The Application of CAN Bus in Intelligent Substation Automation System

Yuehua HUANG[1, a] , Ruiyong LIU[2, b], Peipei YANG[3, C], Dongxu XIANG[4,D]

[1]Department of Electrical Engineering, Three Gorges University, Yichang, 443000, China

[2]Department of Electrical Engineering, Three Gorges University, Yichang, 443000, China

[3]Department of Electrical Engineering, Three Gorges University, Yichang, 443000, China

[4]Department of Electrical Engineering, Three Gorges University, Yichang, 443000, China

[a]email: 805254454@qq.com, [b]email:liuruiyong163@163.com,[C]email: 308001859@qq.com

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Abstract. Aiming at the defects of CAN bus real-time communication in substation automation system, this paper introduces the application mode of CAN bus in the substation integrated automation system and the defect solution. This paper mainly implements the construction manner of CAN bus distributed network system, in this construction, the protection measurement and control unit in Substation spacing layer can exchange information and data through the CAN bus network. In this way, a efficient data communication network has been built. This paper focuses on the modified design of the network controller on hardware and software, through the advanced design of the photoelectric isolation module and the overall design on the program code writing ideas. In the photoelectric isolation module, 89C52 is used as the micro controller, in this chip, the send and receive interrupt subroutine is built. Comprehensive the above design, the CAN network communication problems in the substation automation system is solved perfectly.

Introduction

With the development of computer technology and detection technology, computer automation technology has become increasingly mature, the more intelligent and networked operating form of unmanned substation has become a trend in the development of the substation [1]. In this trend, higher requirements has been put forward for the communication of substation automation system: a high degree of effectiveness and good real-time performance, the interference of communications in strong electromagnetic environment [2]. This requires us to use high-speed, reliable communications network, and the same time use the efficient communication protocol.

For substation automation control systems, the hierarchical structure is shown in Figure.1:

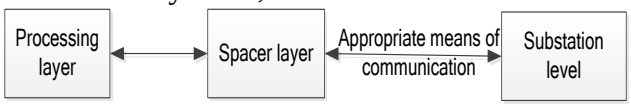

Fig.1. Ideal 35kV and under 35kV substation automation system structure

The structure of the system is mainly composed of three layers: the processing layer, spacer layer and the substation level. The field intelligent control equipment and protective devices are in the spacer layer, the local monitoring host and necessary operation screen belong to substation layer. The spacer layer and the substation level contact to each other through certain means of communication. In connection of spacer and substation level, the used means of communication should ensure the data has a high degree of real-time and complete fully shared of data under the premise of the rapid transmission, and then achieve hierarchical distributed control of automatic control.

The traditional RS232 and RS485 have obvious flaws in the transmission of ensuring the data reliable and real-time. For the traditional RS232, the communication mode of master-slave and the connection of point to point made it has a poor flexibility; for optimum performance of RS485, although improvements in flexibility, the number of nodes is limited, the network extremely inconvenient and poor real-time. Ethernet can achieve the automation control system, but erection

Ethernet and interface device are complexity and high cost. For substation automation systems with a limited amount of information communication, Ethernet does not have the cost performance advantage. In summary, the field CAN bus with multi-master communication mode can transmit large amounts of data, the bus can set a large number of nodes, high transmission speed and good real-time transmission, so it can take full advantage in the substation automation control systems.

Design Brief of Substation Automation System Based CAN bus

So far, CAN is the only international standard field bus, and its multi-master communication mode achieves sharing capabilities that any node in the network can send information to other nodes at any time initiatively, and regardless of master and slave [3]. In the selection of communication media, CAN bus can use fiber optic, twisted pair or fiber optic to communicate. In addition, the longest distance of CAN bus to communicate directly is up to 10km. Transfer rates is up to 1mbps (at this time the communication distance should be limited within 40 meters), in the case of a serious error, CAN node has a function to automatically turn off the output, so that the operation of other nodes on the bus can not be affected. Bus driver circuit determines the nodes number of CAN bus and it can be up to 110, when using the number of message identifier (29 bits) of extended frame, the nodes are basically unchecked. The adoption of Non-destructive arbitration technology in CAN bus makes that when there is a conflict caused by multiple nodes sending message simultaneously, the high priority node can uncontrolled transfer data preferentially and lower priority node will exit send data automatically [4]. Under heavy network load situations, such competition approach will greatly save arbitration time that the bus used when conflicting and then avoid the appearance of paralysis on the bus.

For the structure of substation automation system, the field CAN bus has some advantages in achieving communication, such as good real-time performance, good communication reliability and network convenience, but the same time CAN bus has some technical difficulties on the problems of taking into account the communication distance and real-time communication. The following table shows the relationship between the communication distance and communication rate:

Bit rate(kbps)	1000	500	250	125	100	50	20
Distance(m)	40	130	270	530	620	1300	3300

In order to solve the control of substation sub controller which distribution is more scattered in some cases, intending to increase network controller on the bus to increase communication distance of CAN bus, and ensure the real-time of data transmission in substation control room [5].

The figure 2 shows the design configuration diagram of substation automation system, CAN bus as a serial bus especially suitable for a system or subsystem which contains a group of intelligent device. The chart above shows the smart devices that the substation automation systems involved, CAN bus can be connected together via these devices, and in each node can detect the status of the other nodes

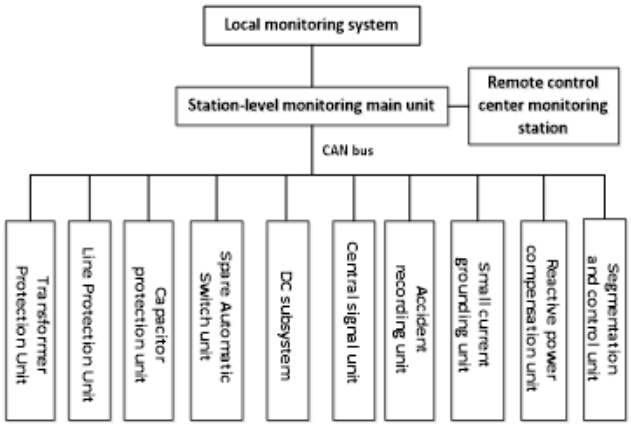

Fig.2. The structure of substation automation system

The design of substation automation system based on CAN bus connection mainly consists of three parts: background database management software design, front acquisition device design and system network design. Network design plays a crucial in the design of substation automation system role because the network is bridge that connects the server to each acquisition unit, and all state information is passed through the network. Since the mechanism of transfer of the bus as well as the characteristics, network data transfer interaction is the part most prone to failure and difficult to maintain in the entire information system which is directly affect the real-time and reliability of information systems. CAN bus as a communication bus in the system play a vital role on the reliability of system operation. Figure 3 shows the network topology of substation automation system.

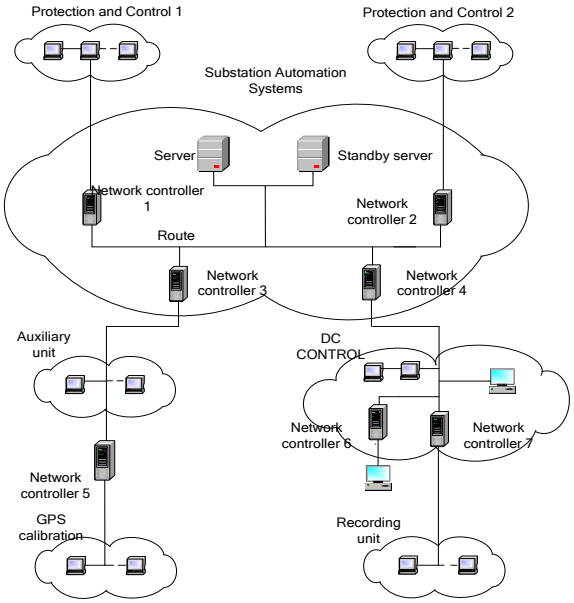

Fig.3. The network topology of substation automation system

Improvement Based on Network Controller Layer

CAN network controller is a network controller that have gateway, interrupt and packet filtering. CAN network controller increase the communication distance of CAN communication bus, and networking more flexible. Network controller has an important role in substation information system mainly includes the following three aspects:

First, the network controller has a relay function and the advantages of a relay. That is increasing the number of nodes on the CAN bus and increasing communication distance, improving the reliability of network communication; Second, having the typical characteristics of the gateway. Large-scale communications network can be decomposed into several separate, smaller subnet via the network controller, each individual subnet traffic than the traffic between the internal network will be greatly reduced, increasing of the network controller makes the communication efficiency between the whole network becomes higher; Third, filter traffic. Network controller has the function to identify the packet transmission direction, this filtering mechanism can send data selectively when the communication network is busy, at the time reduce the communication load on the network.

Network controller also brought the shortcomings of gateway and repeater mainly in:

When the network controller fails, the adjacent two subnets will be impacted. The frame information will be severe overflowed when the traffic load on the network is relatively large, and the storage forwarding of network controller will increase the delay of the nodes.

In the hardware design of CAN communications network controller, the design of entire main circuit consists of two parts: First, 89C52 chip as the network microcontroller among the hardware circuit of CAN bus communication system; second, the interface circuit (CAN controller) used to receive and send messages in the entire hardware circuit design. 89C52 chip as a microcontroller of

CAN communication network hardware circuit module is responsible for monitoring when information exchange on the entire CAN communication network, two CAN controller interface circuits with little difference on structure are component of the CAN network communications controller and optocoupler circuits, SJA1000 independent CAN controller and 82C250 circuits that responsible for receiving and sending data on CAN bus. Wherein the design of two-way CAN interface circuit based on the same design principles, CAN bus transceivers can optimize the design of two-way circuit through a separate and isolated DC/DC power module. Specifically, to achieve the distinction of CAN bus interface circuit that the two-way structure is roughly the same (electrical isolation) by this design. In addition, the design of hardware circuit that two separate power supply module without common ground is largely realized the isolating between the CAN bus and network controller. Such isolated design allows the occurred fault confine to a segment, when some problems or failure occurs in a network segment, other adjacent segment will not be affected, and then generating positive role in both maintaining stability of systems and ease to maintain. Figure 4 shows the hardware block diagram of the CAN network controller.

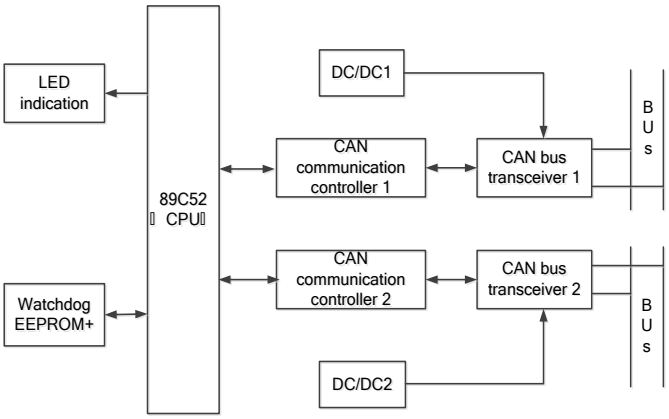

Fig.4. The hardware block diagram of the CAN network controller

Software design is also an important part in the design of CAN network controller, the design should be based on the characteristics and shortcomings of CAN bus communication, in software part should be able to solve part of the problem of missing the frame, and increasing the reliability and stability of the system. Based on the substation automation system described in this article, the main objective of the software design is to complete the forwarding of data real time without losing the frame between the two CAN network segments separated by network controller. CAN bus communication is a typical communication system characterized in real time, reducing the time of network controller during storing and forwarding messages to meet the needs of real-time, and because the storage space (internal storage capacity of 89C52 chip is only 256 bytes) inside the CPU on hardware chip of CAN network controller is relatively small, therefore, to shorten the time of storing and forwarding when designing the software, thereby solving the defects that each node delay growth after increasing network controller in the software part. In addition, the software design of network controller should follow the simplified system architecture principles. During transmission of data, using error control to control its reliability, but too much error control may reduce the operating efficiency of network controller, increasing risk of fault occurred, and thus should be simplified in the software design.

In order to achieve the above requirements, the way that the CPU receive data from network controller should be changed to interrupt mode in software design, and the coding should be streamlined as much as possible for improving the running speed of software, and using FIFO mechanism to manage the RAM inside CPU. In order to meet the design requirements, the software design of network controller includes four parts: Send and receive subprogram, the main monitoring program, CAN network controller initialization procedure.

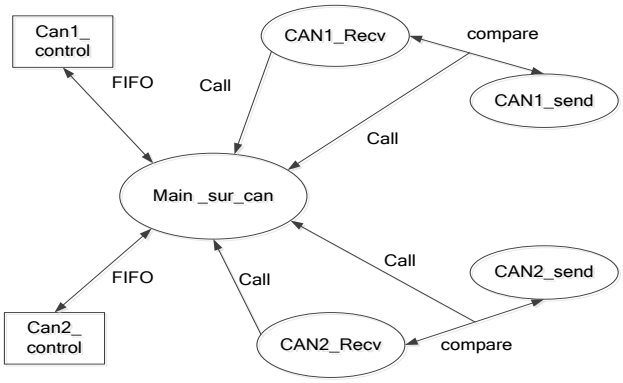

Fig.5. The software design schematics of CAN network controller

Improved Design Based Network Controller Layer

By using the configuration parameters of network communication of the CAN communication nodes to realize many functions of the substation automation system similar to the Ethernet IP address assignment. The main parameters of network equipment in automation system, including the distribution of the identifier (ID), acceptance codes (ACR), the acceptance of the shielding registers (AMR) and the set of parameters such as baud rate (BTR). Server network equipment parameters can be configured automatically and all parameters of the automatic or manual configuration are saved in the database server in the background.

The parameters of the simple network configuration, as shown in figure 6, we can see the server, network control and data acquisition terminal.

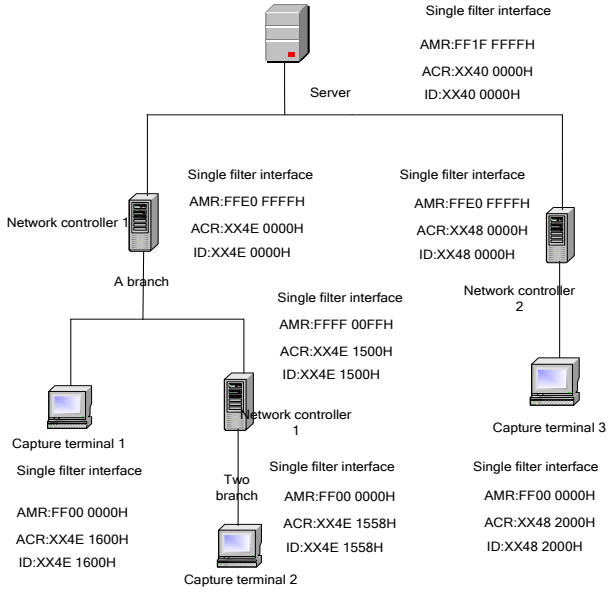

Fig.6. Network parameter configuration diagram

The expansion of system adopts expansion of the 29 frame model and identifier is directly related to the type of network equipment, so we should pay attention to the different definition of the identifier. In the substation automation system the lower three of the identifier is undefined, the high 8-bit used as fixed command byte. Identifier is allocated according to the following table 2 :

31-24	23-2	20-16	15-8	7-3
ID. 28-21	ID. 20-18	ID. 17-13	ID. 12-5	ID. 4-0
As the command byte	server	One network controller	Two network controller Or capture terminal	Acquisition Terminal

Substation automation system defines the communication protocol by the way that together the

ID, the combined data, command, and checksum with each other. And put the 21 new ID from 0 to 20 as a network device identifier, at the same time put the ID number from 20 to 28 as a command, the command not to participate in the filtering process. The data represents the specific content of communication and the check for a byte with the general form of the checksum. Ideally, the strength of 15 check is enough to meet its requirements, In fact many of the verification is not the case. The experiment adopted three simulated communication acquisition device that two use 80 kbps of the communication rate and another one uses 160 kbps. The total number of communication is 60 times per second, under the condition of the communication, the error probability of statistics found that 0.02% ~ 0.02%, when the communication rate of each machine is restricted, the error probability is reduced greatly. The above shows that in CAN bus network communication, despite the CRC check of the strength is large, errors often occur, however, and at the peak of communication (the number of communication is greater), the error rate is likely to also will rise. Because the required of the substation automation system to reliability is higher and most of the time and communication rate is larger, so we add a checksum byte in the application layer and complete the control of end to end error to enhance the reliability of communication.

Conclusion

The application of field bus on the field of substation communication control is becoming more mature, the corresponding problems also occur. Based on these issues, using the new principles and new technology to improve the reliability of CAN bus when communicating real time, thereby improving the level of automation of substation automation system.

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