makes the receiving buffer empty so that the CAN node can receive new information.

Figure 3 DeviceNet interface circuit

Among them, the two bits of 8-bit dial switch are used for setting node address of intelligent appliances (the bus can hang 64 nodes at most). The display combination of two LEDs is used to
display the results.

3.2. Data acquisition I / O circuit
It is mainly composed of AI / AO (analog input / output), di / do (digital input / output), etc. under the control of single chip microcomputer, various data of intelligent electrical appliances are sent to the upper computer through DeviceNet Bus communication interface, or the control commands and data of upper computer are transmitted to intelligent electrical appliances. Therefore, this part of the circuit is different according to the actual functions of intelligent electrical appliances. This design adopts 8-channel AI, 2-channel AO, 8-Channel DI and 8DO. AI uses the combination logic of CD4051 array unit to make address gating and A / D conversion through serial A / D MAX1247; D / A conversion is realized by MA X532 with two analog outputs; digital input / output consists of data buffer 74HC245 / data latch 74HC37 and optocoupler.

In addition, the voltage provided by DeviceNet Bus is + 24V, while the control system uses + 5V. Therefore, it is necessary to convert the bus voltage. The DC-DC power module HZD05-24S05J is used to realize the single channel conversion from 24V to 5V.

4. Protocol analysis and software design of DeviceNet application layer
DeviceNet protocol specification is a set of protocol to describe the connection and exchange of data between DeviceNet devices, which is described by object-oriented method. The object model of I / O node device should be established on the basis of familiar with DeviceNet protocol in application layer software design. The properties and behaviors of objects, the interaction between objects, the trigger conditions of state transition of objects, and the operations that can be performed by objects in different states are clear. Then, the writing of various classes and the design of main program are carried out.

4.1. Message transmission of DeviceNet
There are two types of messages related to communication link: I / O message and explicit message. I / O message is suitable for real-time and control oriented data. The 8-byte data field in the I / O message data frame does not contain any protocol related information. Only when VO message is an I / O message segment formed by large packet segmentation, one byte in the data field is used by packet segmentation protocol. The connection identifier provides the relevant information of I / O message. Before I / O message is sent by connection identifier, the sending and receiving equipment of the message must be set first. The settings include the attributes of the source and destination objects, as well as the addresses of data producers and consumers. Explicit message is suitable for multi-purpose point-to-point message transmission between two devices. It is a typical request response communication mode. It is commonly used in node configuration, problem diagnosis, etc., such as setting attributes, obtaining attributes, etc.

4.2. Object model description of I / O node device
These level 4 addresses are combined with display message connections to transfer data from one point on the DeviceNet Network to another. The object model of the design node device is shown in Figure 4. It can be seen that it defines the behavior of the external physical interface of the device, such as the connection with other devices.
Figure 4 Object model instance of node device

Connection object: allocate and manage internal resources related to connection. All services and properties can be obtained by explicit information connection. The explicit request message is sent by the master station, and sending the explicit response message and unconnected response message to the master station to establish the connection.

Message router object: the object corresponding to an explicit message in the router, which can connect the message router to any object or instance in the device.

Identity object: provides the general identification information of the device. The instance attribute of the identification object is read by explicit message when the master station scans, and the master station identifies the node type by these attribute values.

DeviceNet object: provides important information about the status and configuration of the physical connection. Its instance properties include MAC ID and baud rate. In addition, it is also responsible for the receiving of group 2 unconnected explicit request message and the sending and receiving of node address duplicate detection message.

The main task of composition object is to combine the data and the system. The input / output data of equipment is structured by composite objects. The instance attribute defines whether the data is input or output.

The combination objects of this design include: polling input combination object, which is responsible for packing the data of 8 analog / 8 digital input objects for I / O polling connection objects; polling output combination object is responsible for unpacking the digital output and analog output received by I / O polling connection object for the use of switch output object and analog output object.

4.3. Predefined master / slave connection groups
Connections in DeviceNet provide a path to exchange information between multiple applications. When a connection is established, an identifier will be assigned to the transmission of connection related information, which is called connection identifier (CID). The group 2 allows the slave device to establish communication with DeviceNet with few resources, so a set of identifier is reserved in information group 2 to simplify the I / O data exchange and configuration data in the master / slave structure. The predefined master / slave connection group contains an explicit message connection and
several I/O connections. All configuration of the connection object is completed when the node is powered on.

4.4. Software design
The main program implementation steps are shown in Figure 5.

![Figure 5 Main program flow chart](image)

Interrupt service program is a function that describes the attributes of each object in the node device model, the completed services, and the connections and interfaces between objects at all levels of the network protocol. For writing each class, it is necessary to consider the attributes of the class to be written, the attributes of the instance (such as Revision and Data) and the services of the class and instance (such as Get-Attribute-Single, etc.). According to the above characteristics, the interrupt service program adopts the object-oriented programming technology (KeilC51), which regards the object as a module, each module has its own independence, and the service of each object class and instance is realized by the function and called by the main program. The whole system is a network structure composed of interrelated objects.

Instance properties are implemented by structs, and each instance is defined as a variable of the structure. Application object property contains application data. DeviceNet accesses application data by calling read and write functions. For example, Set-Attribute-Single means write access, Get Attribute Single means read access. The behavior of an object can be triggered by a service. Based on the attribute value of service access, service and attribute value together cause state change in the object. Communication interrupt service program is responsible for receiving and sending node message, which is shared by all programs.

5. Conclusion
Based on DeviceNet Bus, this paper presents the structure of intelligent electrical control network system. After completing the design of general I/O software and hardware of DeviceNet, a control network with three nodes is formed in the laboratory. The upper computer selects the general PCI-CAN card and writes the communication application program with VC + 10. It realizes the monitoring of network traffic, the establishment and transmission of messages. According to the design idea proposed in this development, DeviceNet interface can be easily provided for the existing intelligent appliances, so as to meet the requirements of modularization, digitization and networking.

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