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Feature

Development of Servo Actuator Supporting DeviceNet

Yasutaka Narusawa   Eiichi Nisio   Nobutosi Nakamura   Masao Nagasato

1. Introduction

Connection between the PLC or controller and the field equipment has changed in recent years from the conventional I/O connection to the serial communication in many systems. This change has been caused by benefits of less wiring and easier equipment diagnosis and maintenance even though new equipment is required for serial communication.
Field networks are still mainly used for actuators such as sensors, switches and solenoids that can be easily controlled, while servo actuators are still controlled by an independent motion bus or the conventional analog interface system in most cases. But more users are now wanting to construct their own systems by integrating servo actuators on the same network with other field equipment as networking has progressed in equipment and on the shop floor in manufacturing factories.
With this background and as a part of our commitment to factory automation open architecture, we decided to develop a series of products containing the de-facto standard network, DeviceNet interface, in Sanyo Denki's main business line: AC servo amplifiers "PV" and "PB", and "PM" driver for stepping motor drive systems.

2. Outline of DeviceNet

2.1 About DeviceNet

DeviceNet is a field network that is used to connect field equipment such as actuators and PLCs (Programmable Logic Controller). Its communication protocol is fully open and all of its technical rights are owned by ODVA (Open DeviceNet Vendor Association). Nearly 200 enterprises have already registered as vendors, and DeviceNet offers a bright future as a field network.

2.2 Technical Overview

DeviceNet is an object-oriented network that is ideal for simple networks such as master/slave or pier-to-pier configurations. Its structure is the OSI reference model with the 3rd, 4th, 5th and 6th layers omitted. A sophisticated CAN (Controller Area Network) is used in part of the physical layer and in the data link layer so the protocol is well-rounded.

Fig. 1 OSI reference model

2.2.1 Physical Layer of DeviceNet

The DeviceNet specifications of the physical layer are shown below.

① Bus configuration	Trunk/drop line structure conforming to ISO11898 specifications
② Number of nodes	Up to 64
③ Cable	The signal and the power are supplied by the same cable. Two twisted-pair cables, #18 for the signal pair and #15 for the power supply pair, are used.

④ Connector	Open type (terminal table type) and shield type (mini and micro types)
⑤ Communication speed	125 kbps, 250 kbps or 500 kbps. The total length of cable extension depends on the communication speed (see Table 1).

Table 1 Communication speed versus total length of cable extension

Communication speed	Total length of trunk line cable	Length of drop line	
		Maximum (every drop)	Maximum (total)
500kbps	100m	3m	39m
250kbps	250m	3m	78m
125kbps	500m	3m	156m

2.2.2 About CAN

CAN (Controller Area Network) is a LAN designed for use in automobiles originally that was developed for German automobile manufacturers. Its specifications were made public in ISO11898. Several networks based on CAN have been standardized and widely used since requirements such as high temperature resistance and high noise immunity for automobiles are similar to those for FA equipment. The format of the CAN data frame is shown in Fig. 2. One of the characteristics of CAN is its structure in which any one of the nodes can acquire the privilege of bus access rights by a non-destructive method when two or more nodes access the bus at the same time (CSMA/NBA system). The bus access right is determined in the arbitration field, while the actual data is stored in the data field. The data length ranges from 0 to 8 bytes.

2.2.3 Application Layer of DeviceNet

The arbitration field and the data field as shown in Fig. 2 are mainly defined in the DeviceNet application layer. The device profile is also standardized and defines the object and the message format to be supported in accordance with the type of equipment to ensure equipment compatibility and mutual operating compatibility. There are two types of DeviceNet message: I/O messages and Explicit messages.

I/O messages are used for high-priority communication such as transferring time-critical data, and the contents of the messages are pre-determined when the network is constructed. There are four events as shown below to initiate communication.

① Polling

The master station sends the output data to the respective slave stations. The slave stations return the input data (see Fig. 3).

② Bit strobe

All slave stations return the data in order in response to one transmission command from the master station.

③ Cyclic

Data is transferred cyclically in accordance with the timer.

④ Change of state

Data is transferred only when it changes.

Explicit messages are used to send and receive relatively low-priority data in 1-to-1 master/slave communication such as equipment setting, diagnosis, etc.

In this paper, we introduce support for I/O polling messages and Explicit messages.

3. DeviceNet-compliant Servo Actuator

3.1 Product Positioning and Features

Because the three types of servo actuator ("PV", "PB" and "PM") that we selected for product development have different characteristics and features, a simple comparison of performance is difficult. For example, the positioning of these products is shown in Fig. 4. (The performance refers to resolution power, output torque, control system, etc.) Each product is described briefly below.
"PM" driver is a five-phase stepping motor drive system. Because it can be easily controlled by open-loop control, it is used in applications to drive relatively light loads such as semiconductor manufacturing equipment and general industrial machinery.
"PB" series is positioned between the stepping motor and the conventional type AC servo motor, and is suited for applications having short stroke and high hit rate.
"PV" amplifier is an AC servo motor drive amplifier in the range of 30 W to 1 kW, and is suited for applications that require a higher resolution, speed and torque.
In addition, a simple position setting function is installed in these products to allow them to be controlled by DeviceNet. The master (controller) can set the motor position simply by setting the motor profiles such as the target position, target speed, acceleration/deceleration speeds, etc. Thus, the position setting unit and motion card that are required in conventional systems are no longer necessary, and so the system can be made more compact and the cost reduced.

3.2 Message Format

Communication between the controller (master) and the amplifier (slave) is performed by the polling system as described in chapter 2. The controller issues commands such as the target position, target speed, acceleration/deceleration speeds, etc., and data. The slave (amplifier) returns the status information such as alarms, various limits, etc., and the monitor information such as the present position. The format of input messages from the controller to amplifiers (or to the step drivers) is shown in Fig. 5. The format of output messages from amplifiers to the controller is shown in Fig. 6.
Because these message formats are the same for all models ("PV", "PB" and "PM"), the userssoftware that controls or manages these actuators can be simple, and the system can be built more quickly.

Fig. 5 Input message format

Byte	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	Control bit							
1	Reserved(0×00)							
2	Axis No(0×00)			Command code				
3	Axis No(0×00)			Response code				
4	Command data							
5								
6								
7								

Fig. 6 Output message format

Byte	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0	Lower status bit							
1	Reserved(0×00)							
2	High status bit							
3	Axis No(0×01)			Response type				
4	Response data							
5								
6								
7								

4. Conclusion

We have described a servo actuator that supports DeviceNet. As described at the outset, servo actuators are typically not controlled by the field network at present. We anticipate that many user applications can benefit by merging servo actuators with the field network.

*) DeviceNet is a registered trademark of Allen Bradley Inc.

Yasutaka Narusawa
Joined company in 1991
Servo Systems Division, Software Development Dept.
Worked on design and development of "PV" amplifier

Eiichi Nishio
Joined company in 1985
Servo Systems Division, 1st Design Dept.
Worked on development of "ROBUSTSYN" and "PB"

Nobutoshi Nakamura
Joined company in 1985
Servo Systems Division, 2nd Design Dept.
Worked on design and development of "PM" driver

Masao Nagasato
Joined company in 1988
Servo Systems Division, 1st Design Dept.
Worked on development of "ROBUSTSYN" and "PB"

Fig.1 OSI reference model

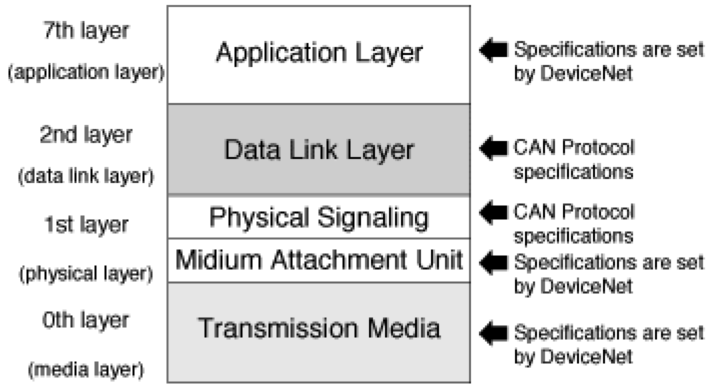

Fig.2 CAN data frame format

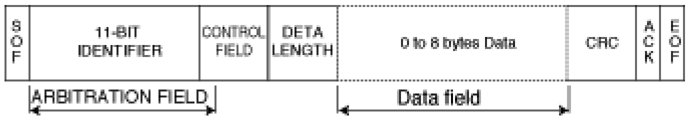

Fig.3 I/O polling message

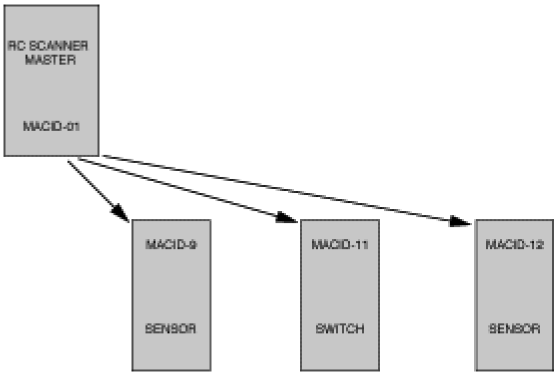

Fig.4 Product Positioning