Position-Control Module for MICREX-SX Series

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1. Introduction

Generally, in order to operate various machines, various controllers that correspond to a brain and actuators that correspond to the hands and feet are required. Motors or solenoid valves are utilized for the actuators, and servo-motors are widely used for machines that require high speed and high response. Numerical controllers (NC) or robot controllers (RC) serve as typical controllers for servo-motor systems, while many machines are controlled by the programmable logic controllers (PLC). The scalable multi-controllers SPH (hardware PLC) for the integrated controller "MICREX-SX series" recently developed and manufactured (hereinafter referred to as SX) are characterized by high speed and advanced performance so that they are the most suitable for control of the servo-motor systems. In the SX, the novel concepts of "development of software for position-control function" and "single function of the hardware module", which differ from the conventional PLC, are realized. Hence, the position-control module as well as the extended function block for position-control (extended function block : software library) of the SX and their application examples are presented in this paper.

2. Configuration of the System

The configuration of the position-control system for the SX is characterized by the fact that the position-control modules (hardware) are kept to a minimum, and establishment of the various position-control systems with numerous extended function blocks is possible.

Figure 1 shows a comparison between the conventional position-control module and the position-control system for the SX.

The operation procedures and processing in the position-control system by the conventional PLC include:

(1) Processing of user applications in the CPU modules
  (a) Writing of positioning data and feedrate into the position-control module
  (b) Switching the positioning start command signal on
  (c) Waiting for the positioning end signal (waiting for switching the end signal on)

All processing for position-control is executed by the position-control module side.

(2) Processing in the position-control modules
  (d) Dimension conversion (converts dimension data in millimeters to number of pulses)
  (e) Accel./decel. calculation (linear-curve accel./decel., S-curve accel./decel.)
  (f) Command pulse outputting
  (g) Feedback pulse counting and reverse conversion to input increment

Various processing at the position-control module side is executed by a micro-computer mounted inside the module having advanced performance capability.

Fig.1 System configuration for position control

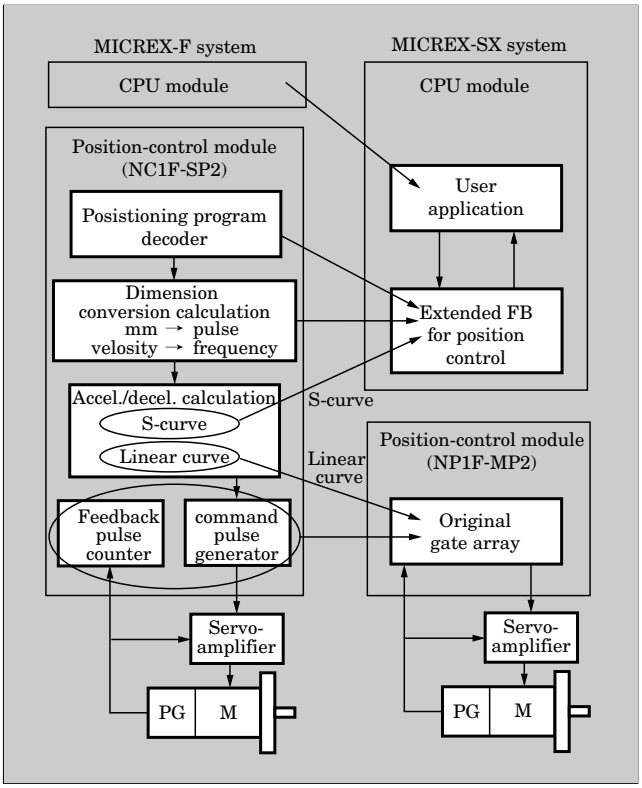


Table 1 Basic specifications of position-control module

Item	NP1F-MA2	NP1F-MP2	NP1F-HP2
Specific slot	1 slot	1 slot	1 slot
Word number of input/output	22 words (input 14 words/output 8 words)	22 words (input 14 words/output 8 words)	16 words (input 8words/output 8 words)
Number of control axis	2 axes/module	2 axes/module	2 axes/module
Control system	Closed loop control	Open loop control	Open loop control
Output control signal	○ Analog speed reference ○ 0 to ±10.24V (VR adjust)	○ Pulse reference (open collector) ○ CCW pulse + CW pulse ○ Max frequency 250 kHz	○ Pulse reference (open collector) ○ CCW pulse + CW pulse ○ Max frequency 250kHz
Feedback pulse	○ Line driver/open collector ○ ϕA, ϕB signal ○ Max frequency 500kHz (×1)	○ Line driver/open collector ○ ϕA, ϕB signal ○ Max frequency 500kHz (×1)	——
Manual pulse generator	○ Line driver/open collector ○ ϕA, ϕB signal or CCW pulse + CW pulse ○ Max frequency 500kHz (×1)	○ Line driver/open collector ○ ϕA, ϕB signal or CCW pulse + CW pulse ○ Max frequency 500kHz (×1)	——
Input/output signal	○ 5 special input signal (EMG, ±OT, LS at machine datum, external interrupt signal) ○ 2 general-purpose output signal	○ 5 special input signal (EMG, ±OT, LS at machine datum, external interrupt signal) ○ 2 general-purpose output signal	○ 5 special input signal (EMG, ±OT, LS at machine datum, external interrupt signal) ○ 2 general-purpose output signal
Inner function	○ Linear-curve accel./decel. ○ The continuation change of the frequency ○ Pre-reading of positioning data ○ Feed-forward control	○ Linear-curve accel./decel. ○ The continuation change of the frequency ○ Pre-reading of positioning data	○ Linear-curve accel./decel. ○ The continuation change of the frequency
Actuator	○ Servo-amplifier of analog reference system	○ Servo-amplifier of pulse reference system ○ Driver for stepping motor	○ Servo-amplifier of pulse reference system ○ Driver for stepping motor
Extended FB	○ 1 axis PTP positioning (simple linear interpolation) ○ Numerous function 1 axis PTP ○ 4 axes interpolation ○ Special synchronous operation	○ 1 axis PTP positioning (simple linear interpolation) ○ Numerous function 1 axis PTP ○ 4 axes interpolation ○ Special synchronous operation	○ 1 axis PTP positioning (simple linear interpolation)

That means, theoretically, if computing capability of the CPU module in the PLC is higher than that of the advanced micro-computer, position-control processing can be executed by the CPU module side. Since numerous numeric calculations must be executed quickly in position-control processing, execution was impossible with the numeric calculation capability of the conventional PLC. However, high speed operation capability of the CPU module in the SX enables execution of position-control calculations by the CPU module side. The position-control module side of the SX only provides the interface circuit as hardware and fundamental functions such as pulse oscillator and counting of feedback pulse. Various functions for position-control are executed by the extended FB in the CPU module side. The following merits are achieved by this system:

(1) Spontaneous combination between the position-control module and the extended FB

In the past, functions were decided by position-control module type. For example, specific hardware modules were utilized for every function including PTP (point to point) position-control module for pulse string output, cam module for pulse string output and synchronous position-control module for the running cutting machine.

(2) Easy transfer of software property

For example, even if servo-amplifier interface changed from the analog reference to network, transfer of applications is possible by means of FB exchange at interface regions only (corresponds to the driver for various printers, in the case of a personal computer).

(3) Build-in of user side know-how

The conventional modules were a type of multi-functional black-box, but the SX is configured by the extended FB for every function. Therefore, it points to an open system and enables addition of functions or customization based on user application.

3. Specification of the Modules

Table 1 shows the basic specifications of the position-control modules for the SX. In this Table, specification of the two axes modules that are typical in the SX are shown.

○ NP1F-MA2: Analog speed command type module
Counting of feedback pulse and connection with one set of manual pulse generators are possible

○ NP1F-MP2: Pulse string command type module
Counting of feedback pulse and connection with one set of manual pulse

Table 2 The interface signal with PLC

Address	F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0	Data
0	Bit status signal 1 for channel 1 Nearly zero, positioning complete, detects a ϕZ signal, detects a external interrupt signal, error of emergency stop error, error of ±over-travel, error of Error counter over, etc.																Channel 1 Input area
1	Bit status signal 2 for channel 1 Emergency input signal, ±over-travel input signal, LS at machine datum input signal, ready signal, write command response, read command response, etc.																
2 to 3	Current position data 1 (feedback position, etc.)																
4 to 5	Current position data 2 (command position)																
6	Bit status signal 3 for channel 2 (same as bit status signal 1)																Channel 2 Input area
7	Bit status signal 4 for channel 2 (same as bit status signal 2)																
8 to 9	Current position data 3 (feedback position etc.)																
10 to 11	Current position data 4 (command position)																
12	Current position data 5 for external input counter																Manual pulse generator
13	Current position data 6 for module detection timer																
14	Bit command signal 1 for channel 1 Run command, counter reset, ϕZ detection command, external interrupt detection command, stop command, compulsory stop command, alarm reset. etc.																Channel 1 output area
15	Bit command signal 2 for channel 1 Write REG select, REG write command, Read REG select, REG read command, etc.																
16 to 17	Write REG data set area 1 for channel 1																
18	Bit command signal 3 for channel 2 (same as bit command signal 1)																Channel 2 output area
19	Bit command signal 4 for channel 2 (same as bit command signal 2)																
20 to 21	Write REG data set area 2 for channel 2																

generators are possible

○ NP1F-HP2: Pulse string command type module
Only the most fundamental functions are provided. (without feedback and manual pulse generator input)

All three kinds of modules are capable of executing various position-control actions by combination with the extended FB for position-control, but the extended FBs that are able to combine with NP1F-HP2 are restricted.

In addition, direct command of the position-control module from user application is possible. Table 2 shows input and output signals of the NP1F-MA2 (common with MP2).

There are 32 registers (REG) inside the position-control module, and position-control actions are executed by switching the start command on after writing the positioning data (pulse dimension) from the application side and the data corresponding to frequency. Table 3 shows a list of typical REGs. Figure 2 shows an example of the most fundamental position-control actions. At first, data is written onto "Max. frequency control REG," "Accel./decel. control REG" and "Least frequency control REG" from the application side (corresponds to parameters for position-control in the conventional module).

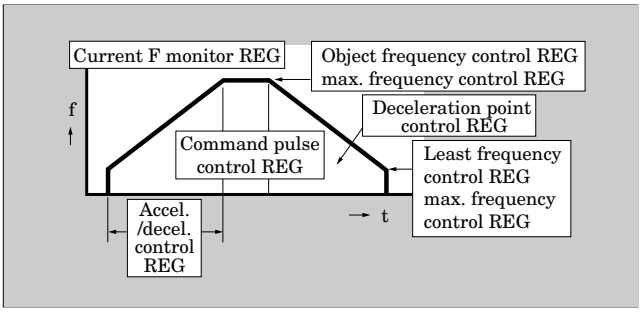
Each time, the position-control actions begin under the setting of "Command pulse control REG" and "Object frequency control REG." In "Deceleration point control REG," the remaining pulse numbers until start of deceleration are stored by automated calculation. (When auto deceleration calculation is enable.)

The fundamental action functions mentioned above are built into a specific LSI for two axes control that was developed recently. Even when outputting command pulse at linear-curve accel./decel. (pulse output provides a solution of 0.25Hz at the maximum command frequency of 250kHz), smooth frequency change control is realized.

Table 3 The inner register of the position-control module

No.	Register name	R/W
0	Object frequency control REG	W
1	Least frequency control REG	W
2	Current frequency monitor REG	R
3	Command pulse control REG	R/W
4	Deceleration point control REG	R/W
5	Acceleration/deceleration control REG 1 (This data is used by the usual Acceleration/deceleration control)	W
6	Acceleration/deceleration control REG 2 (This data is used by the EMG stop and Compulsory stop)	W
7	Max frequency control REG	W
⋮		

Fig.2 Basic function of position-control module



4. Extended FB for Position-Control

More than 70 kinds of libraries are prepared in the extended FB for position-control in order to realize various operative functions on every kind of machine.

Fig.3 Sample of extended FB for position control

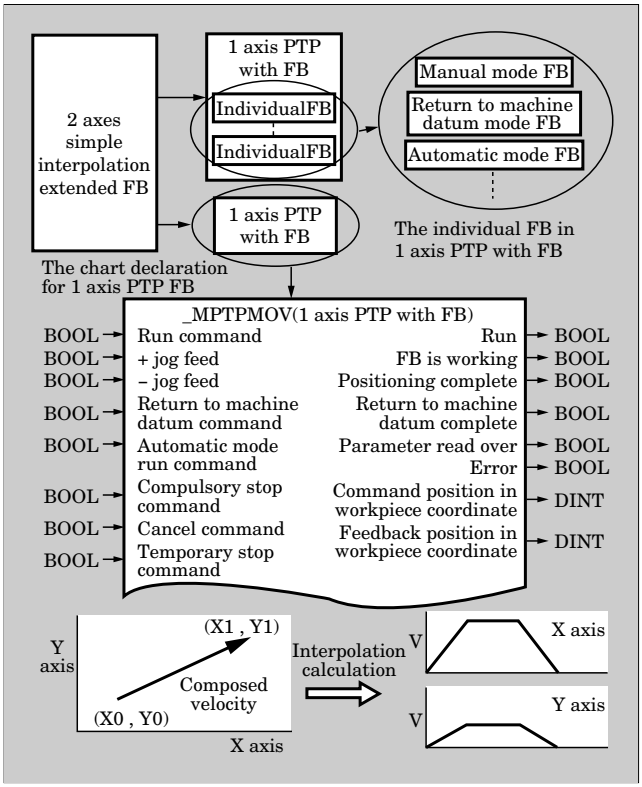


Fig.4 The running cutting machine (rotary-shear)

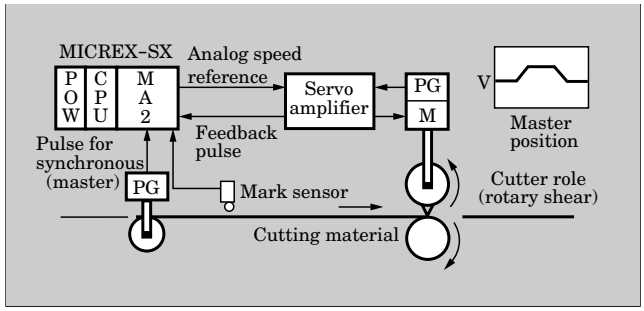
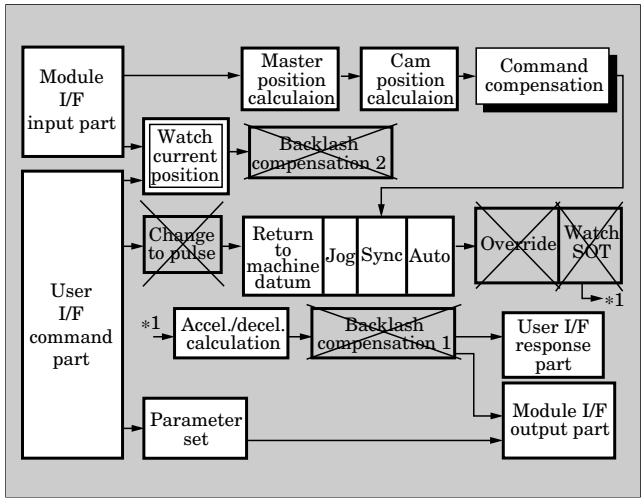


Fig.5 The application example of extended FB for the positioning (the running cutting machine)



The following are four that are included in the typical FB group.

(1) One axis point to point position-control FB group

The FB group that executes one axis point to point position-control

(2) Simple linear interpolative calculation FB group

The FB group that calculates the axis speed of two to four axes

(3) Cam FB, synchronous control for the running cutting machine FB group

The FB group applied to synchronous position-control for cam position control and the running cutting machine

(4) Four axes interpolative operation FB group

The FB group for linear interpolation of four axes and circular interpolative operation of two axes

Although there are various applications for the position-control FB such as a succeeding FB is started according to calculated results of a certain FB (two FBs are connected with equivalent levels) or construction of one FB composed of FBs with individual functions, a typical example is shown in Fig. 3. This Figure shows processing that executes interpolative action for two axes. In two axes simple linear interpolative calculation FB, the synthetic velocity of the X-axis and the Y-axis is the resolved data of each axis, and single axis PTP with combined FB is started (both FBs are of equivalent levels). The single axis PTP with combined FB calls the individual FB and executes the position-control action (the individual FB is one rank lower in level than the combined FB). A signal corresponding to the conventional position-control module interface (I/F) is allocated to input and output data for the single axis PTP with combined FB. For example, even if the position-control module side is configured with only the fundamental functions which command the pulse unit, assignment with setting unit (millimeter etc.) is possible to the single axis PTP with combined FB from the user application side. The combined FB executes the conversion from setting unit to pulse number. This demonstrates that the same handling as the conventional position-control module is possible by building in the extended FB.

In addition, direct commands from the users application are possible to the individual FB. If only FBs with required individual functions are combined, a compact program and rapid processing are realized.

5. Application Examples

A application examples of the SX are delineated in Figs. 4 and 5. Figure 4 shows the running cutting machine system with rotary shear in which the SX controls the cutter section. When the cutting length is longer than the cutter roll circumference at the cutting section, the speed pattern is controlled, as shown in the Figure.

Figure 5 shows configuration of the extended FB for

position-control in this system. Each process enclosed by rectangular frames is the extended FB for positioning-control (the FB with individual function). Except the "Command compensation calculation FB" (shaded) and "Current position calculation FB" (in bold), all FBs were prepared by Fuji Electric. In this system, top priority is given to rapid response of the cutter shaft so that rapid processing (a position-control calculation cycle of 2 ms) is realized by deletion of the FBs with unnecessary functions.

(1) FB related to backlash control (backlash compensation function for the mechanical system)

Backlash control FB is not mounted for rotary shear, due to rotary motion in one direction.

(2) FB for conversion of pulse dimension (conversion processing from millimeters etc. to pulse number)

This function is not mounted because conversion calculation can be executed by the controller of the operation region.

(3) FB for override calculation (change action speed function)

This function is not necessary due to the synchronous operation system.

(4) FB for monitoring of software over travel (±SOT)

This function is not necessary due to rotary action. Since all functions indicated in the Figure are provided in the conventional position-control module, elimination of unused functions is difficult.

(5) FB for calculation of present position

Since the conversion calculation to setting unit (millimeter or inch) is not necessary, the standard extended FB is replaced by this FB.

(6) FB for command pulse compensation calculation

The FB that executes special compensation calculations corresponds to machine configuration and is inserted between "FB for cam position calculation" and "FB for synchronous operation" (the additional FB for new functions).

6. Conclusion

The position-control modules and the FB for the SX have been outlined. The position-control system for the SX points to an open system that prepares FBs for every function, contrary to the conventional position-control module whose functions were in a black box. Since the SX is characterized by the selection and mounting of FBs that provide necessary functions for the intended control for the machines, the authors hope this paper will serve actual applications.

Fuji Electric will endeavor to respond to the requirements of automation with high speed and highly precise control for various machines by further enriching the position-control FB for the SX.