Gateway Design for Network based Multi-Motor Control with CAN and Profibus (ICCAS 2005)

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Abstract: Various types of fieldbus are used in factories in order to achieve the communication between the parts of process. But the protocol of the fieldbus doesn't have the standardized unique protocol. Thus, it is hard to exchange information each other with real time base when the different type protocols are adopted in the same network. In this paper, we implement two types of gateway for CAN and Profibus-DP: PC-based gateway and stand-alone gateway using the 80186 core based Dstni-LX network processor. The performance of proposed PC-based and stand-alone gateway is verified experimentally.

Keywords: fieldbus, gateway, network processor, CAN, Profibus

1. INTRODUCTION

Recently, the fieldbus such as DeviceNet, Profibus and World FIP is increasingly becoming an important factor in modern manufacturing system in case of exchanging information and control signals between the each hard-wired system components such as controllers, sensors and actuators. Furthermore, thanks to the development of the communication and the networking technology, the system management such as system control, threshold checks, diagnostic and maintenance checks, etc. is carried out by connecting system components or equipments with the supervisory computer through the serial communication line. It is obvious that the networked control system remarkably reduces the wiring and makes the diagnosis and the maintenance easy for the entire system [1].

But, it is hard to exchange information each other with real time base when the different type protocols are adopted in the same network because the protocol of the fieldbus doesn't have the standardized unique protocol. In the manufacturing system which adopts network based automation, there usually exist many kinds of equipments or devices that have different type communication protocols, and it is very important to communicate with different type protocols in order to realize the desired functions.

In this paper, we have developed two different types of the gateway for CAN and Profibus: PC-based and Stand-alone gateway. In the PC-based gateway, CAN and Profibus PCI card are installed inside PC. And, also, Siemens' CP5614 Profibus-DP Master card and KVASER's PCIcan card are used for Profibus PCI card and CAN PCI card, respectively. Profibus slave node is implemented using Siemens' Profibus-DP slave development kit. CAN node is implemented using SJA1000 CAN controller and TMS320C32 DSP processor. In the stand-alone gateway, the 80186 core based network processor is used, which supports the embedded communication with multiple CAN channels and Profibus-DP. The firmware and application program for CAN and Profibus node are designed using Paradigm's C++ Pro compiler.

This paper is organized as follows. The outline of Profibus and CAN communication are presented in Section 2 and 3, respectively. In section 4, the principles of gateway are described and the experimental results are given in Section 5. Finally, we present our conclusion.

2. COMMUNICATION FROM PROFIBUS TO CAN

Profibus was developed by Germanic Bosch, Siemens, Klockener-Moller and it has been standardized the native standard DIN 19245 and European standard EN50170. Profibus has been applied to industry network system widely and recently, it is used for real time communication between field equipments in field of manufacturing automation, process control and building automation. Profibus protocol based on OSI reference model is consisted of physical layer, data link layer and application layer. The frame of Profibus is shown in Fig. 1 [2].

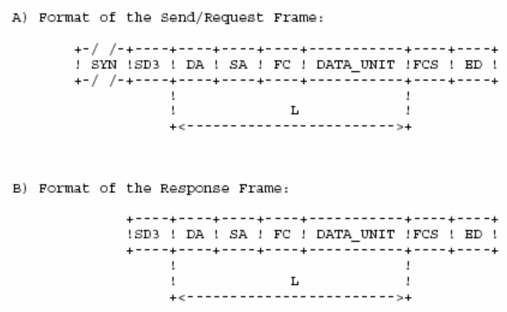


Fig. 1 Profibus frame format

Master-slave method is applied in our Profibus system. Therefore, it must pass through communication certification process between two nodes to run communication using a Profibus. After Profibus achieves identification of equipment and error detection, its master node sends information by using diagnosis telegram. The structure of diagnosis telegram is shown in table 1. Address of Profibus node can be assigned from 0 to 125. In our study, address of master node and slave node are assigned by 1 and 2, respectively. The data transmission speed is from 9.6KBaud to maximum 12MBaud.

Table 2 describes the relation of data mapping between CAN I/O data and Profibus-DP telegram in the view of Profibus. The Profibus byte number is set to be same as CAN because the maximum I/O byte number of CAN protocol is 8 Byte from Table 2. Put and compose Profibus frame on DATA_UNIT part in Profibus frame bringing I/O part among CAN data frame.

Table 1 Profibus diagnosis telegram

Byte		Meaning
1		Station_status 1
2		Station_status 2
3		Station_status 3
4		Diag.Master_Add.
5,6		Ident._Number
7	1	Ext._Diag. Header
8	2	CAN_Status
9	3	CAN_Add.
10	4	CAN_Data rate

Table 2 CAN data to Profibus-DP telegram mapping

Profibus input data	CAN output data
Byte 0	Byte 0
…	…
Byte 7	Byte 7
Profibus output data	**CAN input data**
Byte 0	Byte 0
…	…
Byte 7	Byte 7

3. COMMUNICATION FROM CAN TO PROFIBUS

Since the end of the 1980s, the so-called "autobus" protocols have been in their final development or early production phase. CAN protocol, which stands for Controller Area Network, being one of the most advanced autobus protocol in those days, was launched in 1989 as a standard product by Intel and it has been standardized internationally by ISO11898. Because the requirements applicable for data communication in vehicles are also interest for use in general industrial applications, CAN protocol is not only used in mobile system but also in other fields such as embedded system or factory automation. A main reason for the wide acceptance of CAN is the availability of extremely low cost protocol chips and/or integrated protocol interfaces. As a result, almost all manufacturers of microcontrollers provide at least one controller version with integrated CAN controller.

CAN uses NBA(Non-deductive Bit-wise Arbitration) method and CSMA/CD+AMP(Carrier Sense Multiple Access / Collision Detection + Arbitration on Message Priority) protocol which is similar to IEEE 802.3 CSMA/CD protocol [3],[4].

Table 3 describes the relation of data mapping between Profibus I/O data and CAN telegram. Upper table shows how CAN's input data is mapped into Profibus' output data of through CAN telegram in the view of CAN. And, the lower table describes the opposite case from Profibus node to CAN node.

Table 3 Profibus data to CAN telegram mapping

CAN-Header

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Hex
Byte 0	0	0	1	1	0	0	0	0	30
Byte 1	0	1	0	0	1	0	0	0	48

CAN-Data

Byte 2	Profibus output data byte 0
Byte 3	Profibus output data byte 1
Byte 4	Profibus output data byte 2
Byte 5	Profibus output data byte 3
Byte 6	Profibus output data byte 4
Byte 7	Profibus output data byte 5
Byte 8	Profibus output data byte 6
Byte 9	Profibus output data byte 7

CAN-Header

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Hex
Byte 0	0	1	0	0	0	0	0	0	40
Byte 1	0	1	0	0	1	0	0	0	48

CAN-Data

Byte 2	Profibus input data byte 0
Byte 3	Profibus input data byte 1
Byte 4	Profibus input data byte 2
Byte 5	Profibus input data byte 3
Byte 6	Profibus input data byte 4
Byte 7	Profibus input data byte 5
Byte 8	Profibus input data byte 6
Byte 9	Profibus input data byte 7

4. GATEWAY SYSTEM

Fig. 2 shows the principle of the gateway system for communication between CAN nodes and Profibus nodes. In case of data transmission from CAN node to Profibus node, data stored in the reception buffer of CAN moves to the transmission buffer of Profibus. And then, the gateway transmits that data to the destination Profibus node after mapping CAN input data to Profibus-DP output telegram in the view of Profibus as shown in table 3. Inversely, if we want to transmit data from Profibus node to CAN node, the inverse process is carried out and the data is transferred to CAN node from Profibus node after mapping Profibus-DP input data to CAN output telegram in the view of CAN as described in Table 3.

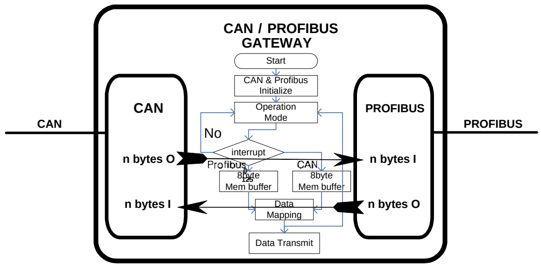


Fig. 2 Block diagram of gateway

4.1 PC based gateway

Fig. 3 shows the heterogeneous network system with PC based gateway for CAN and Profibus.

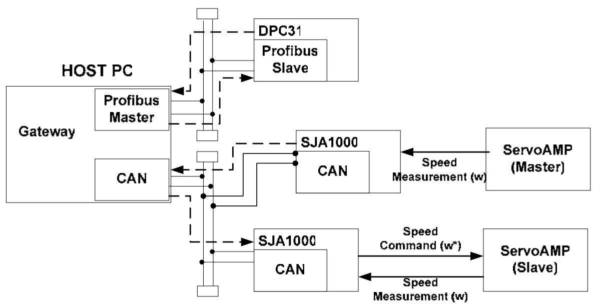


Fig. 3 Heterogeneous network system with PC based gateway

In our study, Host PC is used as gateway without additional PC. Profibus and CAN PCI card are installed inside PC in order to verify fieldbus gateway based on PC. CP5614 Profibus-DP Master card made by Siemens and KVASER's PCIcan card is used for Profibus PCI card and CAN PCI card, respectively. Profibus slave node is implemented using Siemens' Profibus-DP slave development kit. Stand-alone CAN node is implemented using TMS320C32 DSP processor and SJA1000 CAN controller [5]. Host PC software to implement gateway is designed with the aid of Visual Studio. And, stand-alone type Profibus slave node is based on V1SL DPC31 Profibus-DP firmware. The firmware and application program for CAN node is designed using Keil C compiler.

Fig. 4 shows the window of gateway operating program for monitoring operating condition of gateway.

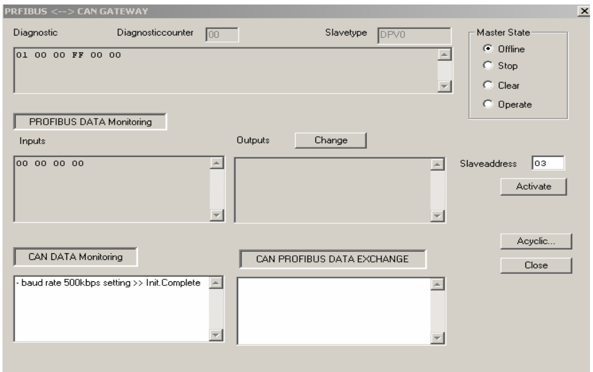


Fig. 4 Window of operating program for PC based gateway

And this program executes data communications between heterogeneous protocol such as CAN and Profibus.

4.2 Network processor based stand-alone gateway

The network processor, Dstni-LX, is adopted to implement stand-alone gateway system. Figure 5 shows the block diagram of Dstni-LX network processor. Dstni-LX is basically 80186 core based processor in which CAN protocol and Profibus protocol are integrated. DStni-LX supports the embedded communication: on board support for multiple CAN channels and Profibus-DP as shown in Fig. 5. So, it is very convenient to use Dstni-LX to implement the gateway using stand-alone board. The firmware and application program for CAN and Profibus node are designed using Paradigm's C++ Pro compiler.

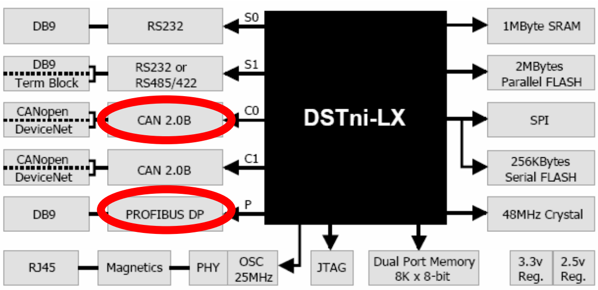


Fig. 5 Functional block diagram of Dstni-LX

Fig. 6 shows Dstni-LX stand-alone heterogeneous network system with gateway for CAN and Profibus.

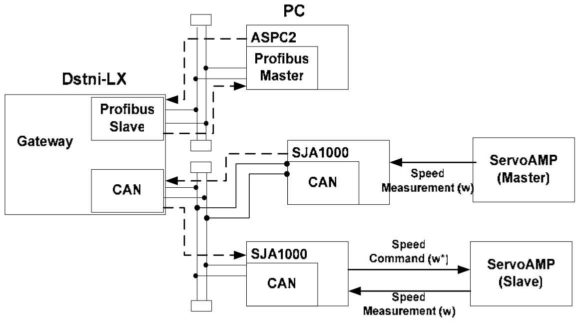


Fig. 6 Heterogeneous network system with Dstni-LX stand-alone gateway

In stand-alone gateway, the host PC is replaced to Dstni-LX stand-alone board compared to PC-based gateway. Because Profibus protocol stack and CAN protocol stack is integrated inside together, the gateway system can be implement only by the software programming within the board level. It doesn't need additional devices (e.g. CAN card, Profibus PCI card, etc.).

Fig 7 shows Dstni-LX gateway system program for monitoring and operating the Profibus protocol.

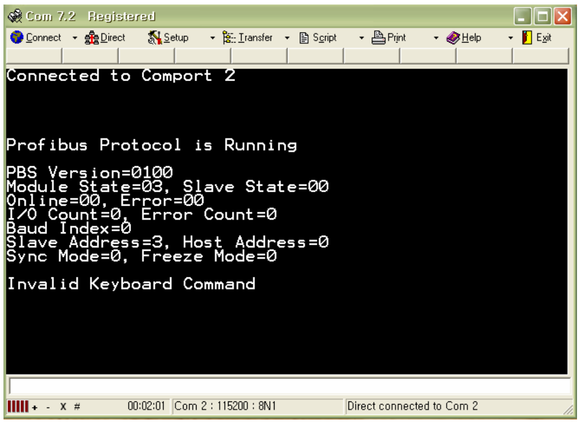
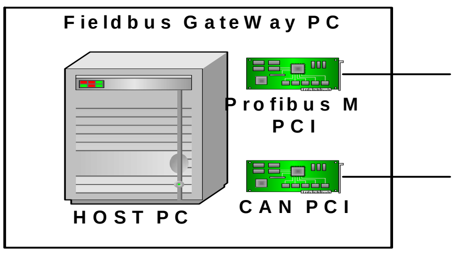


Fig. 7 Window of gateway operating program in stand-alone.

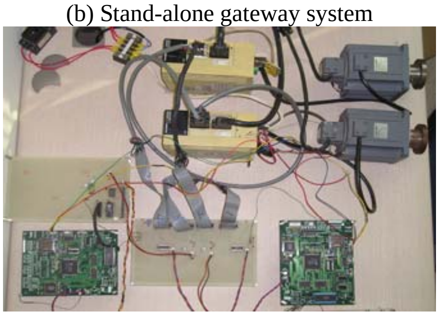
5. EXPERIMENT RESULTS

Multi-motor control system is used to verify gateway systems.



(a) PC based gateway system

(b) Stand-alone gateway system



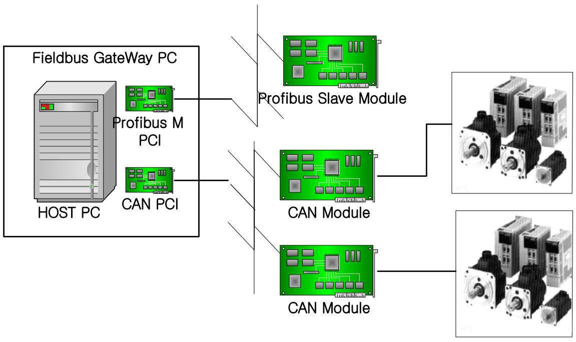
(c) Multi-motor system

Fig. 8 Experimental equipments for networked system

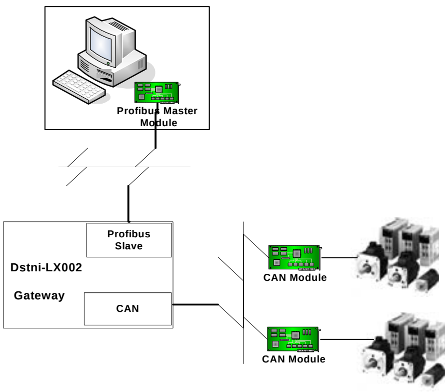
Mitsubishi's MELSERVO motors are used for experiment and the rated output and current are 400W and 3000rpm, respectively. Experimental equipments are shown in Fig. 8.

The speed synchronization for two motor is achieved for PC based and stand-alone gateway system.

Experimental network systems are shown in Fig. 9.



(a) PC based network systems



(b) Stand-alone network system

Fig. 9 Experimental network systems

In experimental systems shown in Fig. 9, the transmission speed of CAN and Profibus are established by 1Mbps and 12Mbps, respectively.

Fig. 10 and fig. 11 show the data signals of control input from Profibus node and speed information to CAN node for the PC based and the stand alone gateway system, repectively.

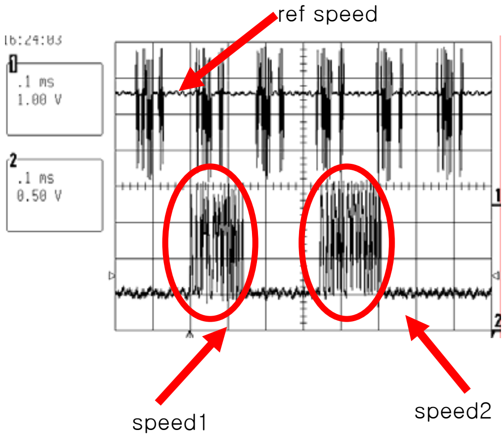


Fig. 10 Data signal for PC based gateway system

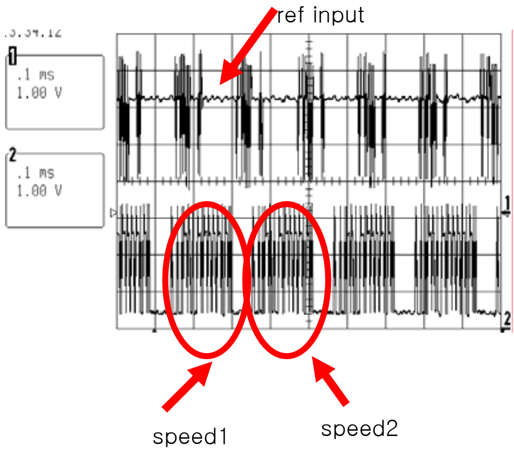


Fig. 11 Data signal for stand alone gateway system

Fig. 12 shows transmission delay between CAN node and Profibus node in order to verify the real-time performance of PC based gateway. Fig. 13 shows transmission delay from Profibus node to CAN node for DStni-LX based stand alone gateway. As is shown in Fig. 12 and 13, the delay time is almost lower than 50[us] and this is enough to achieve real time network system such as networks for multi-motor driving or robot cooperation.

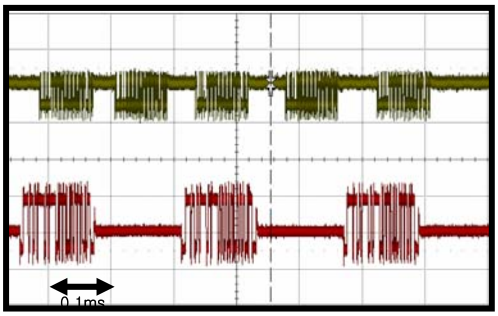


Fig. 12 Transmission delay of PC based gateway

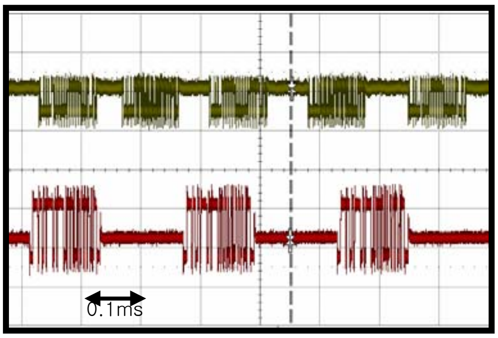


Fig. 13 Transmission delay of stand-alone gateway

The performance of speed synchronization for multi-motor is verified using Vector CANalyzer. A node in Profibus detects the speed of the master motor and delivers it as a speed reference for the slave motor. As shown in Fig. 14, the speed of the slave motor coincides with the master motor very well.

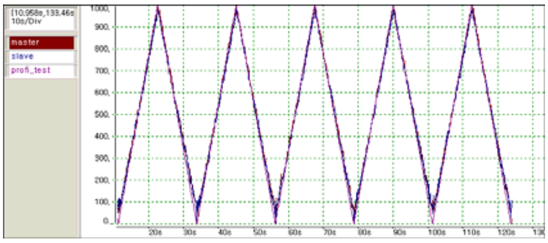


Fig. 14 Speed waveforms for multi-motor

6. CONCLUSTION

In this paper, we have developed the PC-based and the stand-alone gateway for real time communication between the network with CAN and Profibus which are used widely in factory automation system. The performance of the developed gateways is verified experimentally. The proposed gateways are flexible and easy to modify for special purpose compared to traditional stand-alone type gateways. Furthermore, this kind of gateway can be applied to another fieldbus protocol that can be implemented by PCI bus.

ACKNOWLEDGMENTS

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