

Analysis and Research of Process Control Adopting Field Bus Control System

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Abstract—Whether the field bus control system was available, real-time and reliable would relate to its process monitoring system accuracy, safety and stability, as well as affected the unit reliability and economic operation. According to the standards of the industrial Ethernet and the demands of the process control systems, the paper was studied and analyzed field bus control system technology in which it mainly included following: the communication protocol、 the configuration、 the message format、 the rate of data signaling and the network architecture. Results showing that the field bus system communication protocol、 the configuration and the message format are up to the standards of industrial Ethernet, and the reliability and security of field bus meet the requirements of process monitor.

Keyword: *Process control; Field bus; Availability; Real-time; Reliability*

I. Introduction

Field bus control system is a full open, full digital, distributed new control system, which realized the site equipment digitization and networking. In this paper, [2] combined with the characteristics of plant monitor, researched and analyzed the field bus communication protocol, the configuration form, message format, the rate of data signaling and the network construction, analyzed its availability, real-time performance, safety and reliability, in order to provides the basis for that the field bus control system could been applied to the power plant process control.

II. Analyzed to the field bus available

Field signals were transmitted to the monitoring system by the digital communication technology, all field instruments were smart, if the communication protocols, the topological structure and the form of message of the field bus system were in accordance with the industrial requirements, we would be considered that field bus system met availability requirements of the process control.

A. The form of field bus system communication protocol

Figure 1 was the comparative model between ISO/OSI Internet protocol and field bus. It could be seen from figure 1, field bus was similar to ISO/OSI Internet reference model and be accord with IEC61158 field bus network protocol standard. [1]

ISO/OSI protocol		Field bus model	
7	Application Layer	User layer	
		Function block service	Device description service
6	Presentation Layer	Application Layer	
5	Session Layer	The 3-6layer simplified, ellipsis	
4	Transport Layer		
3	Network Layer		
2	Link Layer	Link Layer	
1	Physical Layer	Physical Layer	

Figure1. comparative model between ISO/OSI Internet protocol and field bus.

ISO/OSI is an open, powerful, 7 layers protocol communication transmission network, it could fully solved any problems of the network transmission. By contrast, field bus focused on the certainty, real-time and reliability of the network communication, it used the

same hosts and routers, therefore, it were omitted and simplified the 4 layer network protocol (network layer, transport layer, session layer, presentation layer) in the OSI 7 layer network protocol. functions bore by 4 layers omitted were moved to the link layer and application layer in the field bus model, meanwhile, according to the field bus monitoring features and following the standard model protocol, the field bus model increased user layer. [1] Sum it up, because that the new technology of network development melted into field bus, it was more suitable for the factory, the process and the building automation control.

B. field Bus topology

Field bus was one kind of industrial local area network(LAN), it existed in the LAN of process instruments, the model was showed in figure 2, In case of PROFIBUS, the bus access protocol was as follows:

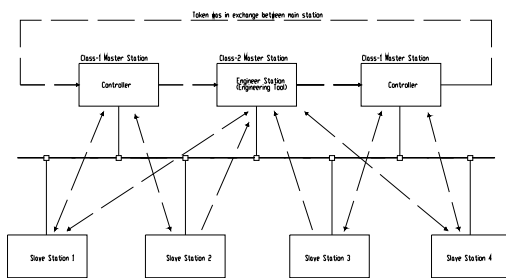


Figure 2. Field bus industrial local area network (LAN) model

1) PROFIBUSDP, PROFIBUSFMS and PROFIBUSPA was used the same bus access protocol. The agreement was achieved through second layer (data link layer) of the OSI reference model, it included data reliability assurance technology, transmission protocol and message processing, ensured that only one note was sent data in any one time.

2) PROFIBUS access protocol was used a token transfer mode between the master stations. Master-slave mode was used between master station and slave station, so as to ensure the communication between the master stations. At determined intervals, there were enough times finished the communication task in each note, so as to ensure that the real time data transmission were finished quickly and simply between the main stations and slave station. [3]

3) The token was only transferred between the Master stations the token transfer process ensured that each station got bus access right in a precisely defined time.

- Class -1 master station: It Completed control and management, generally refers to the DCS/PLC (distributed control system/programmable logic controller) with DP interface etc.
- Class -2 master station: It was responsible for the DP system configuration, network diagnosis, generally refers to the Engineer station.
- Slave station: PLC would be used as a slave station, drivers, sensors, actuators and other intelligent field devices would be used as a slave station.

C. Field bus message form

Field bus was complied with the following message form:

1) Between the class-1 master stations and the slave stations, master station sent a request message to the slave station and the slave station sent back the request response message, it included some information, such as diagnosis, parameter, configuration, data exchange etc.

2) Between class-2 master station and slave station, master station sent a request message to the slave station, and the slave station sent back the request response message, it included some information, such as diagnosis, parameter, configuration, data exchange, the setting value of the slave station address, the reading value of the input and output, the reading value of access configuration.

3) Between class-1 master station and class-2 master station, the task mainly included that realized the reading and downloading of configuration data, and reading class-1 master data message.

Above the information transmitted by the form of message 、 the control demand and the feedback information were in the data flow exchange, which belonged to the cycling data information, parameter setting, remote configuration, alarm information and the device transmitted fault diagnosis information belonged to the non circular data information. The master station was determined the relationship with the slave station through the parameterized message, it designated slave station operating mode, and then determined the type and nature of the slave station s' I/O by the configuration message. When abnormal, the faults were analyzed by diagnostic message, distinguished and identified the causes, troubleshooting in final. According to the input

data and the requirements of the production process, the information were processed by the process controller, operation results were sent from the master station to the slave station, slave station performed related operations, and then, slave station sent the new data back to the master station, realizing the process control.

Above the analysis, field bus protocols adopted, structure and the form of message kept with industrial Ethernet standards. Field bus met process control availability requirements.

III. Analyzed to the field bus real time

When field bus control technology was applied to the process control, the real-time of field bus related to whether the monitoring task was completed in the required time period, which is a key indicator. this chapter would analyzed the real-time of the related control system, PROFIBUS-DP bus was as an example, the data of PROFIBUS-DP bus transfer rate was up to 12Mbit/s.

PROFIBUS-DP bus response time was calculated following the formula.

$$\tau_{X\psi\chi\lambda\epsilon_ΔΠ} = (\nu\Sigma\lambda\alpha\pi\epsilon\sigma)(317 + 11\xi(\nu B\psi\tau\epsilon\sigma))\xi T\beta\tau \quad (1)[4]$$

In the equation, 317 was constant, which presented a data bit DP slave station established communication connection. $t_{\text{Cycle_DP}}$ was the response time of the bus cycle data information access; the first n presented the slave station number of PROFIBUS-DP ; second n presented the total data transmitted byte number of PROFIBUS-DP. Unit was byte.

The PA bus response time was calculated following the formula:

$$\tau_{X\psi\chi\lambda\epsilon_ΠΑ-χ\eta\alpha\nu\nu\epsilon\lambda} = (\nu\Sigma\lambda\alpha\pi\epsilon\sigma) (317 + 8\xi(\nu B\psi\tau\epsilon\sigma))\xi T\beta\tau \quad (2)[4]$$

In the equation, $t_{\text{Cycle_PA}}$ -channel PA was the response time of bus cycle data information access; T bit is that each bytes needed times, Unit was second. For $t_{\text{Cycle_DP}}$, it was 1/12Mbit/s. for $t_{\text{Cycle_PA}}$, it was 1/31.2Kbit/s.

The entire PROFIBUS-DP system response time was calculated following the formula:

$$\tau_{X\psi\chi\lambda\epsilon} = \tau_{X\psi\chi\lambda\epsilon_ΠΑ-χ\eta\alpha\nu\nu\epsilon\lambda} + \tau_{X\psi\chi\lambda\epsilon_ΔΠ} + \tau_{A\chi\psi\chi\lambda\iota\chi} \quad (3)[4]$$

In the equation, t_A cyclic was the response time of DP bus acyclic data access.

Above the calculations showed: the response time of a typical intelligent instrument connected by a PA bus was 10ms; the response time of a typical smart actuator connected by PA bus was 15ms; a PROFIBUS-DP slave station s' response time < 0.3ms; a DP Branch inquiry cycle was 2ms in PROFIBUS bus system, a PA Branch inquiry cycle was 80ms.

In the DCS technical specification, acquisition cycle requirements for the field signals were: At least, all analog input signals were scanned and updated 4 times per second, all digital inputs signals were scanned and updated 10 times per second. In order to meet the needs for some fast processing control circuit, the analog input signals were scanned 8 times per second, the digital input signals scanned 20 times per second. Thus, the real-time of PROFIBUS bus control can fully meet the general requirement of the processing input, output signal in a unit control.

IV. Analyzed to the Field bus safety, reliability

According to the safety, reliability requirements of the DCS technical specification, DCS design should be adopted suitable redundant configuration, an arbitrary component of the system failure would did not affected the whole system work; Control system should be considered in the functional and physical proper dispersion and met the functional and physical dispersion principle. DCS would be followed the single failure criterion, single fault did not caused other system fault. Therefore, this article would analyze whether the field bus control system in process control field could completed monitoring task in safe, reliable. It would be done from the three aspects segment design principle, dispersion, redundancy principle.

A. The segment designed

Signal strength varied with the change of the network line length, the field bus network normal running would be affected by the load capacity of master station, slave station and the load power supply capability. Based on

the PROFIBUS network as an example, according to the different distance, information transmitted rate would not be same in the master station DP line net.[4]

as follows: 1000m distance DP line information transmitted rate was 187.5KBIT/S; 400m distance DP line information transmitted rate was 500KBIT/S; 200m distance DP line information transmitted rate was 15MBIT/S; the distance of 100 m DP line information transmitted rate was 3.6~12MBIT/S.

Used optical fiber as follows: 15000m distance DP line information transmitted rate was 12MBIT/S. DP bus redundantly connected points was the 122 stations, DP station branch connection points was 32 stations, increased repeater DP branch connection points was the 64 stations, increased repeater after DP bus connected points was 244 stations. In the practical engineering application, considered the signal attenuation, DP branch connecting the stations were generally not more than 16 stations.

DP/PA branch network used twisted pair 1900 meters, information transfer rate was 31.25KBIT/s, network of connection slave station number was 32 stations, maximum transmission current of a bus was 1A. Considered the attenuation of the signal and load current in a bus limited ($\leq 1A$), DP/PA branch connecting the stations were generally not more than 8 stations.[5]

B. Dispersion

To the field bus system of the power plant, the safety and reliability of control were mainly improved through the network dispersion and the control dispersion. Through the design of the upper network regional divided and of the lower network risk management, it was done that a circuit fault does not affected another loop.

In the power plant monitoring circuit, in order to ensure the safe and economic operation of the unit, the control system and instrument configuration were presented the reliability requirements, mainly included: force draft fan, primary air fan, induced draft fan etc, these auxiliaries are double row in the unit, when distributed the bus network, control information were connected to different main process control stations. Such as Boiler air and gas system in A side measurement information were into the A main process control station, boiler air and gas system in B side measurement

information were into the B main process control station.

C. Redundancy

Through network redundancy, transmitter redundancy, bus power supply redundancy, link equipment redundancy, controller redundancy and field bus system redundancy was realized. In the project, all electric actuators and motor drive control units had redundant bus interface would were considered redundant bus connection; all the bus power supplies were redundancy configuration in the control systems.

V. Conclusion

Above the analysis for the plant field bus communication protocols, the configuration form, message mode, rate of information transmission, network construction, dispersion and redundancy design, we could seen that the field bus system used in power plant process control not only being feasible but also greatly improving the monitoring safety, reliability, more further, as part of digital power plant foundation, it would made it possible that digital power plant be realized.[1]

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