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Protocol Conversion Gateway Design for Fieldbus

Abstract. *The rapid development of the field bus technology, causing the diversity of communication network, not only brings users more options but also a lot of problems. Such as a variety of Profibus coexist and different industries and even enterprise communication standards coexist, sometimes even the production lines in the same shop can adopt different bus standards, therefore, the users will have to face a technology problem that a variety of bus and all kinds of communication protocol products should access the same kind of profibus. It is urgently to be solved to develop protocol conversion interface, making these supporting different profibus interconnect and achieving real data sharing. This paper developed a gateway, which introduces in detail the hardware platform scheme of the gateway, and the idea of software design. The gateway can be applied to different bus equipment connections, which is of great help to implement the network and intelligent automation system.*

Streszczenie. *W artykule przedstawiono schemat hardware'owy i koncepcję sterowania dla bramki w układzie sieci złożonej z wielu szyn Profibus, pozwalającą na sprawną wymianę danych między użytkownikami, korzystającymi z różnych protokołów i standardów. Bramka może być zastosowana w różnych konfiguracjach szyn, co pozwala na sprawną budowę systemów automatyki przemysłowej.* ***(Projekt bramki do konwersji protokołów w układzie Fieldbus).***

Keywords: Profibus, CAN, Gateway, Protocol conversion.
Słowa kluczowe: Profibus, CAN, bramka, protokół konwersji.

Introduction

The emergence of the field bus technology makes the Profibus data largely exchange and realizes the controller, instrument of intelligent control, distributed control[1]. Therefore, the coexisting situation of field bus with multiple standards is likely to last for a long time, and various bus equipments' mutual communication is a practical problem. In numerous bus products, bus gateway products occupy a big proportion. The field bus serial class gateway, whose purpose is to have RS - 232/422/485 interface equipment access field bus and industrial Ethernet[2]; Field bus, Ethernet connection gateway, and Ethernet in the industrial control field application is gradually mature day after day, through this kind of gateway different bus equipments will compose of a large network; by different connections of field bus standard between the equipment, this kind of product is mainly AnyBus - X products of HMS company. Anybus - X bus gateway is a new product line based on the Anybus technology. With the aid of supporting 17 kinds of fieldbus and industrial network Anybus technology, Anybus - X has more than 150 kinds of different models, which can realize almost connections between any two kinds of industrial network.

Anybus - X has more than 150 kinds of different models, which can realize almost any two kind of industrial network connection between. Anybus - X supports all mainstream field bus and industrial Ethernet, for example, PROFIBUS[3], DeviceNet, CANopen, CC-Link, ControlNet, Modbus Plus, Modbus TCP, EtherNet/IP, Profinet, etc. These technology researches and product applications have made progress, but they are all in either serial port to a single field bus conversion, or conversion two kinds of field bus, while to realize the serial port to a variety of field bus conversion in an interface, whose function is simple, flexibility is poor, can't meet many field bus needs to the practical industrial system. At present the mature protocol conversion method is the realization of the gateway[4]. This paper will take profibus-DP bus and CAN bus that widely used as example, researching the bus protocol conversion method, and using the high performance ARM processor and special agreement chip to build protocol conversion gateway.

Analysis of CAN Protocol and Profibus Protocol Conversion

1. Contrast Analysis of CAN and Profibus Protocol Address

To take CAN2.0 A frame structure as the foundation. The frame message format is shown as figure 1, A CAN2.0 A standard frame consists of 11 ID, a RTR, four DLC, and data area (up to 8 bytes).

ID10	ID9	ID8	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0	RTR
PRI	Source address (0-125)							TYPE			0
DLC (1-8)											
Destination address											
Data or index (1 byte)											
Data (1-6 bytes)											

Fig.1. The frame message format of CAN

PRI: Keep a position (as a priority position). Usually, it can be set to 1 and can be as a priority position, then 1 for low priority. For high priority and the rest of the priority up to the source address, and low address priority is high. The reserve function can effectively deliver the emergency information, such as alarm, etc.

Source address: Source address, said to send data node address, and range can only be set to 0-125.

TYPE: Frame type. Mainly includes single frame and multiple frame.

DLC: Each frame bytes (1-8).

Destination address: Destination address, said to receive data node address, and range can only be set to 0-125.

Index: Index byte. For single frame data, this byte represents the first byte of data transmission, and for multiple frame data, the byte represents the index byte, namely the frame data in the position of the packet.

Profibus has 127 station addresses, and address range is 0-126127 global address.

So we can uniformly address for all the Profibus devices and CAN equipments. As station address is the only one in the whole system, in the frame only when the frame transformation occurring, just to directly copy the corresponding bit address information into the station adress.

2. Protocol frame split and merge

If put the profibus long frame into the CAN of short frame inside, just only split the profibus frame data fractionation suitable for CAN frame the length of the transmission. The domain length of the CAN frame data maximzes only 8 bytes, of which two bytes are used as the destination address and frame index, so the rest of the six bytes are used for data transmission. In the longest Profibus data frame, there are 246 data bytes. Demanding 246/6 = 41 CAN frame to accommodate Profibus long frame, so during the frame transformation, just split Profibus protocol frame into six bytes of each part, plusing the

destination address and frame index CAN, such will become the content of CAN frame. After collecting the destination nodes then put them to be connected with reduction, as a result of achieving its information to be sent.

3. Protocol Conversion Realization Contrast

1) achieve project for SCM and software

Profibus is a totally open protocol which isn't related to the manufacturers and it is also an protocol standard without the protection of intellectual property. So every organization, institution or person around the world can offer the design scheme to Profibus[5].

In general, Profibus protocol can be realized in any main controllers. As long as we install the UART in the extension outside or inside the main controller, the protocol of data link layer can use the software to make exploration, which can finish the exploration of Profibus' interface.

However, this implementation has its own limitation, because the baud rate of monolithic integrated circuits is too low. typical equation should be as:

$$\text{baud rate}_{max} = \frac{f}{32} \times \frac{1}{(65536 - T)} = 750\text{Kbit/s} \quad (1)$$

where: f of monolithic integrated circuits is 24M and T = 6553.

Actually this is an ideal situation which is difficult to reach the above speed in the practical application. Although it is technically feasible to explore the interface of Profibus by using the monolithic integrated circuits, which has an advantage of the cost price, at the same it has some practical problems. It demands that the developers should know the details of Profibus' technology clearly, which can lengthen the cycle of developing products, make the technical indicators lower and the testing complex.

2) Dual-CPU architecture of the gateway design

The two kinds of CPU deal with these two bus protocols respectively and place the needed information into the dual-port RAM in order to share and transfer the information. This program is easy to control and the software is simple. Meanwhile, it reduces the CPU load and enforces the reliability. Although this method has been improved over the previous method, but the processing core is still a microcontroller which can only process the small amount of data instantly. When there are large amounts of data, the microcontroller can not be working timely.

3) ARM-based field bus protocol conversion

Currently, it is common to use ARM as the processor in the study of the field bus conversion. The advantage of this approach is that the above shortcomings of the data processing delay can be solved.

So, in this paper will be adopted with method 2 and 3 combined.

Hardware and Software of Protocol Conversion

1. Embedded Gateway Hardware System

According to the characteristics of embedded gateway, the ARM9 micro controller of Samsung, S3C2440 as a master control chip, and S3C2440 based on the core of ARM920T, 32-bit RISC processor, by adopting above structures the ARM920T realized very small, but the structure of high performance. ARM processor simple structure makes ARM kernel very small, which makes power device very low. With the address bus and data bus separating, to adopt one piece of 89C51 single-chip microcomputer to control independent 2 slices CAN conversion chip SJA1000 constituting a dual channel CAN interface. In order to achieve 89C51 and S3C2440 communication function high speed parallel, and at the same time, in order to increase the anti-interference ability to the system, to improve the system stability, the device also use high-speed optical coupling 6N137 conversion chip. PROFIBUS-DP conversion chip is Siemens Company's special chip-SPC3, 5v power isolation HDN125S5 module. Data sharing and relay is realized through the dual port RAM, choosing the device IDT7132, which has 2 sets of fully independent of the data, address line and reading and writing control line, it can independently access to its internal RAM resources. Dual port RAM communication is high speed, strong real-time property, interface simple, so both sides can actively carry out data transmission. Hardware system structure of the gateway is shown in fig. 2.

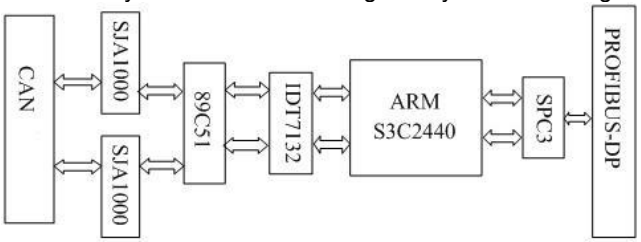

Fig. 2. Hardware system structure of gateway diagram

According to the above device selection, one conclusion can be summed up that PROFIBUS-DP communication interface module consists of PROFIBUS-DP protocol controller SPC3[6], light coupling isolator and RS-485 drive. The composition principle is that SPC3 protocol controller is a kind of intelligent communication ASIC chip, it which can complete PROFIBUS-DP physical layer and data link layer. And as it only integrated part function of the transmission technology with no integrated simulation function, therefore, it needs to add RS-485 drive circuits. SPC3 connection is shown in figure 3.

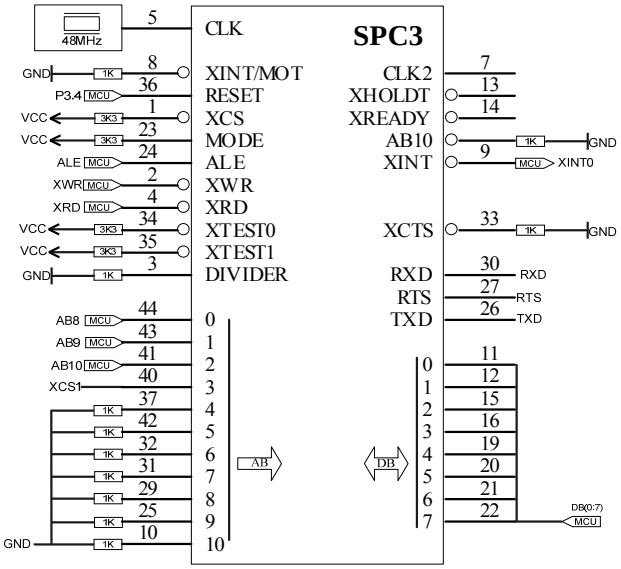

Fig. 3. SPC3 connection diagram

The transmission and share of data of the S3C2440 main control chip and the 89C51 control chip are realized through the dual-port RAM; therefore the IDT7132 chip was used. This chip has two sets of separate data lines, address lines and speaking-and-writing lines, thus it can access the internal RAM resources. The dual-port RAM has the merit of higher communication speed, strong real-time, simpler interfaces and the data can be transmitted through both sides. IDT7132 has a 2K high-speed static storage. IDT7132 is designed as a separate 8-bit dual interface or as dual interface storage. Using the IDT major/minor double interface storage method, the 16-bit system is applied and no mistake is generated, therefore there is no need for extra discrete logic. The device provides two separate interfaces, two separate control address and an I/O interface. It allows separate asynchronous access reading or writing into any

place of the storage. It also allows the circuit to enter into a low power-consumption standby condition through the CE automatic power failure. The high performance technology makes the power consumption lower than 550mW. The dual-port RAM is shown in Figure 4.

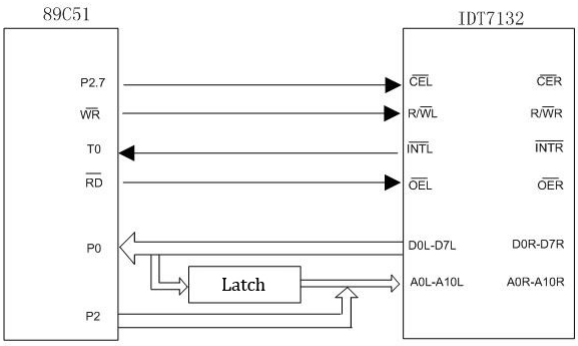

Fig.4. Dual-port RAM

The P0.0~P0.7 of 89C51 and the AD7~AD0 address date line driver are connected to exchange the data. The INTO and the interrupt output SJA1000, INT, are connected to trigger the interruption of the controller. P2.7 is connected with the chip selecting signal CS of SAJ1000 (low-index material level is accessible to SJA1000). RD/E (from the RD signal of microcontroller (Intel model or the E enable signal (Motorola model)) and WR (from the WR signal of microcontroller (Intel model) or the RD/WR enable model) are independently connected with 89C51.

The address assignment of 89C51 is as table 1:

Table 1. 89C51 address assignment

RAM address	Function
000H~0FFFH	DIP switch
1000H~1FFFH	SJA1000 Internal storage
2000H~7FFFH	—
8000H~81FFFH	IDT7132

2. Embedded Gateway Software System

Here we choose Profibus as master, CAN as slave. The main operation of data conversion process is as follows: First of all, master sends data to the conversion gateway, after receiving the data from the conversion gateway, analyse command, address, operand etc. And then, the conversion gateway encapsulates the data in CAN protocol format to send to the original CAN site; the original CAN site receives the data, the response information is sent back to conversion gateway, after receiving message conversion interface analyse data, and then convert to CAN protocol format, send to master. Note that, due to the length of CAN bus data transmission up to 8 bytes, if CAN protocol transmit data is longer than 8 bytes it will send data many times, Protocol conversion flow chart is shown as Figure 5.

Conclusion

This paper designs a Profibus and CAN protocol conversion gateway, and these two kinds of protocols are widely used in the field of industrial control system. The interface will provide a good solution to these two kinds of devices connection.

If the conversion gateway is used in the industrial scene, Profibus and CAN bus protocol conversion can be realized. Interface development is of low cost, which is able to adapt to the complex industrial environment and also provide some benefits to industrial manufacturers.

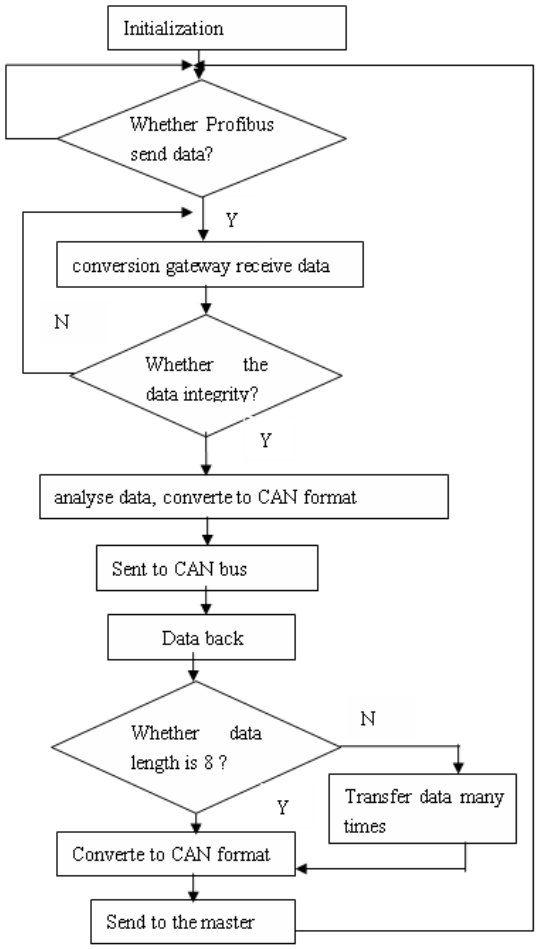

Fig.5. Protocol conversion flow chart

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