GE Fanuc Automation

Computer Numerical Control Products

Alpha Series AC Servo Motor

Parameter Manual

GFZ-65150E/04 December 1999

GFL-001

Warnings, Cautions, and Notes as Used in this Publication

Warning

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

Caution

Caution notices are used where equipment might be damaged if care is not taken.

Note

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

This document is based on information available at the time of its publication. While efforts have been made to be accurate, the information contained herein does not purport to cover all details or variations in hardware or software, nor to provide for every possible contingency in connection with installation, operation, or maintenance. Features may be described herein which are not present in all hardware and software systems. GE Fanuc Automation assumes no obligation of notice to holders of this document with respect to changes subsequently made.

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DEFINITION OF WARNING, CAUTION, AND NOTE

This manual includes safety precautions for protecting the user and preventing damage to the machine. Precautions are classified into Warning and Caution according to their bearing on safety. Also, supplementary information is described as a Note. Read the Warning, Caution, and Note thoroughly before attempting to use the machine.

WARNING

Applied when there is a danger of the user being injured or when there is a damage of both the user being injured and the equipment being damaged if the approved procedure is not observed.

CAUTION

Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

NOTE

The Note is used to indicate supplementary information other than Warning and Caution.

- Read this manual carefully, and store it in a safe place.

CONTENTS

1 OVERVIEW

This manual describes the servo parameters of the following NC models using an α servo system. The descriptions include the servo parameter start-up and adjustment procedures. The meaning of each parameter is also explained.

1.1 SERVO SOFTWARE AND MODULES SUPPORTED BY EACH NC MODEL

NC product name	Series and edition of applicable servo software	Module
Series 0-MODEL C Series 15-MODEL A	Series 9046/A(01) and subsequent editions (Supporting standard and high-speed positioning) Series 9041/A(01) and subsequent editions (Supporting dual position feedback)	Serial axis board
Series 15-MODEL B (Note 2) Series 16-MODEL A Series 18-MODEL A	Series 9060/J(10) and subsequent editions	320C25 module
Series 20-MODEL A Series 21-MODEL A Series 21-MODEL B Power Mate-MODEL D Power Mate-MODEL F Power Mate-MODEL H Power Mate-MODEL I	Series 9060/J(10) and subsequent editions (Supporting standard and high-speed positioning) Series 9066/F(06) and subsequent editions (Supporting FAD & HRV control) (Note 1)	320C25 module
Series 15-MODEL B (Note 2) Series 16-MODEL B Series 18-MODEL B Series 16-MODEL C Series 18-MODEL C	Series 9070/A(01) and subsequent editions	320C51 module 320C52 module
Series 15-B (FS15-B) (Note 2) Series 16-C (FS16-C) Series 18-C (FS18-C)	Series 9080/E(05) and subsequent editions (Supporting FAD & HRV control and linear motor) Series 9081/A(01) and subsequent editions (Supporting SUPER-precision machining)	320C52 module
Series 16*i* -MODEL A (Note 3) Series 18*i* -MODEL A Series 21*i* -MODEL A Power Mate *i* -MODEL D Power Mate *i* -MODEL H	Series 9090/A(01) and subsequent editions (Supporting *i* series CNC)	320C52 servo card
	Series 90A0/A(01) and subsequent editions (Supporting *i* series CNC and level-up HRV control)	320C543 servo card
Series 15*i*-MODEL A	Series 90A0/A(01) and subsequent editions (Supporting *i* series CNC and level-up HRV control)	320C543 servo card
Power Mate-MODEL E (PME)	Series 9064/E(05) and subsequent editions (Standard) Series 9065/A(01) and subsequent editions (Supporting HRV control)	

NOTE 1 For some models of the Series 21, Power Mate-D, and Power Mate-F, the NC software and servo software are integrated.
The NC software of the following series and editions includes servo software supporting the α servo motor.

Series21-TA	Series 8866/001B and subsequent editions
Series21-TB control A type	Series DE01/001A and subsequent editions
Power Mate-D	Series 8831/001A and subsequent editions Series 8836/001A and subsequent editions
Power Mate-F	Series 8870/001A and subsequent editions

NOTE 2 The servo software series of the Series 15-B depends on the incorporated servo module, as shown below:

Servo software	CNC CPU	Servo module
Series 9060	68030	320C25 module
Series 9070	68040	320C51 module
Series 9080 Series 9081	68040	320C52 module

NOTE 3 The servo software series of the Series 16*i*, 18*i*, 21*i*, and Power Mate *i* depend on the incorporated servo card, as shown below.

Servo software	Servo card
Series 9090	320C52 card
Series 90A0	320C543 card

1.2 ABBREVIATIONS OF THE NC MODELS COVERED BY THIS MANUAL

The models covered by this manual, and their abbreviations are :

NC product name	Abbreviations	
FANUC Series 0-MODEL C	Series 0-C	Series 0
FANUC Series 15-MODEL A	Series 15-A	Series 15 (Note 1)
FANUC Series 15-MODEL B	Series 15-B	
FANUC Series 15***i***-MODEL A	Series 15*i*-A	
FANUC Series 16-MODEL A	Series 16-A	Series 16 (Note 1)
FANUC Series 16-MODEL B	Series 16-B	
FANUC Series 16-MODEL C	Series 16-C	
FANUC Series 16i-MODEL A	Series 16*i*-A	
FANUC Series 18-MODEL A	Series 18-A	Series 18 (Note 1)
FANUC Series 18-MODEL B	Series 18-B	
FANUC Series 18-MODEL C	Series 18-C	
FANUC Series 18***i***-MODEL A	Series 18*i*-A	
FANUC Series 20-MODEL A	Series 20-A	Series 20
FANUC Series 21-MODEL A	Series 21-B	Series 21 (Note 1)
FANUC Series 21-MODEL B	Series 21-C	
FANUC Series 21***i***-MODEL A	Series 21*i*-A	
FANUC Power Mate-MODEL D	Power Mate-D	Power Mate (Note 2)
FANUC Power Mate-MODEL F	Power Mate-F	
FANUC Power Mate-MODEL H	Power Mate-H	
FANUC Power Mate-MODEL I	Power Mate-I	
FANUC Power Mate *i*-MODEL D	Power Mate *i*-D	
FANUC Power Mate *i*-MODEL H	Power Mate *i*-H	
FANUC Power Mate-MODEL E	Power Mate-E	Power Mate-E (Note 2)

NOTE

1 In this manual, a reference to the Series 15, 16, 18, or 21, without a specific model name refers to all the models of the series.

2 In this manual, Power Mate refers to the Power Mate-D, Power Mate-F, Power Mate-H, Power Mate-I, Power Mate *i*-D, and Power Mate *i*-H.
The Power Mate-E, which uses different servo software and different parameter numbers, is designated by its full name or as Power Mate-E.

1.3 RELATED MANUALS

The following ten kinds of manuals are available for FANUC SERVO MOTOR α/β series.
In the table, this manual is marked with an asterisk (*).

Table 1. Related manuals of SERVO MOTOR α/β series

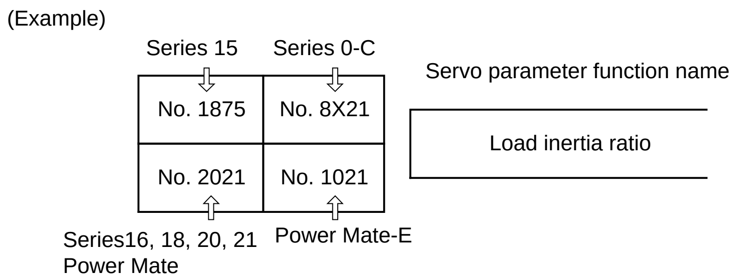
Document name	Document number	Major contents	Major usage	
FANUC AC SERVO MOTOR α series DESCRIPTIONS	B-65142E	• Specification • Characteristics • External dimensions • Connections	• Selection of motor • Connection of motor	
FANUC AC SERVO MOTOR β series DESCRIPTIONS	B-65232EN	• Specification • Characteristics • External dimensions • Connections		
FANUC AC SPINDLE MOTOR α series DESCRIPTIONS	B-65152E	• Specification • Characteristics • External dimensions • Connections		
FANUC SERVO AMPLIFIER α series DESCRIPTIONS	B-65162E	• Specifications and functions • Installation • External dimensions and maintenance area • Connections	• Selection of amplifier • Connection of amplifier	
FANUC CONTROL MOTOR AMPLIFIER α series (SERVO AMPLIFIER UNIT) DESCRIPTIONS	B-65192EN			
FANUC CONTROL MOTOR α series MAINTENANCE MANUAL	B-65165E	• Start up procedure • Troubleshooting • Maintenance of motor	• Start up the system (Hardware) • Troubleshooting • Maintenance of motor	
FANUC CONTROL MOTOR AMPLIFIER α series (SERVO AMPLIFIER UNIT) MAINTENANCE MANUAL	B-65195EN	• Start up procedure • Troubleshooting	• Start up the system (Hardware) • Troubleshooting	
FANUC SERVO MOTOR β series MAINTENANCE MANUAL	B-65235EN	• Start up procedure • Troubleshooting • Maintenance of motor	• Start up the system (Hardware) • Troubleshooting • Maintenance of motor	
FANUC AC SERVO MOTOR α series PARAMETER MANUAL	B-65150E	• Initial setting • Setting parameters • Description of parameters	• Start up the system (Software) • Turning the system (Parameters)	*
FANUC AC SPINDLE MOTOR α series PARAMETER MANUAL	B-65160E	• Initial setting • Setting parameters • Description of parameters		

Other manufactures' products referred to in this manual

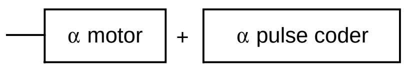
* IBM is registered trademark of International Business Machines Corporation.
* MS-DOS and Windows are registered trademarks of Microsoft Corporation.
* 486SX and 486DX2 are registered trademarks of Intel corporation.

All other product names identified throughout this manual are trademarks or registered trademarks of their respective companies.

In this manual, the servo parameters are explained using the following notation:



The α servo motor can take either of the following configurations:



The following α pulse coders are available.

Pulse coder name	Resolution	Type
αA64	65,536 pulse/rev	Absolute
αI64	65,536 pulse/rev	Incremental
αA1000	1,000,000 pulse/rev	Absolute

When parameters are set, these pulse coders are all assumed to have a resolution of 1,000,000 pulses per motor revolution.

NOTE
The αA1000 is used for 0.1-μm detection control and high-speed high-precision control.

2 SETTING α SERIES SERVO PARAMETERS

2.1 INITIALIZING SERVO PARAMETERS

2.1.1 Before Servo Parameter Initialization

Before starting servo parameter initialization, confirm the following:

<1> NC model (ex.: Series 15-B)
<2> Servo motor model (ex.: α 6/2000)
<3> Pulse coder built in a motor (ex.: α A1000)
<4> Is the separate position detector used? (ex.: Not used)
<5> Distance the machine tool moves per revolution of the motor
(ex.: 10 mm per one revolution)
<6> Machine detection unit (ex.: 0.001 mm)
<7> NC command unit (ex.: 0.001 mm)

2.1.2 Parameter Initialization Flow

On the servo setting and servo adjustment screens, set the following:

In emergency stop state, switch on NC.

↓

Initialization bits	00000000 (except Power Mate-E) (Note) 00011000 (for Power Mate-E)
Motor No.	See (4) in Subsec. 2.1.3.
AMR	00000000
CMR	See (6) in Subsec. 2.1.3.
Move direction	111 (Clockwise as viewed from detector) –111 (Counterclockwise as viewed from detector)
Reference counter	See (10) in Subsec. 2.1.3.
Velocity gain	Set 100% if the machine inertia is unknown. (Equivalent to load inertia ratio parameter)

↓

Which system is being used?

Closed loop

Make settings for using separate detector.
No. 1807#3 = 1, 1815#1 = 1 (Series 15)
Set bits 0 to 3 of No. 37 to 1. (Series 0-C)
No. 1815#1 = 1 (Series 16, 18, 21, Power Mate)
No. 1002 = 10001000 (Power Mate-E)

↓

Set flexible feed gear.

↓

Number of velocity pulses	8192 (Note)
Number of position pulses	Ns (Note)

Semi-closed loop

Set flexible feed gear.

↓

Number of velocity pulses	8192 (Note)
Number of position pulses	12500 (Note)

← See (7) in Subsec. 2.1.3. →

↓

Turn power off then on.

↓

End of parameter setting

For the phase A/B separate detector and serial linear scale:

Ns: Number of feedback pulses per motor revolution, received from the separate detector

For the serial rotary scale:

Ns: 12500 × (motor-to-table deceleration ratio)

Example: When the motor rotates ten turns while the table rotates one turn

$$12500 \times \frac{1}{10} = 1250$$

Set Ns to 1250.

> **NOTE**
> When initialization bit 0 is set to 1, the settings of the number of velocity pulses and the number of position pulses must be reduced by a factor of 10.

2.1.3 Servo Parameter Initialization Procedure

(1) Switch on the NC in an emergency stop state.
Enable parameter writing (PWE = 1).

(2) Initialize servo parameters on the servo setting screen.
For a Power Mate with no CRT, specify a value for an item number on the servo setting screen. See Fig. 2.1.3.
To display the servo setting screen, follow the procedure below, using the key on the NC.

● Series 0-C

Press the PARAM key several times, and the servo setting screen will appear.

If no servo screen appears, set the following parameter as shown, and switch the NC off and on again.

	#7	#6	#5	#4	#3	#2	#1	#0
0389								SVS

SVS (#0) 0: Displays the servo screen.

● Series 15

Press the SERVICE key several times, and the servo setting screen will appear.

● Series 16, 18, 20, 21

SYSTE → [SYSTEM] → [▷] → [SV-PRM]

If no servo screen appears, set the following parameter as shown, and switch the NC off and on again.

	#7	#6	#5	#4	#3	#2	#1	#0
3111								SVS

SVS (#0) 1: Displays the servo screen.

When the following screen appears, move the cursor to the item you want to specify, and enter the value directly.

Servo set			01000 N0000
		X axis	Z axis
INITIAL SET BITS		00001010	00001010
Motor ID No.		16	16
AMR		00000000	00000000
CMR		2	2
Feed gear	N	1	1
(N/M)	M	100	100
Direction Set		111	111
Velocity Pulse No.		8192	8192
Position Pulse No.		12500	12500
Ref. counter		10000	10000

Fig. 2.1.3 Servo setting menu

Power Mate	Power Mate-E
No. 2000	No. 1000
2020	1020
2001	1001
1820	100
2084	1084
2085	1085
2022	1022
2023	1023
2024	1024
1821	324

⇧ **Correspondence of Power Mate**

(3) Start initialization.

	#7	#6	#5	#4	#3	#2	#1	#0
INITIAL SET BIT					**PRMC**		**DGPR**	**PLC0**

(⇧ Note)

Start initialization (Keep the NC power on until step (11).)

↓

DGPR (#1) = 0 ⇦ Automatically set to 1 after initialization.

NOTE

Once initialization has been completed, the Series 0-C and Series 15-A automatically set bit 3 (PRMC) for initialization to 0, while other NC models set the bit to 1. Note that the bit 3 (PRMC) bit must be set to 0 for the Series 0-C and Series 15-A.

(4) Specify the motor ID No.
Select the motor ID No. of the servo motor to be used, according to the motor model and drawing number (the middle four digits of A06B-XXXX-BXXX) listed in the tables on subsequent pages.

α series servo motor

Motor model	α1/3000	α2/2000	α2/3000	α2.5/3000	α3/3000
Motor specification	0371	0372	0373	0374	0123
Motor type No.	61	46	62	84	15

Motor model	α6/2000	α6/3000	α12/2000	α12/3000	α22/1500
Motor specification	0127	0128	0142	0143	0146
Motor type No.	16	17	18	19	27

Motor model	α22/2000	α22/3000	α30/1200	α30/2000	α30/3000
Motor specification	0147	0148	0151	0152	0153
Motor type No.	20	21	28	22	23

Motor model	α40/FAN	α40/2000	α65	α100	α150
Motor specification	0158	0157	0331	0332	0333
Motor type No.	29	30	39	40	41

Motor model	α300/2000	α400/2000
Motor specification	0337	0338
Motor type No.	111	112

αL series servo motor

Motor model	αL3/3000	αL6/3000	αL9/3000	αL25/3000	αL50/2000
Motor specification	0561	0562	0564	0571	0572
Motor type No.	56 or 68*	57 or 69*	58 or 70*	59	60

Use the motors marked by * with the servo software that supports HRV control (Series 9066, 9080, 9081, 9090, and 90A0).

αC series servo motor

Motor model	αC3/2000	αC6/2000	αC12/2000	αC22/1500
Motor specification	0121	0126	0141	0145
Motor type No.	7	8	9	10

αHV series servo motor

Motor model	α3HV	α6HV	α12HV	α22HV	α30HV
Motor specification	0171	0172	0176	0177	0178
Motor type No.	1	2	3	102	103

αM series servo motor

Motor model	αM2/3000	αM2.5/3000	αM3/3000	αM6/3000	αM9/3000
Motor specification	0376	0377	0161	0162	0163
Motor type No.	98	99	24	25	26

Motor model	αM22/3000	αM30/3000	αM40/3000FAN (360A amplifier driving)	αM40/3000 (130A amplifier driving)
Motor specification	0165	0166	170	170
Motor type No.	100	101	108	110

Motor model	αM6HV	αM9HV	αM22HV	αM30HV
Motor specification	0182	0183	0185	0186
Motor type No.	104	105	106	107

Linear motor

Motor model	1500A	3000B	6000B	9000B	15000C
Motor specification	0410	0411	0412	0413	0414
Motor type No.	90	91	92	93	94

Remark)

β series servo motor

Motor model	β0.5	β1/3000	β2/3000	β3/3000	β6/2000
Motor specification	0113	0031	0032	0033	0034
Motor type No.	13	35	36	33	34

These motor type Nos. may not be supported depending on the servo software being used.
The following lists the motor type Nos. together with the applicable servo software series and editions.

α series servo motor

Motor model and motor type number \ Servo software series		9041	9046	9060	9066	9070	9080	9081	9090	90A0	9064	9065
α1/3000	61	A	B	M	A	C	A	C	A	A	E	A
α2/2000	46	A	B	M	A	C	A	C	A	A	E	A
α2/3000	62	A	B	M	A	C	A	C	A	A	E	A
α2.5/3000	84	A	B	M	A	C	A	C	A	A	E	A
α3/3000	15	A	B	M	A	C	A	C	A	A	E	A
α6/2000	16	A	B	M	A	C	A	C	A	A	E	A
α6/3000	17	A	B	M	A	C	A	C	A	A	E	A
α12/2000	18	A	B	M	A	C	A	C	A	A	E	A
α12/3000	19	A	B	M	A	C	A	C	A	A	E	A
α22/1500	27	A	B	M	A	C	A	C	A	A	E	A
α22/2000	20	A	B	M	A	C	A	C	A	A	E	A
α22/3000	21	A	B	M	A	C	A	C	A	A	E	A
α30/1200	28	A	B	M	A	C	A	C	A	A	E	A
α30/2000	22	A	B	M	A	C	A	C	A	A	E	A
α30/3000	23	A	B	M	A	C	A	C	A	A	E	A
α40/FAN	29	A	B	M	A	C	A	C	A	A	E	A
α40/2000	30	A	B	M	A	C	A	C	A	A	E	A
α65	39	A	B	M	A	C	A	C	A	A	E	A
α100	40	A	B	M	A	C	A	C	A	A	E	A
α150	41	A	B	M	A	C	A	C	A	A	E	A
α300/2000	111						Y		M	K		
α400/2000	112						Y		M	K		

αL series servo motor

Motor model and motor type number \ Servo software series		9041	9046	9060	9066	9070	9080	9081	9090	90A0	9064	9065
αL3/3000	56 68	A	B	M	A I	C	A K	C E	A A	A A	E	A
αL6/3000	57 69	A	B	M	A I	C	A K	C E	A A	A A	E	A
αL9/3000	58 70	A	B	M	A I	C	A K	C E	A A	A A	E	A
αL25/3000	59	A	B	M	A	C	A	C	A	A	E	A
αL50/3000	60	A	B	M	A	C	A	C	A	A	E	A

αC series servo motor

Motor model and motor type number \ Servo software series		9041	9046	9060	9066	9070	9080	9081	9090	90A0	9064	9065
αC3/2000	7	A	B	M	A	C	A	C	A	A	E	A
αC6/2000	8	A	B	M	A	C	A	C	A	A	E	A
αC12/2000	9	A	B	M	A	C	A	C	A	A	E	A
αC22/1500	10	A	B	M	A	C	A	C	A	A	E	A

αHV series servo motor

Motor model and motor type number \ Servo software series		9041	9046	9060	9066	9070	9080	9081	9090	90A0	9064	9065
α3HV	1			W	B	M	A	A	A	A	F	A
α6HV	2			W	B	M	A	A	A	A	F	A
α12HV	3	A	B	M	A	C	A	C	A	A	E	A
α22HV	102				I		K	E	D	A		
α30HV	103				I		K	E	D	A		

αM series servo motor

Motor model and motor type number \ Servo software series		9041	9046	9060	9066	9070	9080	9081	9090	90A0	9064	9065
αM2/3000	98				I		K	E	D	A		
αM2.5/3000	99				I		K	E	D	A		
αM3/3000	24	A	B	M	A	C	A	C	A	A	E	A
αM6/3000	25	A	B	M	A	C	A	C	A	A	E	A
αM9/3000	26	A	B	M	A	C	A	C	A	A	E	A
αM22/3000	100				I		K	E	D	A		
αM30/3000	101				I		K	E	D	A		
αM40/3000 (360A driving)	108						Y		L	D		
αM40/3000 (130A driving)	110						Y		L	D		
αM6HV	104				I		K	E	D	A		
αM9HV	105				I		K	E	D	A		
αM22HV	106				I		K	E	D	A		
αM30HV	107				I		K	E	D	A		

Linear motor

Motor model and motor type number \ Servo software series		9041	9046	9060	9066	9070	9080	9081	9090	90A0	9064	9065
1500A	90				D		A	A	A	A		
3000B	91				D		A	A	A	A		
6000B	92				D		A	A	A	A		
9000B	93				D		A	A	A	A		
15000C	94				K		S		J	C		

Reference)

β series servo motor

Motor model and motor type number \ Servo software series		9041	9046	9060	9066	9070	9080	9081	9090	90A0	9064	9065
β0.5/3000	13	A	B	M	A	C	A	C	A	A	E	A
β1/3000	35	A	B	M	A	C	A	C	A	A	E	A
β2/3000	36	A	B	M	A	C	A	C	A	A	E	A
β3/3000	33		G	W	B	H	A	C	A	A	F	A
β6/2000	34	A	B	M	A	C	A	C	A	A	E	A

(5) Set AMR as described below:

α pulse coder	00000000

(6) Set CMR with the scale of a distance the NC instructs the machine to move.
CMR = Command unit / Detection unit

CMR 1/2 to 48	Setting value = CMR × 2

Usually, CMR = 1, so specify 2.

(7) Specify the flexible feed gear (F·FG). This function makes it easy to specify a detection unit for the leads and gear reduction ratios of various ball screws by changing the number of position feedback pulses from the pulse coder or separate detector.

Setting for the α pulse coder in the semi-closed mode

$$\frac{\text{F·FG numerator } (\leq 32767) \text{ (Note 1)}}{\text{F·FG denominator } (\leq 32767)} = \frac{\text{Necessary position feedback pulses per motor revolution}}{1{,}000{,}000 \text{ (Note 2)}} \quad \text{(as irreducible fraction)}$$

NOTE

1 For both F·FG number and denominator, the maximum setting value (after reduced) is 32767.
2 α pulse coders assume one million pulses per motor revolution, irrespective of resolution, for the flexible feed gear setting.
3 If the calculation of the number of pulses required per motor revolution involves π, such as when a rack and pinion are used, assume π to be approximately 355/113.
4 The setting for serial pulse coder A is the same as for the α pulse coder.

Example of setting

For detection in 1 μm units, specify as follows:

Ball screw lead (mm/rev)	Number of necessary position pulses (pulses/rev)	F·FG
10	10000	1/100
20	20000	2/100 or 1/50
30	30000	3/100

Example of setting

If the machine is set to detection in 1,000 degree units with a gear reduction ratio of 10:1 for the rotation axis, the table rotates by 360/10 degrees each time the motor makes one turn.
1000 position pulses are necessary for the table to rotate through one degree.
The number of position pulses necessary for the motor to make one turn is:

$360/10 \times 1000 = 36000$ with reference counter = 36000

$$\frac{\text{F·FG numerator}}{\text{F·FG denominator}} = \frac{36000}{1{,}000{,}000} = \frac{36}{1000}$$

Setting for use of a separate detector (full-closed)
$\frac{\text{F·FG numerator } (\leq 32767)}{\text{F·FG denominator } (\leq 32767)} = \frac{\text{Number of position pulses corresponding to a predetermined amount of travel}}{\text{Number of position pulses corresponding to a predetermined amount of travel from a separate detector}}$ (as irreducible fraction)

DMR can also be used with the parallel type separate position detector, provided that F·FG = 0.

Example of setting

To detect a distance of 1 μm using a 0.5-μm scale, set the following:

$$\frac{\text{Numerator of F·FG}}{\text{Denominator of F·FG}} = \frac{L/1}{L/0.5} = \frac{1}{2}$$

(8) Specify the direction in which the motor rotates.

111	Clockwise as viewed from the pulse coder
–111	Counterclockwise as viewed from the pulse coder

(9) Specify the number of velocity pulses and the number of position pulses.

	Semi-closed			Full-closed					
				Parallel type		Serial liner scale		Serial rotary scale	
Command unit (µm)	1	0.1		1	0.1	1	0.1	1	0.1
Initialization bit	b0 = 0	b0 = 0	b0 = 0	b0 = 0	b0 = 1	b0 = 0	b0 = 1	b0 = 0	b0 = 0
Number of velocity pulses	8192	8192	8192	8192	819	8192	819	8192	8192
Number of position pulses	12500	12500	12500	Ns	Ns/10	Ns	Ns/10	Np	Np

Ns : Number of position pulses from the separate detector when the motor makes one turn

Np: 12500 × (motor-to-table deceleration ratio or acceleration ratio)
(Example: When the motor rotates ten turns while the table rotates one turn: Np = 12500/10 = 1250)

Conventionally, the initialization bit, bit 0 (high-resolution bit), was changed according to the command unit. The command unit and initialization bit 0 have no longer been interrelated with each other in all CNCs except the Series 0-C and Series 15-A.
Of course, the conventional setting method may also be used. For easier setting, however, set the bit as follows:

Semi-closed: Initialization bit bit 0 = 0
Full-closed: Initialization bit bit 0 = 1
Only when the number of position pulses exceeds 32767.

In the above table, the number of position pulses is likely to exceed 32767 when the command unit is 0.1 µm in full-closed mode.
When using a separate detector (full-closed mode), also specify the following parameters:

(When using the separate serial detector, see Subsec. 2.1.4.)

● Series 0–C

	#7	#6	#5	#4	#3	#2	#1	#0
0037			STP8	STP7	STP4	STPZ	STPY	STPX

STPX to 8 (#0 to #5) The separate position detector is:

0: Not used for the X-axis, Y-axis, Z-axis, fourth axis, seventh axis, or eighth axis

1: Used for the X-axis, Y-axis, Z-axis, fourth axis, seventh axis, and eighth axis

- **Series 15, 16, 18, 20, 21, Power Mate**

	#7	#6	#5	#4	#3	#2	#1	#0
1807					PFSE			
–								

↑ Must be specified only for Series 15.

PFSE (#3) The separate position detector is:
0: Not used
1: Used

> **CAUTION**
> This parameter is used only for Series 15.

	#7	#6	#5	#4	#3	#2	#1	#0
1815							OPTX	

↑ Must be specified for all NCs.

OPTX (#1) The separate position detector is:
0: Not used
1: Used

> **NOTE**
> For Series 16, 18, 20, and 21, setting this parameter causes bit 3 of parameter No. 2002 to be set to 1 automatically.

- **Power Mate–E**

	#7	#6	#5	#4	#3	#2	#1	#0
1002	GRSL				PFSE			
–								

GRSL (#7) The separate position detector is:
PFSE (#3) 0: Not used
1: Used
Specify the same value for both GRSL and PFSE.

(10) Specify the reference counter.
The reference counter is used in making a return to the reference position by a grid method.

Semi-closed loop

Count on the reference counter	=	Number of position pulses corresponding to a single motor revolution or the same number divided by an integer value

Example of setting

α pulse coder and semi-closed loop (1-μm detection)

Ball screw lead (mm/revolution)	Necessary number of position pulses (pulse/revolution)	Reference counter	Grid width (mm)
10	10000	10000	10
20	20000	20000	20
30	30000	30000	30

When the number of position pulses corresponding to a single motor revolution does not agree with the reference counter setting, the position of the zero point depends on the start point.
Should this occur, eliminate the difference by changing the detection unit.

Example of setting

System using a detection unit of 1 μm, a ball screw lead of 20 mm/revolution, a gear reduction ratio of 1/17, the number of position pulses corresponding to a single motor revolution set to 1176.47, and the reference counter set to 1176

In this case, increase all the following parameter values by a factor of 17, and set the detection unit to 1/17 μm.

Parameter modification	Series 0-C	Series 15, 16, 18, 20, 21, Power Mate	Power Mate-E
FFG	Servo screen	Servo screen	Nos. 1084, 1085
CMR	Servo screen	Servo screen	100
Reference counter	Servo screen	Servo screen	324
Effective area	Nos. 500 to 503	Nos. 1826, 1827	200
Position error limit in traveling	504 to 507	1828	202
Position error limit in the stop state	593 to 596	1829	231
Backlash	535 to 538	1851, 1852	221

(All other CNC parameters set in detection units, such as the amount of grid shift and pitch error compensation magnification, are also multiplied by 17.)

CAUTION
In addition to the above parameters, there are some parameters that are to be set in detection units.
For details, see Appendix C.

Making these modifications eliminates the difference between the number of position pulses corresponding to a single motor revolution and the reference counter setting.
Number of position pulses corresponding to a single motor revolution = 20000
Reference counter setting = 20000

CAUTION

In rotation axis control for the Series 16, 18, and Power Mate, continuous revolution in the same direction will result in an error if the result of the following calculation is other than an integer, even if the reference counter setting is an integer. Therefore, set parameter No. 1260 so that the result of the calculation is an integer.

(Amount of travel per rotation of the rotation axis (parameter No. 1260)) × CMR ×
(reciprocal of flexible feed gear) × $2^{21}/10^{6}$

This problem has been corrected in the following system software version and later versions:

B0F2/04 (16*i*M)
B1F2/04 (16*i*T)
BDF2/04 (18*i*M)
BEF2/04 (18*i*T)
DDF2/04 (21*i*M)
DEF2/04 (21*i*T)

Full-closed loop

Reference counter setting	=	Z-phase (reference-position) interval divided by the detection unit, or this value sub-divided by an integer value

Example of setting

Example 1) When the Z-phase interval is 50 mm and the detection unit is 1 μm:
Reference counter setting = 50,000/1 = 50,000

Example 2) When a rotation axis is used and the detection unit is 0.001°:
Reference counter setting = 360/0.001 = 360,000

Example 3) When a linear scale is used and a single Z phase exists:
Set the reference counter to 10000, 50000, or another round number.

(11) When using an S-series amplifier, set the following parameters:

		#7	#6	#5	#4	#3	#2	#1	#0
1809	8X04	DLY1	DLY0	TIB1	TIB2	TRW1	TRW0	TIB0	TIA0
2004	1004	0	1	0	0	0	1	1	0

(↑ S-series amplifier)

1866	8X54	Current dead band compensation (PDDP)
2054	1054	

Set value 3787 (S-series amplifier)

(12) Switch the NC off and on again.
This completes servo parameter initialization.
If an invalid servo parameter setting alarm occurs, go to Subsec. 2.1.4.
If a servo alarm related to pulse coders occurs for an axis for which a servo motor or amplifier is not connected, specify the following parameter.
A feedback connector is used in conventional Series 0-C and 15-A models. However it cannot be used in a system designed for operation with an α pulse coder.
This parameter should be specified instead of the dummy connector.

		#7	#6	#5	#4	#3	#2	#1	#0
1953	8X09								SERD
2009	1009								

SERD (#0) The dummy serial feedback function is: (See Sec. 4.6 for function detail)
0 : Not used
1 : Used

(13) When you are going to use an α pulse coder as an absolute pulse coder, use the following procedure.
This procedure is somewhat different from one for conventional pulse coders. (Steps 3 to 5 have been added.)
1. Specify the following parameter, then switch the NC off.

● Series 0–C

	#7	#6	#5	#4	#3	#2	#1	#0
0021			APC8	APC7	APC4	APCZ	APCY	APCX

APCX to 8 (#0 to #5) The absolute position detector is:
0: Not used for the X-axis, Y-axis, Z-axis, fourth axis, seventh axis, or eighth axis.
1: Used for the X-axis, Y-axis, Z-axis, fourth axis, seventh axis, and eighth axis.

● Series 15, 16, 18, 20, 21, Power Mate

	#7	#6	#5	#4	#3	#2	#1	#0
1815			APCX					

APCX (#5) The absolute position detector is:
0: Not used
1: Used

● Power Mate–E

	#7	#6	#5	#4	#3	#2	#1	#0
0017								APCX

APCX (#0) An absolute position detector is:

0: Not used

1: Used

2. After making sure that the battery for the pulse coder is connected, switch the NC on.
3. A request to return to the reference position is displayed.
4. Cause the motor to make one turn by jogging.
5. Turn off and on the CNC.

⇐ These steps were added for the α pulse coder.

6. A request to return to the reference position is displayed.
7. Do the zero return.

2.1.4 Setting Servo Parameters When a Separate Detector for the Serial Interface Is Used

(1) Overview

When a separate detector of the serial output type is used, there is a possibility that the detection unit becomes finer than the detection unit currently used. Accordingly, a few modifications are made to the setting method and values of servo parameters.
When using a separate detector of the serial output type, follow the method explained below to set parameters.

(2) Series and editions of applicable servo software

Series 9080/M (13) and subsequent editions (Series 15-B, 16-C, and 18-C)
Series 90A0/H (08) and subsequent editions (Series 15*i*, 16*i*, 21*i*, Power Mate *i*)

(3) Separate detectors of the serial output type

(1) The serial output type linear scales currently available are listed below:

	Minimum resolution	Backup
Mitsutoyo Co., Ltd.	0.5 μm	Not required
Heidenhein Co., Ltd.	0.1 μm	Not required
Sony Precision Technology Inc.	0.1 μm	Incremental

(2) The serial output type rotary encoders currently available are listed below:

	Minimum resolution (Note 1)	Backup
FANUC	2^{20} pulse/rev	Required
Heidenhein Co., Ltd.	2^{20} pulse/rev	Not required (Note 2)

NOTE
1 The minimum resolution of a rotary encoder is the resolution of the encoder itself.
FANUC's rotary encoder, however, is treated as having a resolution of 1,000,000 pulses per revolution because of the servo software configuration.
2 Only data within one revolution is backed up; data for more than one revolution is not backed up.

(4) Setting parameters

Linear type

In addition to the conventional settings for a separate detector (bit 1 of parameter No. 1815 (Series 15, 16, and 18), bit 3 of parameter No. 1807 (Series 15), and if needed, FSSB), note the following parameters:

[Flexible feed gear]

Parameter Nos. 2084 and 2085 (Series 16 and 18) or Nos. 1977 and 1978 (Series 15-B)

[Flexible feed gear N/M]

= Detection unit of the detector (μm)/least input increment of the controller (μm)

[Number of position pulses]

Parameter No. 2024 (Series 16 and 18) or No. 1891 (Series 15-B)

Number of position pulses = the amount of movement per motor revolution (mm)/detection unit of the detector (mm)

* If the number of position pulses exceeds 32767 as a result of the above calculation, set bit 0 of parameter No. 2000 (Series 16 and 18) or No. 1804 (Series 15-B) to 1, and reduce the following parameter values by a factor of 10:
  Number of position pulses: No. 2024 (Series 16 and 18),
  No. 1891 (Series 15-B)
  Number of velocity pulses: No. 2023 (Series 16 and 18),
  No. 1876 (Series 15-B)

This completes parameter setting. Turn the power off then back on.

If an invalid parameter setting alarm is then issued, check the following parameters:

* Number of position pulses: No. 2024 (Series 16 and 18) or
  No. 1891 (Series 15-B) > 13100

If the above formula is satisfied, modify the parameter by referencing supplementary 1 of Table 2.1.5.

(Example of parameter setting)

- The Series 16 is used.
- A linear scale with a minimum resolution of 0.1 μm is used.
- The least input increment of the controller is 1 μm.
- The amount of movement per motor revolution is 16 mm.

To enable a separate detector, set bit 1 of parameter No. 1815 to 1.

First, calculate the parameters for the flexible feed gear.

[Flexible feed gear] Parameter Nos. 2084 and 2085

[Flexible feed gear N/M]

= Detection unit of the detector (μm)/least input increment of the controller (μm)

= 0.1 μm/1 μm = 1/10

Calculate the number of position pulses.

[Number of position pulses] Parameter No. 2024

Number of position pulses = the amount of movement per motor revolution (mm)/detection unit of the detector (mm)

= 16 mm/0.0001 = 160000

If the number of position pulses exceeds 32767 as shown above, set bit 0 of parameter No. 2000 to 1, and reduce the number of position pulses (parameter No. 2024) and number of velocity pulses (parameter No. 2023) by a factor of 10. (16000 is set in parameter No. 2024.)

The number of position pulses, obtained with the above method, is 16000 which is greater than 13100. An overflow occurs in the internal calculation of the servo software, resulting in an invalid parameter setting alarm. To prevent this, divide the value in parameter No. 2024 by 2 so that the value does not exceed 13100, and modify the following parameters accordingly:

Parameter No.	Remarks
2000#0	1
2023	8192/10/2
2024	160000/10/2
2043	(Value to be set originally)/2
2044	(Value to be set originally)/2
2047	(Value to be set originally)*2
2053	(Value to be set originally)*2
2054	(Value to be set originally)/2
2056	(Value to be set originally)/2
2057	(Value to be set originally)/2
2059	(Value to be set originally)*2
2074	(Remainder of the value to be set originally/4096)/ 2 + (quotient of the value to be set originally/4096) × 4096
2076	(Value to be set originally)/2
2128	(Value to be set originally)/2
2129	(Quotient of the value to be set originally/256) × 2 × 256 + (remainder of the value to be set originally/256)

When the Series 90A0 is used, a position feedback pulse overflow can be prevented by a simple method. For this method, see Supplementary 1 of Subsec. 2.1.5, "Actions for Invalid Servo Parameter Setting Alarms."

Rotary type

In addition to the conventional settings for a separate detector (bit 1 of parameter No. 1815 (Series 15, 16, and 18), bit 3 of parameter No. 1807 (Series 15), and if needed, FSSB), note the following parameters:

[Flexible feed gear] Parameter Nos. 2084 and 2085 (Series 16 and 18), or Nos. 1977 and 1978 (Series 15-B)
[Flexible feed gear N/M] = (Amount of table movement (degrees) per detector revolution)/(detection unit (degrees))/1,000,000

[Number of position pulses] Parameter No. 2024 (Series 16 and 18) or No. 1891 (Series 15-B)
Number of position pulses = 12500 × motor-to-table deceleration ratio or acceleration ratio

> **NOTE**
> * When multiplication by the deceleration ratio reduces the number of position pulses, resulting in the issuance of an invalid parameter setting alarm, modify parameter setting as follows:
>   Set bit 4 of parameter No. 2000 to 1 (Series 16 and 18), or bit 4 of parameter No. 1804 to 1 (Series 15-B).
> * When multiplication by the acceleration ratio increases the number of position pulses (32767 or more), resulting in the issuance of an invalid parameter setting alarm, modify parameter settings as follows:
>   Set bit 0 of parameter No. 2000 to 1 (Series 16 and 18), or bit 0 of parameter No. 1804 to 1 (Series 15-B).
>   Reduce the number of position pulses in parameter No. 2024 (Series 16 and 18) or No. 1891 (Series 15-B) by a factor of 10.
>   Reduce the number of velocity pulses in parameter No. 2023 (Series 16 and 18) or No. 1876 (Series 15-B) by a factor of 10.

This completes setting. Turn power off then back on.

(Example of parameter setting)

- The Series 16 is used.
- The least input increment of the controller is 1/1000 degree.
- The amount of movement per motor revolution is 180 degrees (deceleration ratio: 1/2)
- Table-to-separate-encoder deceleration ratio = 1/1

To enable the separate detector, set bit 1 of parameter No. 1815 to 1.

First, calculate the parameters for the flexible feed gear.

[Flexible feed gear] Parameter Nos. 2084 and 2085

[Flexible feed gear N/M] = (Amount of table movement (degrees) per detector revolution)/(detection unit (degrees))/1,000,000
= 360 degrees/0.001 degree/1,000,000
= 36/100

Calculate the number of position pulses.

[Number of position pulses] Parameter No. 2024

Number of position pulses = 12500 × motor-to-table deceleration ratio
= 12500 × (1/2) = 6250

This completes parameter setting.

Setting the signal direction of the separate detector

With a conventional parallel type separate detector, when the signal direction of the separate detector and the movement direction of the machine is opposite to each other, the feedback cable signal had to be connected in reverse by hardware.

With a serial type separate detector, it is impossible to connect signal in reverse. So, the signal direction can be reversed by setting the parameter shown below.

Parameter

		#7	#6	#5	#4	#3	#2	#1	#0
1960	–								RVRSE
2018	–								

RVRSE (#0) The signal direction of the separate detector is:

1: Reversed.

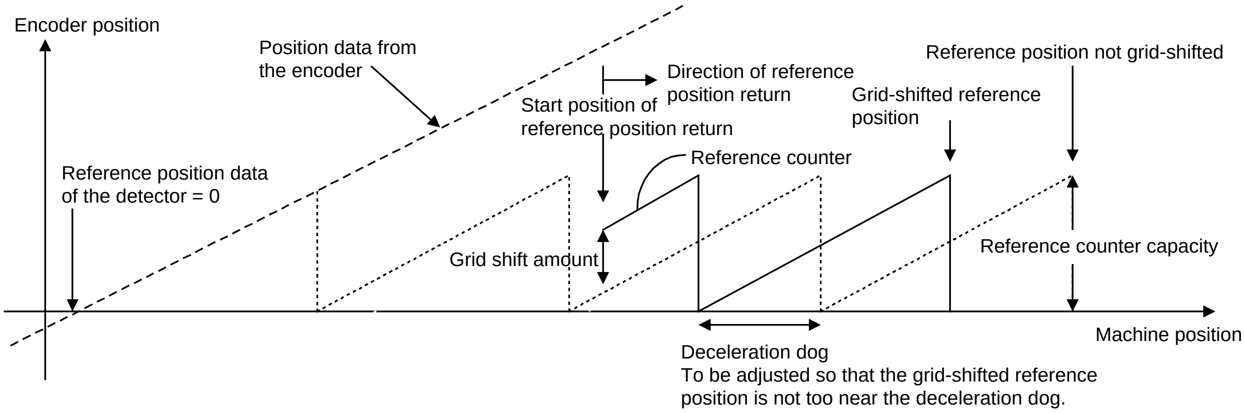
0: Not reversed.

> **NOTE**
> This parameter can be used only for serial type separate detectors; the parameter cannot be used for parallel type separate detectors. To reverse the signal direction of a parallel type separate detector, replace A and $\overline{A}$.

(5) Reference position return when a serial type separate detector is used as an absolute-position detector

When a serial type separate detector is used as an absolute-position detector, the phase-Z position must be passed once before a reference position return is performed. Then, turn the CNC off then back on to allow reference position return.

When reference position return is performed, adjust the deceleration dog so that the grid-shifted reference position is not too near the deceleration dog.



2.1.5 Actions for Invalid Servo Parameter Setting Alarms

(1) Overview

When a setting value is beyond an allowable range, or when an overflow occurs during internal calculation, an invalid parameter setting alarm is issued.
This section explains the procedure to output information to identify the location and the cause of an invalid parameter setting alarm.

(2) Series and editions of applicable servo software

Series 9080/N (14) and subsequent editions (Series 15-B, 16-C, and 18-C)
Series 9090/E (05) and subsequent editions (Series 16*i*, 18*i*, and Power Mate *i*)
Series 90A0/A (01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, and Power Mate *i*)

(3) Invalid parameter setting alarms that can be displayed in parameter error detail display

Invalid parameter setting alarms detected by the servo software can be displayed. Alarms detected by the system software cannot be displayed here.
To check whether an alarm is detected by the servo software, check the following:

	#7	#6	#5	#4	#3	#2	#1	#0
Alarm 4 on the servo screen				**PRM**				

1: Alarm detected by the servo software (Detail display is enabled.)
0: Alarm detected by the system software (Detail display is not enabled.)

(4) Method

When an invalid parameter setting alarm detected by the servo software is issued, analyze the cause of the alarm by following the procedure explained below.

* When more than one alarm is issued, one of the causes of these alarms is displayed. Analyze the alarms one by one.

Procedure for displaying detail information about an invalid parameter setting alarm

(For the Series 15*i*)
On the servo alarm screen, an item indicating parameter error details is located in the lower left side. Check the number indicated here.

(For the Series 16*i*, 18*i*, 21*i*, and Power Mate *i*)
On the diagnosis screen, search for No. 352. Check the number written in No. 352.

(For the Series 15-B)
Check the value in No. 1023 for the axis where a parameter error occurred. According to the value, set a parameter as follows:
Axis for which an odd value is set in parameter No. 1023:
No. 1726 = 20480
Axis for which an even value is set in parameter No. 1023:
No. 1726 = 22528
Then, open the contents-of-memory screen, and check the data at the address shown below. Check the 4-digit hexadecimal value.
[When the system is not a multiaxis system]
Axis for which 1 is set in No. 1023: > 908001C0
Axis for which 2 is set in No. 1023: > 908001C2
Axis for which 3 is set in No. 1023: > 90A001C0
Axis for which 4 is set in No. 1023: > 90A001C2
Axis for which 5 is set in No. 1023: > 43C801C0
Axis for which 6 is set in No. 1023: > 43C801C2
Axis for which 7 is set in No. 1023: > 43CA01C0
Axis for which 8 is set in No. 1023: > 43CA01C2
[When the system is a multiaxis system]
Axis for which 1 is set in No. 1023: > A9C801C0
Axis for which 2 is set in No. 1023: > A9C801C2
Axis for which 3 is set in No. 1023: > A9CA01C0
Axis for which 4 is set in No. 1023: > A9CA01C2
Axis for which 5 is set in No. 1023: > AAC801C0
Axis for which 6 is set in No. 1023: > AAC801C2
Axis for which 7 is set in No. 1023: > AACA01C0
Axis for which 8 is set in No. 1023: > AACA01C2
Axis for which 9 is set in No. 1023: > ABC801C0
Axis for which 10 is set in No. 1023: > ABC801C2
Axis for which 11 is set in No. 1023: > ABCA01C0
Axis for which 12 is set in No. 1023: > ABCA01C2
Axis for which 13 is set in No. 1023: > ACC801C0
Axis for which 14 is set in No. 1023: > ACC801C2
Axis for which 15 is set in No. 1023: > ACCA01C0
Axis for which 16 is set in No. 1023: > ACCA01C2

NOTE
To display these addresses, search for the following address. (Otherwise, a system alarm is issued.)
For 9-inch CRT display: Address xxxxx180
For 15-inch CRT display: Address xxxxx100

(For the Series 16-C and 18-C)
Set parameters according to the following table:

Setting in No. 1023	1st axis	2nd axis	3rd axis	4th axis	5th axis	6th axis	7th axis	8th axis
No. 8950#0	1	1	1	1	1	1	1	1
No. 8960	1304	1304	1312	1312	1800	1800	1808	1808
No. 2115	20480	22528	20480	22528	20480	22528	20480	22528

Then, open the memory screen by pressing an appropriate soft key. The upper and lower bytes of a parameter error detail number are displayed in the following addresses:

Axis for which an odd value is set in parameter No. 1023:

> 1C1 (upper byte)

> 1C0 (lower byte)

Axis for which an even value is set in parameter No. 1023:

> 1C3 (upper byte)

> 1C2 (lower byte)

For example, when an invalid parameter setting alarm is caused for the first axis (set in parameter No. 1023), and 34 is set at address 1C0 and 04 is set at address 1C1 on the memory screen, alarm detail No. is 0434.

NOTE

To display address 1Cx, search for address 199, then perform page feed by two pages.
However, page feed by more than two pages causes a system alarm.

Analyzing invalid parameter setting alarms in detail

The detail alarm data basically consists of four digits as shown:

0	4	3	4

Location where an alarm was caused (0 4 3) — Cause of the alarm (4)

Upper three digits: Indicate the location where an alarm was caused.
Table 2.1.5 lists the displayed numbers and corresponding parameter numbers.
* Remark: Basically, the lower three digits in a 4-digit parameter number in the Series 16 are indicated.

Lowest digit: Indicates the cause of an alarm.
The displayed numbers and their meanings are explained below:

1: Because the parameter value is beyond the setting range, a clamped value is used. (This is not an alarm but a caution. It is not used at present.)

2: The set parameter is invalid. The corresponding function does not operate.

3: The parameter value is beyond the setting range. Alternatively, the parameter is not set.

4 to 9: An overflow occurred during internal calculation.

NOTE

Basically, 4-digit data is indicated as alarm detail information. However, 3- or 5-digit data may be indicated in the following cases:

1. When the diagnosis screen is displayed, three-digit data is indicated.
   Add 0 to the top of the three digits, and read the data as 4-digit data.
2. When the diagnosis screen is displayed, five-digit data is indicated.
   The data displayed as Axxx on the memory screen is indicated as 10xxx on the diagnosis screen.

Table 2.1.5 Detail analysis of invalid parameter setting alarms

Alarm detail No.	Parameter No. (Series 15)	Parameter No. (Series 16, etc.)	Cause	Action
0233	1876	2023	When initialization bit 0 is set to 1, the number of velocity pulses exceeds 13100.	Correct the number of velocity pulses so that it is within 13100.
0243	1891	2024	When initialization bit 0 is set to 1, the number of position pulses exceeds 13100.	Correct the number of position pulses so that it is within 13100. → See Supplementary 1.
0434 0435	1855	2043	The internal value of the velocity loop integral gain overflowed.	Decrease the value of the velocity loop integral gain parameter.
0444 0445	1856	2044	The internal value of the velocity loop proportional gain overflowed.	Use the function for changing the internal format of the velocity loop proportional gain. → See Supplementary 2.
0474 0475	1859	2047	The internal value of the observer parameter (POA1) overflowed.	Correct the setting to (–1) × (desired value)/10.
0534 0535	1865	2053	The internal value of a parameter related to dead zone compensation overflowed.	Decrease the setting to the extent that the invalid parameter setting alarm is not caused.
0544 0545	1866	2054	The internal value of a parameter related to dead zone compensation overflowed.	Decrease the setting to the extent that the invalid parameter setting alarm is not caused.
0686 0687 0688	1961	2068	The internal value of the feed-forward coefficient overflowed.	Use the position gain expansion function. → See Supplementary 3.
0694 0695 0696 0699	1962	2069	The internal value of the velocity feed-forward coefficient overflowed.	Decrease the velocity feed-forward coefficient.
0754 0755	1968	2075	The value set in the parameter shown to the left overflowed.	This parameter is not used at present. Set 0.

Alarm detail No.	Parameter No. (Series 15)	Parameter No. (Series 16, etc.)	Cause	Action
0764 0765	1969	2076	The value set in the parameter shown to the left overflowed.	This parameter is not used at present. Set 0.
0783	1971	2078	With the closed-loop linear motor, the conversion coefficient parameter shown to the left is not set. (For the Series 9080 only)	Set a value in the parameter shown to the left.
0793	1972	2079	With the closed-loop linear motor, the conversion coefficient parameter shown to the left is not set. (For the Series 9080 only)	Set a value in the parameter shown to the left.
0843	1977	2084	A positive value is not set as the flexible feed gear numerator. Alternatively, the numerator of the feed gear is greater than the denominator.	Set a positive value as the flexible feed gear numerator. Alternatively, correct the parameter so that the numerator of the feed gear is less than or equal to the denominator. (For other than parallel type separate detectors)
0853	1978	2085	A positive value is not set as the flexible feed gear denominator.	Set a positive value as the flexible feed gear denominator.
0884 0885 0886	1981	2088	The internal value of the machine velocity feedback coefficient overflowed.	Decrease the machine velocity feedback coefficient. Alternatively, use the vibration-damping control function that has an equivalent effect.
0883	1981	2088	For an axis with a serial type separate detector, a value exceeding 100 is set as the machine velocity feedback coefficient.	For an axis with a serial type separate detector, the upper limit of the machine velocity feedback coefficient is 100. Correct the coefficient so that it does not exceed 100.
0926 0927 0928	1985	2092	The internal value of the advanced preview feed-forward coefficient overflowed.	Use the position gain expansion function. → See Supplementary 3.
0996	1992	2099	The internal value for N pulse suppression overflowed.	Decrease the value set in the parameter shown to the left.
1123	1705	2112	Although a linear motor is used, the AMR conversion coefficient parameter is not input.	Set the AMR conversion coefficient.
1183	1729	2118	With a closed-loop linear motor, the semi-closed loop error threshold parameter is not set. (For the Series 9080 only)	Set the semi-closed loop error threshold value in the parameter shown to the left.
1284 1285	1736	2128	When a small value is set as the number of velocity pulses, the internal value of a parameter	Decrease the value in the parameter shown to the left to the extent that the alarm is

Alarm detail No.	Parameter No. (Series 15)	Parameter No. (Series 16, etc.)	Cause	Action
			related to current control overflows.	not caused.
1294 1295	1752	2129	When a large value is set as the number of velocity pulses, the internal value of a parameter related to current control overflows.	When the value set in the parameter shown to the left is resolved to the form a × 256 + b, set a smaller value in a again.
1393	1762	2139	The AMR offset value of a linear motor exceeds ±45.	Correct the parameter shown to the left so that it is within ±45.
1446 1447 1448	1767	2144	In the cutting feed/rapid traverse FAD function, the feed-forward coefficient for cutting overflowed.	Use the position gain expansion function. → See Supplementary 3.
1454 1455 1456 1459	1768	2145	In the cutting feed/rapid traverse FAD function, the velocity feed-forward coefficient for cutting overflowed.	Decrease the velocity feed-forward coefficient.
8213	1896	1821	A positive value is not set in the reference counter capacity parameter.	Set a positive value in the parameter shown to the left.
8254 8255 8256	1825	1825	The internal value of the position gain overflowed.	Use the position gain expansion function. → See Supplementary 3.
10016 (A016) 10019 (A019)	1740bit0	2200bit0	The internal value of a parameter related to runaway detection overflowed.	Do not use the runaway detection function. (Set bit 0 to 1.)
10033 (A033)	1809	2004	When the ITP cycle is 16 ms, 500 μs is selected as the velocity control cycle. 2 ms is selected as the velocity control cycle.	Correct the parameter related to interrupt cycle setting shown to the left.
10043 (A043)	1807#3 1815#1 1954#2	1815#1 2010#2	When a linear motor is used, the closed loop is set. (For series other than the Series 9080)	The closed loop cannot be set when the linear motor is used.
10053 (A053)	1960#0	2018#0	When a linear motor is used, the scale reverse connection bit is set.	When the linear motor is used, the scale reverse connection bit cannot be used.
10062 (A062)	1749#4	2209#4	The amplifier used does not support the HC alarm prevention function.	When you use the current amplifier continuously, set the function bit shown to the left to 0. When using the HC alarm prevention function, use an appropriate amplifier that supports the function.

Supplementary 1: Setting the number of position pulses

For a separate detector with a fine resolution, the number of position feedback pulses may exceed 13100 even when initialization bit 0 is set to 1. In such cases, use the position feedback pulse conversion coefficient.

Suppose:

Number of position feedback pulses = A × B

Select B so that A is within 32767. Then, set the following:

A: Number of position feedback pulses set in the parameter (less than or equal to 32767)

B: Conversion coefficient for the number of position feedback pulses

2628	–	**Conversion coefficient for the number of position feedback pulses**
2185	–	

> **NOTE**
> This function is available only with the Series 90A0/N (14) and subsequent editions.

When the servo software series/edition used does not support this function, make modifications listed below to prevent invalid parameter setting alarms.

E in the table satisfies the following:

Current number of position pulses/E < 13100

Parameter No.				**Parameter modification method**
Series 0-C	**Series 15**	**Series 16, etc.**	**Power Mate-E**	
8x00#0	1804#0	2000#0	1000#0	1
8x23	1876	2023	1023	(Value to be set originally)/10/E
8x24	1891	2024	1024	(Value to be set originally)/10/E
8x43	1855	2043	1043	(Value to be set originally)/E
8x44	1856	2044	1044	(Value to be set originally)/E
8x47	1859	2047	1047	(Value to be set originally)*E
8x53	1865	2053	1053	(Value to be set originally)*E
8x54	1866	2054	1054	(Value to be set originally)/E
8x56	1868	2056	1056	For series supporting HRV control(*): Leave the setting unchanged. For series not supporting HRV control: (Value to be set originally)/E
8x57	1869	2057	1057	For series supporting HRV control(*): Leave the setting unchanged. For series not supporting HRV control: (Value to be set originally)/E
8x59	1871	2059	1059	(Value to be set originally)*E
8x74	1967	2074	1074	For series supporting HRV control: Leave the setting unchanged. For series not supporting HRV control: (Remainder of the value to be set originally/4096)/E + (quotient of the value to be set originally/4096) × 4096

Parameter No.				Parameter modification method
Series 0-C	Series 15	Series 16, etc.	Power Mate-E	
8x76	1969	2076	1076	(Value to be set originally)/E
–	1736	2128	–	(Value to be set originally)/E
–	1752	2129	–	(Quotient of the value to be set originally/256) × E × 256 + (remainder of the value to be set originally/256)

* The series supporting HRV control includes the Series 9065, 9066, 9080, 9081, 9090, and 90A0.

Supplementary 2: Function for changing the internal format of the velocity loop proportional gain

An overflow may occur in the velocity loop proportional gain during internal calculation by the servo software. This can be avoided by setting the parameter shown below.
(This parameter can be used with the Series 9080/U (21) and subsequent editions, Series 9090/L (12) and subsequent editions, and Series 90A0/D (04) and subsequent editions.)

		#7	#6	#5	#4	#3	#2	#1	#0
1740	–		P2EX						
2200	–								

P2EX (#6)
1: Changes the internal format of the velocity loop proportional gain to prevent an overflow.
0: Uses the standard internal format for the velocity loop proportional gain.

Supplementary 3: Preventing an overflow in the feed-forward coefficient

An overflow in the feed-forward coefficient may be able to be prevented by using the position gain setting range expansion function. (For series other than the Series 0-C)

		#7	#6	#5	#4	#3	#2	#1	#0
1804	–				PEX				
2000	1000								

PEX (#4)
1: Enables the position gain setting range expansion function.
0: Disables the position gain setting range expansion function.

The Series 90A0/I (09) edition employs an internal calculation algorithm that tends to cause less overflows in the feed-forward coefficient. Before trying the above function, the user of the Series 90A0 should check whether an overflow can be prevented by updating the software to edition I or subsequent edition.

Supplementary 4: Preventing an overflow in the position gain

An overflow in the feed-forward coefficient may be able to be prevented by using the position gain setting range expansion function. (For series other than the Series 0-C and 15-A)

		#7	#6	#5	#4	#3	#2	#1	#0
1804	–				PEX				
2000	1000								

PEX (#4) Position gain setting range expansion function

1: Enables the position gain setting range expansion function.

0: Disables the position gain setting range expansion function.

The setting of the number of position pulses need not be changed.
For the Series 0-C and 15-A, a different method is used to set the position gain setting range expansion function.

		#7	#6	#5	#4	#3	#2	#1	#0
1955	8X11			PEX					
–	–								

PEX (#5) Position gain setting range expansion function

1: Enables the position gain setting range expansion function.

0: Disables the position gain setting range expansion function.

When setting this function bit to 1, increase the value set as the number of position pulses by a factor of 8.

		#7	#6	#5	#4	#3	#2	#1	#0
1891	8X24	Number of position feedback pulses							
–	–								

If a position gain overflow still occurs even after the above settings are made, change CMR.
When CMR is multiplied by A (integer), the flexible feed gear setting must also be multiplied by A. Since this means that the detection unit is reduced by a factor of A, the parameters that must be set in detection units must all be multiplied by A.
Appendix C lists the parameters that are to be set in detection units.

(5) When the NC used does not support parameter error detail display

When using an NC that cannot display parameter error detail information, check for the problems listed in Table 2.1.5 one by one. (Determine an invalid parameter by, for example, setting each parameter to 0 to check whether the alarm disappears.)

(6) Invalid parameter setting alarm caused by setting an invalid motor number

The table given below lists the valid motor numbers for each series.
If a number beyond the indicated range is set, an invalid parameter setting alarm is issued.
(In this case, bit 4 of alarm 4 on the servo screen is not set to 1.)

Servo software series/edition	Motor No.
Series 9041/A (01) and subsequent editions	3 to 89
Series 9046/A (01)	15 to 89
Series 9046/B (02) and subsequent editions	3 to 89
Series 9046/G (07) and subsequent editions	1 to 89
Series 9060/K (11) and subsequent editions	15 to 89
Series 9060/M (13) and subsequent editions	3 to 89
Series 9060/W (23)	1 to 89
Series 9060/X (23), Y (24)	1 to 93
Series 9064/E (05)	3 to 89
Series 9064/F (06) and subsequent editions	1 to 89
Series 9064/I (09) and subsequent editions	1 to 93
Series 9065/A (01) and subsequent editions	3 to 89
Series 9066/A (01)	3 to 89
Series 9066/B (02)	1 to 89
Series 9066/C (03) and subsequent editions	1 to 93
Series 9066/I (09) and subsequent editions	1 to 108
Series 9066/K (11) and subsequent editions	1 to 112
Series 9070/C (03) and subsequent editions	3 to 89
Series 9070/H (08)	1 to 89
Series 9070/I (09) and subsequent editions	1 to 93
Series 9080/A (01) and subsequent editions	1 to 93
Series 9080/K (11) and subsequent editions	1 to 108
Series 9080/Y (25)	1 to 112
Series 9081/C (03) and subsequent editions	1 to 93
Series 9081/E (05) and subsequent editions	1 to 108
Series 9090/A (01) and subsequent editions	1 to 93
Series 9090/D (04) and subsequent editions	1 to 108
Series 9090/L (12) and subsequent editions	1 to 110
Series 90A0/A (01) and subsequent editions	1 to 108
Series 90A0/D (04) and subsequent editions	1 to 110
Series 90A0/K (11) and subsequent editions	1 to 112

3 α SERIES PARAMETER ADJUSTMENT

3.1 SERVO ADJUSTMENT SCREEN

Display the servo adjustment screen, and check the position error, actual current, and actual speed on the screen.
Using the keys on the NC, enter values according to the procedure explained below.
(The Power Mate DPL/MDI does not provide the servo adjustment function.)

● Series 0-C

Press the [PARA] key several times to display the servo setting screen. Then press the page keys [↑ PAGE] [PAGE ↓] to display the servo screen.
If the servo setting screen does not appear, set the following parameter, then switch the NC off and on again.

	#7	#6	#5	#4	#3	#2	#1	#0
0389								SVS

SVS (#0) 0: Displays the servo screen.

● Series 15-A, B, and 15*i*

Press the [SERVICE] key several times to display the servo setting screen. Then press the [↓] key to display the servo adjustment screen.

● Series 16, 18, 20, and 21

[SYSTEM] → [SYSTEM] → [▷] → [SV-PRM] → [SV-TUN]

If the servo screen does not appear, set the following parameter, then switch the NC off and on again.

	#7	#6	#5	#4	#3	#2	#1	#0
3111								SVS

SVS (#0) 1: Displays the servo screen.

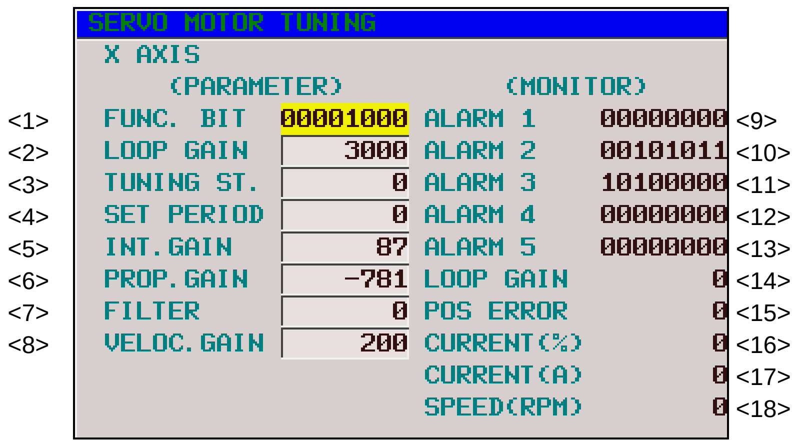


Fig. 3.1 (a) Diagnosis screen

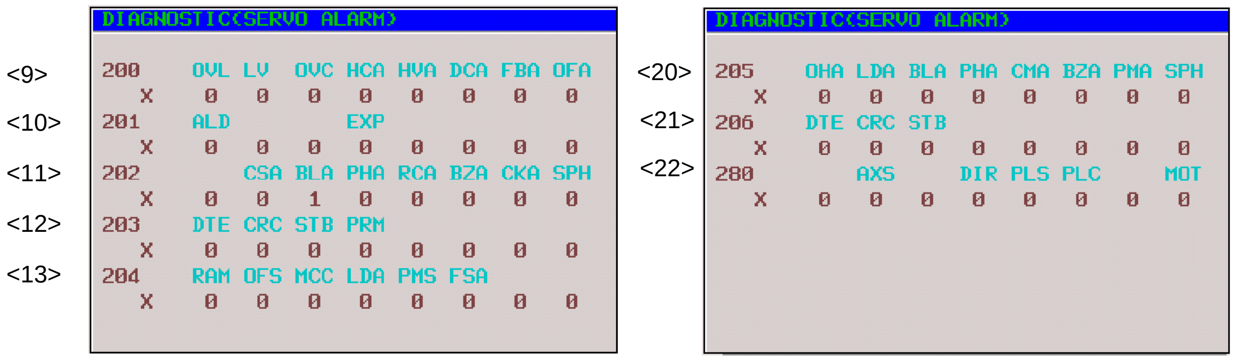


Fig. 3.1 (b) Diagnosis screen

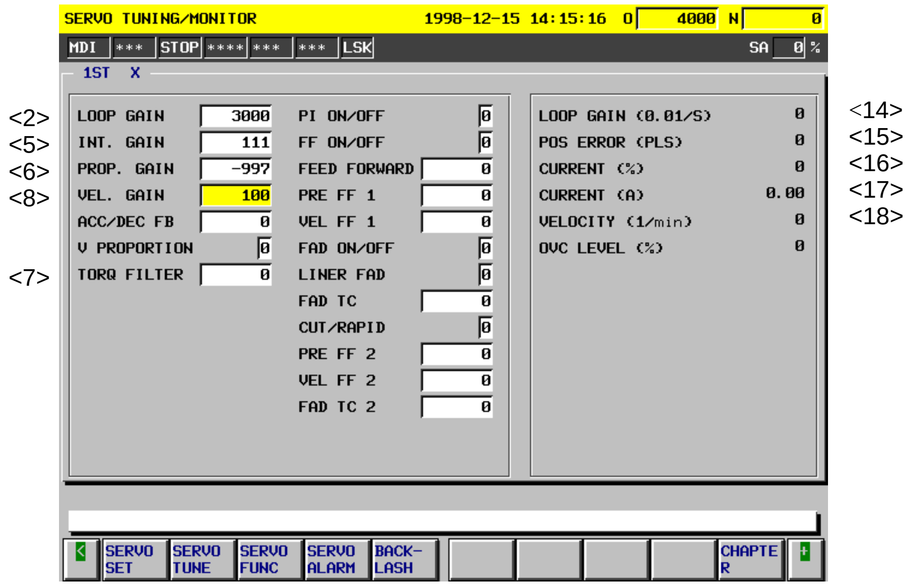


Fig. 3.1 (c) Series 15*i* servo adjustment screen

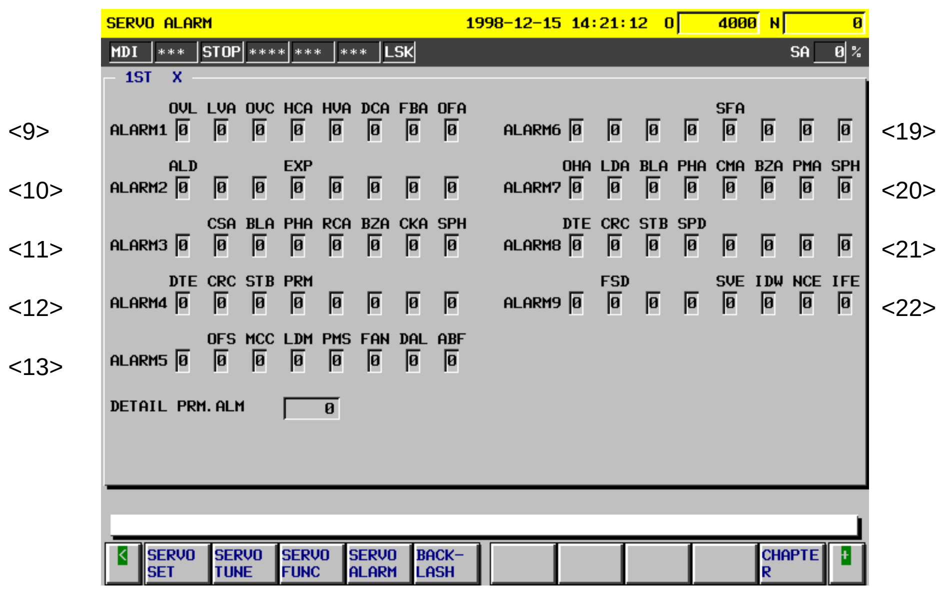


Fig. 3.1 (d) Series 15*i* servo diagnosis screen

The items on the servo adjustment screen correspond to the following parameter numbers:

Table 3.1 Correspondence between the servo adjustment screen and diagnosis screen, and parameters

	Series 0-C	Series 15-A, B, 15*i*	Series 16, 18, 20, 21	PowerMate-E
<1> Function bit <2> Loop gain	No. 8X03 No. 0517	No. 1808 No. 1825	No. 2003 No. 1825	No. 1003 No. 0209
<3> Tuning start bit <4> Setting period	Not used at present Not used at present			
<5> Velocity loop integral gain <6> Velocity loop proportional gain <7> TCMD filter	No. 8X43 No. 8X44 No. 8X67	No. 1855 No. 1856 No. 1857	No. 2043 No. 2044 No. 2067	No. 1043 No. 1044 No. 1067
<8> Velocity loop gain	No. 8X21	No. 1875	No. 2021	Not supported
	The relationship with the load inertia ratio (LDINT) is as follows: Velocity gain = (1 + LDINT/256)*100(%)			
<9> Alarm 1 diagnostic <10> Alarm 2 <11> Alarm 3 <12> Alarm 4 <13> Alarm 5 <19> Alarm 6 <20> Alarm 7 <21> Alarm 8 <22> Alarm 9	Nos. 720 to 723 730 to 733 760 to 763 770 to 773 __________ __________ __________ __________ __________	Nos. 3014 + 20(X - 1) 3015 + 20(X - 1) 3016 + 20(X - 1) 3017 + 20(X - 1) __________ __________ __________ __________ __________	No. 200 201 202 203 204 __________ __________ __________ __________	No. 2711 2710 2713 2712 2714 __________ __________ __________ __________
<14> Loop gain or actual loop gain	The actual servo loop gain is displayed.			Not supported
<15> Position error diagnostic	Nos. 800 to 803	No. 3000	No. 300	No. 3040
	Position error = feedrate/(least input increment × 60 × loop gain × 0.01) (mm/min) (mm)			
<16> Actual current (%) <17> Actual current (A) <18> Actual speed (rpm)	Indicates the percentage (%) of the current value to the continuous rated current. Indicates the current value. Indicates the actual speed.			Not supported

3.2 ACTIONS FOR ALARMS

If a servo alarm is issued, detail alarm information is displayed on the diagnosis screen (Figs. 3.1 (b) and (d)). Based on this information, check the cause of the servo alarm and take appropriate action. For alarms with no action number, refer to relevant manuals such as the maintenance manual on the amplifier.

Table 3.2 Alarm bit names

	#7	#6	#5	#4	#3	#2	#1	#0
Alarm 1	OVL	LVA	OVC	HCA	HVA	DCA	FBA	OFA
Alarm 2	ALD			EXP				
Alarm 3		CSA	BLA	PHA	RCA	BZA	CKA	SPH
Alarm 4	DTE	CRC	STB	PRM				
Alarm 5		OFS	MCC	LDM	PMS	FAN	DAL	ABF
Alarm 6					SFA			
Alarm 7	OHA	LDA	BLA	PHA	CMA	BZA	PMA	SPH
Alarm 8	DTE	CRC	STB	SPD				
Alarm 9		FSD			SVE	IDW	NCE	IFE

NOTE) The blank fields do not contain any alarm code.

(1) Alarms related to the amplifier and motor

These alarms are identified from alarms 1, 2, and 5.

(1-1) Type A interface

Alarm 1							Alarm 5		Alarm 2		Description	Action
OVL	LVA	OVC	HCA	HVA	DCA	FBA	MCC	FAN	ALD	EXP		
			1								Overcurrent alarm	1
				1							Excessive voltage alarm	
					1						Excessive regenerative discharge alarm	
							1				MCC fusing, precharge	
	1										Alarm indicating insufficient power voltage	
1									0	0	Amplifier overheat	2
1									1	0	Motor overheat	2
		1									OVC alarm	3

CAUTION

For alarms with no action number indicated, refer to the maintenance manual on the amplifier.

(1-2) Type B interface

Alarm 1							Alarm 5		Alarm 2		Description	Action
OVL	LVA	OVC	HCA	HVA	DCA	FBA	MCC	FAN	ALD	EXP		
			1						0	0	Overcurrent alarm (PSM)	
			1						0	1	Overcurrent alarm (SVM)	1
			1						0	1	Overcurrent alarm (software)	1
				1							Excessive voltage alarm	
					1						Excessive regenerative discharge alarm	
	1								0	0	Insufficient power voltage (PSM)	
	1								1	0	Insufficient DC link voltage (PSM)	
	1								0	1	Insufficient control power voltage (SVM)	
	1								1	1	Insufficient DC link voltage (SVM)	
1									0	0	Overheat (PSM)	2
1									1	0	Motor overheat	2
							1				MCC fusing, precharge	
								1	0	0	Fan stopped (PSM)	
								1	0	1	Fan stopped (SVM)	

CAUTION

For alarms with no action number indicated, refer to the maintenance manual on the amplifier.

Action 1: Overcurrent alarms

This type of alarm is issued when an extremely large current flows through the main circuit.

When an overcurrent alarm is always issued after emergency stop is released or at the time of moderate acceleration/deceleration, the cause of the alarm is determined to be an amplifier failure, cable connection error, line disconnection, or a parameter setting error. First, check that standard values are set for the following servo parameters. If these parameter settings are correct, check the amplifier and cable status by referencing the maintenance manual on the amplifier.

No. 1809	No. 8X04
No. 2004	No. 1004

No. 1852	No. 8X40
No. 2040	No. 1040

No. 1853	No. 8X41
No. 2041	No. 1041

If an overcurrent alarm is issued only when an abrupt acceleration/deceleration is performed, the operating conditions seem to be too strict. Increase the acceleration/deceleration time constant, and see whether the alarm occurs.

CAUTION

When an emergency stop is released with the power line to the motor disconnected, an overcurrent alarm (software) may be issued. If this poses a problem, set the following parameter bit to 1:
Bit 0 of parameter No. 1747 (Series 15) or bit 0 of parameter No. 2207: Ignores the overcurrent alarm (software).

Action 2: Overheat alarms

If an overheat alarm is issued after long-time continuous operation, the alarm can be determined to have been caused by a temperature rise in the motor or amplifier. Stop operation for a while, and see whether the alarm occurs. If the alarm still occurs after the power is kept off for about 10 minutes, the hardware may be defective.
If the alarm is issued intermittently, increase the time constant, or increase the programmed stop time period to suppress temperature rise.

Action 3: OVC alarms

When an OVC alarm is issued, check that standard values are set for the following parameters. If the parameters are correct, increase the time constant or increase the programmed stop time period to suppress temperature rise.

No. 1877	No. 8X62
No. 2062	No. 1062

No. 1878	No. 8X63
No. 2063	No. 1063

No. 1893	No. 8X65
No. 2065	No. 1065

(2) Alarms related to the pulse coder and separate serial pulse coder

(2-1) Built-in pulse coder

These alarms are identified from alarms 1, 2, 3, and 5. The meanings of the bits are as follows:

Alarm 3						Alarm 5		1	Alarm 2			Description	Action
CSA	BLA	PHA	RCA	BZA	CKA	SPH	LDM	PMA	FBA	ALD	EXP		
						1						Soft phase alarm	2
					1							Clock alarm (serial A)	
				1								Zero volts in battery	1
			1						0	0	0	Abnormal speed (serial A)	
			1						1	1	0	Count error alarm (α pulse coder)	2
		1										Phase alarm	2
	1											Voltage drop in battery (warning)	1
1												Checksum alarm (serial A)	
								1				Pulse error alarm (α pulse coder)	
							1					LED abnormality alarm (α pulse coder)	

CAUTION
For alarms with no action number indicated, the pulse coder may be defective. Replace the pulse coder.

(2-2) Separate serial detector coder
These alarms are identified from alarm 7. The meanings of the bits are as follows:

Alarm 7								Description	Action
OHA	LDA	BLA	PHA	CMA	BZA	PMA	SPH		
							1	Soft phase alarm	2
						1		Pulse error alarm (serial rotary)	
					1			Zero volts in battery	1
				1				Count error alarm (serial rotary)	2
			1					Phase alarm (serial linear)	2
		1						Voltage drop in battery (warning)	1
	1							LED abnormality alarm	
1								Separate detector overheat alarm	

CAUTION
For alarms with no action number indicated, the detector may be defective. Replace the detector.

Action 1: Battery-related alarms
Check whether the battery is connected. When the power is turned on for the first time after the battery is connected, a battery zero alarm is issued. In this case, turn the power off then on again. If the alarm is issued again, check the battery voltage. If the battery voltage drop alarm is issued, check the voltage, then replace the battery.

Action 2: Alarms that may be issued by noise
When an alarm is issued intermittently or issued after emergency stop is released, there is a high possibility that the alarm is caused by noise. Take thorough noise-preventive measures. If the alarm is still issued continuously after the measures are taken, replace the detector.

(3) Alarms related to serial communication

These alarms are identified from alarms 4 and 8.

Alarm 4				Alarm 8				Description
DTE	CRC	STB	PRM	DTE	CRC	STB	SPD	
1								Communication alarm in serial pulse coder
	1							
		1						
				1				Communication alarm in separate serial pulse coder
					1			
						1		

Action: Serial communication is not performed correctly. Check whether cable connection is correct and whether there is a line disconnection. If CRC or STBB occurs, the alarm may be caused by noise. Take noise-preventive measures. If the alarm is always issued after power is turned on, the pulse coder, the control board of the amplifier (*i* Series), or the pulse module (*i* Series) may be defective.

(4) Disconnection alarms

These alarms are identified from alarms 1, 2, and 6.

Alarm 1							Alarm 2		6	Description	Action
OVL	LVA	OVC	HCA	HVA	DCA	FBA	ALD	EXP	SFA		
						1	1	1	0	Hardware disconnection (separate phase A/B disconnection)	1
						1	0	0	0	Software disconnection (closed loop)	2
						1	0	0	1	Software disconnection (α pulse coder)	3

Action 1: This alarm is issued when the separate phase A/B scale is used. Check whether the phase A/B detector is connected correctly.

Action 2: This alarm is issued when the change in position feedback pulses is relatively small for the change in velocity feedback pulses. Therefore, with the semi-closed loop, this alarm is not issued. Check whether the separate detector outputs position feedback pulses correctly. If the detector outputs pulses correctly, the alarm is determined to have been caused by the reverse rotation of only the motor at the start of machine operation because of a large backlash between the motor position and scale position.

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1808	No. 8X03							TGAL	
No. 2003	No. 1003								

TGAL (#1) 1: The level of detecting the software disconnection alarm is set by parameter.

No. 1892	No. 8X64	Software disconnection alarm level
No. 2064	No. 1064	

Standard setting 4: Alarm is issued when motor turns 1/8 of a turn.
Increase this value.

Action 3: This alarm is issued when the absolute position data sent from the built-in pulse coder cannot be synchronized with the phase data. Turn off the NC, and remove the pulse coder cable then attach it again. If this alarm is issued again, replace the pulse coder.

(5) Invalid parameter setting alarm

This alarm is identified from alarm 4.

Alarm 4				Description
DTER	CRC	STB	PRM	
			1	Invalid parameter setting detected by servo software

If PRM is set to 1, an invalid parameter setting has been detected by the servo software. Investigate the cause of the alarm according to Subsec. 2.1.5, "Actions for Invalid Servo Parameter Setting Alarms."

(6) Other alarms

Alarms are identified from alarm 5. The meanings of the bits are as follows:

Alarm 5							Description	Action
OFS	MCC	LDM	PMS	FAN	DAL	ABF		
						1	Feedback mismatch alarm	1
					1		Excessive semi-closed loop error alarm	2
1							Current offset error alarm	3

Action 1: This alarm is issued when the move directions for the position detector and velocity detector are opposite to each other. Check the rotation direction of the separate detector. If the direction is opposite to the direction in which the motor turns, take the following action:

Phase A/B detector: Reverse the A and $\overline{A}$ connections.
Serial detector: Reverse the signal direction setting for the separate detector.

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1960	–								RVRSE
No. 2018	–								

RVRSE (#0) The signal direction for the separate detector is:
0: Not reversed.
1: Reversed.

When there is a large torsion between the motor and separate detector, this alarm may be issued when an abrupt acceleration/deceleration is performed. In such a case, change the detection level.

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1741	–							RNLV	
No. 2201	–								

RNLV (#1) Change of the feedback mismatch alarm detection level
1: To be detected at 1000 rpm or more
0: To be detected at 600 rpm or more

Action 2: This alarm is issued when the difference between the motor position and the position of the separate detector becomes larger than the excessive semi-closed loop error level. Check that the dual position feedback conversion coefficient is set correctly. If the setting is correct, increase the alarm level. If the alarm is still issued after the level is changed, check the scale connection direction.

No. 1971	–	Dual position feedback conversion coefficient (numerator)
No. 2078	–	

No. 1972	–	Dual position feedback conversion coefficient (denominator)
No. 2079	–	

$$\text{Conversion coefficient} = \frac{\left(\text{Number of feedback pulses per motor revolution (detection unit)}\right)}{1{,}000{,}000}$$

No. 1729	–	Dual position feedback semi-closed loop error level
No. 2118	–	

[Setting] Detection unit. When 0 is set, detection does not take place.

Action 3: The current offset (equivalent to the current value in the emergency stop state) of the current detector becomes too large. If the alarm is issued again after the power is turned on and off, the current detector is determined to be abnormal. For the *i* Series, replace the control board of the amplifier. For series other than the *i* Series, replace the servo-related module in the CNC.

3.3 PROCEDURES FOR GAIN ADJUSTMENT AND VIBRATION-DAMPING CONTROL

3.3.1 Gain Adjustment Procedure

Adjusting the position gain and velocity loop gain to the optimum state leads to improvements in control performance and disturbance suppression performance. Therefore, gain adjustment is the item to be adjusted first in every machine. Setting a higher velocity loop gain is effective not only in improvement in surface precision and figure precision in machining at normal speed but also in improvement in high-speed high-precision machining and high-speed positioning performance. The extent to which the velocity loop gain can be increased almost determines the degree of servo adjustment.

Understanding the gain adjustment procedure that aims at the improvement of the oscillation limit helps to determine the action to be taken when vibration occurs. Therefore, it is necessary to understand the gain adjustment procedure thoroughly.

<1> Preparation for gain adjustment 1:
Check that the servo parameters are set to standard values. The position gain and velocity loop gain are set to levels that do not generate vibration (normally, the position gain and velocity loop gain are set to about 3000 and 150%, respectively).

<2> Preparation for gain adjustment 2:
Select the velocity control method. With high-speed high-precision machines, PI control should be selected. With high-speed positioning machines such as a punch press, I-P control should be selected.

<3> Preparation for gain adjustment 3:
Set an auxiliary function to increase the vibration limit. First, set the velocity loop proportional high-speed processing function(*1).

For a machine with low rigidity, however, setting the acceleration feedback function instead of the velocity loop proportional high-speed processing function may produce better results. For a large machine that can easily be vibrated, it is sometimes undesirable that an auxiliary function is used. Therefore, follow the procedure explained below to select a suitable auxiliary function.

(Procedure for selecting an auxiliary function)
First, set the velocity loop proportional high-speed processing function, and performs steps up to step <6>, "Determining the velocity loop gain oscillation limit." If the velocity loop gain cannot attain 300%, set the acceleration feedback function, and perform step <6> again. If a better result is obtained than with the velocity loop proportional high-speed processing function, this procedure terminates. If the result is worse, disable the auxiliary function, and perform step <6> again. Select the settings with which the highest velocity loop gain is obtained.

*1 The velocity loop proportional high-speed processing function restricts the use of auxiliary functions that suppress vibration in the stop state. If vibration in the stop state poses a problem, select the acceleration feedback function.

<4> Setting for suppressing vibration in the stop state:
A stop occurs within a backlash, and the load inertia decreases. Accordingly, the velocity loop can easily oscillate. So, set auxiliary functions for suppressing vibration in the stop state in advance.

Function for changing the proportional gain in the stop state (50%, 75%)(*2)
N pulse suppression function(*3)

With the 9080/P and subsequent editions, the cutting feed/rapid traverse velocity loop gain switch function can be used to decrease the gain during rapid traverse and in the stop state. If vibration in the stop state poses a problem, decrease the rapid traverse velocity loop gain to a level that does not affect the behavior during rapid traverse.

*2 With the 90A0/D and subsequent editions, this function can be used together with the velocity loop proportional high-speed processing function.

*3 This function cannot be used with the velocity loop proportional high-speed processing function.

<5> When using level-up HRV:
When using level-up HRV, set the current control period and adjust the vibration-damping filter according to Subsec. 3.4.1, "Level-up HRV Control Adjustment Procedure."

<6> Determining the velocity loop gain oscillation limit:
After performing the preparatory steps described previously, determine the velocity loop oscillation limit. When adjusting the velocity loop gain, perform rapid traverse with full machine strokes, and observe vibration in the stop state and during high-speed operation by using TCMD and VCMD.

When using the cutting feed/rapid traverse velocity loop gain function, perform cutting feed at the maximum cutting feedrate to determine the oscillation limit during cutting.
(Determining the limit)
As the loop gain increases, the following phenomena start to appear at a certain gain. This gain value is determined to be the oscillation limit.
- The machine sounds.
- There is a large variation in position error in the stop state.
- Torque command vibration increases.

For a machine with low rigidity, the auxiliary functions listed below are sometimes required to suppress vibration. Use these functions as necessary. For details, see Chapter 4, "Servo Function Details."

TCMD filter (*4)	Dual position feedback(*5)
Vibration-damping control(*6)	Machine velocity feedback(*7)

As the velocity loop gain, set 70% to 80% of the oscillation limit.

*4 As the filter coefficient, about 1500 to 2000 is set. You may want to set the cut-off frequency to 100 Hz or less to increase the velocity loop gain. However, this is not a desirable method because the frequency band widened by velocity loop gain adjustment is narrowed by the TCMD filter. Except special cases, when a value greater than 2000 needs to be set, decrease the velocity loop gain itself.

*5 Dual position feedback (optional function) can be used with the closed-loop configuration. Set a time constant of about 10 to 300 ms. A lower time constant improves the command follow-up accuracy. Adjust the time constant after checking the acceleration/deceleration waveform and machined surface.

*6 Vibration-damping control can be used with the closed-loop configuration. The difference in velocity between the motor and machine is fed back to suppress the influence of the torsion between the motor and machine.

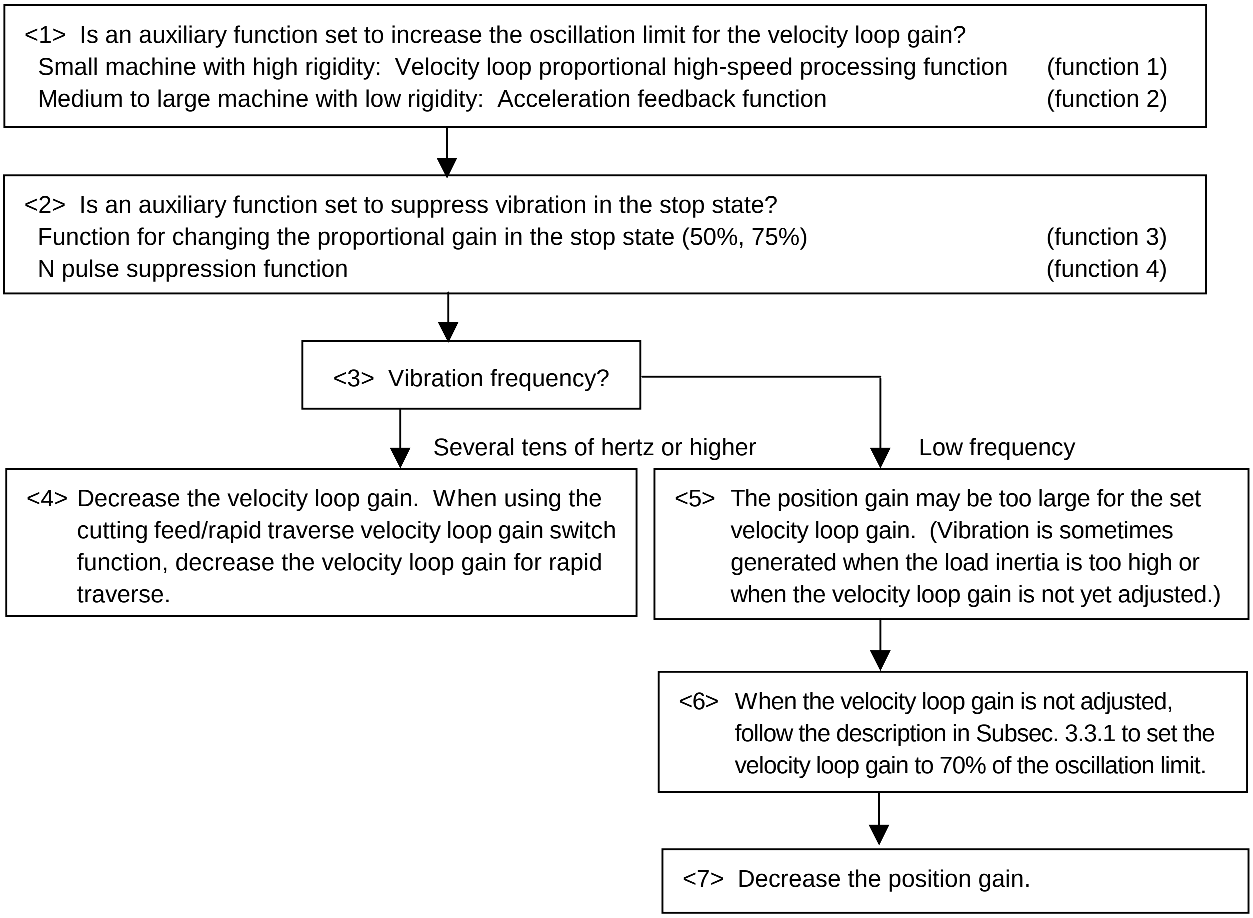
*7 Machine velocity feedback can be used with the closed-loop configuration. The velocity on the machine side is fed back to suppress the influence of the torsion between the motor and machine.

<7> Determining the position loop gain.
Increase the position loop gain to the degree that low-frequency vibration is not generated during movement.

*8 For the axes subject to interpolation, the same value is set as the position gain.

3.3.2 Vibration in the Stop State

Vibration generated only in the stop state is caused by the decreased load inertia in a backlash. Adjust the auxiliary functions for suppressing stop-time vibration. Vibration may be generated only in the stop state also when the position gain is too high.



(Reference: Parameter numbers)
For details, see Chapter 4, "Servo Function Details."

Function 1: Velocity loop proportional high-speed processing function

No. 1959	**–**
No. 2017	**No. 1017**

#7	#6	#5	#4	#3	#2	#1	#0
PK2V25							

PK2V25 (#7) 1: Enables the velocity loop proportional high-speed processing function.

Function 2: Acceleration feedback

No. 1894	**No. 8X66**
No. 2066	**No. 1066**

Acceleration feedback gain

Function 3: Function for changing the proportional gain in the stop state

(1) Series 15*i*, 15-B, 16, 18, 20, 21, and Power Mate

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1958	–					K2VC			
No. 2016	–								

K2VC (#3) 1: Enables the function for changing the proportional gain in the stop state. In the stop state: 75%

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1747	–					PK2D50			
No. 2207	–								

PK2D50 (#3) 1: Decreases the proportional gain in the stop state to 50%.

No. 1730	–	Stop decision level
No. 2119	–	

(2) Series0-C and 15-A

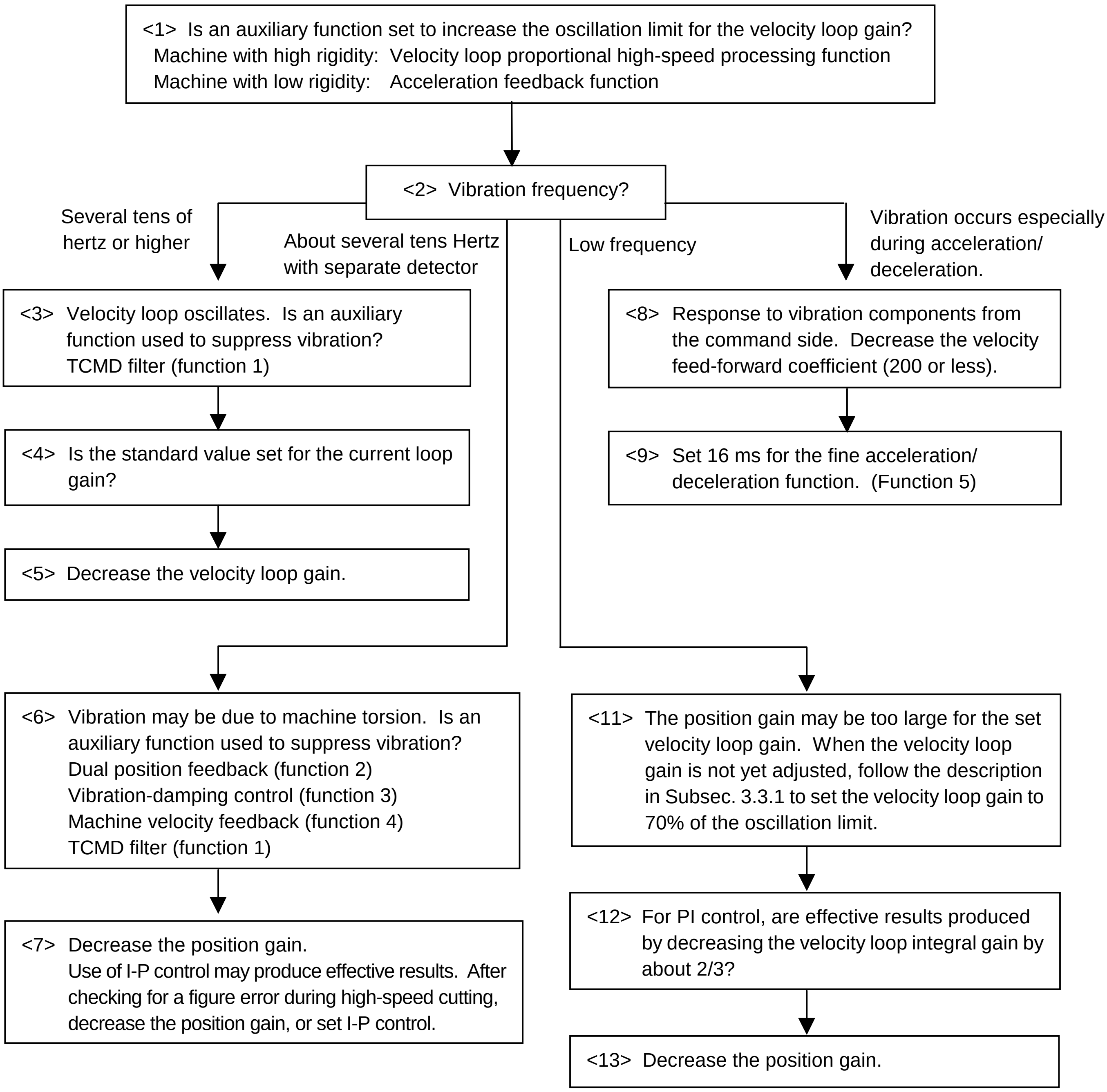
		#7	#6	#5	#4	#3	#2	#1	#0
No. 1953	No. 8X09					K2VC			
–	–								

K2VC (#3) 1: (Enables the function for changing the proportional gain in the stop state. In the stop state: 75%)

No. 1982	No. 8X89	Stop decision level
–	–	

3.3.3 Vibration during Travel

Vibration is generated during travel by various causes. So, a most appropriate method must be selected after observing the vibration status carefully.



(Reference: Parameter numbers)
For details, see Chapter 4, "Servo Function Details."

Function 1: TCMD filter

No. 1895	No. 8X67	TCMD filter coefficient
No. 2067	No. 1067	

Function 2: Dual position feedback function

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1909(*i*,B) No. 1955(A)	No. 8X11	DPFB							
No. 2019	No. 1019								

DPFB (#7) 1: Enables dual position feedback.

No. 1971	No. 8X78	Dual position feedback conversion coefficient (numerator)
No. 2078	No. 1078	

No. 1972	No. 8X79	Dual position feedback conversion coefficient (denominator)
No. 2079	No. 1079	

No. 1973	No. 8X80	Primary delay time constant of dual position feedback
No. 2080	No. 1080	

Function 3: Vibration-damping control

No. 1718	–	Number of position feedback pulses for vibration-damping control function
No. 2033	–	

No. 1719	–	Gain for vibration-damping control function
No. 2034	–	

Function 4: Machine velocity feedback

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1956	No. 8X12							MSFE	
No. 2012	No. 1012								

MSFE (#1) 1: Enables machine velocity feedback.

No. 1981	No. 8X88	Machine velocity feedback gain
No. 2088	No. 1088	

Function 5: Fine acceleration/deceleration function

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1951	–		FAD						
No. 2007	–								

FAD (#6) 1: Enables fine acceleration/deceleration.

No. 1702	–	Fine acceleration/deceleration time constant
No. 2109	–	

3.3.4 Cumulative Feed

When the time from the detection of a position error until the compensation torque is output is too long, a cumulative feed occurs during low-speed feed. Improvement in gain is required. However, for a machine with high friction and torsion, a higher gain cannot be set. In such a case, a cumulative feed phenomenon may occur.

<1> Adjust the position gain and velocity loop gain according to the description in Subsec. 3.3.1.

↓

<2> Set PI control.

↓

<3> To improve torque start, increase the velocity loop integral gain.

↓

<4> Set the VCMD offset function. (Function 1)

↓

<5> Set the incomplete integral coefficient within the range 32700 to 32767 (function 2). For axes subject to interpolation, this coefficient must not be set.

(Reference: Parameter numbers)
For details, see Chapter 4, "Servo Function Details."

Function 1: VCMD offset function

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1808	No. 8X03	VOFS							
No. 2003	No. 1003								

VOFS (#7) 1: Enables the VCMD offset function.

No. 1857	No. 8X45	Incomplete integral gain
No. 2045	No. 1045	

3.3.5 Overshoot

When the machine is operated at high speed or with a detection unit of 0.1 μm or less, the problem of overshoots may arises. Select a most appropriate preventive method depending on the cause of an overshoot.

<1> When the velocity loop gain is not yet adjusted, follow the description in Subsec. 3.3.1 to adjust the gain. Select PI control.

↓

<2> When advanced preview control is used, adjust automatic corner deceleration. Also, increase settings such as the time constant after interpolation to allow commands for corner and stop operations to be executed as moderately as possible.

↓

<3> When feed-forward is used, try to adjust the velocity feed-forward coefficient.

↓

<4> Where possible, decrease the position gain and feed-forward coefficient.

↓

<5> If the overshoot in question is for about one or two pulses, set overshoot compensation (TYPE-1 or -2). (Function 1)

(Reference: Parameter numbers)
For details, see Chapter 4, "Servo Function Details."

Function 1: Overshoot compensation function

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1808	No. 8X03		OVSC						
No. 2003	No. 1003								

OVSC (#6) 1: Enables the overshoot compensation function.

No. 1970	No. 8X77	Overshoot prevention counter
No. 2077	No. 1077	

No. 1857	No. 8X45	Incomplete integral coefficient
No. 2045	No. 1045	

		#7	#6	#5	#4	#3	#2	#1	#0
No. 1742	–					OVS1			
No. 2202	–								

OVS1 (#3) 2: Enables overshoot compensation TYPE-2.

3.4 ADJUSTING PARAMETERS FOR HIGH SPEED AND HIGH PRECISION

3.4.1 Level-up HRV Control Adjustment Procedure

(1) Overview

With standard systems of the *i* Series CNC (Series 15*i*, 16*i*, and 18*i*), the current control period can be changed from the conventional value 250 μs to 125 μs by employment of a high-speed DSP for servo control. (This function is optional with Series 21*i*.) With a reduced current control period, the response of the current loop increases. As the result, a high velocity loop gain and high position loop gain can be set stably. With higher velocity loop and position loop gains, the response and rigidity of a servo system can be improved. This capability enables cutting figure error reduction and higher-speed positioning with machine tools. Moreover, this capability simplifies servo adjustment. Thus, level-up HRV control can improve overall servo performance.

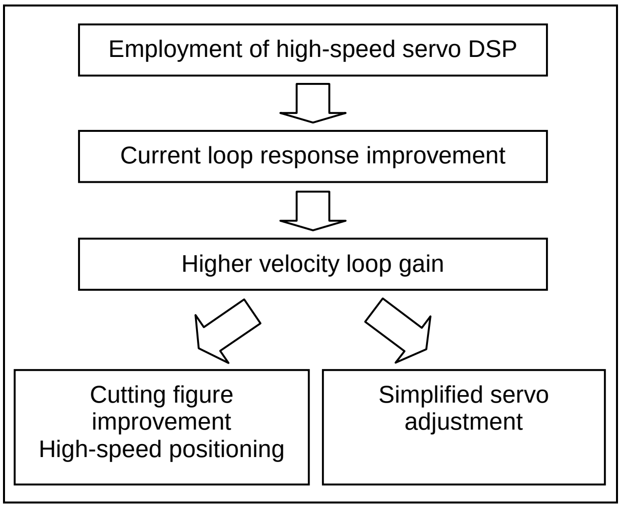


Fig. 3.4.1 (a) Achievements of level-up HRV control

After servo system adjustment with level-up HRV control, the parameters for advanced preview control, AI contour control, and high-precision contour control on the CNC side need to be adjusted. For information about adjustment of these parameters, see Subsec. 3.4.3, "Servo Parameter Adjustment Procedure for Achieving High Speed and High Precision."

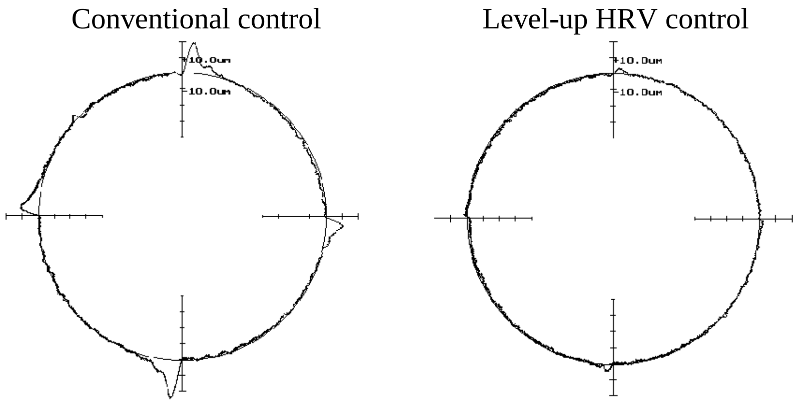


Fig. 3.4.1 (b) Example of effects of level-up HRV control (R100 mm, 10000 mm/min, without quadrant protrusion compensation)

(2) Series and editions of applicable servo software

Series 90A0/E(05) and subsequent editions (Series 15*i*, 16*i*, 18*i*, and 21*i*. The 320C543 servo card is required.)

(3) Adjustment procedure outline

Use the procedure below for level-up HRV control setting.

<1> Setting of a current loop period and current loop gain (*1 in Fig. 3.4.1 (c))
The current control period is reduced from the conventional value 250 μs to 125 μs. An improvement in current response serves as the base for performance improvement.

<2> Vibration suppression filter adjustment (*2 in Fig. 3.4.1 (c))
Some machines may resonate at a particular frequency. In such a case, the use of a vibration suppression filter for removing vibration of a particular frequency is effective.

<3> Velocity loop gain setting (*3 and *4 in Fig. 3.4.1 (c))
A current response improvement due to current control period reduction and mechanical resonance removal using a vibration suppression filter raise the oscillation limit of the velocity loop. When a velocity loop gain adjustment is made, the use of the high-speed loop proportional high-speed processing function for processing a part of the velocity loop at high speed is effective. When the response of a servo system increases, a figure error dependent on the specified distribution period of the CNC may appear. Remove such an error by fine acceleration/deceleration. By setting a velocity loop gain as high as possible, the entire servo performance can be increased.

<4> Feed-forward coefficient adjustment (*5 in Fig. 3.4.1 (c))
By advanced preview feed-forward, a servo delay is eliminated, and a figure error is minimized. Usually, a feed-forward coefficient of 97% to 99% is used.

<5> Position gain adjustment (*6 in Fig. 3.4.1 (c))
As the response of the velocity loop increases, a higher position gain can be set. A higher position gain is also useful for error reduction.

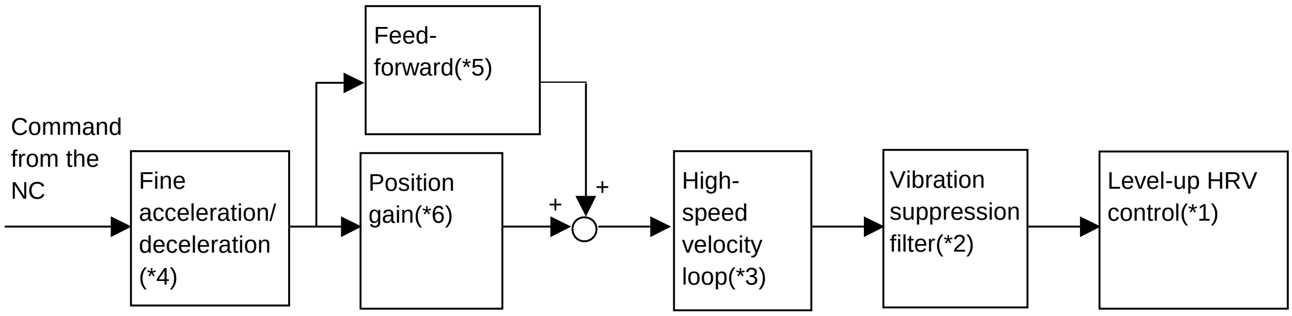


Fig. 3.4.1 (c) Level-up HRV control adjustment

Table 3.4.1 Standard parameters for using level-up HRV control (for machining centers with a relatively high rigidity)

Item	Standard parameter			
	Series 16	Series 15	Setting	Switchable between cutting feed and rapid traverse
1) Level-up HRV control	No. 2004 No. 2040 No. 2041	No. 1809 No. 1852 No. 1853	00000011 (current loop: 125 μs) (Standard value) × 0.8 (Standard value) ×1.6	
2) Vibration suppression filter	No. 2113 No. 2177	No. 1706 No. 2620	Center frequency of vibration 30 (NOTE: Vibration suppression filter adjustment requires a relatively long time. Without this filter, level-up HRV control can be achieved to some extent.)	
3) Velocity loop proportional high-speed processing function	No. 2017, B7 No. 2021	No. 1959, B7 No. 1875	1 (Enables this function.) Approx. 1500 to 2000 (Servo adjustment screen velocity gain: 700% to 900%)	○
4) Fine acceleration/ deceleration function	No. 2007, B6 No. 2209, B2 No. 2109	No. 1951, B6 No. 1749, B2 No. 1702	1 (Enables fine acceleration/ deceleration.) 1 (The fine acceleration/deceleration time constant is of linear type.) 16 (Fine acceleration/deceleration time constant)	○
5) Advanced preview feed-forward	No. 2005, B1 No. 2092 No. 2069	No. 1883, B1 No. 1985 No. 1962	1 (Enables feed-forward.) 9700 to 9900 (Advanced preview feed-forward coefficient) Approx. 100 (Velocity feed-forward coefficient)	○ ○
6) Position gain	No. 1825	No. 1825	8000 to 10000 (Set about 5000 at first.)	

The setting of a function marked with ○ in the column of "Switchable between cutting feed and rapid traverse" in Table 3.4.1 can be switched between cutting feed and rapid traverse. (See Subsec. 3.4.2, "Cutting Feed/Rapid Traverse Switchable Function.")

(4) Details of adjustment

<1> Current loop period setting and current loop gain setting

According to the settings of "1) Level-up HRV control" in Table 3.4.1, set the parameters for current control. **Set the same period for the two axes controlled by the same DSP.**

With these settings, processing is performed using a current loop period of 125 μs and a position loop period of 1 ms. The response of the current loop is improved by a factor of 1.6. In this state, check the activating sound. If, compared with the past, the activating sound during a stop increases, change the current loop gain as follows:

- No. 2040 (Series 16), No. 1852 (Series 15) = 0.6 times the modified value
- No. 2041 (Series 16), No. 1853 (Series 15) = 0.6 times the modified value
- No. 2042 (Series 16), No. 1854 (Series 15) = 0

NOTE

Set the same period for two axes controlled by the same DSP.

<2> Vibration suppression filter adjustment

As shown in Fig. 3.4.1 (d), the vibration suppression filter is a filter that attenuates a particular frequency component included in a torque command. If a strong resonance exceeding 200 Hz is present in the mechanical system, the vibration suppression filter is useful for setting a high velocity gain by suppressing resonance. So, when using level-up HRV control, adjust the vibration suppression filter before "<3> Velocity loop gain setting." If the resonance frequency is 200 Hz or less, do not use a vibration suppression filter.

For resonance frequency measurement using servo adjustment software, see "(5) Method of resonance frequency measurement using servo adjustment software."

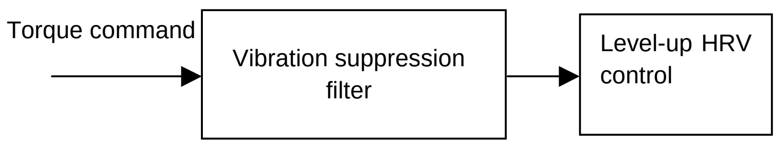


Fig. 3.4.1 (d) Vibration suppression filter

(Adjustment procedure)

- Operate the machine at a relatively low feedrate (F1000 to F10000).
- Increase the velocity loop gain gradually until a slight vibration sound occurs at feed time. If an excessively large velocity loop gain is set at this time, vibration of low frequencies within 200 Hz becomes dominant, disabling the observation of high-frequency vibration that occurs first. If vibration of a high frequency cannot be observed, the vibration suppression filter cannot be used.
- After setting a velocity loop gain that generates a slight vibration sound, observe the TCMD to measure the frequency.
- Set the measured frequency in the parameters described below.

[Parameters for setting the vibration suppression filter]

No. 2113 (Series 16), No. 1706 (Series 15)

Attenuation center frequency (Hz): Set the resonance frequency of the machine.

No. 2117 (Series 16), No. 2620 (Series 15)

Attenuation bandwidth: 30 (40 when the center frequency is 600 Hz or more)

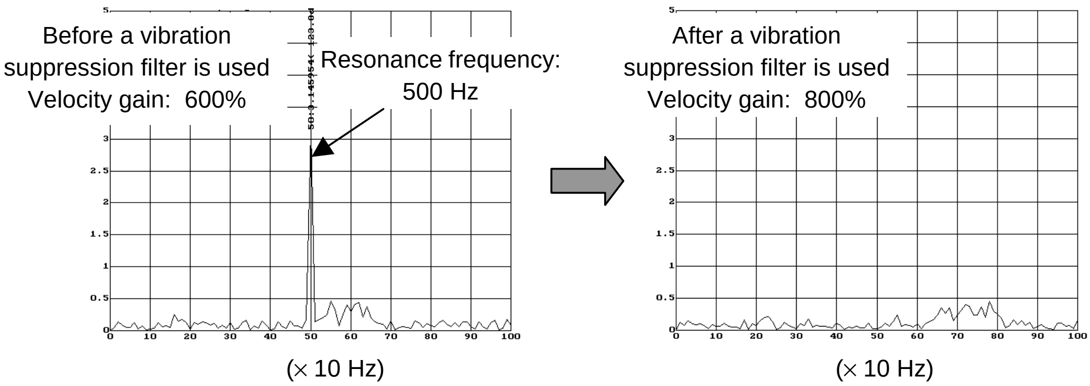


Fig. 3.4.1 (e) Effect of a vibration suppression filter (torque command waveform)

<3> Velocity loop gain setting

Adjust the velocity loop gain according to Subsec. 3.3.1, "Gain Adjustment Procedure."

[Parameters for velocity loop gain adjustment]

No. 2017 (Series 16), No. 1959 (Series 15), B7:

1 (Enables the velocity loop proportional high-speed processing function.)

Velocity gain (gain on the servo adjustment screen):

Increase the velocity gain gradually starting at about 400%. The target is about 1000%.

<4> Fine acceleration/deceleration function setting

When level-up HRV control is used, a high position loop gain and a high velocity loop gain are set. So, when a greater acceleration/deceleration is specified, vibration dependent on the distribution period may occur. To prevent such vibration, fine acceleration/deceleration is used. Be sure to set a multiple of 8 as a fine acceleration/deceleration time constant.

[Parameters for fine acceleration/deceleration setting]

No. 2007 (Series 16), No. 1951 (Series 15), B6:
1 (Enables the fine acceleration/deceleration function.)

No. 2209 (Series 16), No. 1749 (Series 15), B2:
1 (The fine acceleration/deceleration time constant is of linear type.)

No. 2109 (Series 16), No. 1702 (Series 15):
16 (Fine acceleration/deceleration time constant)(*1)

*1 For the parameter to be used with fine acceleration/deceleration switchable for cutting feed and rapid traverse, see Subsec. 3.4.2, "Cutting Feed/Rapid Traverse Switchable Function."

<5> Feed-forward coefficient adjustment

Feed-forward is used to compensate for a servo position loop delay, and velocity feed-forward is used to compensate for a velocity loop delay. While checking the amount of radius reduction by using an arc of R10/F4000 or R100/F10000, adjust the feed-forward coefficient so that the actual path matches the command. Set a velocity feed-forward coefficient of 100. For details of adjustment, see Subsec. 3.4.3, "Servo Parameter Adjustment Procedure for Achieving High Speed and High Precision."

[Parameters for feed-forward setting]

No. 2005 (Series 16), No. 1883 (Series 15), B1:
1 (Enables the feed-forward function.)

No. 2092 (Series 16), No. 1985 (Series 15):
9700 to 9900 (advanced preview feed-forward coefficient)

No. 2069 (Series 16), No. 1962 (Series 15):
Approx. 100 (velocity feed-forward coefficient)

<6> Position gain adjustment

A specified feedrate is calculated as follows:

Specified feedrate = (position gain) × (positional deviation) + (feed-forward)

Therefore, if a deviation occurs between the command and actual position, a higher position gain makes a stronger error correction, thus making a figure error smaller. When level-up HRV control is used, the response of the velocity loop is improved, so that a position gain higher than before can be set. With a medium-size machining center, a value up to about 80 to 100 [1/s] can be set. (When a large machine or closed-loop machine is used, a lower value needs to be set if the backlash between the motor and machine is large.)

Perform rapid traverse and cutting feed at a maximum cutting feedrate, and find a position gain limit while observing the TCMD at the time of acceleration/deceleration. Then, set a value of about 80% of the limit. A position gain limit appears where a large swell of about 10 to 30 Hz is observed in the TCMD waveform.

After determining a position gain value, readjust the position feed-forward coefficient of <5> above.

[Parameter for position gain setting]

No. 1825 (Series 16, Series 15): 5000 to 10000

(5) Method of resonance frequency measurement using servo adjustment software

For machine resonance measurement, use the procedure below. It is assumed that servo adjustment software of a version of October, 1998 and later is used.

<1> Make a preparation to use servo adjustment software (SD). Set the type of measurement data in Adjustment 2. (When using a check board of analog/digital integrated type, set 6 as the number of data digits. When using a digital check board, set the DIP switch to 12 (for an odd-numbered axis) or 13 (for an even-numbered axis).

<2> Set bit 7 of the parameter No. 2206 (Series 16) or No. 1746 (Series 15) to 1. Set this bit for both axes controlled by the same DSP.

<3> In this state, a TCMD waveform is output for each current loop control period.

This means that a torque command for 1 second for 4000 data items can be acquired when the current control period is 250 μs, and a torque command for 1 second for 8000 data items can be acquired when the current control period is 125 μs.

<4> For the setting of each channel on the F9 screen of SD, select TCMD Measurement. For ampere setting, set a maximum current value of the amplifier.

<5> In this state, accelerate/decelerate the motor, and obtain a waveform to check that the correct acceleration/deceleration waveform is output.

<6> With SD, set the number of data points so that data for 0.1 second can be acquired.
When the current control period is 250 μs: 400 data items
When the current control period is 125 μs: 800 data items

<7> While moving the motor, obtain data when an unusual sound is generated.

<8> Ensure that SD displays a waveform for only the first axis or second axis at a time. (Waveforms for the first axis and second axis can be displayed or hidden with SHIFT+1, and SHIFT+2.)
In addition, set an appropriate value on the F3 menu for enlargement so that vibration in a TCMD waveform can be viewed well.

<9> Here, press CTRL+F to set the frequency analysis mode. The scale value under a spike multiplied by 10 is the frequency of the vibration.

<10> Upon completion of adjustment, reset the value of bit 7 of No. 2206 (Series 16) or No. 1746 (Series 15) to 0.

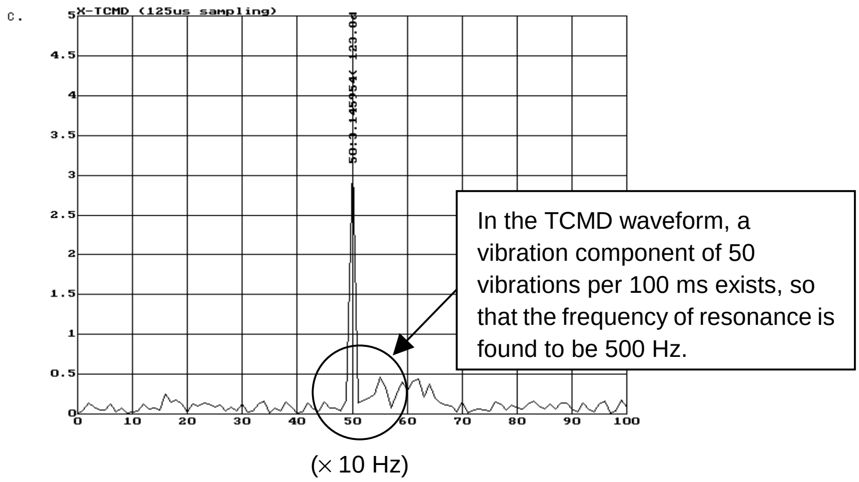


Fig. 3.4.1 (f) Example of resonance frequency

3.4.2 Cutting Feed/Rapid Traverse Switchable Function

(1) Overview

For cutting figure improvement, the setting of higher position loop and velocity loop gains is useful. In general, however, a higher maximum feedrate and higher acceleration for acceleration/deceleration are used in rapid traverse, compared with cutting feed. This means that those settings that achieve stable operation in cutting feed can cause velocity loop vibration and position loop hunting in rapid traverse. To avoid such trouble, a function for parameter switching between cutting feed and rapid traverse for the functions indicated below is available.

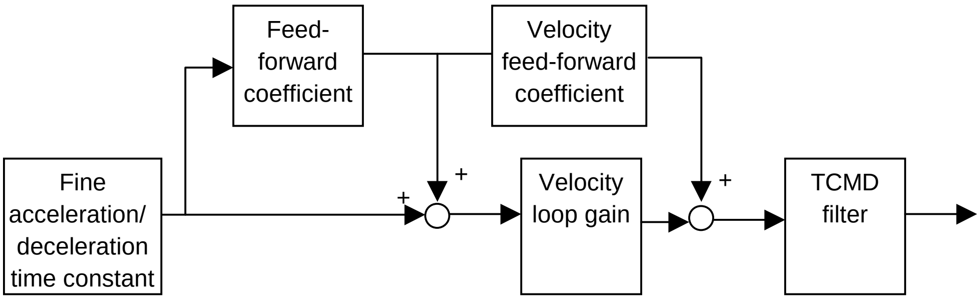


Fig. 3.4.2 Parameters switchable between cutting feed and rapid traverse

> **NOTE**
> 1 The TCMD filter and vibration suppression filter can be used at the same time by parameter setting.
> 2 The cutting feed/rapid traverse switchable function is not usable for the vibration suppression filter.
> 3 With the Series 15-B, the cutting feed/rapid traverse switchable function is not usable.

(2) Setting procedure

<1> Velocity loop gain

If acceleration in rapid traverse causes TCMD saturation, the velocity loop tends to oscillate at the end of acceleration in rapid traverse. Some machine systems tend to oscillate at a higher frequency when a higher feedrate is used. In such cases, gain switching between cutting feed and rapid traverse is effective. If the cutting feed/rapid traverse switchable velocity loop gain function is set, the conventional velocity gain is used for rapid traverse, and an overridden value is used for cutting feed. Usually, an override value of 150% to 200% is set. If vibration occurs only when the machine stops, use the function for changing the proportional gain in the stop state. (With Series 90A0, the function for changing the proportional gain in the stop state and the velocity loop proportional high-speed processing function can be used at the same time.)

[Applicable servo software]

Series 9080/P(16) and subsequent editions
(Series 16-C, 18-C)
Series 16-MC: BOB1/E and subsequent editions
Series 16-TC: B1B1/C and subsequent editions
Series 18-MC: BDB1/C and subsequent editions
Series 18-TC: BEB1/C and subsequent editions

Series 9090/F(06) and subsequent editions
(Series 16*i*, 18*i*, 21*i*, Power Mate *i*. The 320C52 servo card is required.)

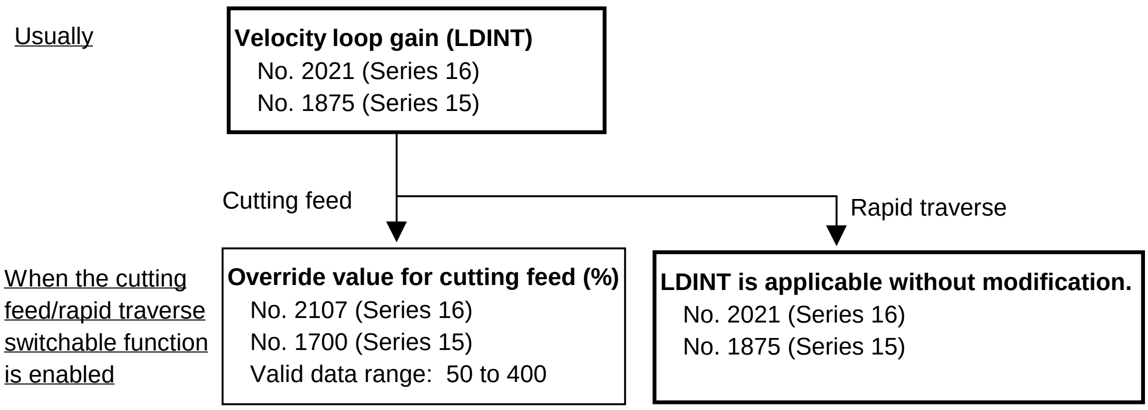
Series 90A0/A(01) and subsequent editions
(Series 15*i*, 16*i*, 18*i*, 21*i*. The 320C543 servo card is required.)

[Function bit]

	#7	#6	#5	#4	#3	#2	#1	#0
No. 1742 / **No. 2202**							**VGCCR**	

1: Enables the cutting feed/rapid traverse switchable velocity loop gain function.

0: Disables the cutting feed/rapid traverse switchable velocity loop gain function.



When a velocity loop gain of 200% (LDINT = 256) and a cutting-time override of 150% are set, the velocity loop gain for cutting feed is 300% (LDINT = 512).

<2> A fine acceleration/deceleration time constant of about 16 is optimal for fine acceleration/deceleration, position feed-forward, and velocity feed-forward cutting. In rapid traverse, however, the setting of a time constant of 32 to 40 ms may be desirable to reduce a shock at the time of acceleration/deceleration. Note that the feed-forward coefficient for figure minimization in cutting is not always the same as the feed-forward coefficient for minimizing time for high-speed positioning by rapid traverse. In such a case, use the cutting feed/rapid traverse switchable fine acceleration/deceleration function.

[Applicable servo software]

Series 9080/J(10) and subsequent editions

(Series 16-C, 18-C): The series/edition of the CNC software is the same as <1>.

Series 9090/C(03) and subsequent editions

(Series 16*i*, 18*i*, 21*i*, Power Mate *i*. The 320C52 servo card is required.)

Series 90A0/A(01) and subsequent editions

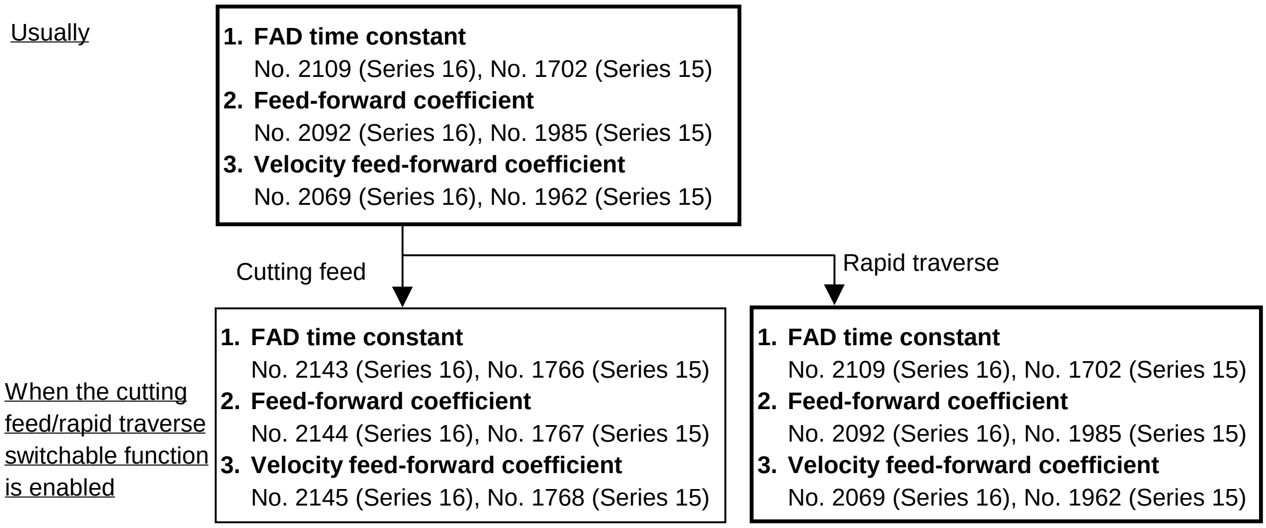
(Series 15*i*, 16*i*, 18*i*, 21*i*. The 320C543 servo card is required.)

[Function bit]

	#7	#6	#5	#4	#3	#2	#1	#0
No. 1742 / No. 2202								FADCH

1: Enables the cutting feed/rapid traverse switchable fine acceleration/deceleration function.

0: Disables the cutting feed/rapid traverse switchable fine acceleration/deceleration function.



<3> TCMD filter

If high-frequency vibration occurs only in rapid traverse, the TCMD filter may be more useful than the vibration suppression filter. On the other hand, if the TCMD filter is used in cutting feed when it is not needed, the oscillation limit of velocity loop gain decreases due to a filter delay. In such a case, the use of the TCMD filter only in rapid traverse is effective.

[Applicable servo software]

Series 9080/U(21) and subsequent editions

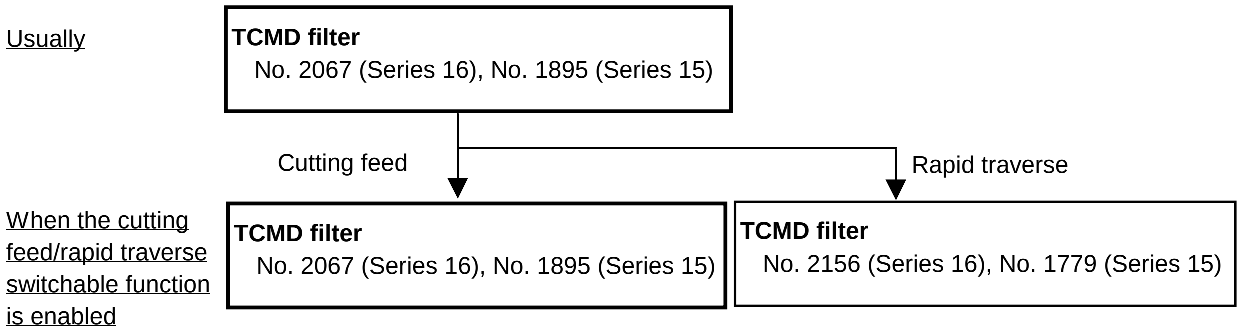
(Series 16-C, 18-C): The series/edition of the CNC software is the same as <1>.

Series 90A0/D(04) and subsequent editions

(Series 15*i*, 16*i*, 18*i*, 21*i*. The 320C543 servo card is required.)

[Parameter]

No. 1779	TCMD filter coefficient in rapid traverse
No. 2156	



<4> If the cutting feed/rapid traverse velocity gain switch function is enabled for the current loop 1/2PI function when the cutting feed/rapid traverse switchable velocity loop gain function is enabled, the current loop 1/2PI function is automatically turned off in rapid traverse. Set the rapid traverse enable bit only if the current loop 1/2PI function needs to be used also for rapid traverse when the cutting feed/rapid traverse velocity gain switch function is enabled.

[Applicable servo software]

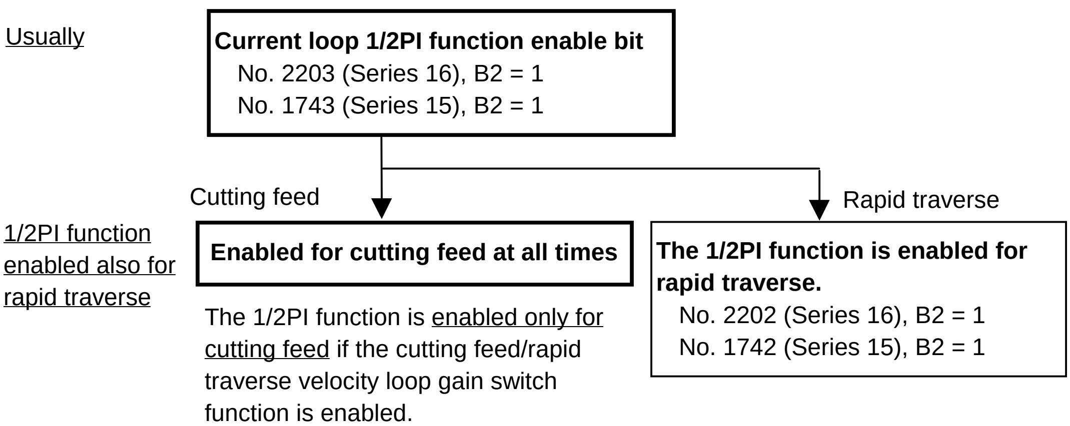
Series 9080/X(25) and subsequent editions
(Series 16-C, 18-C): The series/edition of the CNC software is the same as <1>.

Series 90A0/E(05) and subsequent editions
(Series 15*i*, 16*i*, 18*i*, 21*i*. The 320C543 servo card is required.)

[Function bit]

	#7	#6	#5	#4	#3	#2	#1	#0
No. 1742						CPIAL		
No. 2202								

1: Enables the 1/2PI function also for rapid traverse.
0: Disables the 1/2PI function for rapid traverse.



3.4.3 Servo Parameter Adjustment Procedure for Achieving High Speed and High Precision

(1) Overview

This section describes the procedure for determining the digital servo parameters used for advanced preview control, high-precision contour control, and AI nano-contour control, and the parameters for CNC acceleration and deceleration based on a feedrate difference. This section assumes that the servo adjustment software SD.EXE (of a version of November 1997 and later) is used.

(2) Standard settings

Before staring an actual adjustment, set the default parameters according to Table 3.4.3 (a). With the servo software series (Series 9080, 9090, and 90A0) that allows the application of fine acceleration/deceleration, fine acceleration/deceleration can be used instead of linear acceleration/deceleration after interpolation. However, fine acceleration/deceleration is disabled during high-precision contour control, AI contour control, and AI nano-contour control. So, be sure to set the parameter for acceleration/deceleration after interpolation on the CNC side during batch transfer (such as during RISC use).

Table 3.4.3 (a) Standard settings of parameters for high-speed and high-precision machining

Function	Series 16	Series 15	Standard setting
Velocity loop PI	2003 B3	1808 B3	1
Feed-forward enable	2005 B1	1883 B1	1
Velocity feedback acquisition 1 ms	2006 B4	1884 B4	1
Advanced preview feed-forward coefficient	2092	1985	9900
Velocity feed-forward coefficient	2069	1962	50
Velocity loop proportional high-speed processing function(*1)	2017 B7	1959 B7	1
Fine acceleration/deceleration enable(*2)	2007 B6	1951 B6	1
Linear-type fine acceleration/deceleration	2209 B2	1749 B2	1
Fine acceleration/deceleration time constant(*3)	2109	1702	32 for large machines 24 for medium-sized machines or small machines

*1 When this function is used, high-frequency vibration can occur, depending on the resonance point of the machine system. In this case, stop the use of this function. If high-frequency vibration occur when a high velocity loop gain is set, use the torque command filter.

*2 Instead of fine acceleration/deceleration, linear acceleration/deceleration after interpolation on the CNC can be used. During batch transfer, do not use fine acceleration/deceleration, but use acceleration/deceleration after interpolation on the CNC software side.

*3 For rapid traverse, a time constant of about 40 to 64 ms is required to perform high-speed positioning by fine acceleration/deceleration plus feed-forward. In this case, use the cutting feed/rapid traverse switchable fine acceleration/deceleration function.

(3) Velocity loop gain adjustment

Make a velocity loop gain adjustment according to Subsec. 3.3.1, "Gain Adjustment Procedure." Use level-up HRV control when it is applicable.

[Purpose of adjustment]

By setting a high velocity loop gain, the following can be achieved:

- Servo rigidity improvement
- Servo response improvement

In machining at normal feedrate, a high velocity loop gain improves surface precision and figure precision as long as vibration does not occur. A high velocity loop gain improves high-speed high-precision machining and high-speed positioning as well.

For setting a high velocity loop gain stably, the velocity loop proportional high-speed processing function is useful. As described in an example given later, the level of an adjustment that can be made for high-speed high-precision machining almost depends on the maximum allowable velocity loop gain.

(4) Feed-forward coefficient adjustment (using an arc of R10/F4000)

[Purpose of adjustment]

In a conventional position control loop where feed-forward control is not exercised, a velocity command is output based on (positional deviation) × (position loop gain). This means that the machine moves only when there is a difference between the specification of a command and the machine position. When the position gain is 30 [1/s], for example, a feedrate of 10 m/min generates a positional deviation of 5.56 mm. In linear feed, this positional deviation does not cause a figure error. For an arc or corner, however, this positional deviation causes a large figure error.

A function for eliminating such a positional deviation is feed-forward. Feed-forward converts a position command from the CNC to a velocity command for velocity command compensation. Feed-forward can reduce a positional deviation (to almost 0, theoretically). Accordingly, feed-forward can reduce arc and corner figure errors. However, the servo response is improved, so that a shock can occur. To prevent a shock from occurring, acceleration/deceleration before interpolation must be used at the same time.

[Guideline for adjustment value setting]

Theoretically, a feed-forward coefficient of 100% leads to a positional deviation of 0, and eliminates figure errors. Actually, however, there is a delay in velocity loop response. So, a value slightly less than 100% produces a specified figure. Usually, a value between 95% to 99% (settings of 9500 to 9900) is optimum. As the default, use 9800.

First, adjust the feed-forward coefficient while viewing an arc figure. (Set a velocity feed-forward coefficient of 50% before starting adjustment.)

[Actual adjustment]

Create a program as indicated below for circular movement by R10/F4000, and measure the path with SD. G08P1 and G08P0 in the program are G codes for starting and ending the advanced preview control mode in Series 16, respectively. For a mode to be used, select the corresponding G codes from Table 3.4.3 (b).

```
G91;
G08P1;
G17G02I-10.F4000.;
I-10.;
I-10.;
G08P0;
G04X3.;
M99;
```

Table 3.4.3 (b) Codes for starting and ending each mode

	Start	End
FS16, 18, 21 + Advanced preview control	G08P1	G08P0
FS16 + High-precision contour control FS15B + High-precision contour control FS15*i* + Fine HPCC	G05P10000	G05P0
FS16*i* + AI contour control FS16*i* + AI nano-contour control FS15B + Advanced preview control FS21*i* + AI advanced preview control	G05.1Q1	G05.1Q0

In Fig. 3.4.3 (a), the feed-forward coefficient is insufficient, resulting in a radius reduction of about 5 μm. In addition, the velocity loop gain is low, so that swells and quadrant protrusions are observed. By adjusting the feed-forward coefficient as shown in Fig. 3.4.3 (b), the arc radius reduction can be reduced to nearly 0.

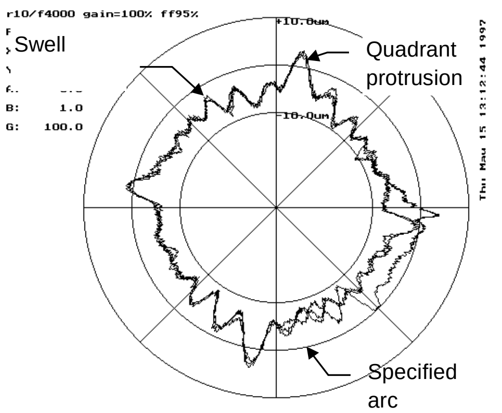


Fig. 3.4.3 (a) Feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 95%
FAD time constant: 24 ms (linear type)

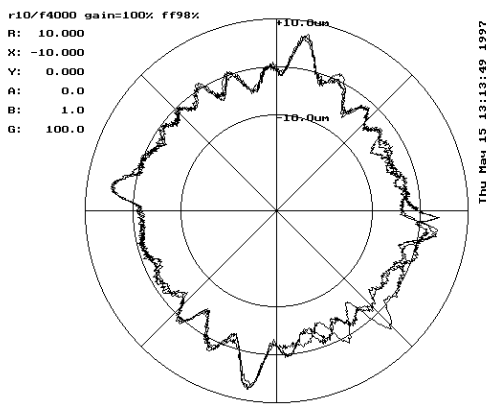


Fig. 3.4.3 (b) Feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 98%
FAD time constant: 24 ms (linear type)

In the figures above, a low velocity loop gain is used for measurement. By using an increased velocity loop gain, swells and quadrant protrusions can be reduced (Fig. 3.4.3 (c)). Increase the velocity loop gain to 70% to 80% of the limit. Adjust the feed-forward coefficient finely, and apply quadrant protrusion compensation (backlash acceleration/deceleration) to reduce the quadrant protrusions and improve the roundness (Fig. 3.4.3 (d)).

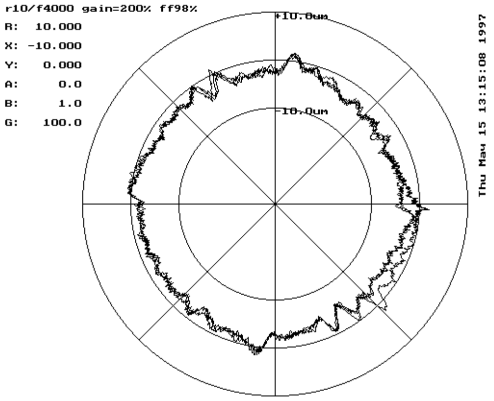


Fig. 3.4.3 (c) Effect of velocity loop gain
Velocity loop gain: 200%
Advanced preview feed-forward coefficient: 98%
FAD time constant: 24 ms (linear type)

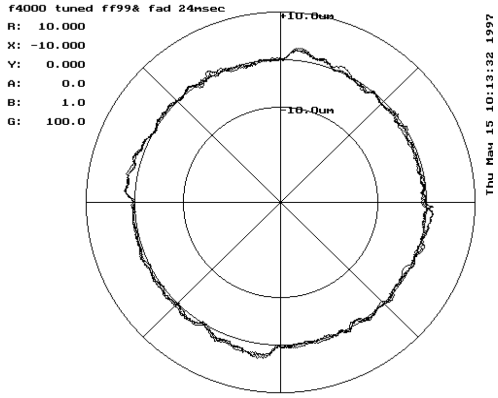


Fig. 3.4.3 (d) Effect of velocity loop gain
Velocity loop gain: 300%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)

(5) Velocity feed-forward coefficient adjustment (example using a square figure with 1/4 arcs)

[Purpose of adjustment]

Feed-forward coefficient adjustment can reduce positional deviation and figure errors. If the response of the velocity loop for executing a velocity command is low, velocity control cannot be exercised as specified where the specified acceleration varies to a large extent, thus causing a figure error. The response of the velocity loop can be improved by increasing the velocity loop gain and by adjusting the velocity feed-forward coefficient.

Velocity feed-forward multiplies a specified rate of variation (acceleration) by an appropriate coefficient for torque command compensation. In the servo velocity loop (PI control), a compensation torque occurs only when a difference (velocity deviation) between a specified velocity and actual velocity actually occurs. On the other hand, velocity feed-forward performs torque command compensation according to an acceleration value specified beforehand. So, a figure error that occurs due to a velocity loop delay can be reduced.

[Guideline for adjustment value setting]

The formula below is applicable. In actual adjustment, however, make an adjustment starting with a velocity feed-forward coefficient of 100.

$$\text{(Velocity feed-forward coefficient)} = 100 \times \frac{\text{(Motor rotor inertia + load inertia)}}{\text{Motor rotor inertia}}$$

[Actual adjustment]

Make a velocity feed-forward coefficient adjustment by using a square figure with four 1/4 arcs of a 5-mm radius. In this adjustment, disable the velocity clamp function based on an arc radius. (Disable the function, or in the example below, ensure that a velocity equal to or greater than F4000 can be specified.)

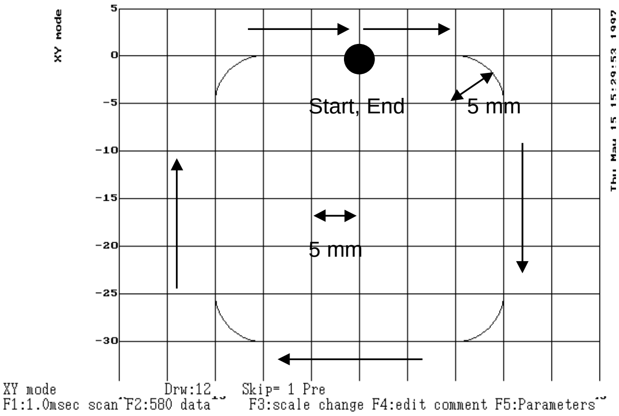


Fig. 3.4.3 (e) Programmed figure

```
G91;
G08P1;
G01X10.F4000;
G02X5.Y-5.R5.;
G01Y-20.;
G02X-5.Y-5.R5.;
G01X-20.;
G02X-5.Y5.R5.;
G01Y20.;
G02X5.Y5.R5.;
G01X10.;
G08P0;
G04X3.;
M99;
```

Press the uppercase character P to enable the display of a reference path. Execute the program and measure an actual path. Then, an actual path and reference path are drawn simultaneously as shown below.

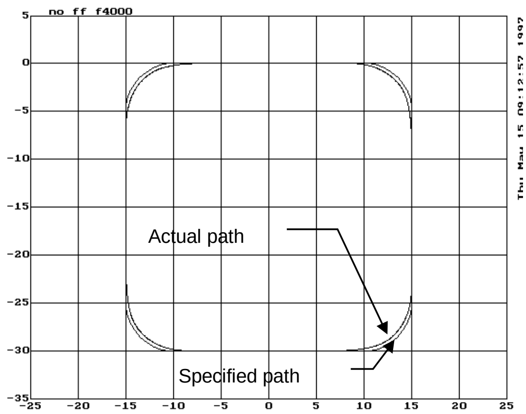


Fig. 3.4.3 (f) Specified path and actual path

When advanced preview feed-forward is disabled, a figure error of hundreds μm occurs as shown in Fig. 3.4.3 (f), and therefore can be viewed even in the XY mode. However, if advanced preview feed-forward is enabled for figure error reduction, it is difficult to evaluate a figure error correctly unless the error is enlarged.

In such a case, use the figure comparison mode (contour mode) for enlarging errors only for display (ctrl O).

In addition, set an error display magnification with F3 (scale change). For Fig. 3.4.3 (g), a display magnification of 100 is set.

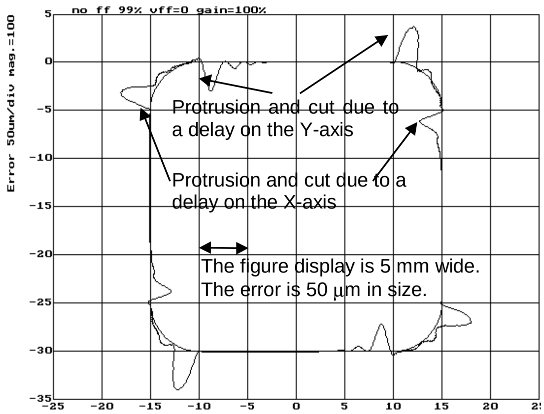


Fig. 3.4.3 (g) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: 0%

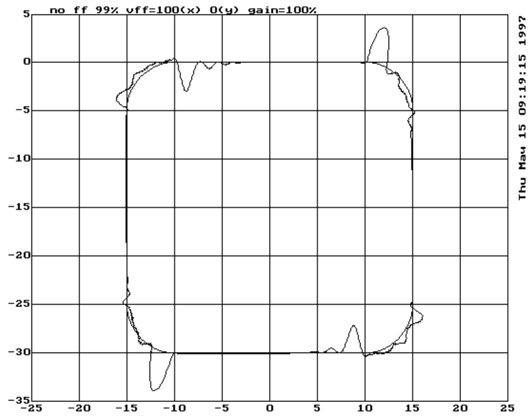


Fig. 3.4.3 (h) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X100%

In Fig. 3.4.3 (g), the velocity feed-forward coefficient is not specified, so that the movement along each axis delays where acceleration changes to a large extent. As the result, a protrusion occurs at the joint of a straight line with an arc, and a cut occurs at the joint of an arc with a straight line. In Fig. 3.4.3 (h), a velocity feed-forward coefficient is set for the X-axis only. The response of the X-axis has improved, so that a figure improvement can be seen in the areas where acceleration changes to a large extent along the X-axis.

In Fig. 3.4.3 (i), excessively large velocity feed-forward coefficients are specified, so that the protrusions shown in Fig. 3.4.3 (g) have changed to cuts, and the cuts have changed to protrusions. This means that optimum velocity feed-forward coefficients exist and they are less than the values of Fig. 3.4.3 (i). Fig. 3.4.3 (j) shows the result of adjustment to the optimum values. Fig. 3.4.3 (k) enlarges the errors only for display.

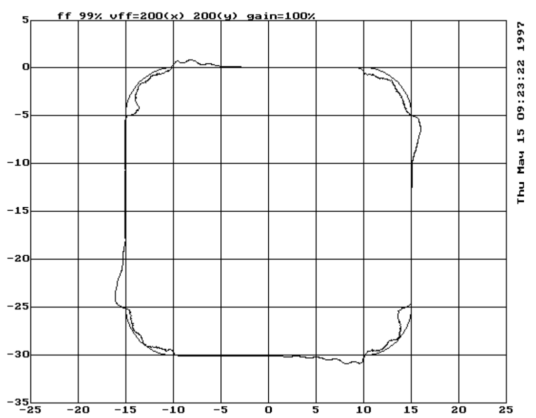


Fig. 3.4.3 (i) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X200%, Y200%

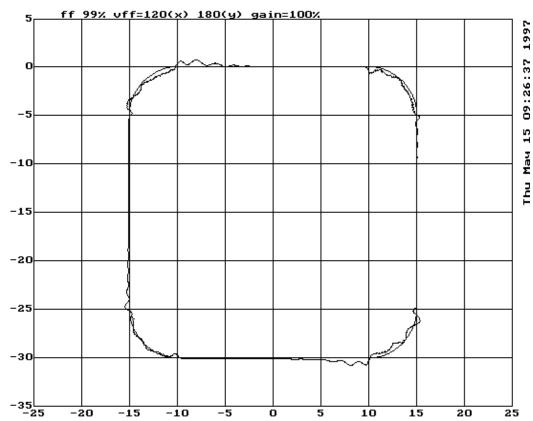


Fig. 3.4.3 (j) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X120%, Y180%

When the enlarged range is viewed, it is seen that the machine is vibrating in the arc areas. This vibration is caused by a low velocity loop gain. To reduce this vibration, two methods are available. One method increases the velocity loop gain. (This method cannot be used when the velocity loop gain has already been increased to the oscillation limit.) The other method decreases the feedrate in the arc areas with the arc radius based feedrate clamp function as described in Subsec. 3.4.3 (6).

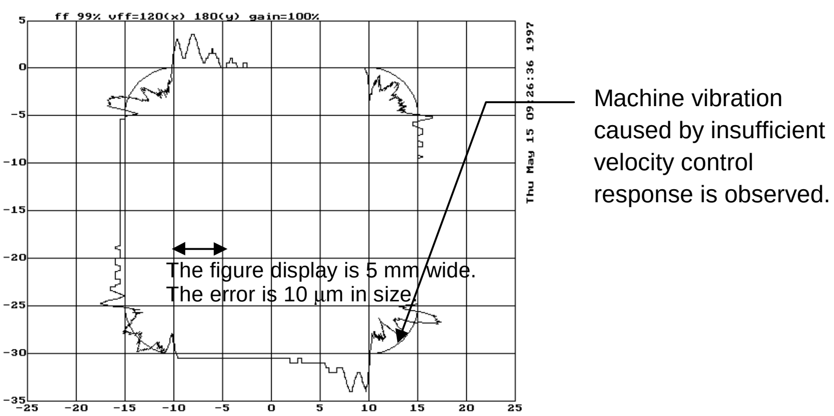


Fig. 3.4.3 (k) Velocity feed-forward adjustment

Swells in the arc areas can be reduced by increasing the velocity loop gain (Fig. 3.4.3 (l)). However, figure errors that occur at the joints of straight lines and arcs cannot be fully eliminated. Swells can be additionally reduced by fine adjustment of the velocity feed-forward coefficient or by using the arc radius based feedrate clamp function described in Subsec. 3.4.3 (6).

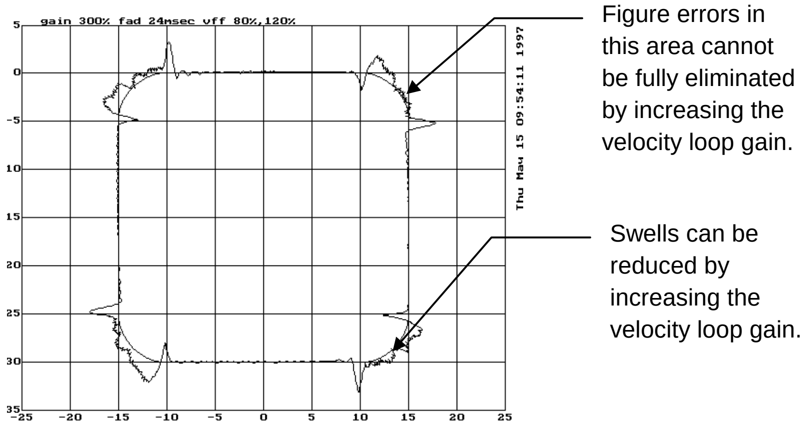


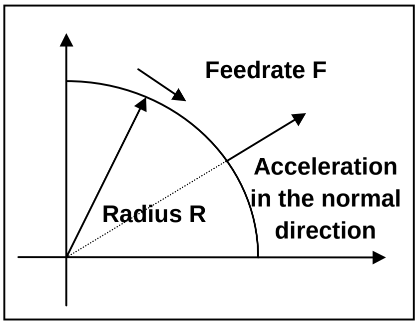
Fig. 3.4.3 (l) Velocity feed-forward adjustment
<u>Velocity loop gain: 300%</u>
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X120%, Y180%

(6) Adjustment of the parameters for arc radius based feedrate clamping

[Purpose of adjustment]

As mentioned above, velocity feed-forward coefficient adjustment can improve a velocity loop response delay, thus reducing figure errors in areas where specified acceleration changes to a large extent. However, velocity feed-forward coefficient adjustment alone cannot fully eliminate figure errors. Moreover, if the rigidity of a machine itself is low, the machine may vibrate due to a change in acceleration.

To reduce changes in specified acceleration in areas where acceleration changes to a large extent, the specified feedrate in the tangent direction is reduced. In part machining (advanced preview control), the arc radius based feedrate clamp function performs this feedrate reduction. By adjusting the parameter of this function, an acceleration value in the normal direction allowable with a machine can be found. As detailed below, such an acceleration value can be used as a guideline for setting the parameter for feedrate reduction by acceleration in high-precision contour control (small successive blocks).



In the figure at left, let R be the radius of the arc, and F be the feedrate. Then, the acceleration in the normal direction is F^2/R. The arc radius based feedrate clamp function specifies R and F as its parameters to ensure that the acceleration in the normal direction at a specified arc does not exceed the specified value.

For example, suppose that when R = 5 mm and F = 4000 mm/min are specified as the parameters of the arc radius based feedrate clamp function, the acceleration in the normal direction at the arc is:

$F^2/R = (4000/60)^2/5 = 889$ mm/sec^2

When using the high-precision contour control function, set about the same value as this acceleration as the parameter for feedrate reduction function based on acceleration in small blocks. In the example above, if a cutting feedrate of F4000 (mm/min) is set, the time required to reach this feedrate is calculated as follows:

4000/60/889*1000 = 75 msec

When the feedrate at an arc is reduced using the arc radius based feedrate clamp function, figure precision improves. However, a longer machining time is required as a side effect. Fig. 3.4.3 (m) shows a tangent feedrate and processing time when the arc radius based feedrate clamp function is not used with the adjustment program used in (5) and later. Fig. 3.4.3 (m) indicates that the tangent feedrate remains to be F4000. On the other hand, when feedrate reduction to F3000 at R5 mm is specified with the arc radius based feedrate clamp function, the tangent feedrate is reduced to F3000 at corners as shown in Fig. 3.4.3 (n), but the machining time has increased by 200 msec.

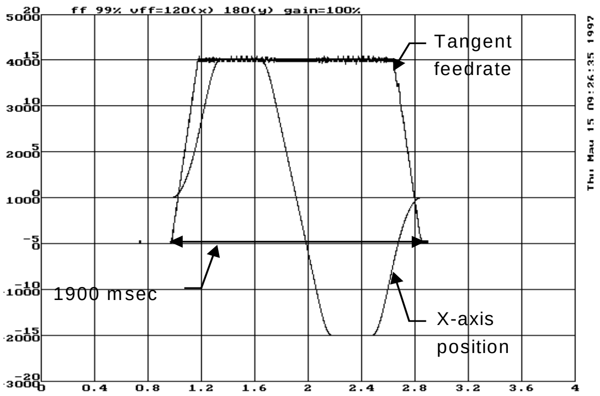


Fig. 3.4.3 (m) When the arc radius based feedrate clamp function is not used

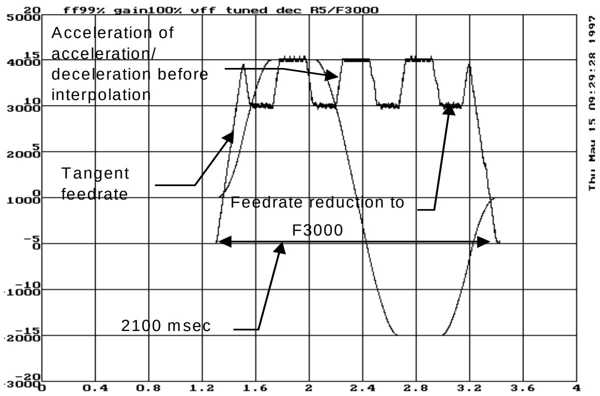


Fig. 3.4.3 (n) When the arc radius based feedrate clamp function is used

[Guideline for adjustment value setting]

Empirically, the values below are adequate. For the parameter numbers, refer to the parameter manual of each CNC.

High-rigidity small machines: F4000 for R5 (889 mm/sec^2)

Medium-size or small machining centers with a relatively high rigidity: F3000 for R5 (500 mm/sec^2)

Large machines: F2500 for R5 (347 mm/sec^2)

Large machines with a very high rigidity: F2000 for R5 (222 mm/sec^2)

[Actual adjustment]

Fig. 3.4.3 (o) shows the results of setting R5 mm and F3000 with the arc radius based feedrate clamp function for Fig. 3.4.3 (k). Fig. 3.4.3 (o) indicates that the figure errors at the entries and exits of the arc areas have been reduced.

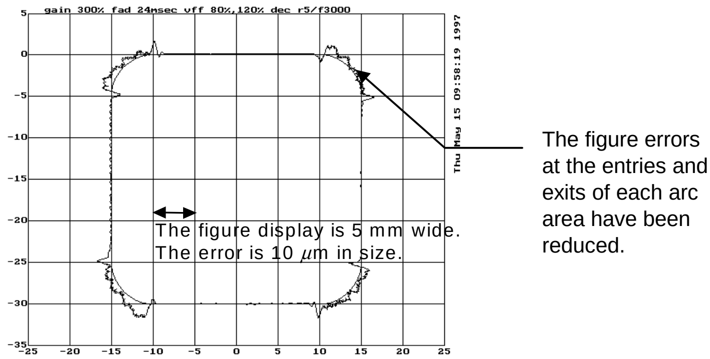


Fig. 3.4.3 (o) Arc radius based feedrate clamping

(7) Adjustment of an allowable feedrate difference of the feedrate difference based corner deceleration function

[Purpose of adjustment]

In the program shown in Fig. 3.4.3 (p), the feedrate along each axis changes to a great extent at each block joint. With a high-precision high-speed system, the CNC reads programmed figures beforehand. If the feedrate along each axis changes at a block joint, such a system can decrease the feedrate by a parameter-specified allowable feedrate difference to reduce a shock and figure error at the block joint. Acceleration/deceleration is performed based on the time constant for acceleration/deceleration before interpolation. A more reduced corner feedrate makes a figure error improvement to a greater extent, but requires a longer machining time. Set a reduced corner feedrate to a highest possible value as long as an allowable figure error is obtained.

[Guideline for setting]

For the parameter number, refer to the parameter manual of each CNC.

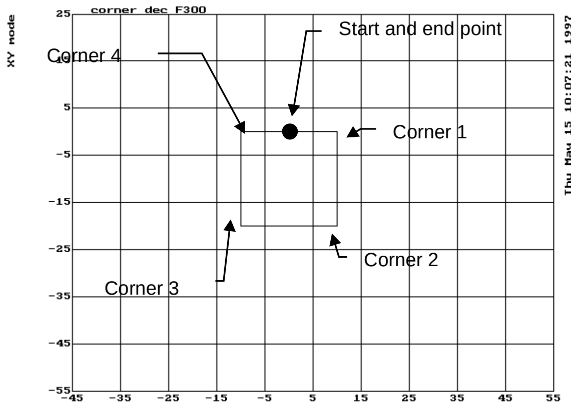
Small machines with a high rigidity: F400

Medium-size or small machining centers with a relatively high rigidity: F300

Large machines: F200

[Actual adjustment procedure]

Execute the following program, and measure the actual path.




```
G91;
G08P1;
G01X10.F4000;
G01Y-20.;
G01X-20.;
G01Y20.;
G01X10.;
G08P0;
G04X3.;
M99;
```

Fig. 3.4.3 (p) Programmed figure

The XY mode (ctrl-X) is used for drawing. To observe an overshoot along an axis to be stopped, the figure is enlarged in the direction of the axis to be stopped. Corner 1 and corner 3 in Fig. 3.4.3 (p) are enlarged in the X-axis direction, and corner 2 and corner 4 are enlarged in the Y-axis direction. In the examples below, corner 1 is displayed using 0.01 mm/div in the X-axis direction and 0.1 mm/div in the Y-axis direction.

In Fig. 3.4.3 (q) where a reduced corner feedrate of F1000 is set, an overshoot of 10 μm or more has occurred. In Fig. 3.4.3 (r), however, the overshoot is reduced to about 3 μm.

If an overshoot cannot be removed by setting a reduced corner feedrate close to 0, the acceleration of acceleration/deceleration before interpolation may be too large. In such a case, set a longer time for acceleration/deceleration before interpolation. (In this case, a longer machining time results.)

Fig. 3.4.3 (s) shows the feedrate along the X-axis and Y-axis (corner 1) when the corner deceleration function is used.

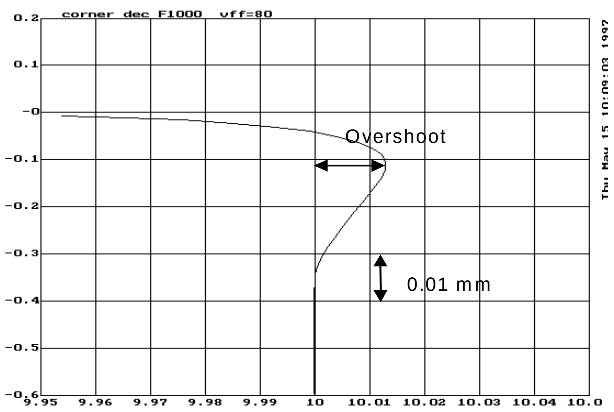


Fig. 3.4.3 (q) Reduced corner feedrate F1000

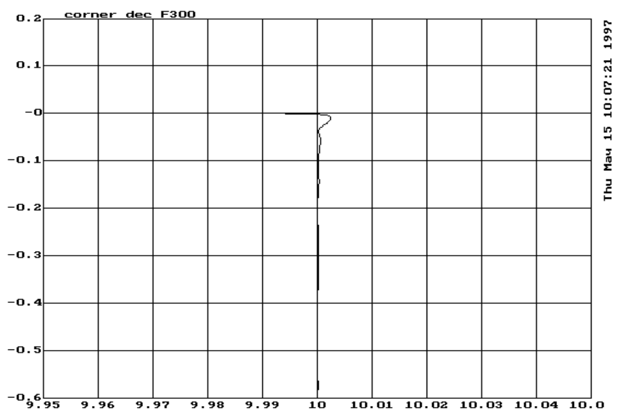


Fig. 3.4.3 (r) Reduced corner feedrate F300

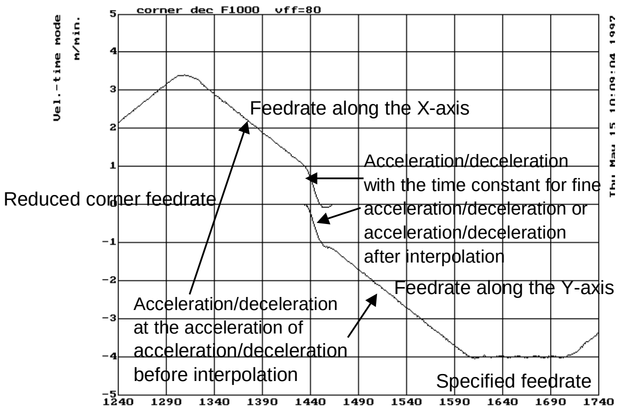


Fig. 3.4.3 (s) Time and feedrate relationship for reduced corner feedrate F1000

3.4.4 High-Speed Positioning Adjustment Procedure

(1) Overview

This section describes the adjustment procedure for high-speed positioning required with a punch press and PC board drilling machine.

(2) Adjustment procedure

Make a high-speed positioning adjustment while viewing the VCMD (servo error amount) and TCMD. Set a measurement range as described below.

- VCMD: Adjust the VCMD magnification, measurement voltage level (when an analog check board is used), and measurement range (when the servo adjustment software is used) to allow viewing to a requested positioning precision. In the example below, a requested precision of 10 μm is assumed.
- TCMD: Make an adjustment to view a specified maximum current value. If an adjustment is made to reduce positioning time, TCMD saturation may occur. Make an adjustment so that the TCMD lies within a specified maximum current.

<1> I-P control setting

Select I-P control for velocity loop control. In general, PI control reduces start-up time for a command, but requires a longer setting time, so that PI control is not suitable for high-speed positioning. On the other hand, I-P control reduces time required to reach a target position, so that I-P control is generally used for high-speed positioning adjustment.

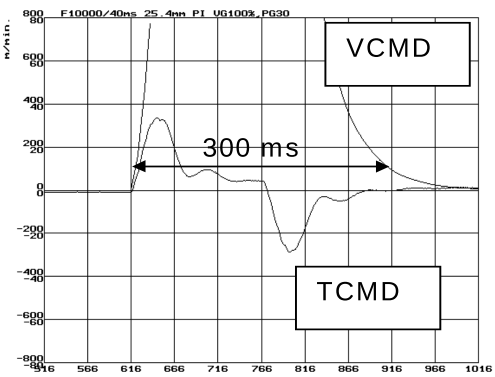


Fig. 3.4.4 (a) When PI control is used

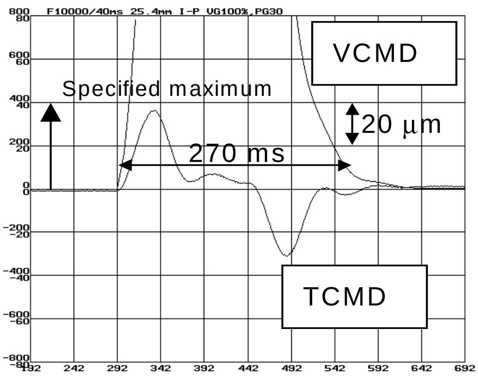


Fig. 3.4.4 (b) When I-P control is used

<2> Set a highest possible velocity loop gain according to Subsec. 3.3.1, "Gain Adjustment Procedure."

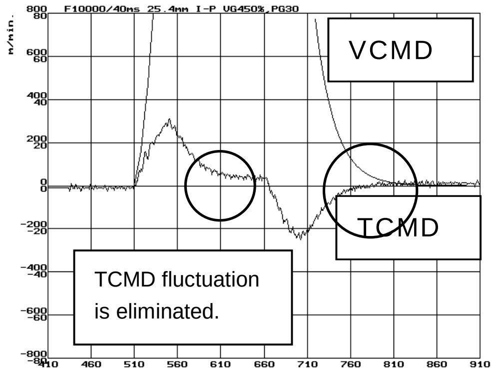


Fig. 3.4.4 (c) After velocity loop gain adjustment

<3> Set a switch speed of 1500 (15 rpm) with the position gain switch function (see Subsec. 4.8.1).

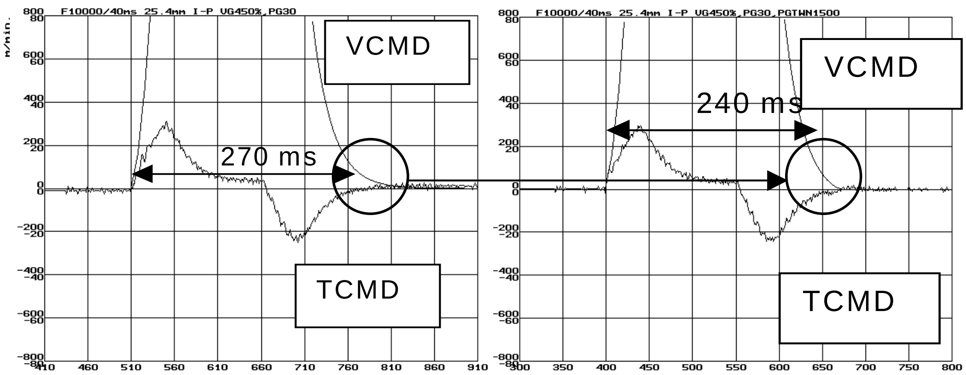


Fig. 3.4.4 (d) Position gain switch function

<4> Set a highest possible position gain. While viewing the VCMD waveform, make an adjustment so that the overshoot value lies within a requested precision. After setting a position gain, perform rapid traverse for a long distance to check that low-frequency vibration due to an excessively increased position gain does not occur. If the set position gain is too high, vibration after an overshoot exceeds a requested precision. An overshoot itself can be suppressed to some extent by adjustment of <5>.

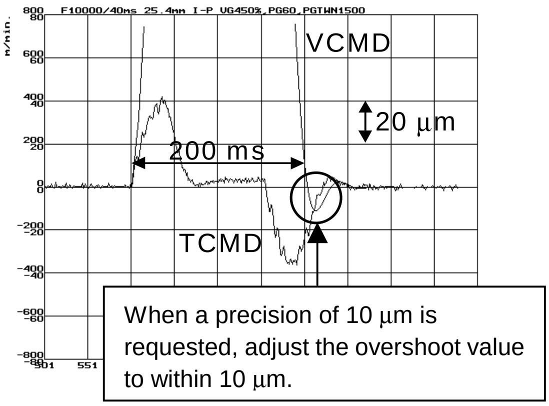


Fig. 3.4.4 (e) Adequate position gain

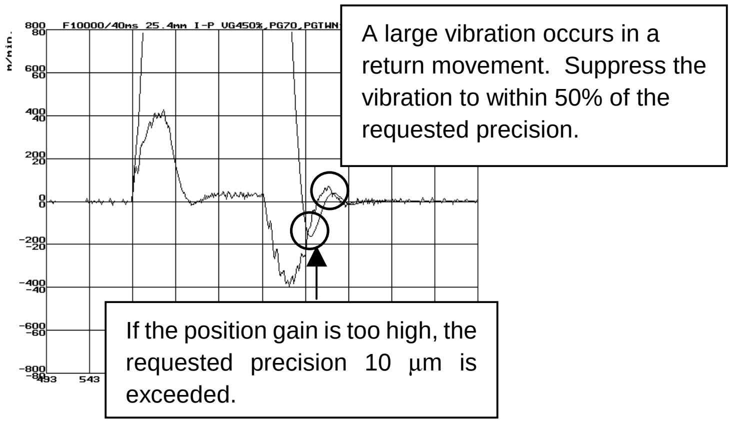


Fig. 3.4.4 (f) Excessively high position gain

<5> Make a fine PK1V adjustment to eliminate an overshoot and undershoot. If a large value is set for PK1V, a large undershoot occurs.

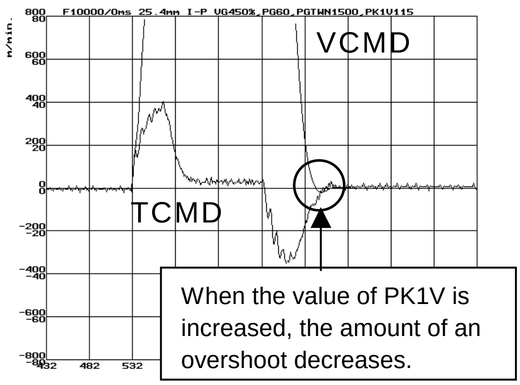


Fig. 3.4.4 (g) After PK1V adjustment

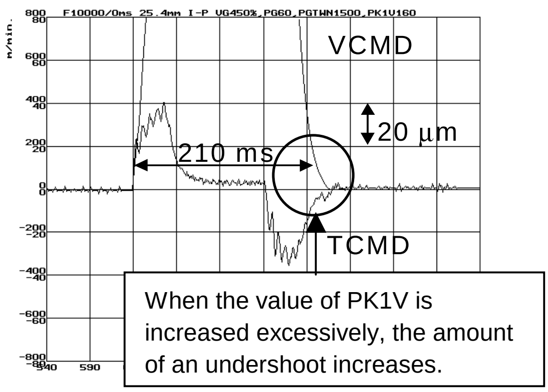


Fig. 3.4.4 (h) When the value of PK1V is too large

3.4.5 Rapid Traverse Positioning Adjustment Procedure

(1) Overview

The fine acceleration/deceleration function applies a filter to each axis in the servo software to reduce a shock associated with acceleration/deceleration. By combining the fine acceleration/deceleration function with feed-forward, high-speed positioning can be achieved in rapid traverse. This section describes rapid traverse positioning adjustment.

(2) High-speed positioning by a combination of fine acceleration/deceleration and feed-forward

(Rapid traverse positioning when fine acceleration/deceleration is not used)

A servo loop not performing feed-forward has a delay equivalent to a position loop gain. The time required for positioning after completion of distribution from the CNC is four to five times the position gain time constant (33 ms for 30 [1/s]) (133 to 165 ms for a position gain of 30).

In normal rapid traverse, rapid traverse linear acceleration/deceleration (Fig. 3.4.5 (a)) is used, so that acceleration changes to a large extent at the start and end of acceleration. However, since feed-forward is not used, acceleration change is made moderate by a position loop gain, and a shock does not occur.

If a low linear acceleration/deceleration time constant is set for high-speed positioning, and a high position gain and feed-forward are set, the time required for positioning is reduced, but a shock occurs. In this case, a shock can be reduced by setting rapid traverse bell-shaped acceleration/deceleration (optional function) (Fig. 3.4.5 (b)).

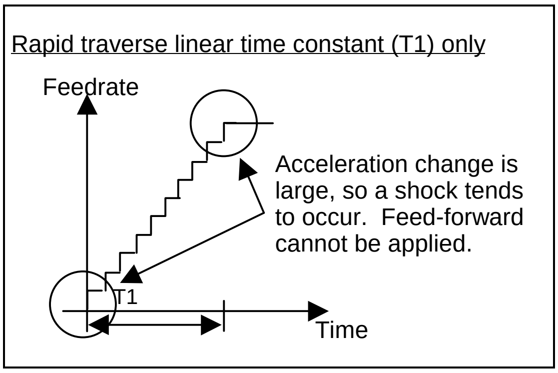


Fig. 3.4.5 (a) Rapid traverse linear acceleration/deceleration

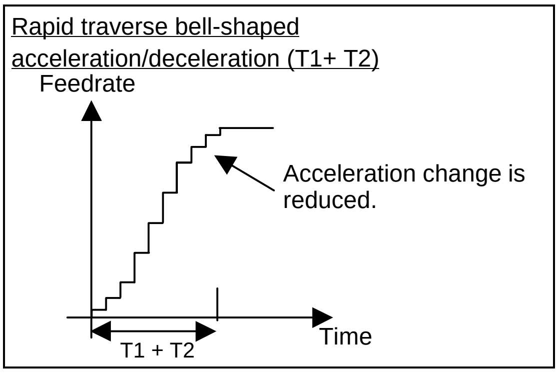


Fig. 3.4.5 (b) Rapid traverse bell-shaped acceleration/deceleration

(Rapid traverse positioning when fine acceleration/deceleration is used)

For further reduction in the time required for rapid traverse positioning, a delay due to a position gain needs to be minimized. For this purpose, feed-forward needs to be fully utilized. When feed-forward is applied, the positional deviation decreases. Accordingly, positional deviation convergence occurs more rapidly after distribution, thus reducing the time required for positioning.

If feed-forward close to 100% is applied to normal acceleration/deceleration (Fig. 3.4.5 (a) and (b)), a mechanical shock due to acceleration change at the start and end of acceleration/deceleration, and a torque command vibration during acceleration/deceleration can pose a problem. To cope with this, the fine acceleration/deceleration function is available (Fig. 3.4.5 (c) and (d)).

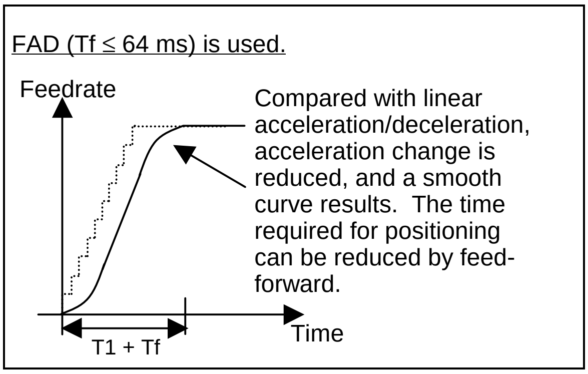


Fig. 3.4.5 (c) Fine acceleration/deceleration (FAD)

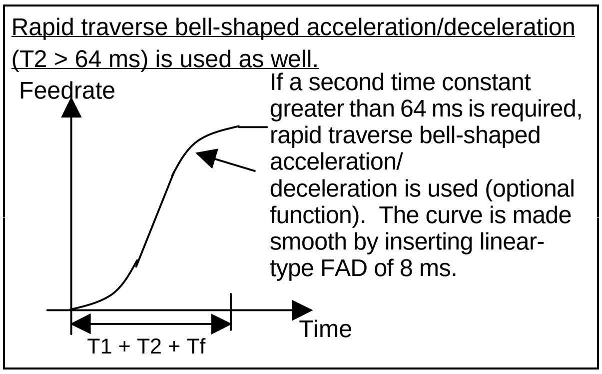


Fig. 3.4.5 (d) Rapid traverse bell-shaped acceleration/deceleration + FAD

Fine acceleration/deceleration increases the time required for command distribution by a time constant. However, a time reduction in positioning achieved by feed-forward is greater than this increase, so the time required for positioning can be reduced in total. Thus, positioning can be speeded up using fine acceleration/deceleration. The adjustment procedure is described in (3) below.

(T1 + positioning time based on a position gain)

> (T1 + Tf + positioning time based on feed-forward)

A time constant up to 64 ms can be set for fine acceleration/deceleration. If a time constant greater than 64 ms is required, use rapid traverse bell-shaped acceleration/deceleration, and set 8 ms for linear-type fine acceleration/deceleration (Fig. 3.4.5 (d)).

(3) Adjustment procedure

Make a rapid traverse positioning adjustment while viewing the VCMD (servo error amount). Adjust the measurement range so that the time required for position deviation convergence within the in-position width can be seen. At the same time, observe the TCMD to check that the TCMD is not saturated. Before proceeding to the adjustment described below, adjust the velocity loop gain according to Subsec. 3.3.1, "Gain Adjustment Procedure."

The measurement data of Fig. 3.4.5 (e) has been obtained under the condition below. Fine acceleration/deceleration and feed-forward are not used.

- Rapid traverse rate: 20000 mm/min
- Rapid traverse time constant: 150 ms
- Position gain: 30/s
- Travel distance: 100 mm

When the in-position width is 20 pulses, a time of about 180 ms is required from distribution completion to positioning. Reducing this time can speed up positioning.

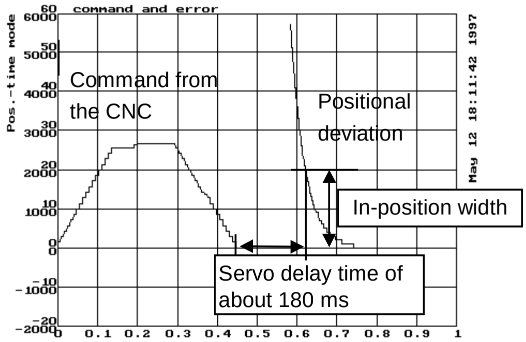


Fig. 3.4.5 (e) Measurement of time before adjustment

<1> Default parameter setting for fine acceleration/deceleration and feed-forward
Set the parameters according to Table 3.4.5. By setting the default parameters, the time required for positioning can be much reduced.

Table 3.4.5 Default parameters for rapid traverse positioning adjustment

Item	Default parameter		
	Series 16	Series 15	Setting
Rapid traverse feed-forward enable	No. 1800, B3	No. 1800, B3	1
Fine acceleration/deceleration function enable	No. 2007, B6	No. 1951, B6	1
Linear-type fine acceleration/deceleration	No. 2009, B2	No. 1749, B2	1
Fine acceleration/deceleration time constant	No. 2109(*1)	No. 1702(*2)	40
Feed-forward enable	No. 2005, B1	No. 1883, B1	1
Feed-forward coefficient	No. 2092(*1)	No. 1985(*2)	9700
Velocity feed-forward coefficient	No. 2069(*1)	No. 1962(*2)	100

*1 When using different values for cutting and rapid traverse, use the cutting feed/rapid traverse switchable fine acceleration/deceleration function according to Subsec. 3.4.2, "Cutting Feed/Rapid Traverse Switchable Function."

*2 Series 15-B does not support the cutting feed/rapid traverse switchable function.

<2> Velocity feed-forward adjustment

When feed-forward is enabled, the time required for positioning can be reduced, but a swell may occur due to insufficient velocity loop response immediately before machining stops. A swell can be reduced by an increased velocity loop gain, but there is an upper limit on the velocity loop gain. So, adjust the velocity feed-forward coefficient to reduce a swell for positioning time reduction.

The default settings cause a swell immediately before machining stops (Fig. 3.4.5 (f)). The swell can be reduced by increasing the velocity feed-forward coefficient (Fig. 3.4.5 (g)).

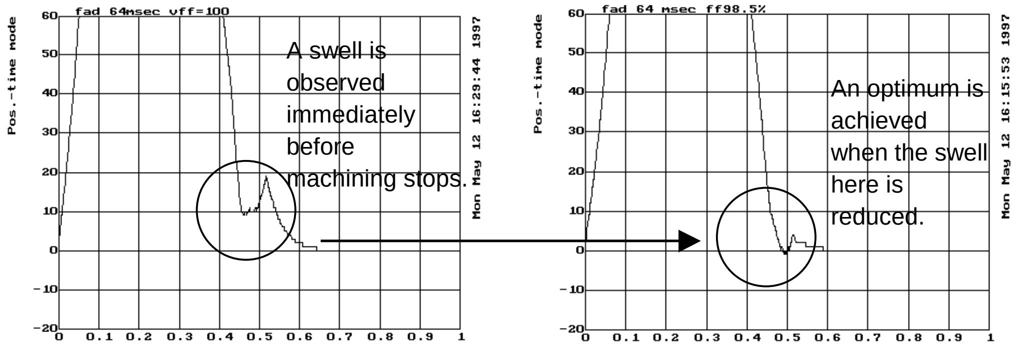


Fig. 3.4.5 (f) Before velocity feed-forward adjustment

FAD: 64 ms
Feed-forward: 98.5%
Velocity feed-forward coefficient: 100%

Fig. 3.4.5 (g) After velocity feed-forward adjustment

FAD: 64 ms
Feed-forward: 98.5%
Velocity feed-forward coefficient: 250%

<3> Fine adjustment of feed-forward

Reduce the time required for positioning by making a fine adjustment of the feed-forward coefficient. If the feed-forward coefficient is not sufficiently large (Fig. 3.4.5 (h)), increase the feed-forward coefficient by about 0.5%. If the feed-forward coefficient is too large (Fig. 3.4.5 (i)), decrease the feed-forward coefficient by about 0.5%.

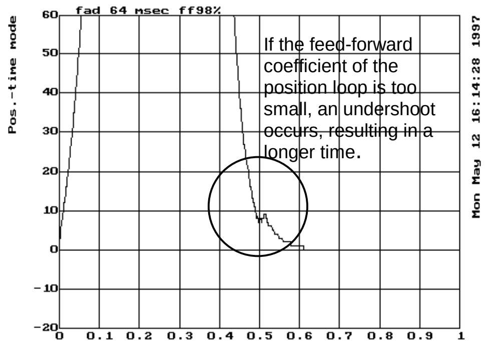


Fig. 3.4.5 (h) When the feed-forward coefficient is too small
FAD: 64 ms
Feed-forward: 98%
Velocity feed-forward coefficient: 250%

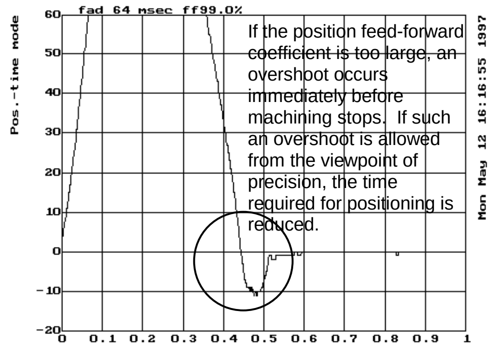


Fig. 3.4.5 (i) When the feed-forward coefficient is too high
FAD: 64 ms
Feed-forward: 99%
Velocity feed-forward coefficient: 250%

If an adequate feed-forward coefficient is set, the in-position width is satisfied nearly at the same as distribution command completion, and shortest-time positioning is achieved as shown in Fig. 3.4.5 (j).

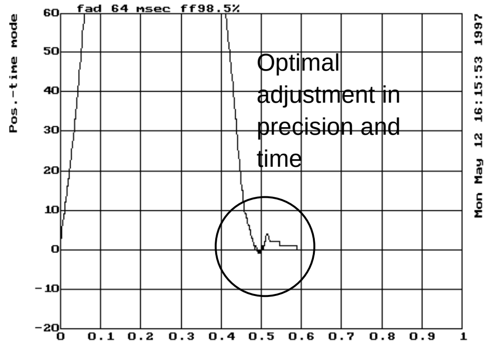


Fig. 3.4.5 (j) When an adequate feed-forward coefficient is set
FAD: 64 ms
Feed-forward: 98.5%
Velocity feed-forward coefficient: 250%

4 SERVO FUNCTION DETAILS

4.1 LIST OF SERVO FUNCTIONS

Servo software series / Function name	9041	9046	9060	9064	9065	9066	9070	9080	9081	9090	90A0	Related section in this manual
[Servo initialization functions]												
Flexible feed gear	A	A	C	B	A	A	A	A	C	C	A	2.1
Parameter invalid alarm detail output	-	-	-	-	-	-	-	N	-	E	A	2.1.5
Position gain setting range expansion function	A	A	C	B	A	A	A	A	C	C	A	Supplement 4 of Subsec. 2.1.5
[Servo functions]												
HRV control	-	-	-	-	A	F	-	E	C	C	A	4.2
OVC alarm (type 2)	-	-	-	-	A	F	-	E	C	C	A	4.2
Level-up HRV	-	-	-	-	-	-	-	-	-	-	A	4.3
250 µs acceleration feedback	A	A	C	B	A	A	A	A	C	C	A	4.4.1
Velocity loop high cycle management function (IP)	-	-	-	-	-	-	-	A	C	C	A	4.4.2
Velocity loop high cycle management function (PI)	-	-	-	-	-	B	G	A	C	C	A	4.4.2
Velocity loop proportional, support for tandem	-	-	-	-	-	-	-	-	-	-	I	4.4.2
Function for changing the proportional gain in the stop state	-	D	Q	-	-	A	F	A	C	C	A	4.4.3
Improvement of the function for changing the proportional gain in the stop state	-	-	-	-	-	-	-	U	-	-	D	4.4.3
Addition of the N pulse suppress function	A	A	C	B	A	A	A	A	C	C	A	4.4.4
Machine speed feedback function	A	A	C	B	A	A	A	A	C	C	A	4.5.1
Machine speed feedback function (normalized)	A	-	N	-	-	A	D	F	C	C	A	4.5.1
Observer function	A	A	C	B	A	A	A	A	C	C	A	4.5.2
Observer function (addition of the stop-time disable function)	-	-	W	-	-	B	H	A	C	C	A	4.5.2
Torque command filter	A	A	C	B	A	A	A	A	C	C	A	4.5.3
Torque command filter (switchable between cutting feed/rapid traverse)	-	-	-	-	-	-	-	U	-	-	D	4.5.3
Dual position feedback function	A	-	C	B	A	A	A	A	C	C	A	4.5.4
Dual position feedback function (zero width improvement)	-	-	Y	I	A	F	J	F	C	C	A	4.5.4
Vibration-damping control function	-	-	-	-	-	-	D	A	A	C	A	4.5.5
Notch filter	-	-	G	-	-	A	A	A	C	C	A	4.5.6
Vibration suppression filter	-	-	-	-	-	-	-	-	-	-	E	4.5.6
Current loop 1/2PI function	-	-	-	-	-	-	-	K	-	C	A	4.5.7
Feed-forward function	A	A	C	B	A	A	A	A	C	C	A	4.6.1
Advanced preview control (advanced preview feed-forward)	A	A	C	-	-	A	A	A	C	C	A	4.6.2

Function name \ Servo software series	9041	9046	9060	9064	9065	9066	9070	9080	9081	9090	90A0	Related section in this manual
Advanced preview control (RISC based high-precision contour control)	A	A	C	-	-	A	A	A	C	C	A	4.6.3
Advanced preview control (RISC based high-precision contour control) type 2	-	-	-	-	-	-	-	A	C	C	A	4.6.3
Backlash acceleration function	A	A	C	B	A	A	A	A	C	C	A	4.6.4
Two-stage backlash acceleration function	-	-	Q	-		A	F	A	C	C	A	4.6.5
Two-stage backlash acceleration function (enabled only for cutting)	-	-	-	-	-	-	K	J	E	C	A	4.6.5
Static friction compensation function	A	A	C	B	A	A	A	A	C	C	A	4.6.6
Overshoot compensation function	A	A	C	B	A	A	A	A	C	C	A	4.7
Overshoot compensation function type 2	-	-	-	-	-	-	-	K	-	C	A	4.7
Position gain switch function	-	B	C	-	-	A	A	A	C	C	A	4.8.1
Position gain switch function type 2	-	-	-	-	-	-	-	M	-	E	A	4.8.1
High-speed positioning function setting range expansion	-	-	-	-	-	-	-	O	-	F	A	4.8.1
Low-speed integration function	-	B	C	-	-	A	A	A	C	C	A	4.8.2
Fine acceleration/deceleration function	-	-	-	-	-	D	-	E	C	C	A	4.8.3
Fine acceleration/deceleration function (switchable between cutting feed/rapid traverse)	-	-	-	-	-	-	-	J	-	C	A	4.8.3
Fine acceleration/deceleration function (linear-type acceleration/deceleration)	-	-	-	-	-	-	-	K	-	E	A	4.8.3
Dummy serial feedback function	B	D	Q	I	A	A	E	A	C	C	A	4.9.1
FSSB dummy function	-	-	-	-	-	-	-	-	-	-	C	4.9.1
Brake control	A	A	C	B	A	A	A	A	C	C	A	4.10
Emergency stop distance reduction function type 1	A	B	L	-	-	A	C	A	C	C	A	4.11.1
Emergency stop distance reduction function type 2	-	-	-	-	-	-	-	Y	-	L	I	4.11.2
Separate detector hardware disconnection stop distance reduction function	-	-	-	-	-	-	-	N	-	E	A	4.11.3
OVC and OVL alarm stop distance reduction function	-	-	-	-	-	-	-	Y	-	-	E	4.11.4
Abnormal load detection	-	-	E	E	A	A	A	A	C	C	A	4.12
Abnormal load detection (switchable between cutting feed/rapid traverse)	-	-	-	-	-	H	-	G	-	C	A	4.12.1
Function for obtaining current offsets at ESP	-	-	-	-	-	-	-	A	C	C	A	4.13
Support for linear motors	-	-	-	-	-	D	-	A	C	C	A	4.14.1
Current loop gain quadruple function	-	-	-	-	-	-	-	R	-	-	D	4.14.1
Linear motor torque ripple correction	-	-	-	-	-	-	-	E	C	C	A	4.14.2
Torque control function type 1	-	-	-	-	-	E	-	E	C	C	A	4.15
Torque control function type 2	-	-	-	-	-	H	-	S	-	I	D	4.15
Super-precision machining function	-	-	-	-	-	-	-	-	C	-	-	4.16
Tandem control function	-	-	F	-	-	-	A	A	C	C	A	4.17
Tandem control function (damping compensation function)	-	-	Q	-	-	-	-	A	C	C	A	4.17.2

Function name \ Servo software series	9041	9046	9060	9064	9065	9066	9070	9080	9081	9090	90A0	Related section in this manual
Tandem control function (servo alarm two-axis monitor function)	-	-	-	-	-	-	-	K	-	C	A	4.17.4
Tandem control function (feedback sharing)	-	-	-	-	-	-	-	A	C	C	A	4.17.5
Tandem control function (full preload function)	-	-	P	-	-	-	-	A	C	C	A	4.17.7
Tandem control function (Position feedback switching)	-	-	P	-	-	-	-	A	C	C	A	4.17.8
Personal computer based automatic tuning	-	-	W	-	-	F	H	A	C	C	A	4.18
Actual current limit function	A	A	E	B	A	A	A	A	C	C	A	
Velocity loop proportional gain (PK2V) format modification	-	-	-	-	-	-	-	U	-	L	D	Supplement 2 of Subsec. 2.1.5
VCMD offset function	A	A	C	B	A	A	A	A	C	C	A	3.3.4
Enabling 1/2PI at all times with a cutting feed/rapid traverse switchable velocity gain	-	-	-	-	-	-	-	X	-	-	E	3.4.2
Upper cutting feed/rapid traverse switchable velocity loop gain limit of 400%	-	-	-	-	-	-	-	U	-	-	C	3.4.2
Cutting feed/rapid traverse velocity loop gain switching	-	-	-	-	-	-	-	P	-	F	A	3.4.2
[Functions related to CNC functions]												
Support for PMC-based velocity loop gain overwrite	-	-	-	-	-	-	F	A	C	C	A	
Support for the EGB function	-	-	C	-	-	A	A	A	C	C	A	
Support for the high-speed response function	-	-	-	-	-	-	-	-	-	-	E	
Support for nano-interpolation	-	-	-	-	-	-	-	-	-	-	I	
[Support for peripheral devices]												
Support for α amplifiers (TYPE-B interface)	-	-	S	-	-	A	G	A	C	C	A	
Support for serial A pulse coders	A	A	C	B	A	A	A	A	C	C	A	
Support for α pulse coders	A	A	J	E	A	A	A	A	C	C	A	
Support for separate serial detectors	-	-	-	-	-	-	-	A	C	C	A	
Support for I/O modules	-	-	-	-	-	-	-	-	-	I	D	

4.2 HRV CONTROL

(1) Overview

HRV control is one of the digital servo current control methods. Compared with the conventional control methods, HRV control can reduce a delay that occurs in current control at the time of high-speed rotation. As the result, HRV control can improve velocity control characteristics at the time of high-speed rotation.

(2) Series and editions of applicable servo software

HRV control can be used with the following servo software:

Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

With the servo software series listed above, HRV control is exercised automatically. (No function bit is assigned.)

NOTE

1 For switching from a conventional control method to HRV control, the user needs to switch to a servo software series that supports HRV control.
2 The motor-specific standard parameters differ between HRV control and the conventional control methods. (For details, see parameter lists in Sec. 6.2 and Sec. 6.3.) When switching from a conventional control method to HRV control, be sure to initialize the parameters. (See Sec. 2.1, "Initializing Servo Parameters.")

(3) Improved functions available with HRV control

The use of servo software supporting HRV control replaces the current control method with HRV control as described above, and can improve control performance. In addition, the functions below can be optimized by modifying the settings.

<1> OVC alarm

In the medium time range (20 to 60 s), the current OVC alarm characteristics are relatively overprotective with respect to the characteristics of the servo motor and servo amplifier to be actually protected.

To make full use of the capabilities of the servo motor and servo amplifier, HRV control provides a function for matching with the characteristics of the actually used servo motor and servo amplifier by loosening the level of the medium time range of the OVC alarm. (See Fig. 4.2.)

To use this function, the following parameter needs to be set:

		#7	#6	#5	#4	#3	#2	#1	#0
1959	–		OVCR						
2017	1017								

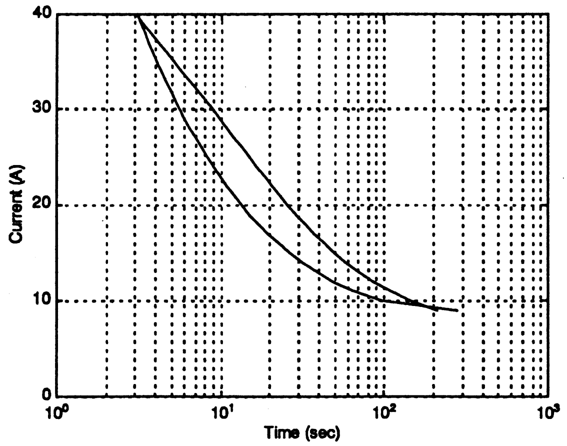
OVCR(#6) 1: To enable OVC alarm improvement

In addition, modify the following OVC parameters according to Table 4.2:

1877	–	POVC1
2062	1062	

1878	–	POVC2
2063	1063	

1893	–	POVCLMT
2065	1065	



Example of improving OVC protection characteristics
Lower line: Conventional characteristics
Upper line: Improved characteristics
(The alarm suppression level in the medium time range is improved.)

NOTE
In the long time range (60 s and up), the alarm level is lowered on the contrary.

<2> Abnormal load detection

If a motor (such as α12/2000) with a large back electromotive force is used, a difference between the torque command and the value of current actually flowing becomes large in the high speed area because of the effect of the back electromotive force, thus disabling a disturbance torque from being estimated correctly with the abnormal load detection function.

When HRV control is used, disturbance torque estimation taking the effect of control current saturation into consideration is enabled by setting the function bit below to ON. (For more information, see Sec. 4.12, "Abnormal-load Detection Function.")

[For Series 9080, 9090, and 90A0]

		#7	#6	#5	#4	#3	#2	#1	#0
1740	–			IQOB					
2200	–								

[For Series 9065 and 9066]

		#7	#6	#5	#4	#3	#2	#1	#0
–	–							IQOB	
2009	1009								

IQOB This function bit specifies whether to remove the effect of control current saturation in disturbance torque estimation.

1: Removes the effect of control current saturation in disturbance torque estimation.

0: Does not consider the effect of control current saturation in disturbance torque estimation.

Table 4.2 OVC parameters

ID No.	MOTOR	Conventional setting (standard)			Setting for improvement		
		POVC1	POVC2	POVCLMT	POVC1	POVC2	POVCLMT
1	α3HV	32686	1031	3059	32738	379	2247
2	α6HV	32637	1639	4866	32720	603	3575
3	α12HV	32568	2505	7445	32694	922	5470
4	α22HV(40A)	32370	4981	14847	32621	1837	10908
5	α30HV(40A)	32359	5110	15235	32617	1884	11193
7	αC3	32686	1030	3056	32738	379	2245
8	αC6	32637	1636	4858	32720	602	3569
9	αC12	32412	4446	13245	32637	1639	9731
10	αC22	32370	4981	14847	32621	1837	10908
13	β0.5	32585	2288	6797	32701	842	4994
15	α3/3000	32713	690	2045	32748	253	1502
16	α6/2000	32689	991	2940	32739	364	2160
17	α6/3000	32698	877	2601	32742	322	1911
18	α12/2000	32568	2505	7445	32694	922	5470
19	α12/3000	32614	1922	5709	32711	707	4194
20	α22/2000	32543	2811	8358	32685	1035	6141
21	α22/3000	32518	3128	9305	32676	1152	6836
22	α30/2000	32668	1245	3695	32731	458	2715
23	α30/3000	32493	3443	10245	32667	1268	7527
24	αM3	32697	886	2627	32742	326	1930
25	αM6	32727	516	1529	32753	190	1124
26	αM9	32692	955	2832	32740	351	2080
27	α22/1500	32370	4981	14847	32621	1837	10908
28	α30/1200	32665	1283	3809	32730	472	2798
29	α40/FAN	32361	5090	15175	32618	1877	11149
30	α40/2000	32579	2358	7007	32699	868	5148
33	β3	32456	3897	11600	32653	1436	8523
34	β6	32456	3897	11600	32653	1436	8523
35	β1	32617	1884	5594	32713	693	4110
36	β2	32540	2850	8474	32684	1049	6226
39	α65	32419	4365	13002	32641	1585	9408
40	α100	32499	3358	9990	32669	1237	7340
41	α150	32281	6086	18168	32588	2246	13348
46	α2/2000	32627	1766	5245	32716	650	3854
59	αL25	32489	3482	10360	32665	1283	7612
60	αL50	32237	6640	19834	32572	2452	14572
61	α1/3000	32623	1811	5377	32715	666	3951
62	α2/3000	32519	3112	9256	32664	1294	7680

Table 4.2 OVC parameters

ID No.	MOTOR	Conventional setting (standard)			Setting for improvement		
		POVC1	POVC2	POVCLMT	POVC1	POVC2	POVCLMT
68	αL3	32693	940	2787	32740	345	2048
69	αL6	32696	894	2653	32742	329	1949
70	αL9	32607	2010	5970	32709	740	4386
84	α2.5/3000	32569	2482	7376	32695	913	5419
90	1500A	32670	1222	3626	32732	449	2664
91	3000B	32670	1222	3626	32732	449	2664
92	6000A	32670	1222	3626	32732	449	2664
93	9000B	32685	1041	3087	32737	383	2268
94	15000C	32712	703	2086	32740	352	2086
98	αM2	32685	1041	3089	32726	521	3089
99	αM2.5	32645	1535	4556	32707	768	4556
100	αM22	32587	2260	6714	32677	1131	6714
101	αM30	32567	2514	7473	32677	1259	7473
102	α22HV	32590	2221	6599	32679	1112	6599
103	α30HV	32586	2279	6771	32677	1141	6771
104	αM6HV	32725	538	1596	32746	269	1596
105	αM9HV	32678	1119	3321	32723	560	3321
106	αM22HV	32596	2149	6385	32682	1076	6385
107	αM30HV	32447	4009	11935	32607	2009	11935
108	αM40/FAN(360A)	32613	1937	5752	32690	970	5752
110	αM40(130A)	32279	6107	18231	32523	3065	18231
111	α300/2000	32326	5521	16468	32546	2770	16468
112	α400/2000	32299	5861	17492	32533	2941	17492

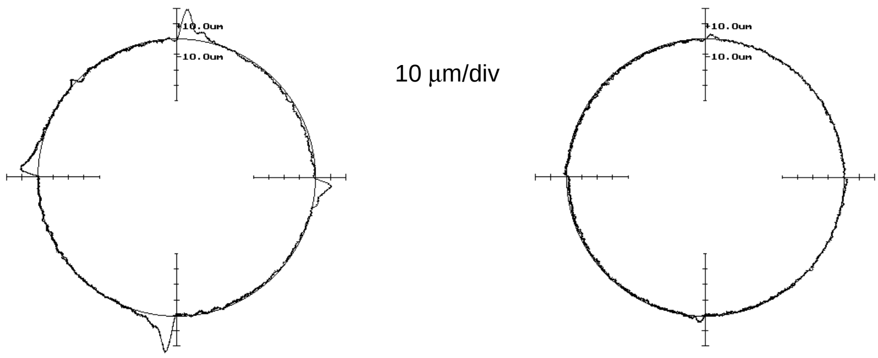
4.3 LEVEL-UP HRV CONTROL

(1) Overview

With standard systems of the *i* Series CNC (Series 15*i*, 16*i*, and 18*i*)(*), the current control period can be changed from the conventional value 250 μs to 125 μs by employment of a high-speed DSP for servo control. With a reduced current control period, the response of the current loop increases. As the result, a high velocity loop gain and high position loop gain can be set stably.
The position loop gain and velocity loop gain much affect the response and rigidity of the servo system. So, increased gains can reduce cutting figure errors, speed up positioning, and simplify servo adjustment.
Thus, level-up HRV control can improve overall servo performance.

* Level-up HRV control can be used with Series 21*i* as well by specifying Series 90A0 as the digital servo function. (This function is optional).

Example of using level-up HRV control (R100 mm, 10000 mm/min, without quadrant protrusion compensation)



Conventional control Level-up HRV control

(2) Series and editions of applicable servo software

Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, and 21*i*, Power Mate *i*)

(3) Setting parameters

<1> To set a current control period of 125 μs, set the parameters as follows:

			#7	#6	#5	#4	#3	#2	#1	#0
1809	–	Conventional setting	DLY1	DLY0	TIB1	DLY2	TRW1	TRW0	TIB0	TIA0
2004	–		0	0	0	0	0	1	1	0

⇩

	#7	#6	#5	#4	#3	#2	#1	#0
Setting for level-up HRV control	DLY1	DLY0	TIB1	DLY2	TRW1	TRW0	TIB0	TIA0
	0	0	0	0	0	0	1	1

<2> Change the current loop gain (integral term).

1852	–	Current loop integral gain
2040	–	

Set the standard parameter value multiplied by 0.8.

<3> Change the current loop gain (proportional term).

1853	–	Current loop proportional gain
2041	–	

Set the standard parameter value multiplied by 1.6.

NOTE

Set the same current control period for two axes(*) controlled by the same DSP.
For example, an axis for which No. 1023 = 1 is set, and an axis for which No. 1023 = 2 is set are controlled by the same DSP. So, the same current control period must be set for these axes.

* An axis for which an odd number is set with the servo axis number parameter (No. 1023), and an axis for which the subsequent even number is set with the same parameter are controlled as a set by the same DSP.

(4) Full utilization of level-up HRV control

Level-up HRV control allows the velocity gain to be increased by decreasing the current control period. In addition, by optimizing each element of the servo system, level-up HRV control can be fully utilized to reduce machining figure errors. (See Subsec. 3.4.1.)

4.4 VIBRATION SUPPRESSION FUNCTION IN THE STOP STATE

4.4.1 250 μsec Acceleration Feedback Function

(1) Overview

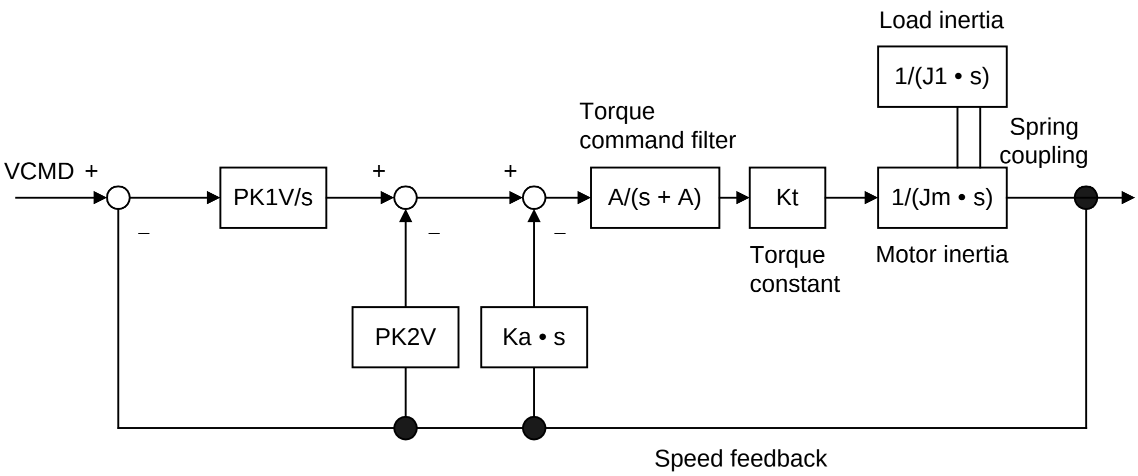
The acceleration feedback function is used to control velocity loop oscillation by using motor speed feedback signal multiplied by the acceleration feedback gain to compensate the torque command.

This function can stabilize unstable servo :

- When motor and machine have a spring coupling.
- When the external inertia is great compared to the motor inertia.

This is effective when vibration is about 50 to 150 Hz.

Fig 4.4.1 is a velocity loop block diagram that includes acceleration feedback function.



PK1V : velocity loop integral gain
PK2V : velocity loop proportional gain
Ka : acceleration feedback gain

Fig. 4.4.1 Velocity loop block diagram that includes acceleration feedback function

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/B(02) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

Specifying the following parameters as a negative value enables the 250 μs acceleration feedback function.

1894	8X66	**250 μsec acceleration feedback gain**
2066	1066	

Setting value = –10 to –20

(4) Caution and note

CAUTION
If the acceleration feedback gain is too large, abnormal sound or vibration can occur during acceleration/deceleration.
To solve this problem, reduce the gain.

NOTE
This function is disabled when the velocity loop high cycle management function (see Subsec. 4.4.2) is used.

4.4.2 Velocity Loop High Cycle Management Function

(1) Overview

This function improves the velocity loop gain oscillation threshold. This is done by performing velocity loop proportional calculation at high speed, which determines the velocity loop oscillation threshold.
The use of this function enables the following:

- Improvement of the command follow-up characteristic of a velocity loop
- Improvement of the servo rigidity

(2) Series and editions of applicable servo software

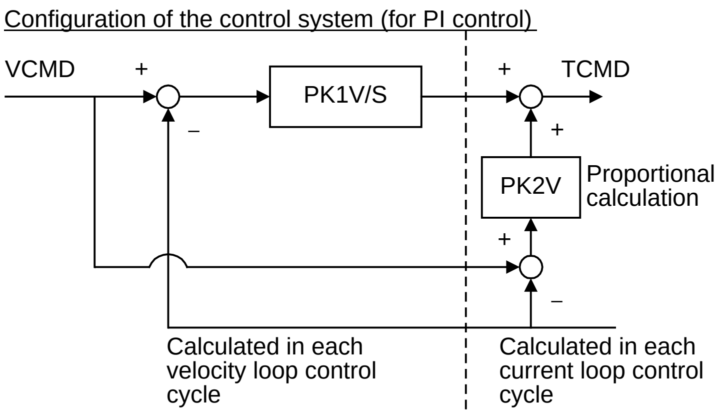
- Velocity loop control method supported by PI only
  Series 9066/B(01) and subsequent editions (Series 20, 21, Power Mate)
  Series 9070/G(07) and subsequent editions (Series 15-B, 16-B, 18-B)
- Velocity loop control method supported by both PI and I-P
  Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
  Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
  Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
  Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

● Series 15, 16, 18

		#7	#6	#5	#4	#3	#2	#1	#0
1959	–	PK25							
2017	–								

PK25 (#7) 1: The velocity loop high cycle management function is used.



(4) Performance comparison with the 250-µs acceleration feedback function

	250-µs acceleration feedback function	Velocity loop high cycle management function
Control method	Acceleration fed back every 250 µs	Only proportional calculated every 250 µs
Adjustment method	Set a value of –10 to –20.	Set the function bit.
Effect	This function may prove more effective than the Velocity loop high cycle management function, depending on the machine system resonance frequency and intensity.	In general, this function is more effective than the 250-µs acceleration feedback function in improving the velocity loop gain.

(5) Caution and notes on use

CAUTION

Depending on the resonance frequency and resonance strength of the machine system, the use of this function may result in machine resonance. If this occurs, do not use this function.

NOTE

1 When this function is used, the observer function is disabled. To remove high-frequency oscillations, use the torque command filter.
2 The normalization of the machine speed feedback function is disabled. If hunting cannot be eliminated by increasing the velocity loop gain, use the vibration-damping control function, which provides a capability similar to the machine speed feedback function.
3 In (torque command) tandem control, velocity loop high cycle management function can be used with Series 90A0/I(09) and subsequent editions. To use velocity loop high cycle management function with other series/editions, velocity command tandem control must be enabled before the high cycle management function is enabled.
4 When this function is used, some functions are restricted as follows:

Unavailable function	Restricted function
Velocity loop gain override	Machine speed feedback; normalization not performed
Function for changing the proportional gain in the stop state(*)	Observer used for unexpected disturbance detection
Non-linear control	
Notch filter	
250-µs acceleration feedback	
N-pulse suppression function	

* Function for changing the proportional gain in the stop state
With Series 9080/U(21) and subsequent editions and Series 90A0/D(04) and subsequent editions, this function can be used together. (See Subsec. 4.4.3.)

4.4.3 Function for Changing the Proportional Gain in the Stop State

(1) Overview

The velocity gain or load inertia ratio is generally increased if a large load inertia is applied to a motor, or to improve the response. An excessively large velocity gain may cause the motor to generate a high-frequency vibration when it stops. This vibration is caused by excessive proportional gain of the velocity loop (PK2V) when the motor is released within the backlash of the machine in the stop state.
This function decreases the velocity loop proportional gain (PK2V) in the stop state only. The function can suppress the vibration in the stop state and also enables the setting of a high velocity gain.

(2) Series and editions of applicable servo software

Series 9046/D(04) and subsequent editions (Series 0-C, 15-A)
Series 9060/Q(17) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/F(06) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(03) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

- **Series 15-B, 15*i*, 16, 18, 20**

		#7	#6	#5	#4	#3	#2	#1	#0
1958	–					K2VC			
2016	–								

K2VC (#3) 1: The function for changing the proportional gain in the stop state is used.

1730	–	Function for changing the proportional gain in the stop state: Stop judgement level
2119	–	

[Increment system] Detection unit

[Valid data range] 2 to 10 (Detection unit: 1 μm)

20 to 100 (Detection unit: 0.1 μm)

For Series 9080/U(21) and subsequent editions and Series 90A0/D(04) and subsequent editions, a function for decreasing the proportional gain in the stop state to 50% is added in addition to the specification for decreasing the proportional gain in the stop state to 75%. When decreasing the velocity loop proportional gain in the stop state to 50%, set the following bit parameter in addition to the function bit for the function for changing the proportional gain in the stop state and the parameter for stop determination level.

		#7	#6	#5	#4	#3	#2	#1	#0
1747	–					PK2D50			
2207	–								

PK2D50 (#3) When the function for changing the proportional gain in the stop state enabled (K2VC = 1):

0: The velocity loop proportional gain in the stop state is 75%.

1: The velocity loop proportional gain in the stop state is 50%.

> **NOTE**
> With servo software series/editions other than Series 9080/U(21) and subsequent editions and Series 90A0/D(04) and subsequent editions, the velocity loop gain in the stop state is fixed at 75% of the setting.

● Series 0-C, 15-A

		#7	#6	#5	#4	#3	#2	#1	#0
1953 (Series 15-A)	8X09				K2VC				
–	–								

K2VC (#4) 1: The function for changing the proportional gain in the stop state is used.

1982 (Series 15-A)	8X89	Function for changing the proportional gain in the stop state: Stop judgement level
–	–	

[Increment system] Detection unit

[Valid data range] 2 to 10

When the absolute value of an error is lower than the stop judgement level, the function changes the proportional gain of the velocity loop (PK2V) to 75% or 50% of the set value.
If the machine vibrates while in the stop state, enable this function and set a value greater than the absolute value of the error causing the vibration as the stop judgement level. The function cannot stop the vibration of a machine in the stop state when the current velocity loop proportional gain is too high. Should this occur, reduce the velocity loop proportional gain.

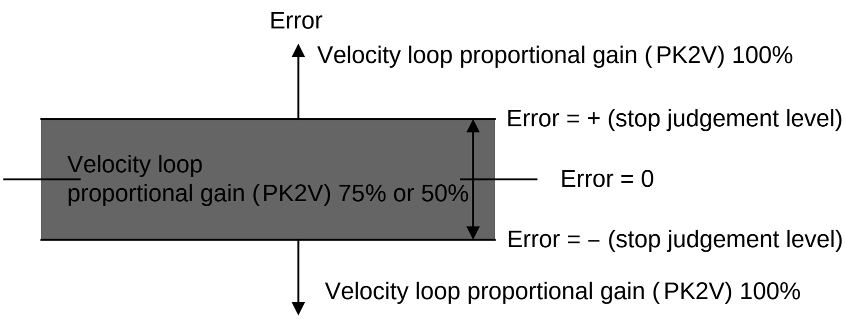


Fig. 4.4.3 Relationship between error and velocity loop proportional gain (PK2V)

> **NOTE**
> When the velocity loop high cycle management function (⇒ Subsec. 4.4.2) is used, this function is disabled for all servo software series/editions except some series/editions.
> (With Series 9080/U(21) and subsequent editions and Series 90A0/D(04) and subsequent editions, this function can be used together with the velocity loop high cycle management function.)

4.4.4 N Pulse Suppression Function

(1) Overview

Even a very small movement of the motor in the stop state may be amplified by a proportional element of the velocity loop, thus resulting in vibration. The N pulse suppression function suppresses this vibration in the stop state.

When vibration occurs as shown in Fig. 4.4.4 (a), the velocity feedback at point B generates an upward torque command to cause a return to point A. A downward torque command, generated by the velocity feedback at point A is greater than the friction of the machine, causing another return to point B. This cycle repeats itself, thus causing the vibration.

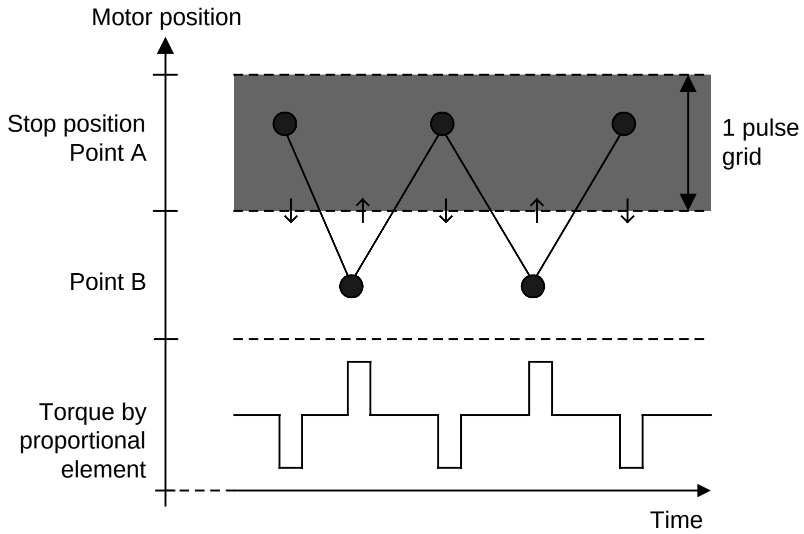


Fig. 4.4.4 (a) N pulse suppression function disabled (Torque due to the proportional term keeps up, leading to vibration.)

To suppress such vibration, it is necessary to exclude from the velocity loop proportional term the speed feedback pulses generated when the motor returns from point B to point A.

If the N pulse suppression function is enabled as shown in Fig. 4.4.4 (b), the feedback pulses generated when the motor returns from point B to point A are excluded from the velocity loop proportional term. The standard setting of the grid width at point A is 1 μm. It can be changed by specifying the level parameter.

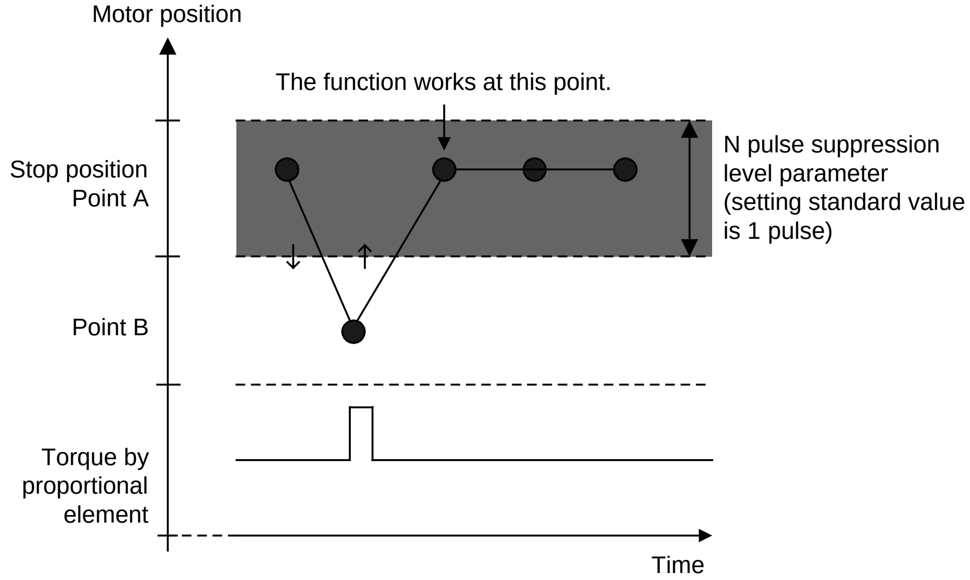


Fig. 4.4.4 (b) N pulse suppression function disabled
(The N pulse suppression function restricts the torques due to the proportional term, thus eliminating vibration.)

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/B(01) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1808	8X03				NPSP				
2003	1003								

NPSP (#4) 1: To enable the N pulse suppression function

1992	–	N-pulse suppression level parameter (ONEPSL)
2099	1099	

[Valid data range] 0 to 32767

[Standard setting] 400

For Series 0-C, the level parameter is fixed at 400.

4.5 MACHINE-RESONANCE SUPPRESSION FUNCTION

4.5.1 Machine Speed Feedback Function

(1) Overview

In many full-closed systems, the machine position is detected by a separate detector and positioning was controlled according to the detected positioning information. The speed is controlled by detecting the motor speed with the pulse coder on the motor. When distortion or shakiness between the motor and the machine is big, the machine speed differs from the motor speed during acceleration and deceleration. Hence, it is difficult to maintain high position loop gain. This machine speed feedback function allows adding the speed of the machine itself to the speed control in a fully closed system, making the position loop stable.

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/B(02) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Control block diagram

Fig. 4.5.1 is a control block diagram

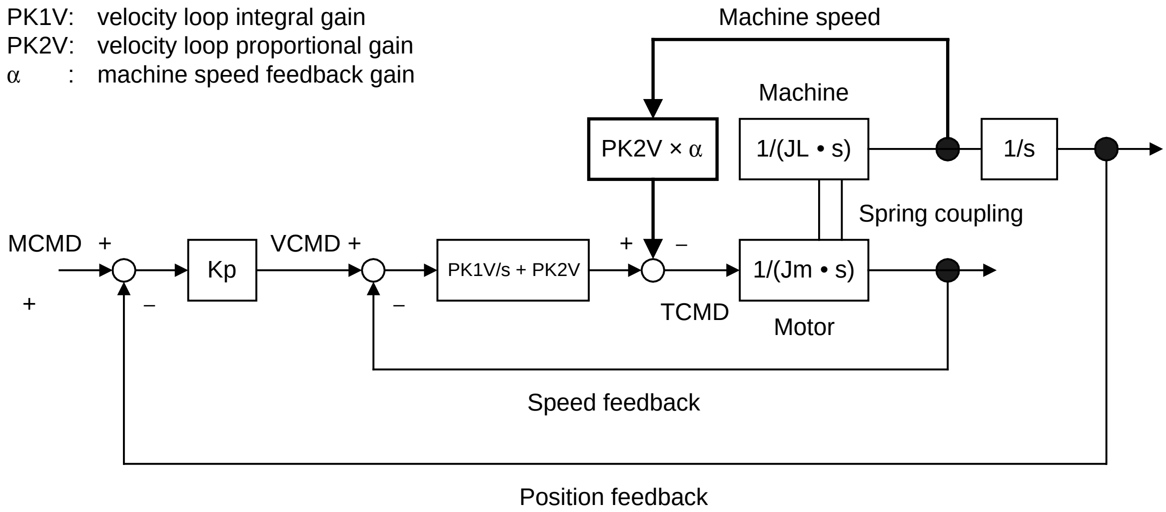


Fig. 4.5.1 Position loop block diagram that includes machine speed feedback function

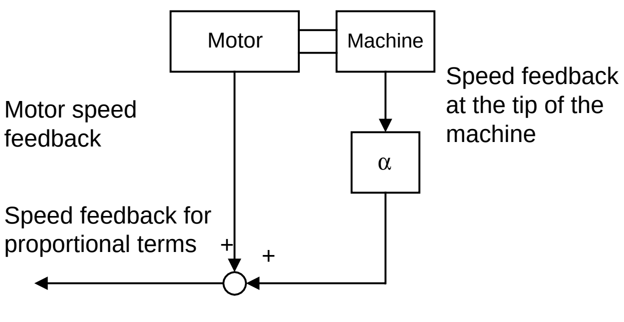
As shown in Fig. 4.5.1, this function corrects the torque command by multiplying the machine speed by machine velocity feedback gain, α, as shown by the bold line. When α = 1, the torque command is corrected equally by the motor speed and the machine speed.

(4) Adding the normalization function

(a) Overview

If an arc is drawn with the machine speed feedback function enabled, the arc may be elongated in the direction parallel to the axis to which the machine speed feedback function is applied. To solve this problem, the machine speed feedback function was improved.

(b) Explanation



The current machine speed feedback configuration is as shown left figure. Assuming that the motor speed feedback is much the same as the speed feedback at the tip of the machine, the speed feedback for the proportional term is (1 + α) times the motor speed feedback. This causes a conflict to the weight of the VCMD.

So, the proportional term speed feedback is divided by (1 + α) to eliminate the conflict.

(5) Series and editions of applicable servo software

The following series and editions support the normalization function.

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/N(14) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/D(04) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/F(06) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(6) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1956	8X12							MSFE	
2012	1012								

MSFE (#1) 1: To enable the machine speed feedback function

1981	8X88	Machine speed feedback gain (MCNFB)
2088	1088	

Methods to specify the parameter vary with the servo ROM series.

● Series 0-C and 15-A

(Servo ROM series 9041 or 9046)

$$\text{MCNFB} = \alpha \times 4096 \times \frac{8192}{\text{Number of position feedback pulses per motor revolution}}$$

Typical values for α range from 0.3 to 1.0.

(When the normalization function is used)
The normalization function cannot be used with Series 9046.
When using the normalization function with Series 9041, set the following parameter:

		#7	#6	#5	#4	#3	#2	#1	#0
Series 0-C	8X10		VFBFM						
Series 15-A	1954								

MVFBFM (#6) The machine speed feedback normalization function is:
0: Disabled.
<u>1: Enabled. ← Set this value.</u>

● Series 15, 16, 18, 20, 21, and Power Mate

(Servo soft series 9060, 9066, 9070, 9080, 9081, 9090, and 90A0)

☆ Flexible feed gear (No. 2084, 2085, 1977, 1978) = 1/1
(Setting range: 1 to 100 or –1 to –100)

(Standard setting)

When the normalization function is not used: MCNFB = 30 to 100

When the normalization function is used: MCNFB = –30 to –100

☆ Other than flexible feed gear (No. 2084, 2085, 1977, 1978) = 1/1
(Setting range: 101 to 10000 or –101 to –10000)

(Standard setting)

When the normalization function is not used: MCNFB = 3000 to 10000

When the normalization function is used: MCNFB = –3000 to –10000

● Power Mate-E

(Servo ROM series 9064 and 9065)

☆ Regardless of what the flexible feed gear (No. 1084, 1085) is:

MCNFB = 30 to 100

The normalization function is not supported, because there is no possibility of simultaneous operation of two axes.

(7) Note

It the machine has a resonance frequency of 200 to 400 Hz, using this function may result in a resonance being amplified, thus leading to abnormal vibration or sound. If this happens, take either of the following actions to prevent resonance.

- Using an observer (⇒ Subsec. 4.5.2)
(If the machine speed feedback function is used together with the observer function, the motor speed and machine speed are filtered out simultaneously.)
- Using a torque command filter (⇒ Subsec. 4.5.3)

4.5.2 Observer Function

(1) Overview

The observer is used to eliminate the high-frequency component and to stabilize a velocity loop when a mechanical system resonates at high frequency of several hundred Hertz.
The observer is a status observer that estimates the controlled status variables using the software.
In a digital servo system, the speed and disturbance torque in the control system are defined as status variables. They are also estimated in the observer. An estimated speed consisting of two estimated values is used as feedback. The observer interrupts the high-frequency component of the actual speed when it estimates the speed. High-frequency vibration can thus be eliminated.

(2) Explanation

Fig. 4.5.2 (a) shows a block diagram of the velocity loop including an observer.

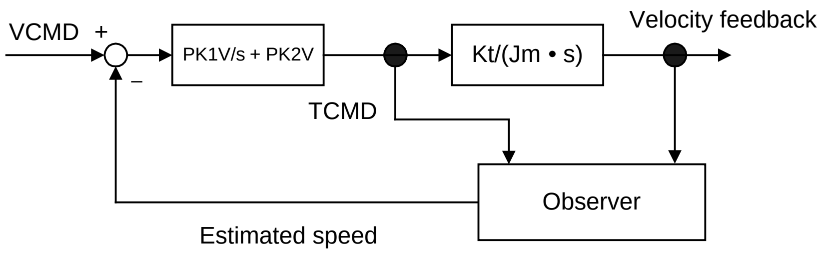


Fig. 4.5.2 (a) Configuration of velocity loop including observer

Fig. 4.5.2 (b) shows a block diagram of the observer.

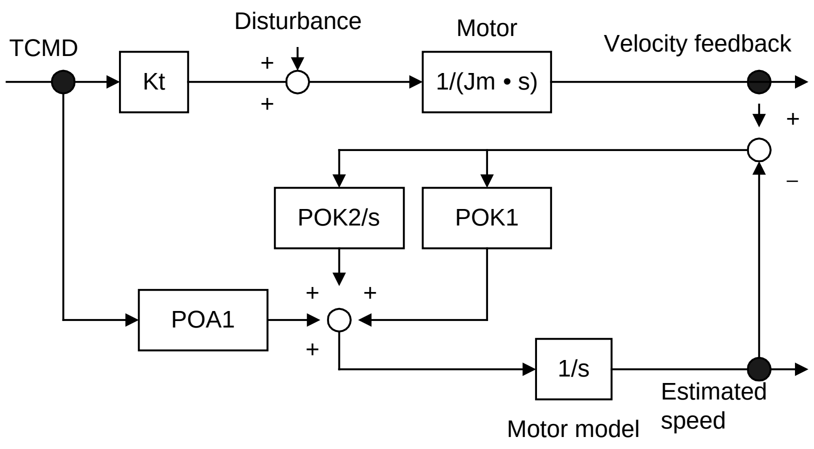


Fig. 4.5.2 (b) Block diagram of the observer

POA1, POK1, and POK2 in Fig. 4.5.2 (b) correspond to digital servo parameters. The observer has an integrator as a motor model. POA1 is a coefficient that converts the torque command into motor acceleration and is the characteristic value of the motor. The motor model is accelerated by this value. The actual motor is also accelerated by the torque and disturbance torque that it generates.

The disturbance torque works on the actual motor. There is a time lag in the current loop. The POA1 value does not completely coincide with the actual motor. This is why the motor's actual velocity differs from the motor speed estimated by an observer. The observer is compensated by this difference. The motor model is compensated proportionally (POK1), and the observer is compensated integrally (POK2/s).

POK1 and POK2 act as a secondary low–pass filter between the actual speed and estimated speed. The cutoff frequency and damping are determined by the POK1 and POK2 values. The difference between the observer and low-pass filter lies in the existence of a POA1 term. Using POA1, the observer's motor model can output an estimated speed that has a smaller phase delay than the low–pass filter.

When an observer function is validated, the estimated speed in Fig. 4.5.2 (b) is used as velocity feedback to the velocity control loop. A high–frequency component (100 Hz or more) contained in the actual motor speed due to the disturbance torque's influence may be further amplified by the velocity loop, and make the entire system vibrate at high frequency. The high frequency contained in the motor's actual speed is eliminated by using the velocity feedback that the observer outputs. High–frequency vibration can be suppressed by feeding back a low frequency with the phase delay suppressed.

In some systems, the use of the observer function can suppress vibration during movement but makes the machine unstable while it is in the stop state. In such cases, use the function for disabling the observer in the stop state, as explained in Art. (6) of this section.

(3) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1808	8X03						OBEN		
2003	1003								

OBEN (#2) 1: To enable the observer function

1859	8X47	Observer coefficient (POA1)
2047	1047	

Usually, use the standard setting.

1862	8X50	Observer coefficient (POK1)
2050	1050	

Usually, use the standard setting.

1863	8X51	Observer coefficient (POK2)
2051	1051	

Usually, use the standard setting.

(4) Note

The parameter is initially set to such a value (standard setting) that the cutoff frequency of the filter becomes 30 Hz. With this setting, the effect of filtering becomes remarkable at resonance frequencies above the range of 150 Hz to 180 Hz.
To change the cutoff frequency, set parameters POK1 and POK2 to a value listed below, while paying attention to Table 4.5.2:
Generally, the observer function does not work unless its cutoff frequency is held below Fd/5 or Fd/6, where Fd is the frequency component of an external disturbance. However, if this bandwidth is some 20 Hz or lower, the velocity loop gain also drops or becomes unstable, possibly causing a fluctuation or wavelike variation.

Table 4.5.2 Changing the observer cutoff frequency

Cutoff frequency (Hz)	POK1	POK2
10	348	62
20	666	237
30	956	510
40	1220	867
50	1460	1297
60	1677	1788
70	1874	2332

(5) Setting observer parameters when the unexpected disturbance detection function is used

The unexpected disturbance detection function (see Sec. 4.12) uses the observer circuit shown in Fig. 4.5.2 (b) to calculate an estimated disturbance. In this case, to improve the speed of calculation, change the settings of observer parameters POA1, POK1, and POK2 by following the explanation given in Sec. 4.12.
When the observer function and unexpected disturbance detection function are used together, however, the defaults for POK1 and POK2 must be used as is.

(6) Series and editions of applicable servo software

Function for disabling the observer in the stop state

Series 9060/W(23) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/B(02) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/H(08) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(7) Setting parameters

<1> Function bit

		#7	#6	#5	#4	#3	#2	#1	#0
1960	–								MOVO
2018	–								

MOVO (#1) The function for disabling the observer in the stop state is:
0: Disabled
<u>1: Enabled ← Set this value.</u>

<2> Level at which the observer is determined as being disabled

1730	–	Level at which the observer is determined as being disabled
2119	–	

[Increment system] Detection unit
[Typical setting] 1 to 10

If the absolute value of the positional deviation is less than the level at which the observer is determined as being disabled, the observer function is disabled.

NOTE
This parameter is also used for the stop determination level of the function for changing the proportional gain in the stop state.

(Usage)
If, when the observer function is enabled, the machine is unstable in the machine stop state, set the function bit and the level at which the observer is determined as being disabled so that it is greater than the peak absolute value of the oscillating positional deviation.

4.5.3 Torque Command Filter

(1) Overview

The torque command filter applies a primary low-pass filter to the torque command.
If the machine resonates at a high frequency of one hundred Hz and over, this function eliminates resonance at such high frequencies.

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/B(02) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Explanation

Fig. 4.5.3 shows the configuration of a velocity loop including the torque command filter.

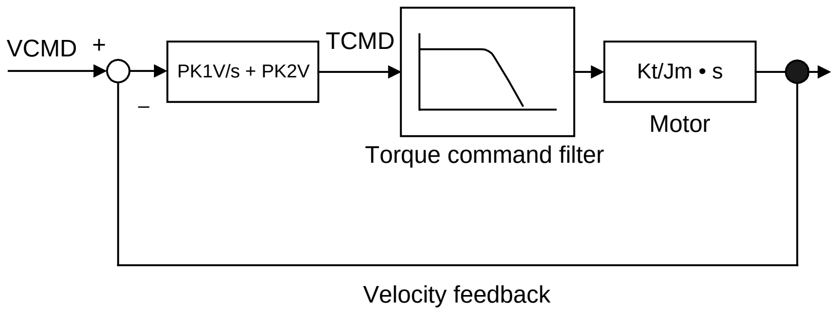


Fig. 4.5.3 Configuration of velocity loop including torque command filter

As shown in Fig. 4.5.3, the torque command filter applies a low–pass filter to the torque command. When a mechanical system contains a high resonant frequency of more than 100Hz, the resonant frequency component is also contained in the velocity feedback shown in Fig. 4.5.3 and may be amplified by proportional term. However, the resonance is prevented by interrupting the high–frequency component of the torque command using the filter.

(4) Proper use of the observer and torque command filter

The torque command filter is set in the forward direction. Therefore, there are fewer bad influences exerted upon the entire velocity control system than the observer that filters a feedback signal. If the resonance is very strong and it cannot be eliminated, use the observer.
Use the torque command filter first when the mechanical system resonates at high frequency. If the resonance cannot be eliminated, use the observer.

(5) Setting parameters

1895	8x67	Torque command filter (FILTER)
2067	1067	

[Setting value] 1166 (200 Hz) to 2327 (90 Hz)
When changing the torque command filter setting, see Table 4.5.3.
As the cut-off frequency, select the parameter value corresponding to a half of the vibration frequency from the table below.

(Example)
In the case of 200-Hz vibration, select a cutoff frequency of 100 Hz for the torque command filter, and set FILTER = 2185.

CAUTION
Do not specify 2400 or a greater value. Such a high value may increase the vibration.

Table 4.5.3 Parameter setting value of torque command filter

Cutoff frequency (Hz)	Parameter	Cutoff frequency (Hz)	Parameter
60	2810	140	1700
65	2723	150	1596
70	2638	160	1499
75	2557	170	1408
80	2478	180	1322
85	2401	190	1241
90	2327	200	1166
95	2255	220	1028
100	2185	240	907
110	2052	260	800
120	1927	280	705
130	1810	300	622

(6) Cutting feed/rapid traverse switchable torque command filter

With this function, the torque command filter coefficient can be switched between rapid traverse and cutting feed to improve figure precision during cutting and increase a maximum feedrate and maximum acceleration during rapid traverse at the same time.

(a) Series and editions of applicable servo software
Series 9080/U(21) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 90A0/D(04) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, 15*i*, Power Mate *i*)

(b) Setting parameters

1779	**TCMD filter coefficient for rapid traverse**
2156	

[Valid data range] 1166 (200 Hz) to 2327 (90 Hz)

When 0 is set, the cutting feed/rapid traverse switchable torque command filter is disabled. The normal filter coefficient (No. 1895 for Series 15 or No. 2067 for Series 16) is used at all times.
When a value other than 0 is set, No. 1779 (Series 15) or No. 2156 (Series 16) is used for stop time, rapid traverse, and jog feed, and No. 1895 (Series 15) or No. 2067 (Series 16) is used for cutting only.

4.5.4 Dual Position Feedback Function

Optional function

(1) Overview

A machine with large backlash may cause vibrations in a closed loop system even if it works steadily in a semi–closed loop system. The dual position feedback function controls the machine so that it operates as steadily as in the semi–close system.
This function is optional function.

(2) Control method

The following block diagram shows the general method of dual position feedback control:

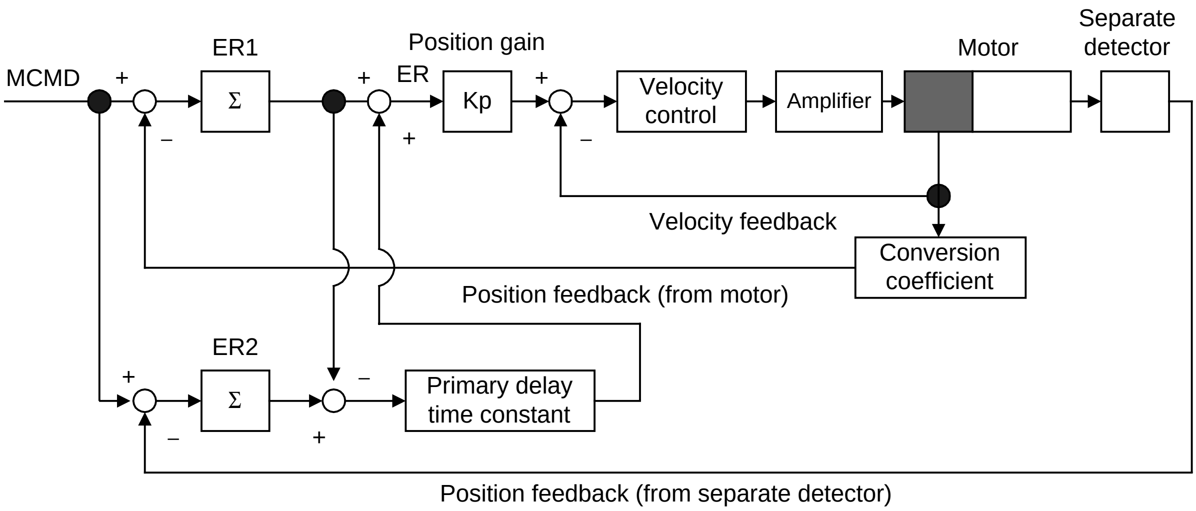


Fig. 4.5.4 Block diagram of dual position feedback control

As shown in Fig. 4.5.4, error counter ER1 in the semi-closed loop system and error counter ER2 in the closed loop system are used. The primary delay time constant is calculated as follows:

Primary delay time constant = $(1 + \tau s)^{-1}$

The actual error, ER, depends on the time constant, as described below:

(1) When time constant τ is 0 ······ $(1 + \tau s)^{-1} = 1$
ER = ER1 + (ER2 – ER1) = ER2 (error counter of the full-closed loop system)

(2) When time constant τ is ∞ ······ $(1 + \tau s)^{-1} = 0$
ER = ER1 (error counter of the semi-closed loop system)

This shows that control can be changed according to the primary delay time constant. The semi-closed loop system applies control at the transitional stage and the full-closed loop system applies control in positioning.

This method allows vibrations during traveling to be controlled as in the semi-closed loop system.

(3) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9064/B(02) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

NOTE

Series 9046 does not support the dual position feedback function.
To use this function with the Series 0-C or 15-A, therefore, specify the Series 9041.

(4) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1955 (Series 15-A) 1709 (Series 15*i*, 15-B)	8X11	DPFB							
2019	1019								

DPFB (#7) 1: To enable dual position feedback

1861	8X49	Dual position feedback maximum amplitude
2049	1049	

[Setting value] Maximum amplitude (μm)/(minimum detection unit for full-closed mode × 64)
This parameter should normally be set to 0.

[Increment system] Minimum detection unit for full-closed mode (μm/p) × 64
If setting = 0, compensation is not clamped. If the parameter is specified, and a position error larger than the specified value occurs during semi-closed and full-closed modes, compensation is clamped. So set the parameter with a value two times the sum of the backlash and pitch error compensation amounts.
If it is impossible to find the sum, set the parameter to 0.

1971	8X78	Dual position feedback conversion coefficient (numerator)
2078	1078	

1972	8X79	Dual position feedback conversion coefficient (denominator)
2079	1079	

[Setting value] Reduce the following fraction and use the resulting irreducible fraction.

$$\text{Conversion coefficient} \left(\frac{\text{Numerator}}{\text{Denominator}}\right) = \frac{\text{Number of position feedback pulses per motor revolution (Value obtained after connecting the feed gear)}}{\text{1 million}}$$

With this setting method, however, cancellation in the servo software internal coefficient may occur depending on constants such as the machine deceleration ratio, causing the motor to vibrate. In such a case, the setting must be changed.
For details, see Art. (7) in this section.

(Example)
When the α pulse coder is used with a tool travel of 10 mm/motor revolution (1 μm/pulse)

$$\text{Conversion coefficient} \left(\frac{\text{Numerator}}{\text{Denominator}}\right) = \frac{10 \times 1000}{1{,}000{,}000} = \frac{1}{100}$$

1973	8X80	Dual position feedback primary delay time constant
2080	1080	

[Setting value] Set to a value in a range of 10 to 300 ms or so.
[Increment system] msec

Normally, set a value of around 100 msec as the initial value. If hunting occurs during acceleration/deceleration, increase the value in 50-msec steps. If a stable status is observed, decrease the value in 20-msec steps. When 0 msec is set, the same axis movement as that in full-closed mode is performed. When 32767 msec is set, the same axis movement as that in semi-closed mode is performed.
For a system that requires simultaneous control of two axes, use the same value for both axes.

1974	8X81	Dual position feedback zero-point amplitude
2081	1081	

[Setting value] Zero width (μm)/minimum detection unit for full-closed mode

[Increment system] Minimum detection unit (μm/p) for full-closed mode

Positioning is performed so that the difference in the position between full-closed mode and semi-closed mode does not exceed the pulse width that corresponds to the parameter-set value.

First set the parameter to 0. If still there is fluctuation, increase the parameter value.

If this is applied to an axis with a large backlash, a large positional deviation may remain. For details, see Art. (5) in this section.

1729	Not supported	Dual position feedback: Level on which the difference in error between the semi-closed and full-closed modes becomes too large
2118	Not supported	

[Setting value] Level on which the difference in error is too large (μm)/minimum detection unit for full-closed mode

[Increment system] Minimum detection unit (μm/p) for full-closed mode

If the difference between the pulse coder and the separate detector is greater than or equal to the number of pulses that corresponds to the value specified by the parameter, an alarm is issued.

Set a value two to three times as large as the backlash.

When 0 is set, detection is disabled.

		#7	#6	#5	#4	#3	#2	#1	#0
1954	8X10			HBBL	HBPE				
2010	1010								

HBBL (#5) The backlash compensation is added to the error count of:

1: The closed loop.

0: The semi-closed loop. (Standard setting)

HBPE (#4) The pitch error compensation is added to the error count of:

1: The semi-closed loop.

0: The closed loop. (Standard setting)

		#7	#6	#5	#4	#3	#2	#1	#0
1746	Not supported				HBSF				
2206	Not supported								

HBFS (#4) A backlash compensation and pitch error compensation are:

1: Added to the closed loop side and semi-closed loop side at the same time.

0: Added after selection according to the conventional parameter (No. 2010 (Series 16, 18) or No. 1954 (Series 15)).
When this parameter is set to 1, the settings of No. 2010 (Series 16, 18) and No. 1954 (Series 15) are ignored.

(5) Zero-width setting for a machine with a large backlash or twist

When servo software earlier than the series and editions indicated below is used, and the dual position feedback function (or hybrid function) is used for an axis where a machine backlash of about 1/10 revolution in terms of the motor shaft exists, the machine may stop with a positional deviation remaining, which is greater than the dual position feedback zero-width parameter value. (In some cases, there may be ten or more pulses left.) To solve this problem, make the following settings:

(i) Use the digital servo software of the edition indicated below or later. (ii) Set the dual position feedback zero-width parameter to 0.

- An improvement in the zero-width function has been made to Series 9080/001K and subsequent editions. With these software series and editions, this problem can be solved without setting the zero-width parameter to 0. For details, see Art. (6) below.

(a) Series and editions of applicable servo software

Series 9060/Y(25) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/F(06) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/I(09) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/L(12) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/F(06) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(6) Improvement in zero-width setting

(a) Series and editions of applicable servo software
Series 9080/K(11) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(b) Setting parameters
To use the improvement, set the following parameter:

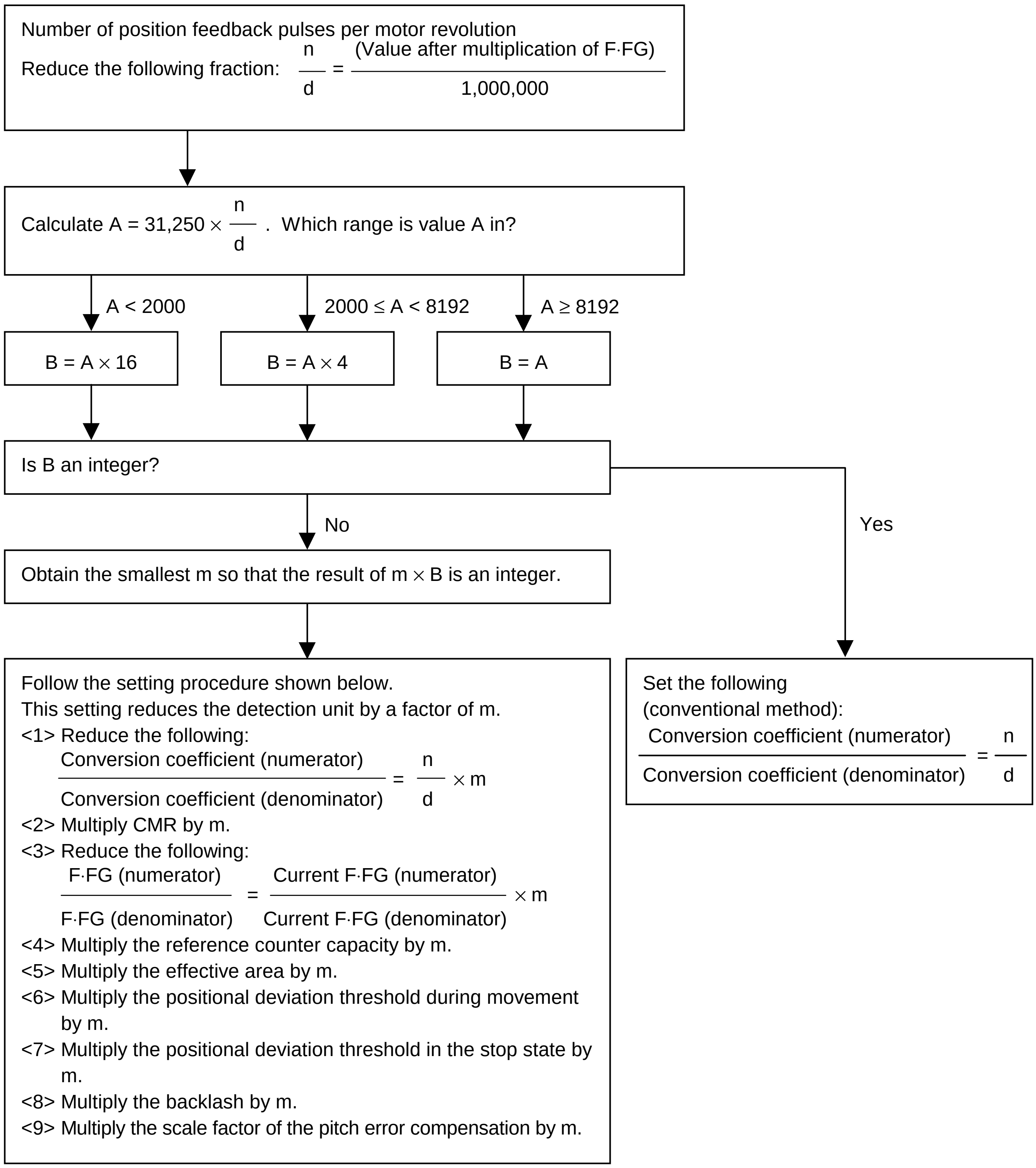
		#7	#6	#5	#4	#3	#2	#1	#0
1742	–				DUAL0W				
2202	–								

DUAL0W (#4) The zero-width determination is performed with:
0: Setting = 0 only.
1: Setting. ← Set this value.

(7) Cautions on setting of the dual position feedback conversion coefficient

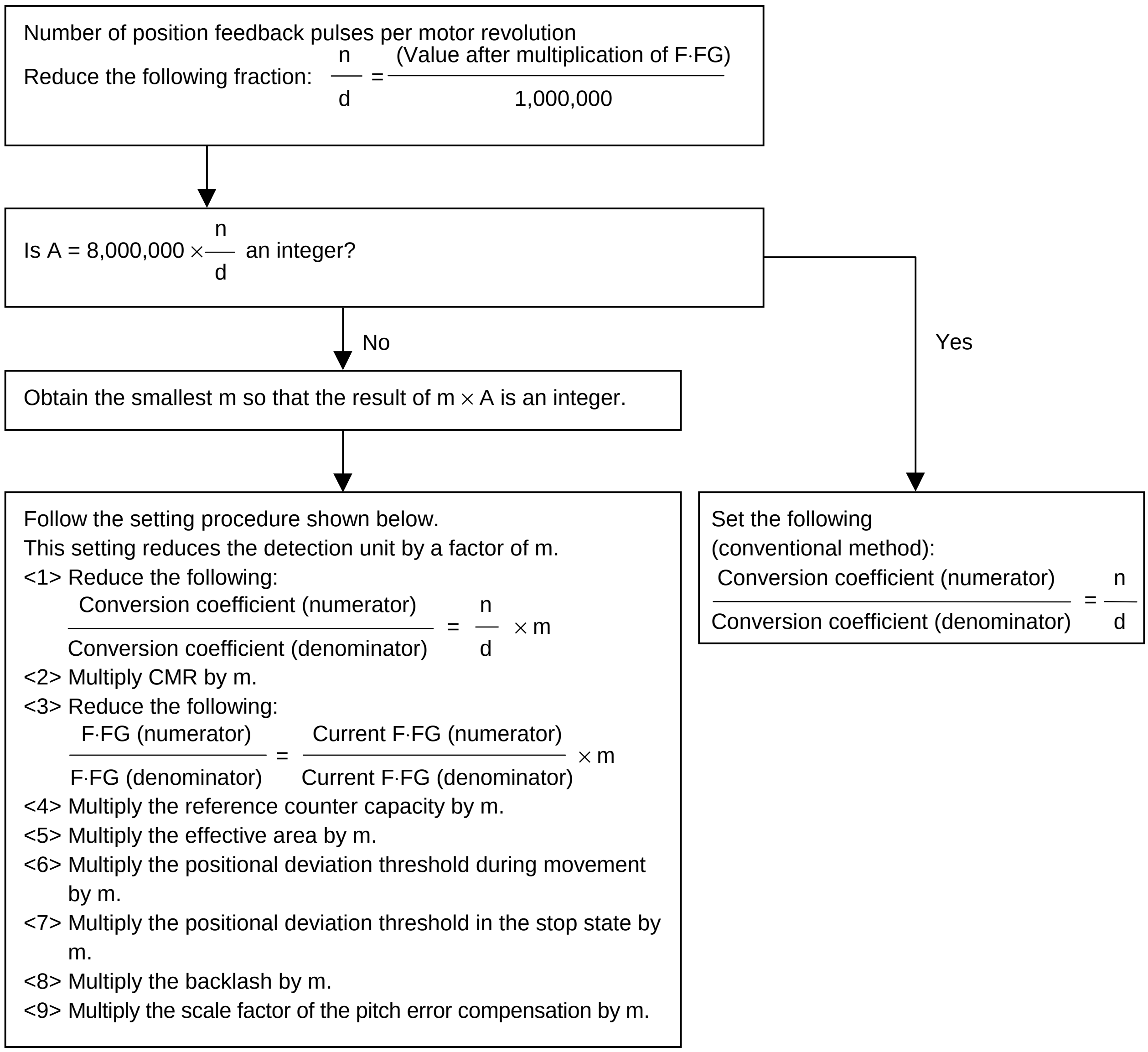
CAUTION
The dual position feedback conversion coefficient is set as explained in Art. (4). With the conventional calculation method, however, cancellation may occur in the conversion coefficient of the servo software depending on constants such as the machine deceleration ratio. If cancellation in the conversion coefficient occurs, feedback errors in the semi-closed loop system are accumulated. In some cases, this may result in motor oscillation.
To prevent this problem, calculate and set the dual position feedback conversion coefficient by following the procedure given below.

(a) Series 9041



For parameters set in detection units, see the list in Appendix C.

(b) Series 9060, 9064, 9065, 9070, 9080, 9081, 9090, and 90A0



For parameters set in detection units, see the list in Appendix C.

4.5.5 Vibration-damping Control Function

(1) Overview

In a closed-loop system, the pulse coder on the motor is used for velocity control and a separate detector is used for position control.

During acceleration/deceleration, the connection between the motor and machine may be distorted, causing the speed transferred to the machine to slightly differ from the actual motor speed. In such a case, it is difficult to properly control the machine (reduce vibration on the machine).

The vibration-damping control function feeds back the difference between the speeds on the motor and machine (speed transfer error) to the torque command, to reduce vibration on the machine.

(2) Control method

The following figure shows the block diagram for vibration-damping control:

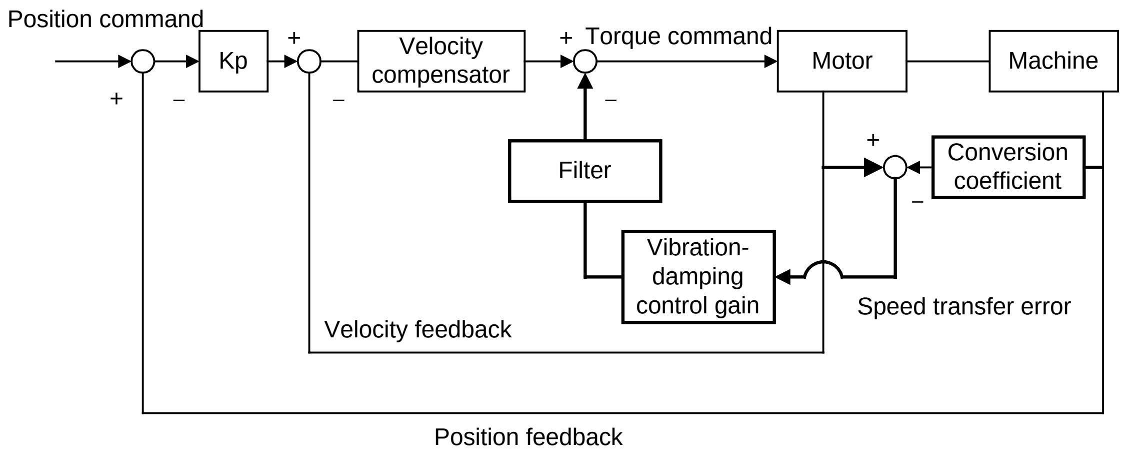


Fig. 4.5.5 Block diagram for vibration-damping control

(3) Series and editions of applicable servo software

Series 9070/D(04) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(4) Setting parameters

1718	**–**	**Number of position feedback pulses for vibration-damping control conversion coefficient**
2033	**–**	

[Valid data range] 0 to 32767
When 0 is set, this function is disabled.

When DMR is used and a flexible feed gear (F·FG) is not used
Set value = Number of feedback pulses per motor revolution, received from separate detector × (DMR/4)/8

(Example 1)

With a 5 mm/rev ball screw, 0.5 μm/pulse separate detector (value obtained from a quadrupling circuit), and a detection unit of 1 μm, the DMR setting is 2. Then,
Set value = 10,000 × (2/4)/8 = 625

When a flexible feed gear (F·FG) is used (In the case of using the A/B phase separate type detector)
Set value = Number of feedback pulses per motor revolution, received from a separate detector/8 (The DMR setting does not affect the set value.)

(Example 2)

If a flexible feed gear is used under the conditions described in example 1 above, F·FG = 1/2
Then,
Set value = 10,000/8 = 1250

When a flexible feed gear (F·FG) is used (In the case of using the serial separate type detector)
Set value = Number of feedback pulses per motor revolution, received from a separate detector (after feedback pulse)/8 (The DMR setting does not affect the set value.)

(Example 3)

If a flexible feed gear is used under the conditions described in example 1 above,
Set value = 10,000/8 = 1250

NOTE
If the above expression is indivisible, set the nearest integer.

1719	–	**Vibration-damping control gain**
2034	–	

[Valid data range] –32767 to 32767

[Standard setting] About 500

This is the feedback gain for vibration-damping control.
Adjust the value in increments of about 100, observing the actual vibration. An excessively large gain will amplify the vibration.
If setting a positive value amplifies the vibration, try setting a negative value.

4.5.6 Vibration Suppression Filter Function

(1) Overview

A filter function for removing high-speed vibration is added. With this function, high-speed resonance can be removed to set a higher velocity loop gain.

(2) Series and editions of applicable servo software

Series 90A0/E(05) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, 15*i*, Power Mate *i*)

(3) Control block diagram

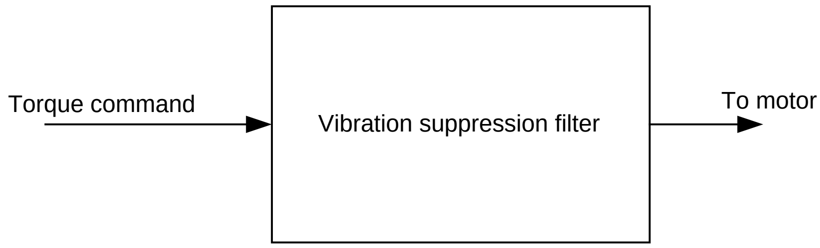


Fig. 4.5.6

(4) Setting parameters

The vibration suppression filter has a function for cutting signals of a particular frequency band. Two parameters are used. One is used to set the center frequency of a cut band, and the other is used to set a cut bandwidth.

1706	–	Attenuation center frequency
2113	–	

[Valid data range] 250 to 992

[Increment system] Hz

2620	–	Attenuation bandwidth
2177	–	

[Valid data range] 20, 30, 40

If a value other than these three values is specified, the value closest to the specified value is selected.

[Increment system] Hz

CAUTION

If a value other than 0 is specified, the vibration suppression filter is enabled.
When setting these parameters, specify No. 2113 (Series 16*i*) or No. 1706 (Series 15*i*), then specify No. 2177 (Series 16*i*) or No. 2620 (Series 15*i*).

4.5.7 Current Loop 1/2PI Function

(1) Overview

To improve servo performance in high-speed high-precision machining, high-speed positioning, ultrahigh-precision positioning, and so forth, a velocity loop gain as high as possible needs to be set stably.
To set a high velocity loop gain stably, the response of the current loop needs to be improved.
The current loop 1/2PI function enables the response of the current loop to be improved.

(2) Series and editions of applicable servo software

Series 9080/K(11) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Control method

As shown in Fig. 4.5.7, in the area where a small current flows, a current loop calculation is based on PI control rather than on the conventional IP control method. When a large current flows, the control method returns to IP control to suppress a current overshoot.

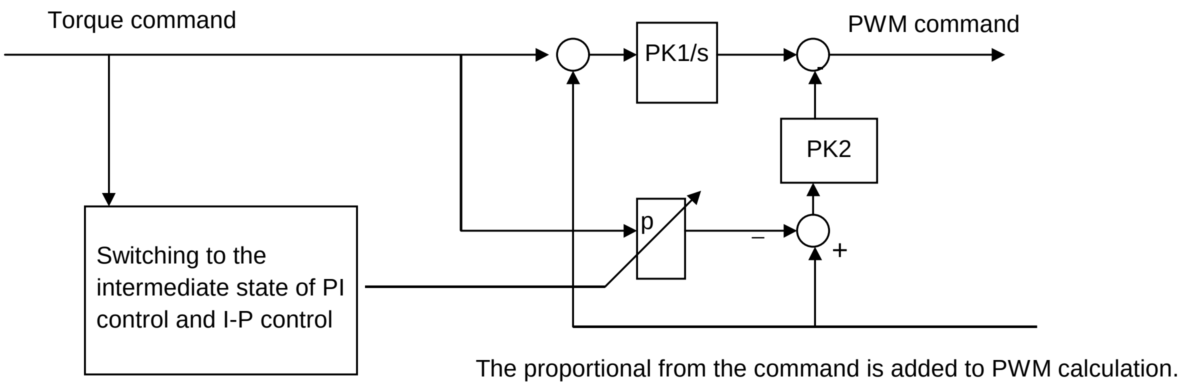


Fig. 4.5.7 Block diagram of current loop 1/2PI control

(4) Setting parameters

<1> Enabling the current loop 1/2PI function at all times

		#7	#6	#5	#4	#3	#2	#1	#0
1743	–						1/2PI		
2203	–								

1/2PI (#2) 1: To enable the current loop 1/2PI function

<2> Enabling the current loop 1/2PI function for cutting only

(a) Series and editions of applicable servo software

Series 9080/P(16) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(b) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1742	–							VGCCR	
2202	–								

VGCCR (#1) 1: To enable the current loop 1/2PI function for cutting only (This function is used together with the cutting feed/rapid traverse velocity loop gain switch function.)

		#7	#6	#5	#4	#3	#2	#1	#0
1743	–						1/2PI		
2203	–								

1/2PI (#2) 1: To enable the current loop 1/2PI function

<3> Enabling the current loop 1/2PI function at all times in the state where bit 1 of parameter No. 1742 (Series 15) or parameter No. 2202 (Series 16) is used

(a) Series and editions of applicable servo software

Series 9080/X(24) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 90A0/E(05) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(b) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1743	–							VGCCR	
2203	–								

VGCCR (#1) 1: To enable the current loop 1/2PI function for cutting only (This function is used together with the cutting feed/rapid traverse velocity loop gain switch function.)

		#7	#6	#5	#4	#3	#2	#1	#0
1742	–						PIALY		
2202	–								

PIALY (#2) 1: To enable the current loop 1/2PI function at all times
(When this function is used together with the cutting feed/rapid traverse velocity loop gain switch function)

		#7	#6	#5	#4	#3	#2	#1	#0
1743	–						1/2PI		
2203	–								

1/2PI (#2) 1: To enable the current loop 1/2PI function

CAUTION
If the motor activation sound or vibration in the stop state increases when this parameter is set, turn off this parameter (do not use this parameter).

4.6 SHAPE-ERROR SUPPRESSION FUNCTION

4.6.1 Feed-forward Function

(1) Principle

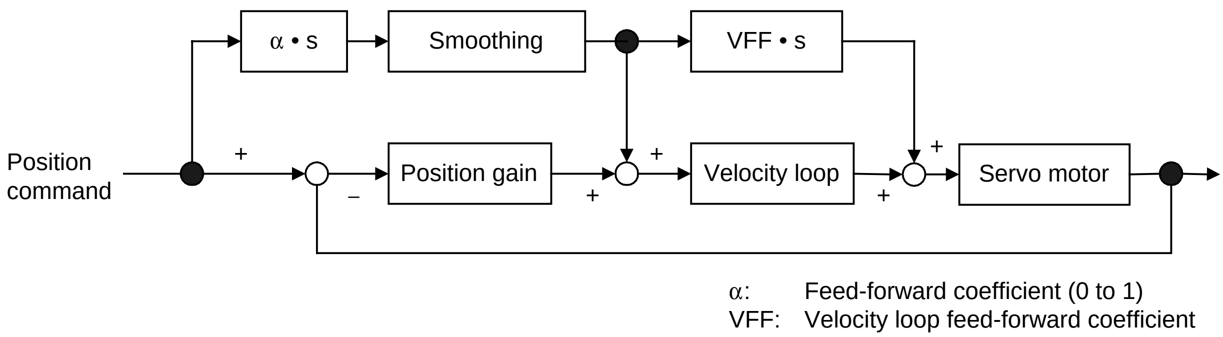


Fig. 4.6.1 (a) Feed-forward control block diagram

Adding feed-forward term α to the above servo system causes the position error to be multiplied by (1 − α).

$$\text{Position error} = \frac{\text{Feedrate (mm/s)}}{\text{Minimum detection unit (mm)} \times \text{position gain}} \times (1 - \alpha)$$

Adding feed-forward term α also causes figure error ΔR1 (mm) due to a radial delay of the servo system during circular cutting to be multiplied by $(1 - \alpha^2)$.

$$\Delta R1 \text{ (mm)} = \frac{\text{Feedrate}^2 \text{ (mm/s)}^2}{2 \times \text{position gain}^2 \times \text{radius (mm)}} \times (1 - \alpha^2)$$

(Example)
If α = 0.7, ΔR1 is reduced to about 1/2.
Beside ΔR1, figure error ΔR2 (mm) may occur in a position command when an acceleration/deceleration time constant is applied after interpolation for two axes.
Therefore, total radial figure error ΔR during circular cutting is:

$$\Delta R = \Delta R1 + \Delta R2$$

This section describes the conventional feed-forward function. However, when using feed-forward for high-speed high-precision machining, be sure to use advanced preview feed-forward described in Subsec. 4.6.2 or RISC feed-forward described in Subsec. 4.6.3.

The shape error in the direction of the radius during circular cutting is as shown in Fig. 4.6.1 (b) below.

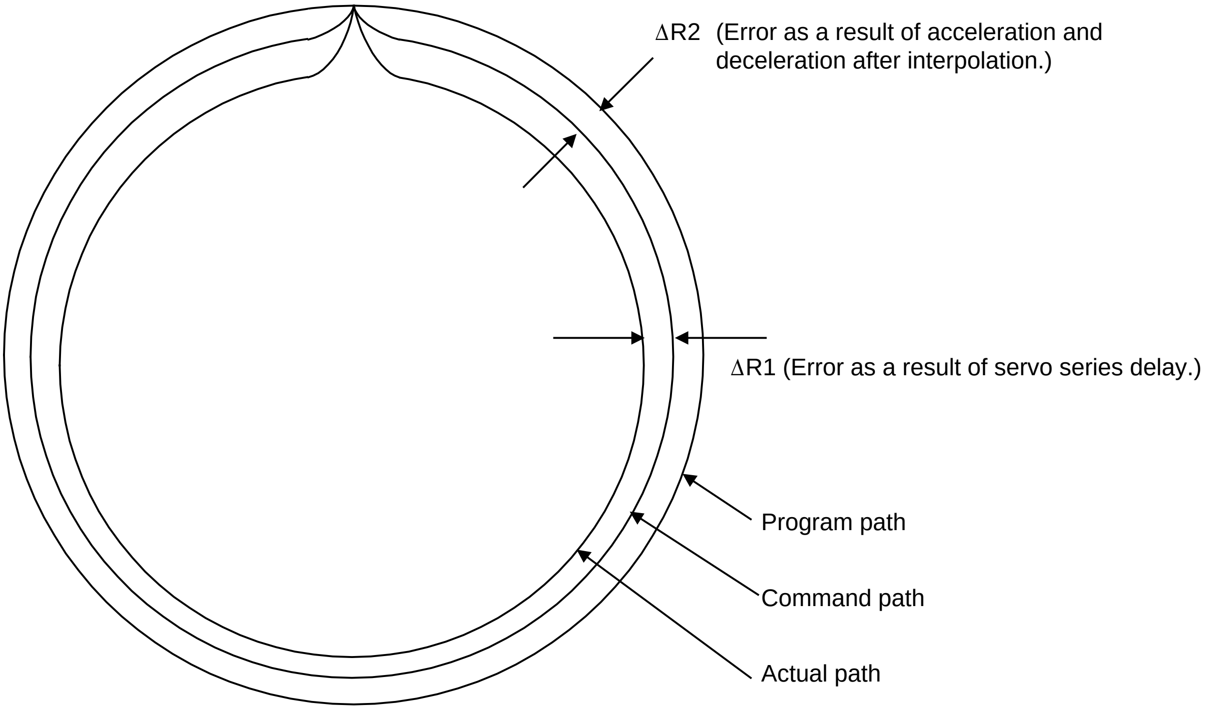


Fig. 4.6.1 (b) Path error during circular cutting

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/B(01) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

<1> Enable PI control and the feed-forward function.

		#7	#6	#5	#4	#3	#2	#1	#0
1808	8X03					PIEN			
2003	1003								

PIEN (#3) 1: To enable PI control

		#7	#6	#5	#4	#3	#2	#1	#0
1883	8X05							FEED	
2005	1005								

FEED (#1) 1: To enable the feed-forward function

<2> Specify the feed-forward coefficient.

1961	8X68	Feed-forward coefficient (FALPH)
2068	1068	

For Series 0-C, 15-A

$$\text{FALPH} = \alpha \times 4096 \times \frac{8192}{\text{Position feedback pulses per revolution of the motor}}$$

For Series 15-B, 16, 18, 20, 21, Power Mate

$$\text{FALPH} = \alpha \times 100 \text{ or } \alpha \times 10000$$

When FALPH is smaller than or equal to 100: In units of 1%
When FALPH is greater than 100: In units of 0.01%

[Typical setting] 70 or 7000

<3> Specify the velocity feed-forward coefficient.

1962	8X69	Velocity feed-forward coefficient (VFFLT)
2069	1069	

For Series 0-C, 15-A

$$\text{VFFLT} = (-\text{PK2V}) \times \frac{\text{Load inertia + rotor inertia}}{\text{Rotor inertia}} \times \frac{0.04 \times 8000}{\text{Position feedback pulses per revolution of the motor}}$$

For Series 15-B, 16, 18, 20, 21, Power Mate

VFFLT = 50 (50 to 200)

<4> Switch the NC off, attach the servo check board, then switch the NC on again. ⇒ See Sec. 4.19.
Run a program to operate the axis for cutting feed at maximum feedrate. Under this condition, check whether the VCMD waveform observed between channels 1 and 3 on the servo check board overshoots and what the shock caused during acceleration /deceleration is like.

⇒ If an overshoot occurs, or the shock is big, increase the acceleration/deceleration time constant, or reduce α.

⇒ If an overshoot does not occur, and the shock is small, reduce the acceleration/deceleration time constant, or increase α.

Linear acceleration/deceleration is more effective than exponential acceleration/deceleration.
Using acceleration/deceleration before interpolation can further reduce the figure error.

<5> By setting the parameter below, the feed-forward function can be used for cutting feed as well.

		#7	#6	#5	#4	#3	#2	#1	#0
1800	–						FFR		
1800	–								

FFR (#3) Specifies whether feed-forward control during rapid traverse is enabled or disabled.
1: Enabled
0: Disabled

By using the feed-forward function during rapid traverse, the positioning time can be reduced. On some machines, however, a shock may occur at the time of acceleration/deceleration. In such a case, use fine acceleration/deceleration (⇒ Subsec. 4.8.3) at the same time, or make adjustments such as increasing the acceleration/deceleration time constant.
By using the cutting feed/rapid traverse switchable fine acceleration/deceleration function at the same time, a feed-forward coefficient can be set separately for cutting feed and rapid traverse. (See Subsec. 3.4.2, "Cutting Feed/Rapid Traverse Switchable Function" and Subsec. 4.8.3 "(5) Setting parameters for the fine acceleration/deceleration function, used separately for cutting and rapid traverse.")

4.6.2 Advanced Preview Feed-forward Function

(1) Overview

The advanced preview feed-forward function is part of the advanced preview control function. It enables high-speed high-precision machining. The function creates feed-forward data according to a command which is one distribution cycle ahead, and reduces the delay caused by smoothing. This new function can upgrade the high-speed, high-precision machining implemented under conventional feed-forward control.

The conventional feed-forward control function executes smoothing in order to eliminate the velocity error of each distribution cycle (see Fig. 4.6.2 (a)). This smoothing, however, causes a delay in the feed-forward data.

The new advanced preview feed-forward control function uses the distribution data which is one distribution cycle ahead and generates delay-free feed-forward data (Fig. 4.6.2 (b)). The function can provide higher controllability than the conventional feed-forward control function.

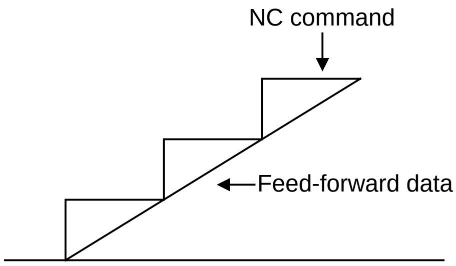


Fig. 4.6.2 (a) Conventional feed-forward control

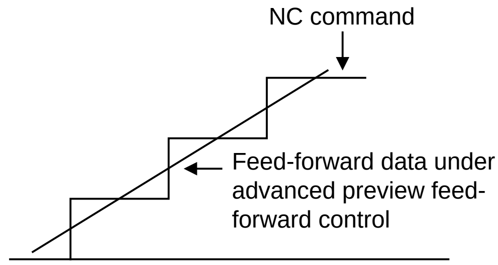


Fig. 4.6.2 (b) Advanced preview feed-forward control

(2) Series and editions of applicable servo software

Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

<1> Set the following parameters in the same way as for conventional feed-forward control.

		#7	#6	#5	#4	#3	#2	#1	#0
1808	–					PIEN			
2003	–								

PIEN (#3) 1: PI control is selected.

		#7	#6	#5	#4	#3	#2	#1	#0
1883	–							FEED	
2005	–								

FEED (#1) 1: The feed-forward function is enabled.

1962	–	Velocity feed-forward coefficient (VFFLT)
2069	–	

[Standard setting] 50 (50 to 200)

<2> Set the coefficient for advanced preview feed-forward control.

1985	–	Advanced preview feed-forward coefficient (ADFF1)
2092	–	

Advanced preview feed-forward coefficient (0.01% unit)

$= \alpha \times 10000 \ (0 \leq \alpha \leq 1)$

[Standard setting] 9850

(Example)

When α equals 98.5%, ADFF1 is 9850.
Feed-forward control is configured as shown below:

Feed-forward control
- Deceleration algorithm and function of acceleration/deceleration before interpolation of CNC
  - Acceleration/deceleration method causing no figure errors
  - Deceleration at a point where a large impact would be expected
- Advanced preview feed-forward function of digital servo
  - Improving the tracking ability of the servo system

Because of this configuration, the function can improve the feed-forward coefficient up to about 1 without impact and also reduce figure error.

> **NOTE**
> For the Series 15-A and 15-B, set bit 2 of parameter No. 1811 to 1, in addition to making the above setting. (This parameter need not be set with Series 15*i*, 16, and 18.)

<3> By specifying the G codes listed below, the modes related to high-speed high-precision machining such as advanced preview control can be turned on/off. In each mode, advanced preview feed-forward is enabled.

G code		Mode	CNC
Mode ON	**Mode OFF**		
G08P1	G08P0	Advanced preview control mode	Series 16, 18, 21*i*
G05.1Q1	G05.1Q0	Acceleration/deceleration mode before look-ahead interpolation	Series 15-B, 15*i*
		AI nano-contour control mode	Series 16*i*
		AI contour control mode	Series 16*i*, 18*i*
		AI advanced preview control mode	Series 21*i*
G05P10000	G05P0	HPCC mode (⇒ Subsec.4.6.3)	Series 15-B, 16, 18

(Example)

G08P1; Advanced preview control mode on

c
c } Advanced preview feed-forward enabled
c

G08P0; Advanced preview control mode off

4.6.3 RISC Feed-forward Function

(1) Overview

The feed-forward system is used during high-precision contour control based on RISC (HPCC mode) in order to shorten the interpolation cycle, improving the performance of high-speed, high-precision machining.

(2) Series and editions of applicable servo software

Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*)

(3) Setting parameters

<1> Set the following parameters in the same way as for the advanced preview feed-forward function. (In the HPCC mode, the same feed-forward coefficients as those for the advanced preview feed-forward mode are used.)

		#7	#6	#5	#4	#3	#2	#1	#0
1883	–							FEED	
2005	–								

FEED (#1) 1: The feed-forward function is enabled.

1962	–	Velocity feed-forward coefficient (VFFLT)
2069	–	

[Standard setting] 50 (50 to 200)

1985	–	Advanced preview feed-forward coefficient (ADFF1)
2092	–	

[Standard setting] 9850

<2> The HPCC mode is enabled over the range bracketed by the following G codes specified in the program. While in this mode, the advanced preview feed-forward coefficient set in the above parameter is used.
(Series 15, 16, 18)
G05 P10000; HPCC mode ON
G05 P0; HPCC mode OFF

When the HPCC mode is off, a normal feed-forward coefficient becomes effective.

(4) RISC feed-forward function (type 2)

(a) Overview

An improvement has been made to further increase servo response when the distribution period is 4 ms, 2 ms, or 1 ms in the HPCC mode.

(b) Series and editions of applicable servo software

(For a distribution period of 2 ms or 1 ms)

Series 9080/C(03) and subsequent editions (Series 15-B, 16-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*)

(For a distribution period of 4 ms)

Series 90A0/I(09) and subsequent editions (Series 15*i*, 16*i*, 18*i*)

(c) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1959	–			RISCFF					
2017	–								

RISCFF (#5) 1: Feed-forward response improves when RISC is used.
0: Feed-forward response remains unchanged when RISC is used.

NOTE

1. Use this function only when very high command response is required.
2. When using this function, set a detection unit of 0.1 μm wherever possible.
   (A detection unit of 0.1 μm can be set by using the IS-C unit or by multiplying the CMR and flexible feed gear by 10 with the IS-B system.)
3. When this function is enabled, servo response to commands increases. So, vibration can occur, depending on the resonance frequency of the machine system. In such a case, use the conventional control method instead of this function.

4.6.4 Backlash Acceleration Function

(1) Overview

If the influence of backlash and friction is large in the machine, a delay may be produced on reversal of motor, thus resulting in quadrant protrusion on circular cutting.
This is a backlash acceleration function to improve quadrant protrusion.
For Series 15-B, 16, 18, 20, and 21, also the two-stage backlash acceleration function also can be used. (⇒ Subsec. 4.6.5)
Using the servo check board makes it easy to adjust the backlash acceleration function. (⇒ Sec. 4.19)

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(01) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

<1> Set the backlash compensation.

1851	**0535 to 0538**	**Backlash compensation**
1851	**–**	

In semi-closed mode:
Set the machine backlash. (Minimum value = 1)
In full-closed mode:
Set the minimum value of 1. To prevent the backlash compensation from being reflected in positions, set the following:

> **NOTE**
> Always set a positive value. If a negative value or 0 is set, the backlash acceleration function is not enabled.

		#7	#6	#5	#4	#3	#2	#1	#0
1884	8X06								FCBL
2006	–								

FCBL (#0) 1: Do not reflect the backlash compensation in positions.

Generally, for a machine in full-closed mode, backlash compensation is not reflected in positions, so this bit is set. (This parameter is applicable also to a machine with a semi-closed loop.)

<2> Enable the backlash acceleration function.

		#7	#6	#5	#4	#3	#2	#1	#0
1808	8X03			BLEN					
2003	–								

BLEN (#5) 1: To enable backlash acceleration

1860	8X48	Backlash acceleration amount
2048	–	

[Typical setting] 600

1964	8X71	Period during which backlash acceleration remains effective (in units of 2 msec)
2071	–	

[Typical setting] 50 to 100

<3> If a reverse cut occurs, use the backlash acceleration stop function.

		#7	#6	#5	#4	#3	#2	#1	#0
1953	8X09	BLST							
2009	–								

BLST (#7) 1: To enable the backlash acceleration stop function

NOTE

When the backlash acceleration stop function is enabled (with BLST = 1), be sure to set a positive value in the backlash acceleration stop timing parameter described below. (If 0 or a negative value is set, backlash acceleration is not performed.)

1975	8X82	Timing at which the backlash acceleration is stopped
2082	–	

[Typical setting] 5

This completes the general setting procedure for the backlash acceleration function.

To disable the backlash acceleration function at handle feed, set the following:

		#7	#6	#5	#4	#3	#2	#1	#0
1953	8X09		BLCU						
2009	–								

BLCU (#6) 1: To enable the backlash acceleration function during cutting feed only

This function is effective when the backlash function is used.
When this function is used with the backlash function, the applicable series and editions of the servo software will be as follows:

Series 9070/K(11) and subsequent editions
Series 9080/K(11) and subsequent editions
Series 9090/A(01) and subsequent editions
Series 90A0/C(03) and subsequent editions

[Reference] Adjustment the backlash acceleration
Use an arc program to monitor check boards ch1 and ch3 (VCMD waveform).
Pay attention to the VCMD waveform when the motor rotation reverses (the VCMD waveform passes the GND level).
If a protrusion appears, increase the backlash acceleration.
An excessive acceleration causes an inverse notch.

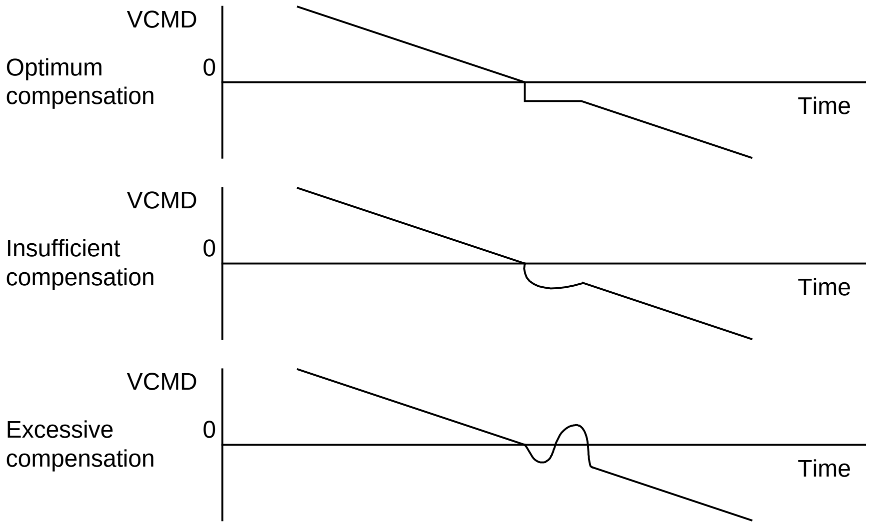


Fig. 4.6.4 (a) Two-stage backlash adjustment using the VCMD waveform

4.6.5 Two-stage Backlash Acceleration Function

(1) Overview

When the machine reverses the direction of feed, two types of delay are likely to occur; one type due to friction in the motor and the other due to friction in the machine.
The two-stage backlash acceleration function compensates for two types of delays separately, thus enabling two-stage compensation.

Two-stage compensation	Stage 1:	The friction torque is canceled when the motor reverses.
	Stage 2:	The friction torque in the machine is canceled.

Furthermore, optimum compensation can be performed at all times for stage 1 against changing speed and load.
The two-stage backlash acceleration function performs compensation as shown below:

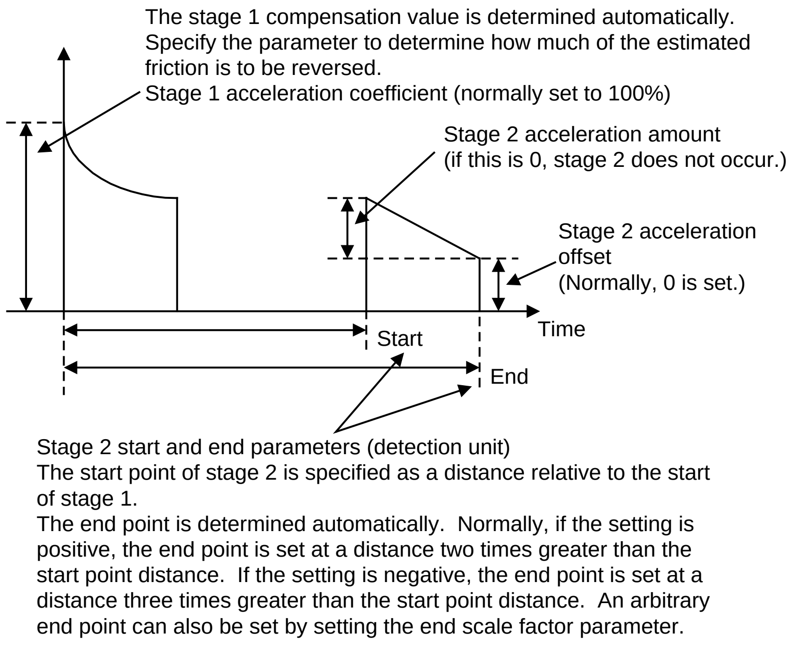


Fig. 4.6.5 (a) Backlash acceleration under control of the two-stage backlash acceleration function

(2) Series and editions of applicable servo software

Series 9060/Q(17) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
9070/F(06) and subsequent editions (Series 15-B, 16-B, 18-B)
9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

<1> Connect the check board to enable motor speed and torque commands to be measured with an oscilloscope or personal computer.
(For details of using the check board, see Sec. 4.19.)
<2> Turn on the power to the NC.
<3> Specify the backlash compensation value.

1851	–	Backlash compensation value
1851	–	

For semi-closed mode, specify the machine backlash (minimum of 1).
For full-closed mode, specify 1. To prevent backlash compensation from being reflected on positions, set the following parameters:

		#7	#6	#5	#4	#3	#2	#1	#0
1884	–								FCBL
2006	–								

FCBL (#0) Backlash compensation is not performed for the position in the full-closed mode.
1: Valid
2: Invalid

> **NOTE**
> Be sure to set a positive value for backlash compensation. If 0 or a negative value is specified, backlash compensation is not performed.

<4> Adjusting the velocity loop gain
Enable PI control, and increase the velocity loop gain (load inertia ratio) as much as possible.
(For velocity loop gain adjustment, see Subsec. 3.3.1.)

* By setting a high velocity loop gain, the response of the motor improves, and quadrant protrusions can be reduced. If the velocity loop gain is changed in the subsequent adjustments, the adjustments become complicate. So, increase the velocity loop gain sufficiently at this stage.

<5> Enable the two-stage backlash acceleration function.

		#7	#6	#5	#4	#3	#2	#1	#0
1808	–			BLEN					
2003	–								

BLEN (#5) 1: To enable the backlash acceleration function

		#7	#6	#5	#4	#3	#2	#1	#0
1957	–		BLAT						
2015	–								

BLAT (#6) 1: To enable the two-stage backlash acceleration function

<6> Set the observer-related parameters.
With the two-stage backlash acceleration function, a friction torque is extracted as an estimated disturbance value with the observer circuit to determine a stage 1 acceleration amount. So, the observer parameter needs to be adjusted to obtain correct acceleration.

> The procedure of this adjustment is the same as for an observer-related parameter adjustment made with the abnormal load detection function (Subsec. 4.12.1). Make an adjustment according to steps <4> through <7> of the parameter adjustment procedure described in (3) in Subsec. 4.12.1 of this manual. The abnormal load detection function is used, so that if an adjustment is already made, a readjustment need not be made.

(Related parameters)

		#7	#6	#5	#4	#3	#2	#1	#0
1957	–			TDOU					
2015	1015								

TDOU (#5) When an estimated disturbance value is output to the check board:
1: The estimated disturbance value is output to the torque command output channel.
0: The torque command output channel is based on the standard specifications.

[Setting value] Set 1 when an estimated disturbance value is measured.

1862	–	Observer gain
2050	1050	

[Setting value] No change is required.

1863	–	Observer gain
2051	1051	

[Setting value] No change is required.

* When setting an observer gain, follow the settings of other functions (observer, abnormal load detection). When the two-stage backlash acceleration function is used, the settings need not be changed.

1859	–	Observer parameter (POA1)
2047	1047	

[Setting value] Adjusted value (Make an adjustment according to steps <4> to <6> in (3) in Subsec. 4.12.1.)

1980	–	Torque offset parameter
2087	1087	

[Setting value] Adjusted value (If the center of an estimated disturbance value does not become zero on an axis such as the gravity axis, make an adjustment according to step <7> in (3) in Subsec. 4.12.1.)

<7> Adjusting the stage 1 acceleration
Specify the following parameters.

		#7	#6	#5	#4	#3	#2	#1	#0
1957	–			TDOU					
2015	–								

TDOU (#5) 0: To output an estimated disturbance torque

1860	–	Stage 1 backlash acceleration amount (%)
2048	–	

[Unit of data] % (Backlash acceleration amount necessary to reverse the torque that is equal to the friction torque in amount is assumed to be 100%.)

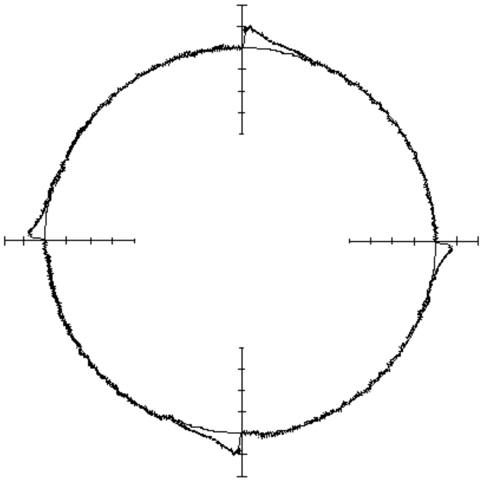
[Typical setting] 50 (Normally, optimum values range from 20% to 70%.)

1987	–	Stage 1 acceleration amount from negative direction to positive direction (%)
2094	–	

[Unit of data] %

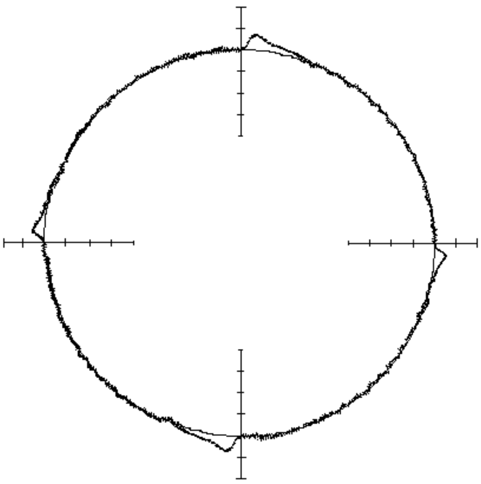
Normally, this parameter is set to 0. If the quadrant protrusion varies with the reverse direction of the position command in the machine conditions, set an appropriate value in this parameter.

When this parameter is set, parameter No. 1860 (Series 15) or No. 2048 (Series 16) specifies the stage 1 positive-to-negative backlash acceleration amount.

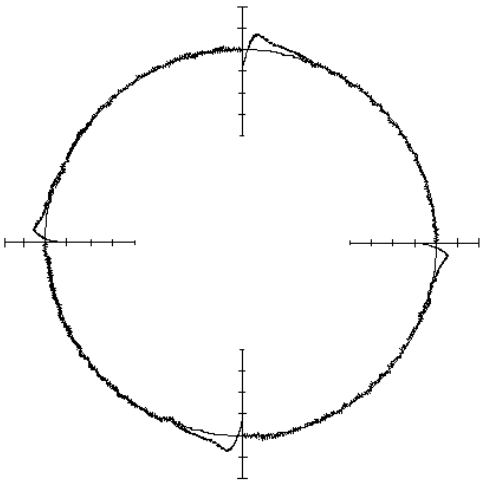


Before two-stage backlash acceleration adjustment
(A delay in reverse motor rotation causes a protrusion at each area of quadrant switching.)

First, set the value of **[Typical setting]**. Then, while viewing the arc figure, adjust the stage 1 acceleration amount parameter. (Make an adjustment at a low feedrate of about F500.)



Stage 1 acceleration amount (adequate)
(Protrusions caused by machine friction remain, but these protrusions are corrected later when stage 2 acceleration is adjusted.)



Stage 1 acceleration amount (too large)
(Cuts are caused by excessively high acceleration at the time of reverse motor rotation.)

Fig. 4.6.5 (c) Two-stage backlash acceleration (stage 1 acceleration amount adjustment)

1975	–	Stage 2 start/end parameter (detection unit)
2082	–	

[Unit of data] Detection unit

[Typical setting] 10 (For a detection unit of 1 μm)
100 (For a detection unit of 0.1 μm)

1982	–	Stage 2 end scale factor
2089	–	

[Unit of data] In units of 0.1

[Valid data range] 0 to 647 (multiplication by 0 to 64.7)

Normally, this value may be set to 0.

If parameter No. 1982 (Series 15) or No. 2089 (Series 16) is set to 0, the start of stage 2 acceleration is determined by the absolute value of the setting in No. 1975 (Series 15) or No. 2082 (Series 16). Stage 2 acceleration ends at a distance two times greater than the start point distance if the value set in No. 1975 (Series 15) or No. 2082 (Series 16) is positive; if the value is negative, stage 2 acceleration ends at a distance three times greater than the start point distance.

If No. 1982 (Series 15) or No. 2089 (Series 16) is set to a non-zero value, the end point of the stage 2 acceleration can be set to an arbitrary point.

(Example)

When No. 1975 (Series 15) or No. 2082 (Series 16) = 10, and No. 1982 (Series 15) or No. 2089 (Series 16) = 50 (meaning multiplication by 5), acceleration is performed as follows:

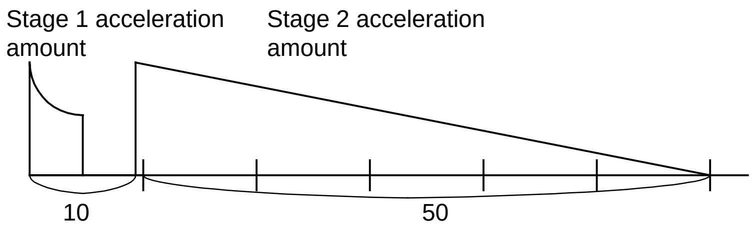
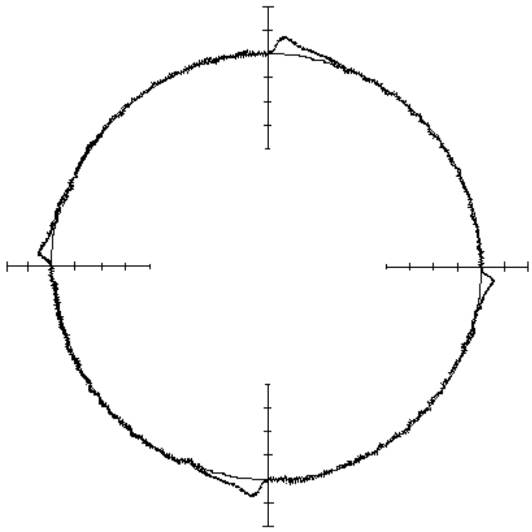
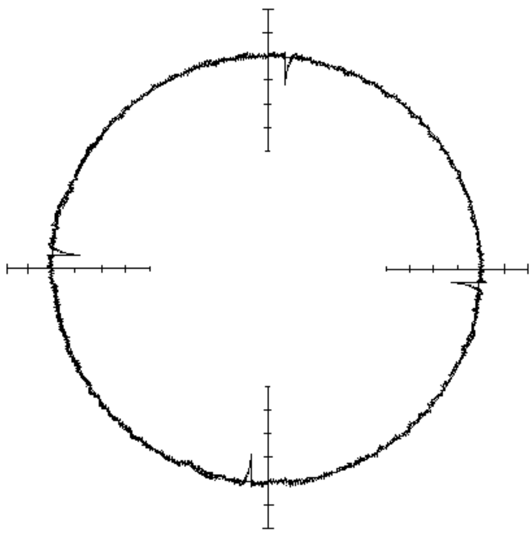


Fig. 4.6.5 (d) Stage 2 end scale factor

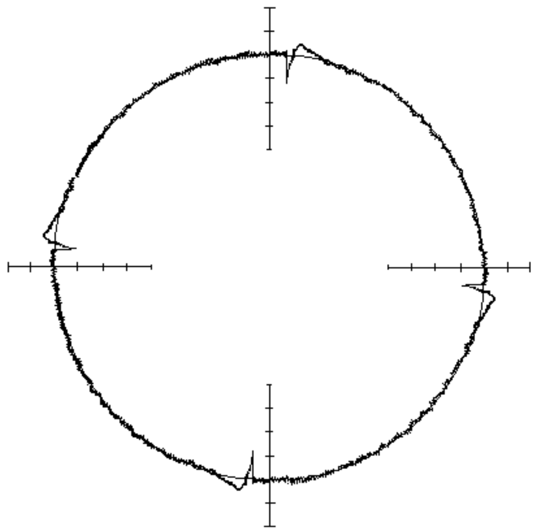


Before start/end parameter adjustment

Set the following:
Start/end parameter = Value of **[Typical setting]**
Stage 2 acceleration amount = 500
Then, adjust the start/end parameter while viewing the timing of stage 2 acceleration from the arc figure.



Start/end parameter (adequate)
(A larger stage 2 acceleration amount is set to view the timing of stage 2 acceleration, so that cuts occur. This is corrected later.)



Start/end parameter (insufficient)
(The time for stage 2 acceleration is too short, so that stage 2 protrusions are not fully eliminated.)

Fig. 4.6.5 (e) Two-stage backlash acceleration (start/end parameter adjustment)

> **NOTE**
> Note that the two-stage backlash acceleration cannot be used together with the backlash stop function.

<8> Stage 2 acceleration adjustment

The two-stage backlash acceleration function has effect even if only stage 1 is used. However, a protrusion may linger because of machine friction. In such a case stage 2 is useful.

Adjust the stage 2 acceleration so that it falls in a range where no cut occurs.

1724	–	Stage 2 acceleration amount for two-stage backlash acceleration
2039	–	

[Typical setting] 100 (Too large a value could cause a cut at low feedrate.)

1790	–	Stage 2 offset for two-stage backlash acceleration
2167	–	

Normally, set 0.

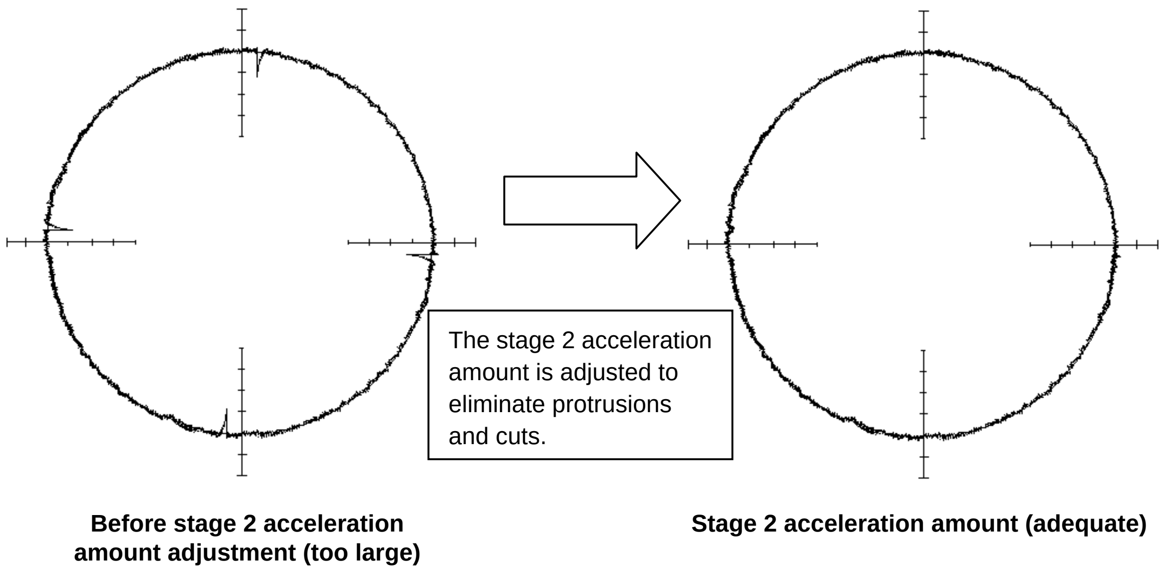


Fig. 4.6.5 (f) Two-stage backlash acceleration (stage 2 acceleration amount adjustment)

<9> Stage 1 and stage 2 acceleration override adjustment
Stage 1 and stage 2 acceleration amounts can be overridden according to the circular acceleration.
When using the stage 1 acceleration override function, set the following. (Normally, this setting is not needed.)

1760	–	Stage 1 acceleration override
2137	–	

[Valid data range] 0 to 32767

When the stage 1 acceleration override function is used, the stage 1 acceleration amount of two-stage backlash acceleration is found from the following formula:

(Stage 1 acceleration amount)

$$= \text{(Stage 1 acceleration amount setting)} \times \left\{ 1 + \alpha \times \frac{\text{(Stage 1 override setting)}}{1024} \right\}$$

Here, let α be a circular acceleration, R be a radius (mm), F be a circular feedrate (mm/min), and P be a detection unit (mm). Then, α can be expressed as:

$$\alpha = \left\{ \frac{2}{R} (F/60 \times 0.008)^2 \right\} \Big/ P$$

If the feedrate is low, $\alpha \to 0$. So, the value of the second term in the acceleration formula above becomes 0, so that acceleration is performed using the stage 1 acceleration amount setting.
This means that the stage 1 override setting and acceleration amount are related as follows:

$$\text{(Stage 1 override setting)} = \frac{1024}{\alpha} \times \left\{ \frac{\text{(Stage 1 acceleration amount)}}{\text{(Stage 1 acceleration amount setting)}} - 1 \right\}$$

(Example)
To obtain a stage 1 acceleration amount that is two times the setting when R10 F4000 (with a detection unit of 1 μm)

$$\alpha = \left\{ \frac{2}{10} (4000/60 \times 0.008)^2 \right\} \Big/ 0.001 = 56.9$$

$$\text{(Stage 1 override setting)} = \frac{1024}{56.9} \times \left\{ \frac{2}{1} - 1 \right\} = 18$$

From the above, set 18 as the override.

When using the stage 2 acceleration override function, set the following.

		#7	#6	#5	#4	#3	#2	#1	#0
1960	–						OVR8		
2018	–								

OVR8 (#2) 1: The format of the stage 2 acceleration override is determined.

1725	–	Stage 2 acceleration override
2114	–	

[Valid data range] 0 to 32767

When the stage 2 acceleration override function is used, the stage 2 acceleration amount of two-stage backlash acceleration is found from the following formula:

$$\text{(Stage 2 acceleration amount)} = \text{(Stage 2 acceleration amount setting)} \times \left\{ 1 + \alpha \times \frac{\text{(Stage 2 override setting)}}{256} \right\}$$

Here, let α be a circular acceleration, R be a radius (mm), F be a circular feedrate (mm/min), and P be a detection unit (mm). Then, α can be expressed as:

$$\alpha = \left\{ \frac{2}{R} (F/60 \times 0.008)^2 \right\} \Big/ P$$

So, the stage 2 override setting and acceleration amount are related as follows:

$$\text{(Stage 2 override setting)} = \frac{256}{\alpha} \times \left\{ \frac{\text{(Stage 2 acceleration amount)}}{\text{(Stage 2 acceleration amount setting)}} - 1 \right\}$$

> **NOTE**
> Stage 2 override is effective for stage 2 offset.

(4) Neglecting backlash acceleration during feeding by the handle

		#7	#6	#5	#4	#3	#2	#1	#0
1953	–		BLCU						
2009	–								

BLCU (#6) 1: To enable backlash acceleration only during cutting feed
When the two-stage backlash function is used, this setting is effective with the following servo software series and editions:
Series 9070/K(11) and subsequent editions
Series 9080/K(11) and subsequent editions
Series 9090/A(01) and subsequent editions
Series 90A0/C(03) and subsequent editions

4.6.6 Static Friction Compensation Function

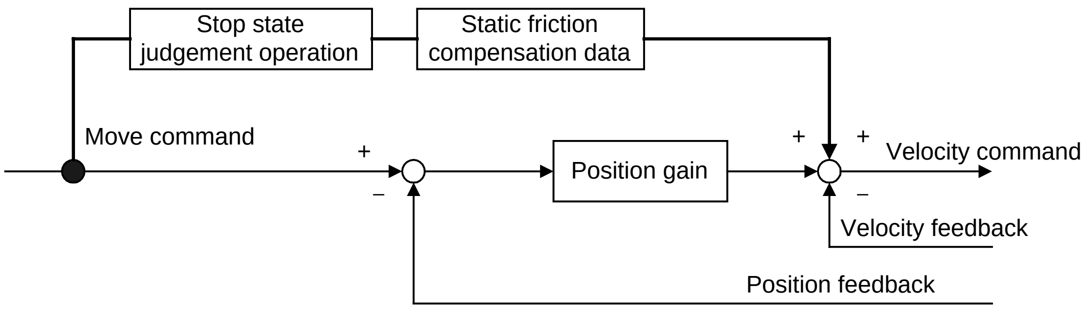
(1) Overview

When a machine, originally in the stop state, is activated, the increase in speed may be delayed by there being a large amount of static friction. The backlash acceleration function (see Subsec. 4.6.4 and Subsec. 4.6.5) performs compensation when the motor rotation is reversed. This function adds compensation data to a velocity command when the motor, originally in the stop state, is requested to rotate in the same direction, thus reducing the activation delay.

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/B(02) and subsequent editions (Power Mate-E)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Block diagram



(4) Setting parameters

<1> Enable this function.

		#7	#6	#5	#4	#3	#2	#1	#0
1808	8X03			BLEN					
2003	1003								

BLEN (#5) 1: The backlash acceleration function is enabled.

		#7	#6	#5	#4	#3	#2	#1	#0
1883	8X05	SFCM							
2005	1005								

SFCM (#7) 1: The static friction compensation function is enabled.

<2> Set adjustment parameters.

1964	8X71	Compensation count
2071	1071	

[Valid data range] 0 to 32767

[Standard setting] 10

1965	8X72	Static friction compensation
2072	1072	

[Valid data range] 0 to 32767

[Standard setting] 100

1996	8X73	Stop state judgement parameter
2073	1073	

[Valid data range] 1 to 32767

[Method of setting] Stop determination time = (parameter setting) × 8 ms
If the machine starts moving after stopping for the time set in this parameter or more, this compensation function is enabled.

NOTE

1 If a small value is set in this parameter, feed at a low feedrate is regarded by mistake as stop state, and compensation may not be performed correctly. In such a case, increase the setting of this parameter.

2 When the static friction compensation function is enabled, be sure to set a nonzero positive value in this parameter.

		#7	#6	#5	#4	#3	#2	#1	#0
1953	8X09	BLST							
2009	1009								

BLST (#7) 1: The function used to release static friction compensation is enabled.

1990	8X97	Parameter for stopping static friction compensation
2097	1097	

[Valid data range] 0 to 32767

[Standard setting] 5

4.7 OVERSHOOT COMPENSATION

(1) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1808	8X03		OVSC						
2003	1003								

OVSC (#6) 1: To enable the overshoot compensation function

1857	8X45	Velocity loop incomplete integral gain (PK3V)
2045	1045	

[Valid data range] 0 to 32767

[Typical setting] 30000

1970	8X77	Overshoot compensation counter (OSCTP)
2077	1077	

[Valid data range] 0 to 32767

[Typical setting] 20

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9064/B(02) and subsequent editions (Power Mate E)
Series 9065/A(01) and subsequent editions (Power Mate E)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Explanation

(a) Servo system configuration
Fig. 4.7 (a) shows the servo system configuration. Fig. 4.7 (b) shows the velocity loop configuration.

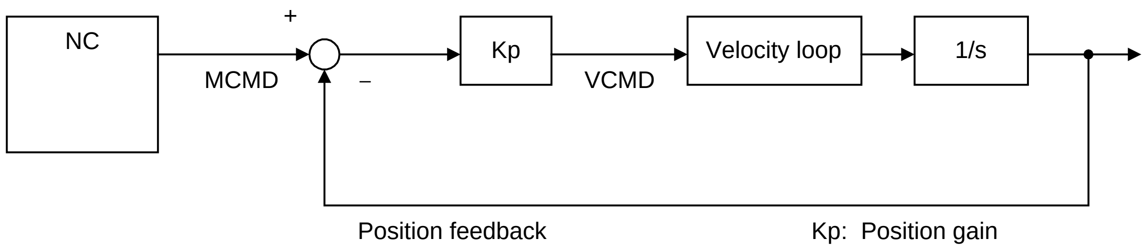


Fig. 4.7 (a) Digital servo system configuration

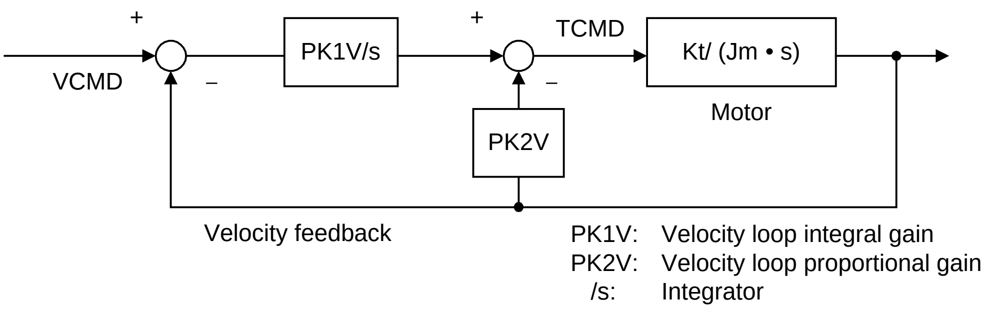


Fig. 4.7 (b) Velocity loop configuration

(b) When incomplete integration and overshoot compensation are not used.
First, the 1–pulse motion command is issued from NC. Initially, because the Position Feedback and Velocity Feedback are "0", the 1–pulse multiplied position gain Kp value is generated as the velocity command (VCMD).
Because the motor will not move immediately due to internal friction and other factors, the value of the integrator is accumulated according to the VCMD. When the value of this integrator creates a torque command, large enough to over come the friction in the machine system, the motor will move and VCMD will become "0" as the value of MCMD and the Position Feedback becomes equal.
Furthermore, the Velocity Feedback becomes "1" only when it is moved, and afterwards becomes "0". Therefore the torque command is held fixed at that determined by the integrator.
The above situation is shown in Fig. 4.7 (c).

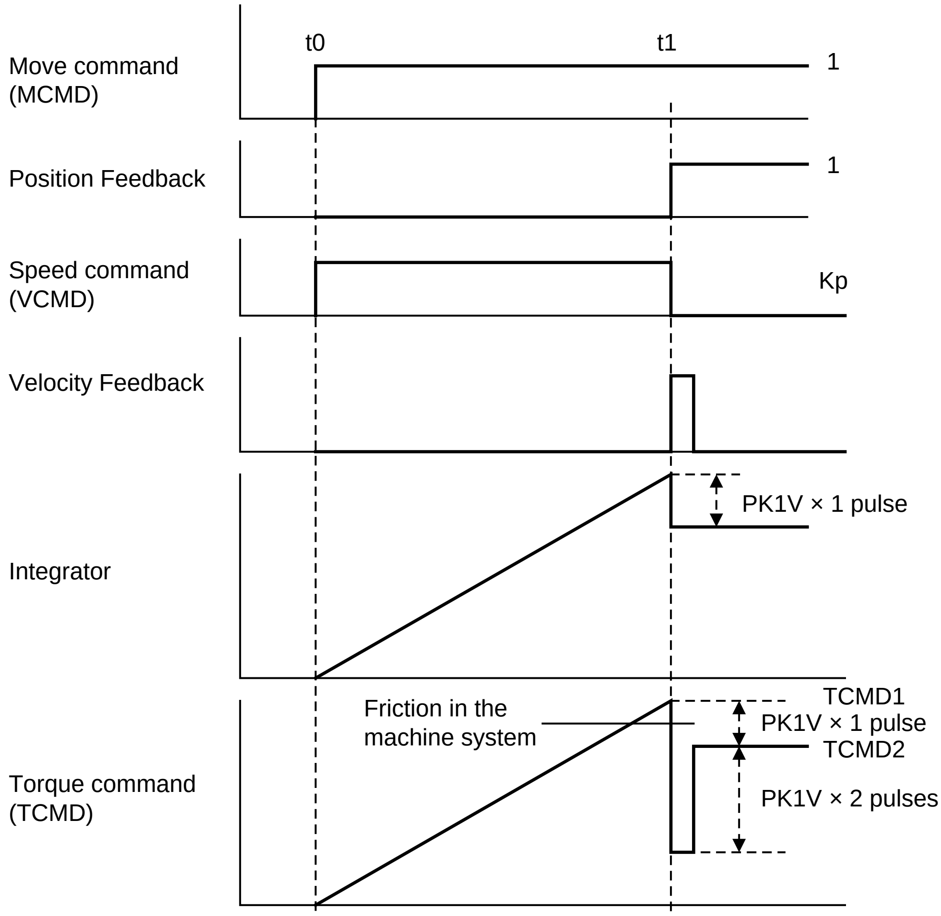


Fig. 4.7 (c) Response to 1 pulse movement commands

If Fig. 4.7 (c) on the previous page, the torque (TCMD1) when movement has started becomes even greater than the machine static friction level. Furthermore, when the motor has moved 1 pulse, it finally comes settled at the TCMD2 level.
Because the moving frictional power of the machine is smaller than the maximum rest frictional power, if the final torque TCMD2 in Fig. 4.7 (c) is smaller than the moving friction level, the motor will stop at the place where it has moved 1 pulse, Fig. 4.7 (d). When the TCMD2 is greater than the moving friction level the motor cannot stop and overshoot will occur Fig. 4.7 (e).
The overshoot compensation function is a function to prevent the occurrence of this phenomenon.

(c) Response to 1 pulse movement commands

(i) Torque commands for standard settings (when there is no overshoot)

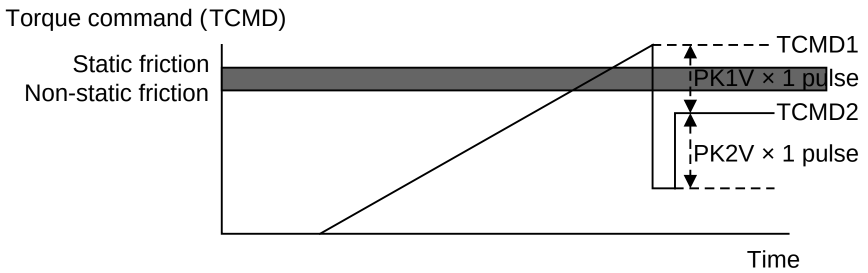


Fig. 4.7 (d) Torque commands (when there is no overshoot)

(ii) Torque commands for standard settings (during overshoot)

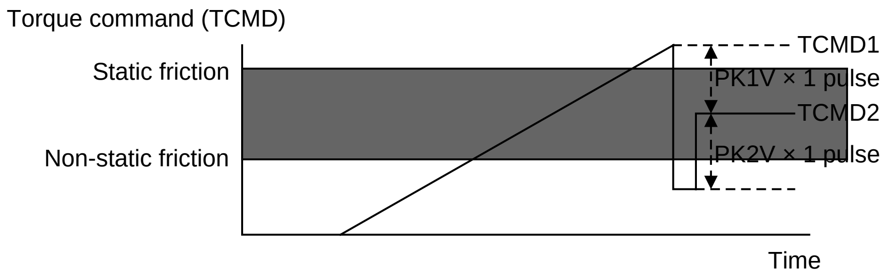


Fig. 4.7 (e) Torque commands (during overshoot)

Conditions to prevent further overshoot are as follows.
When

TCMD1 > static friction > non-static friction
> TCMD2 …… <1>

and there is a relationship there to

TCMD1 > static friction > TCMD2
> non-static friction …… <2>

regarding static and non–static friction like that of (ii), use the overshoot compensation in order to make <2> into <1>. The torque command status at that time is shown in (iii).

(iii) Torque command when overshoot compensation is used

Function bit
OVSC = 1 (Overshoot compensation is valid)
Parameter
PK3V: around 30000 to 25000 (Incomplete integral coefficient)

(Example)
when PK3V=32000 time constant approx. 42 msec
when PK3V=30000 time constant approx. 11 msec
when PK3V=25000 time constant approx. 4 msec

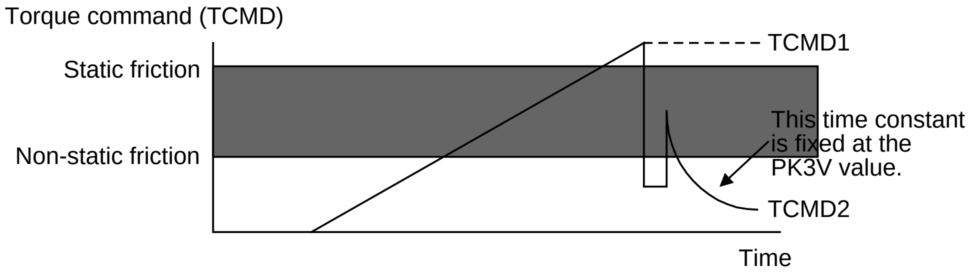


Fig. 4.7 (f) Torque command (when overshoot is used)

If this overshoot compensation function is used, it is possible to prevent overshoot so that the relationship between machine static and non–static friction and TCMD2 satisfies <1>, however the torque TCMD during machine stop is
TCMD2 = 0
the servo rigidity during machine stop is insufficient and it is possible that there will be some unsteadiness at ±1 pulse during machine stop.
There is an additional function to prevent this unsteadiness in the improved type overshoot prevention function and the status of the torque command at that time is shown in (iv).

(iv) Torque command when the improved type overshoot compensation is used

Function bit		
OVSC = 1 (Overshoot compensation is valid)		
Parameter		
PK3V:	around 32000	(Incomplete integral coefficient)
OSCTP:	around 20	(Number of incomplete integral)

When overshooting with this parameter, try increasing the value of the overshoot protection counter (OSCTP) by 10. Conversely, when there is no overshooting, but unsteadiness occurs easily during machine stop, decrease the overshoot protection counter (OSCTP) value by 10.
When overshoot protection counter (OSCTP) = 0 it is the same as existing overshoot compensation.

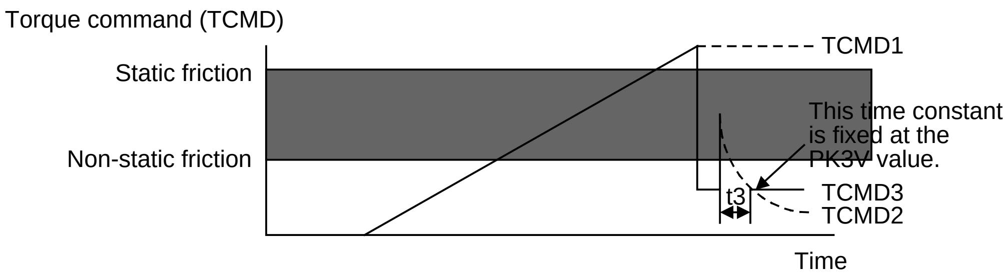


Fig. 4.7 (g) Torque command (using improved type overshoot compensation)

If this function is used, the final torque command is TCMD3. If the parameter PK3V (t3) is fixed so that this value becomes less than the non–static friction level, overshoot is nullified. Because torque command is maintained to some degree during machine stop, it is possible to decrease unsteadiness during machine stop.

(4) Improving overshoot compensation for machines using a 0.1-μm detection unit

(a) Overview

Conventional overshoot compensation performs imperfect integration only when the error is 0.

A machine using a 0.1-μm detection unit, however, has a very short period in which the error is 0, resulting in a very short time for imperfect integration.

The new function judges whether to execute overshoot compensation when the error is within a predetermined range.

(b) Series and editions of applicable servo software

Series 9060/Q(17) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)

Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)

Series 9070/E(05) and subsequent editions (Series 15-B, 16-B, 18-B)

Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)

Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(c) Setting parameters

1994	–	**Overshoot compensation enable level**
2101	–	

[Valid data range] 0 to 32767

[Increment system] Detection unit

[Standard setting] 1 (detection unit: 1 μm)

10 (detection unit: 0.1 μm)

To set an error range for which overshoot compensation is enabled, set Δ, as indicated below, as the overshoot compensation enable level.

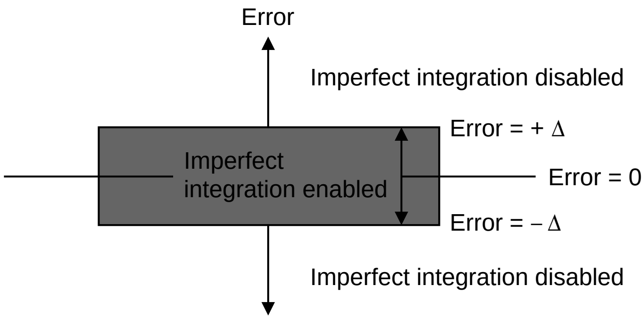


Fig. 4.7 (h) Relationship between error and overshoot compensation

(5) Overshoot compensation type 2

(a) Overview

For a machine using, for example, 0.1-µm detection units, the use of the conventional overshoot compensation function may generate minute vibrations when the machine stops, even if the parameter for the number of incomplete integrations is set.

This is caused by the repeated occurrence of the following phenomena:

- While the machine is in the stopped state, the positional deviation falls within the compensation valid level, and the integrator is rewritten. Subsequently, the motor is pushed back by a machine element such as a machine spring element, causing the positional deviation to exceed the compensation valid level.
- While the positional deviation is beyond the threshold, a torque command is output to decrease the positional deviation, then it decreases to below the threshold again.

In such a case, set the bit indicated below to suppress the minute vibration.

(b) Series and editions of applicable servo software

Series 9080/K(11) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)

Series 90A0/A(01 and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(c) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1742	–					OVS1			
2202	–								

OVS1 (#3) 1: Overshoot compensation is enabled only once after the termination of a move command.

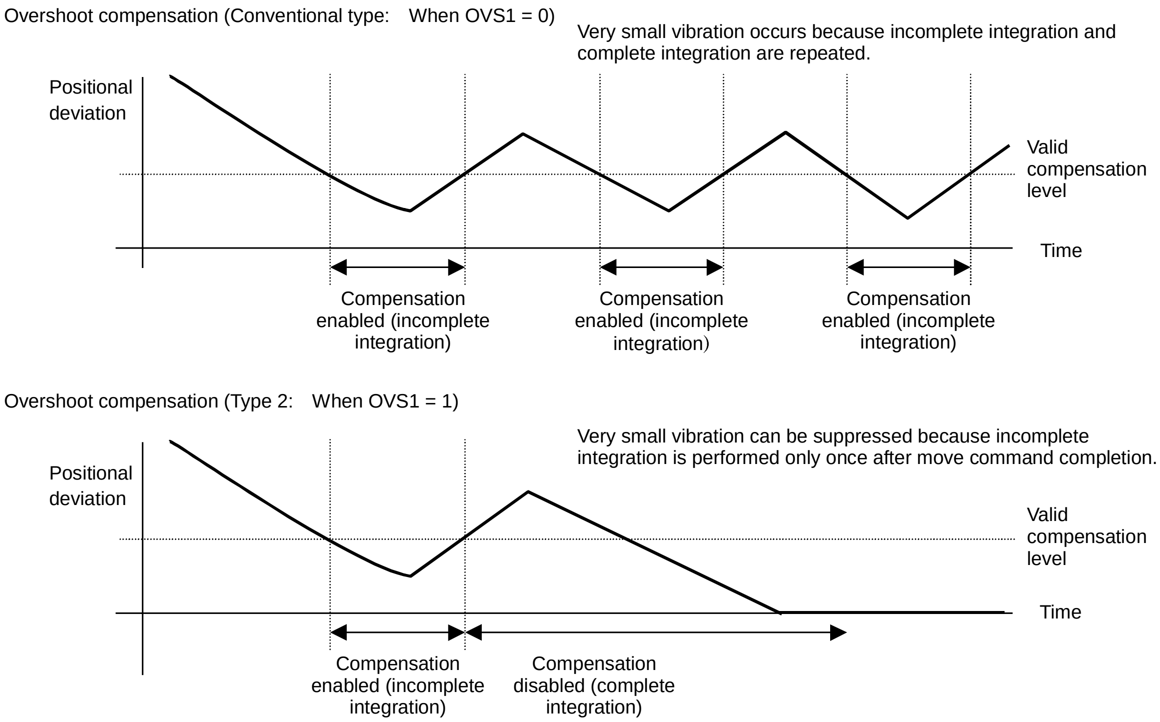


Fig. 4.7 (i) Overshoot compensation type 2

4.8 HIGH-SPEED POSITIONING FUNCTION

High-speed positioning is used in the following cases:

<1> To perform point-to-point movement quickly, where the composite track of two or more simultaneous axes can be ignored such as, for example, in a punch press

<2> To speed up positioning in rapid traverse while errors in the shape during cutting must be minimized (reduction of cycle time)

In case <1>, the position gain switch function and the low-speed integration function are effective (⇒ See Subsec. 3.4.4, "High-Speed Positioning Adjustment Procedure"). In case <2>, the fine acceleration/deceleration (FAD) function is effective. This section explains these functions.

4.8.1 Position Gain Switch Function

(1) General

An increase in the position gain is an effective means of reducing the positioning time when the machine is about to stop.

An excessively high position gain decreases the tracking ability of the velocity loop, making the position loop unstable. This results in hunting or overshoot. A position gain adjusted in high-speed response mode produces a margin in the position gain when the machine is about to stop.

Increase the position gain in low-speed mode so that both the characteristics in high-speed response mode and a short positioning time are achieved.

(2) Series and edition of applicable servo software

Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

<1> This parameter specifies whether to enable the position gain switch function as follows:

• Series 9046

(When this function is used with the Series 15-A and 0-C, specify the parameter for the Series 9046.)

		#7	#6	#5	#4	#3	#2	#1	#0
1954 (Series 15-A)	8X10			PGTW					

• Other than Series 9046

		#7	#6	#5	#4	#3	#2	#1	#0
1957 (Series 15-B, 15*i*)	–								PGTW
2015	1015								

PGTW The position gain switch function is used.
1: Valid
0: Invalid

> **NOTE**
> Exercise care when setting this bit. The setting location for the Series 15-A and 0-C differs from that for other systems.

<2> This parameter specifies whether to set the velocity at which position gain switching is to occur, as follows:

1972 (Series 15-A) 1714 (Series 15-B, 15*i*)	8X79	Limit speed for enabling position gain switching (in units of 0.01 rpm)
2029	1029	

The position gain is doubled with a speed lower than or equal to the speed specified above.

[Unit of data] Rotational motor: 0.01 rpm
Linear motor: 0.01 mm/min
[Valid data range] 0 to 32767
[Standard setting] 1500 to 5000

> **REFERENCE**
> Using the high-speed positioning velocity increment system magnification function (⇒ (4) in Subsec. 4.8.1) can increase the effective velocity to ten times.

Fig. 4.8.1 (a) shows the relationships between the positional deviation and velocity command. (→ Page 173)

(4) High-speed positioning velocity increment system magnification function

(a) Overview

This function increases the velocity increment system for the effective velocity parameter of the high-speed positioning functions (position gain switch and low-speed integration functions) to ten times.

(b) Series and editions of applicable servo software

Series 9080/O(15) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 9090/F(06) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)

Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(c) Setting parameters

Using the following parameter can change the increment system for the effective velocity.

		#7	#6	#5	#4	#3	#2	#1	#0
1744	–							HSTP10	
2204	–								

HSTP10 (#1) Specifies the effective velocity increment system for the high-speed positioning functions (position gain switch and low-speed integration functions) as follows:

1: 0.1 rpm (rotational motor), 0.1 mm/min (linear motor)

0: 0.01 rpm (rotational motor), 0.01 mm/min (linear motor)

NOTE

The value set in this function applies to the increment system of both the "position gain switch function" and "low-speed integration function."

(5) Position gain switch function type 2

(a) Overview

When the conventional position gain switch function is used in conjunction with the feed-forward function, it can cause an overshoot at a relative low feed-forward coefficient, sometimes resulting in a difficulty in adjustment, because also the feed-forward term-based effect is doubled. Position gain switch function type 2 has been improved to make position gain switching independently of the feed-forward function.

(b) Series and editions of applicable servo software

Series 9080/M(13) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 9090/E(05) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)

Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(c) Setting parameters
In addition to the parameter of the position gain switch function described earlier, set the following parameter.

		#7	#6	#5	#4	#3	#2	#1	#0
1744	–			PGTWN2					
2204	–								

PGTWN2 (#5) Specifies whether to double the feed-forward-based effect at position gain switching as follows:
1: To double
0: Not to double

NOTE
This function is invalid when the VCMD interface is in use.
(When the VCMD interface is in use, set PGTWN2 = 0.)

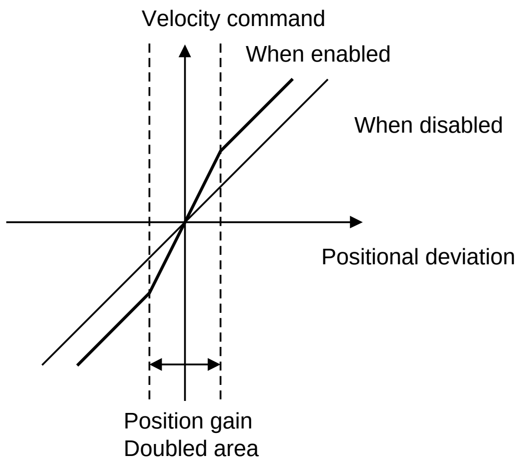


Fig. 4.8.1 (a) Position gain switching

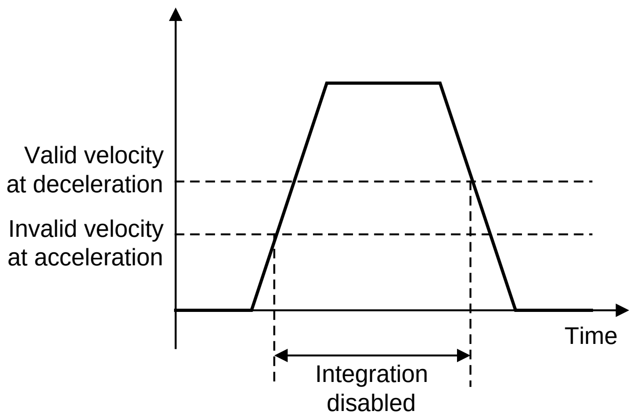


Fig. 4.8.1 (b) Integration invalid range at low-speed integration

4.8.2 Low-speed Integration Function

(1) Overview

To ensure that the motor responds quickly, a small time constant must be set so that a command enabling quick startup is issued.
If the time constant is too small, vibration or hunting occurs because of the delayed response of the velocity loop integrator, preventing further reduction of the time constant.
With the low-speed integration function, velocity loop integrator calculation is performed in low-speed mode only. This function ensures quick response and high stability while maintaining the positioning characteristics in the low-speed and stop states.

(2) Series and edition of applicable servo software

Series 9046/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9060/C(03) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/A(01) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

<1> Specify whether to enable the low-speed integration function.

- **Series 9046**

(When this function is used with Series 15-A and 0-C, specify the parameter for the Series 9046.)

		#7	#6	#5	#4	#3	#2	#1	#0
1954 (Series 15-A)	8X10		SSG1						

- **Other than Series 9046**

		#7	#6	#5	#4	#3	#2	#1	#0
1957 (Series 15-B, 15*i*)	–							SSG1	
2015	1015								

SSG1 The low-speed integration function is used.
1: Valid
0: Invalid

> **NOTE**
> Exercise care when setting this bit. The setting location for the Series 15-A and 0-C differs from that for other systems.

<2> Specify whether to enable integration at acceleration/ deceleration time.

1972 (Series 15-A) 1714 (Series 15-B, 15*i*)	8X79
2029	1029

Limit speed for disabling low-speed integration at acceleration

The integral gain is invalidated during acceleration at a speed higher than or equal to the specified speed.

[Unit of data] Rotational motor: 0.01 rpm
Linear motor: 0.01 mm/min

[Valid data range] 0 to 32767

[Standard setting] 1000

1973 (Series 15-A) 1715 (Series 15-B, 15*i*)	8X80
2030	1030

Limit speed for enabling low-speed integration at deceleration

The integral gain is validated during deceleration at a speed lower than or equal to the specified speed.

[Unit of data] Rotational motor: 0.01 rpm
Linear motor: 0.01 mm/min

[Valid data range] 0 to 32767

[Standard setting] 1500

REFERENCE

Using the high-speed positioning velocity increment system magnification function (⇒ (4) in Subsec. 4.8.1) can increase the effective velocity to ten times.

This function can specify whether to enable the velocity loop integration term for two velocity values, the first for acceleration and the second for deceleration. It works as shown in Fig. 4.8.1 (b).

4.8.3 Fine Acceleration/Deceleration (FAD) Function

(1) Overview

The fine acceleration/deceleration function enables smooth acceleration/deceleration. This is done by using servo software to perform acceleration/deceleration processing, which previously has been performed by the CNC. With this function, the mechanical stress and strain resulting from acceleration/deceleration can be reduced.

(2) Features

- Acceleration/deceleration is controlled by servo software at short intervals, allowing smooth acceleration/deceleration.
- Smooth acceleration/deceleration can reduce the stress and strain applied to the machine.
- Because of the reduced stress and strain on the machine, a shorter time constant can be set (within the motor acceleration capability range).
- Two acceleration/deceleration command types are supported: bell-shaped and linear acceleration/deceleration types.
- An application of the fine acceleration/deceleration function is found in the cutting and rapid traverse operations; for each operation, the FAD time constant, feed-forward coefficient, and velocity feed-forward coefficient can be used separately.

(3) Series and editions of applicable servo software

The fine acceleration/deceleration function (bell-shaped) is supported in the following:

Series 9066/D(04) and subsequent editions (Series 20, 21, Power Mate)
Series 9080/D(05) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

The cutting/rapid traverse-specific fine acceleration/deceleration function is supported in the following:

Series 9080/P(16) and subsequent editions (Series 16-C, 18-C)
Series 9090/F(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*)

The fine acceleration/deceleration function (linear type) is supported in the following:

Series 9080/K(11) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/E(05) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

NOTE
With Series 9066, the fine acceleration/deceleration function, used separately for cutting and rapid traverse, and the linear fine accelration/deceleration funcion cannot be used. (Future support of these functions is not scheduled.)

(4) Setting basic parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1951	–		FAD						
2007	–								

FAD 1: Enables the fine acceleration/deceleration function.

NOTE
To enable this bit setting, the power must be turned off then back on.

		#7	#6	#5	#4	#3	#2	#1	#0
1749	–						FADL		
2209	–								

FADL 0: FAD bell-shaped
1: FAD linear type

NOTE
To enable this bit setting, the power must be turned off then back on.

1702	–	Fine acceleration/deceleration time constant (ms)
2109	–	

[Valid data range] 8 to 64 (Standard setting: 40)

A value exceeding the valid data range is clamped to the upper or lower limit of the range.

When the fine acceleration/deceleration and feed-forward functions are used together, set the coefficient in the following parameter.

(The parameter No. is the same as that used for advanced preview control.)

1985	–	Position feed-forward coefficient (in units of 0.01%)
2092	–	

[Valid data range] 100 to 10000

NOTE

- Feed-forward control is enabled by setting bit 1 of No. 1883 (Series 15) or No. 2005 (Series 16) to 1.
- The velocity feed-forward coefficient is set in parameter No. 1962 (Series 15) or No. 2069 (Series 16) which is the same parameter as that used for normal operation.
- Generally, the fine acceleration/deceleration function is enabled in cutting mode only.
- If No. 1800 #3 = 1, the FAD function is enabled both for cutting and rapid traverse mode.

(Reference)

Using the linear type and bell-shaped type effectively

The linear time constant and bell-shaped time constant have the following features:

Linear type:

In rapid traverse, this time constant is used with the CNC rapid traverse linear time constant. When feed-forward is applied to perform high-speed positioning, the linear type requires a shorter operation time and a smaller torque than the bell-shaped type if the acceleration/deceleration period is the same.

Bell-shaped:

Stress and strain caused by acceleration/deceleration can be reduced more effectively than with the linear type.

Therefore, use the linear type and bell-shaped type as follows:

<1> To enable fine acceleration/deceleration, basically use the linear type function.

<2> Only when the linear type cannot completely eliminate shocks, use the bell-shaped type to moderate them.

(5) Setting parameters for the fine acceleration/deceleration function, used separately for cutting and rapid traverse

As mentioned above, set the fine acceleration/deceleration function bit and the bit for selecting the bell-shaped or linear type.
Then, set the following:

		#7	#6	#5	#4	#3	#2	#1	#0
1800 (Series 15*i*)	–					FFR			
1800	–								

FFR 1: Enables feed-forward in rapid traverse also.

		#7	#6	#5	#4	#3	#2	#1	#0
1742 (Series 15*i*)	–								FAG0
2202	–								

FAG0 1: Enables the fine acceleration/deceleration function, used separately for cutting and rapid traverse.

> **NOTE**
> To enable this bit setting, the power must be turned off then back on.

In cutting mode, the following parameters are used:

1766 (Series 15*i*)	–	**Fine acceleration/deceleration time constant 2 (ms)**
2143	–	

[Valid data range] 8 to 64
A value that falls outside this range, if specified, is clamped to the upper or lower limit.

1767 (Series 15*i*)	–	**Position feed-forward coefficient for cutting (in units of 0.01%)**
2144	–	

1768 (Series 15*i*)	–	**Velocity feed-forward coefficient for cutting (%)**
2145	–	

In rapid traverse mode, the following parameters are used:

1702 (Series 15*i*)	–	**Fine acceleration/deceleration time constant (ms)**
2109	–	

[Valid data range] 8 to 64
A value that falls outside this range, if specified, is clamped to the upper or lower limit.

1985 (Series 15*i*)	**–**	**Position feed-forward coefficient for rapid traverse (in units of 0.01%)**
2092	**–**	

1962 (Series 15*i*)	**–**	**Velocity feed forward coefficient for rapid traverse (%)**
2069	**–**	

NOTE

When FAD, used separately for cutting and rapid traverse, is applied to axes under simple synchronous control, set the function bit for both the master and slave axes. When the function is enabled for the master axis only, switching between cutting and rapid traverse modes cannot be performed.

NOTE

1 When the cutting/rapid traverse-specific acceleration/deceleration switch function is used, the system software must support this function. The following lists the supporting software as of April, 1999. (The function cannot be used in any other CNC.)
Series 16-MC B0B1/E and subsequent editions
Series 16-TC B1B1/C and subsequent editions
Series 18-MC BDB1/C and subsequent editions
Series 18-TC BEB1/C and subsequent editions
All editions for Series 15*i*, 16*i*, 18*i*, 21*i*
* (The function cannot be used in the Series 15-B.)

2 Chopping axes cannot be switched between cutting mode and rapid traverse mode. Therefore, even when the bit for FAD, used separately for cutting and rapid traverse, is set for a chopping axis, the parameters for rapid traverse are always used.

3 In the same way as for the chopping axes, PMC-controlled axes cannot be switched betwween cutting and rapid traverse modes.

Table 4.8.3 Feed-forward coefficient and fine acceleration/deceleration time constant parameters classified by use

Series 16, 18

	Parameter setting				Parameters for cutting			Parameters for rapid traverse		
	No. 2005 #1	No. 2007 #6	No. 1800 #3	No. 2202 #0	Position FF coefficient	Velocity FF coefficient	FAD time constant	Position FF coefficient	Velocity FF coefficient	FAD time constant
Cutting FF	1	0	0	0	No. 2068 No. 2092	No. 2069	–	–	–	–
Usual FF	1	0	1	0	No. 2068 No. 2092	No. 2069	–	No. 2068 No. 2092	No. 2069	–
Cutting FAD	0	1	0	0	–	–	No. 2109	–	–	–
Cutting/rapid traverse-specific FAD	0	1	1	1	–	–	No. 2143	–	–	No. 2109
Cutting FAD + cutting FF	1	1	0	0	No. 2092	No. 2069	No. 2109	–	–	–
Cutting FAD + usual FF	1	1	1	0	No. 2092	No. 2069	No. 2109	No. 2092	No. 2069	–
Cutting/rapid traverse-specific FAD + cutting/rapid traverse-specific FF	1	1	1	1	No. 2144	No. 2145	No. 2143	No. 2092	No. 2069	No. 2109

Series 15*i*

	Parameter setting				Parameters for cutting			Parameters for rapid traverse		
	No. 1883 #1	No. 1951 #6	No. 1800 #3	No. 1742 #0	Position FF coefficient	Velocity FF coefficient	FAD time constant	Position FF coefficient	Velocity FF coefficient	FAD time constant
Cutting FF	1	0	0	0	No. 1961 No. 1985	No. 1962	–	–	–	–
Usual FF	1	0	1	0	No. 1961 No. 1985	No. 1962	–	No. 1961 No. 1985	No. 1962	–
Cutting FAD	0	1	0	0	–	–	No. 1702	–	–	–
Cutting/rapid traverse-specific FAD	0	1	1	1	–	–	No. 1766	–	–	No. 1702
Cutting FAD + cutting FF	1	1	0	0	No. 1985	No. 1962	No. 1702	–	–	–
Cutting FAD + usual FF	1	1	1	0	No. 1985	No. 1962	No. 1702	No. 1985	No. 1962	–
Cutting/rapid traverse-specific FAD + cutting/rapid traverse-specific FF	1	1	1	1	No. 1767	No. 1768	No. 1766	No. 1985	No. 1962	No. 1702

NOTE

1 In the above tables, the abbreviations "FF" and "FAD" refer to the feed-forward function and fine acceleration/deceleration function, respectively.

2 Of two parameter numbers stacked one on the other in each field of the above tables, the upper one is used in non-advance mode, and the lower one, in advance mode.

(6) Cautions for combined use of fine acceleration/deceleration and rigid tapping

(a) Overview

Because using fine acceleration/deceleration causes the servo axis delay (error) to increase by 1 ms, rigid tapping with fine acceleration/deceleration set up results in an increase of synchronization error against the spindle. To avoid this increase, use the following procedure to change the servo axis position gain for rigid tapping.

> **NOTE**
> In advanced preview control mode, rigid tapping cannot be used together with fine acceleration/deceleration. In this case, disable fine acceleration/deceleration.

(b) Setup procedure

For the Series 16, 18, and 21, use either of the following two methods (A and B); do not perform both at a time.

For the Series 15-B and 15*i*, it is impossible to specify different rigid tapping position gains between the servo axis and spindle. Therefore, only method B can be used for the Series 15-B and 15*i*.

A. Method for changing the rigid tapping servo position loop gain

The Series 16, 18, and 21 have the following two different parameter types for position gain setting.

a. Nos. 4065 to 4068: Spindle servo mode position gain
b. Nos. 5280 to 5284: Rigid tapping position loop gain

Parameter type "a" corresponds to the spindle position loop gain for rigid tapping, and parameter type b, to the servo axis position loop gain. Usually, both parameter types take the same values. For a servo axis with fine acceleration/deceleration specified, however, set parameter type b with the values obtained using the following calculation:

$$\left(\text{Newly set position gain value}\right) = \frac{100000}{100000 - \left(\text{Usually set position gain value}\right)} \times \left(\text{Usually set position gain value}\right)$$

Example of parameter setting)

Position gain (1/s)	Usually set value	Newly set value
15	1500	1523
16.66	1666	1694
20	2000	2041
25	2500	2564
30	3000	3093
33.33	3333	3448
35	2500	3627
40	4000	4167
45	4500	4712
50	5000	5263

B. Method for internally changing the servo axis position gain

An additional function is available, which enables internal automatic modification of only the servo axis position gain for synchronization.

(Series and editions of applicable servo software)

Series 9080/N(15) and subsequent editions (Series 15-B, 16-C, 18-C)

Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*)

(Parameter)

		#7	#6	#5	#4	#3	#2	#1	#0
1749	–					FADPGC			
2209	–								

FADPGC (#3) Specifies whether to perform synchronization in rigid tapping mode when FAD is set up, as follows:

1: <u>To perform ← To be set</u>

0: Not to perform

NOTE

After setting this bit, switch the power off and on again.

NOTE

1 If this parameter is set, the servo position gain increases by 1 ms even when rigid tapping is not used.

2 It is necessary to set this parameter for all axes that are subjected to contouring.

NOTE

The following limitations are imposed on the combined use of synchronization with the spindle motor and fine acceleration/deceleration.
(Disable the fine acceleration/deceleration function if the combine use is impossible.)

Function	Combined use with FAD function	Cautions for combined use
Rigid tapping	Allowed	The rigid tapping position gain must be changed (as described earlier).
Advanced preview control rigid tapping	Not allowed	Disable the FAD function.
Cs axis contour control	Not allowed	Disable the FAD function.
Hob function	Not allowed	Disable the FAD function.
EGB function	Not allowed	Disable the FAD function.
Flexible synchronization (between servo axes)	Allowed	The same FAD time constant must be used for both axes to be synchronized with each other.
Flexible synchronization (between servo axis and Cs axis)	Not allowed	Disable the FAD function.

(7) Other specifications to note regarding the fine acceleration/deceleration function

- Advanced preview control and fine acceleration/deceleration can be used together. (The time constants before and after advanced preview interpolation, and the fine acceleration/deceleration time constant are effective.)
- If FAD is set, then the G05 P10000 command is issued with HPCC, FAD is disabled.
- When the G05 P10000 command is issued with Series 9066, the FAD function must be disabled.
- Using the FAD function increases the positional deviation as follows:

$$\text{Deviation incerase (pulses)} = \frac{\text{Feedrate (mm/min)}}{60 \times 1000 \times \text{Detection unit (mm)}} \times \left(\frac{\text{FAD time constant (ms)}}{2} + 1 \right)$$

Example)

When feed operation is performed using F1800 with a position gain of 30 (1/s) and a detection unit of 0.001 mm, the positional deviation is normally expressed as follows:

$$\text{Normal deviation (pulses)} = \frac{\text{Feedrate (mm/min)}}{60 \times \text{Position gain (1/s)} \times \text{Detection unit (mm)}}$$

$$= \frac{1800}{60 \times 30 \times 0.001} \times 1000 \text{ (pulses)}$$

When the FAD function is used with the time constant set to 64 ms, the deviation increases as follows:

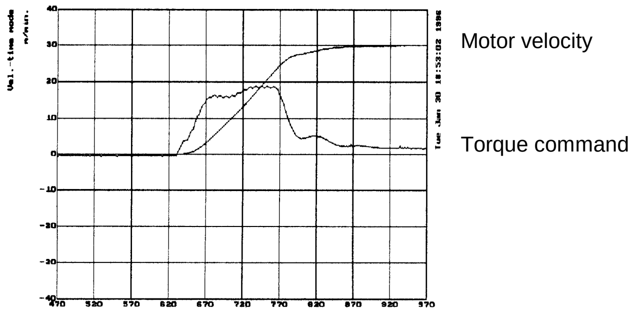
$$\text{Deviation increase (pulses)} = \frac{1800}{60 \times 1000 \times 0.001} \times \left(\frac{64}{2} + 1\right) = 990 \text{ (pulses)}$$

When FAD is used, the entire deviation is then obtained as follows:

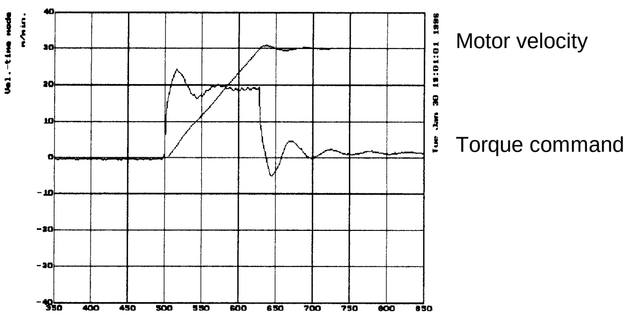
Deviation when FAD is used (pulses) = 1000 + 990
= 1990 (pulses)

The combined use of the FAD function and the feed-forward function does not increase the positional deviation so much as expected, because the feed-forward function decreases a delay against the command. When the FAD function is used alone, however, a higher error overestimation level must be set, considering the increase in the deviation.

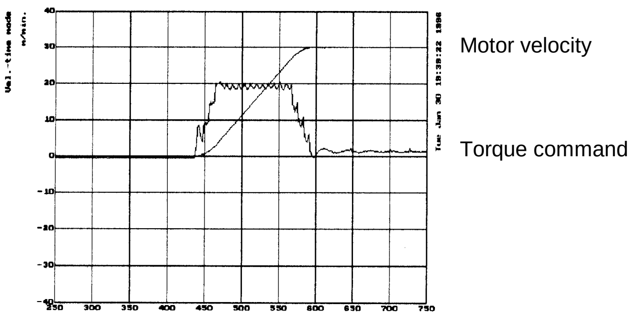
(8) Examples of applying the fine acceleration/deceleration function



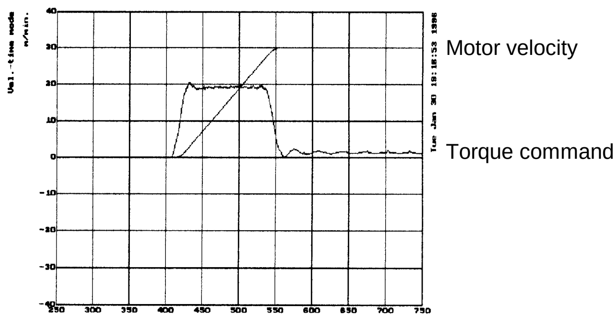
Conventional control in which the feed-forward function is not used



When the feed-forward function is used



When the feed-forward and rapid traverse bell-shaped acceleration/deceleration (acceleration/deceleration by the CNC) functions are used



When the feed-forward and fine acceleration/ deceleration functions are used

4.9 DUMMY SERIAL FEEDBACK FUNCTIONS

4.9.1 Dummy Serial Feedback Functions

(1) Overview

The functions described below are intended to ignore a servo alarm for axes not connected to a servo control circuit.

(2) Setting the built-in pulse coder-based dummy feedback function

Setting the function bit shown below enables ignoring of alarms related to the servo amplifier and built-in pulse coder for an axis not connected to a servo control circuit.

		#7	#6	#5	#4	#3	#2	#1	#0
1953	8X09								SERD
2009	1009								

SERD (#0) Specifies whether to enable the dummy serial feedback function as follows:

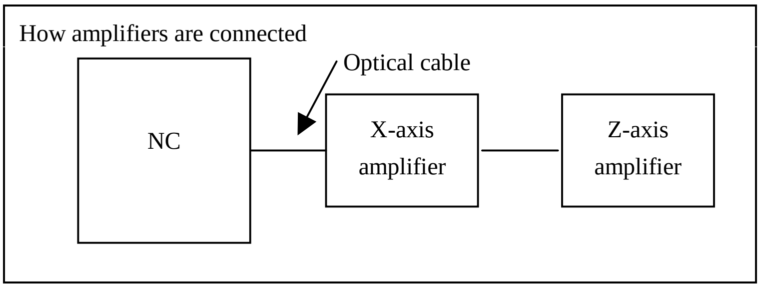
1: To enable

0: To disable

Supplement 1 Handling of dummy axes in the *i* series

Usually in the *i* series, the number of amplifiers must match that of axes. When this condition is satisfied, there is no problem with use of the dummy serial feedback function bit for making an axis as a dummy.
If an axis with no amplifier is set as a dummy, however, an alarm meaning "amplifiers are in short supply" may be issued.
Setting up such a dummy axis needs the following software:
[System software]
(Series 16*i*)
Series B0F1/15 and subsequent editions (M series)
Series B1F1/14 and subsequent editions (T series)
(Series 18*i*)
Series BDF1/15 and subsequent editions (M series)
Series BEF1/14 and subsequent editions (T series)
(Series 21*i*)
Series DDF1/9 and subsequent editions (M series)
Series DEF1/9 and subsequent editions (T series)
[Servo software]
Series 90A0/D(04) and subsequent editions

Example When there are only two amplifiers for a 3-axis NC



Let us consider how to make the Y-axis (second axis) a dummy axis in the above configuration.
Set up the parameters as follows:

No. 1023 X:1 Y:2 Z:3
No. 1902 bit 1 = 0, bit 0 = 1
No. 1905 bit 0 X:0 Y:0 Z:0
No. 1910 0
No. 1911 2
No. 1912 1
No. 2009 bit 0 Y:1

NOTE) For detailed descriptions about FSSB-related setting, refer to the respective CNC parameter manuals.

Supplement 2 V-READY ON alarm

Using the dummy serial feedback function in a system of the following editions or earlier results in an amplifier preparation completion signal being detected by error.

Series 9041/A(01) (Series 0-C, 15-A)
Series 9046/C(03) (Series 0-C, 15-A)
Series 9060/P(16) (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9070/D(04) (Series 15-B, 16-B, 18-B)

As a result, the following alarms are issued.

404 VRDY ON (Series 0-C, 16, 18, 20, 21, Power Mate)
SV014 IMPROPER V-READY ON (Series 15)

In this case, make the following setting. The above servo alarms will be ignored.

[Series 0-C]

	#7	#6	#5	#4	#3	#2	#1	#0
0010						OFFVY		

OFFVY (#2) Specifies whether to issue a servo alarm if the VRDY is on before the PRDY is output, as follows:

0: To issue
1: Not to issue ← To be set

[Other than Series 0-C]

	#7	#6	#5	#4	#3	#2	#1	#0
1800							CVR	

CVR (#1) Specifies whether to issue a servo alarm if the VRDY is on before the PRDY is output, as follows:

0: To issue

1: Not to issue ← To be set

(3) Separate detector-based dummy feedback

The separate detector-based dummy feedback function is intended to ignore alarms for an axis when the separate detector has been disconnected from the axis temporarily. Set the following bit.

		#7	#6	#5	#4	#3	#2	#1	#0
1745	–						FDMY		
2205	–								

FDMY (#2) Specifies whether to enable the separate detector-based dummy feedback function as follows:

1: To enable

0: To disable

NOTE

1 This function is supported by the following servo software:
Series 9080/N(14) and subsequent editions
Series 9090/D(04) and subsequent editions
Series 90A0/A(01) and subsequent editions

2 The relationships of this function with the built-in pulse coder-based dummy serial feedback function are as follows:
When only the built-in pulse coder-based dummy serial feedback function is enabled:
Alarms related to the built-in pulse coder and amplifier are ignored.
When only the separate detector-based dummy feed-back function is enabled:
Alarms related to the separate detector are ignored.
When both the functions are enabled:
Alarms related to the built-in pulse coder, separate detector, and amplifier are ignored.

4.9.2 How to Use the Dummy Feedback Functions for a Multiaxis Servo Amplifiers When an Axis Is Not in Use

If an axis connected to a multiaxis amplifier is not in use, it is necessary to set the dummy function bit described in Subsec. 4.9.1 and connect a dummy connector to the amplifier.
The dummy connector must be set up differently depending on the type of the amplifier as listed below.

Amplifier type	Information about dummy connector	Location
Type A interface amplifier	Jumper between pins 8 and 10.	JVx
Type B interface amplifier	Jumper between pins 8 and 10.	JSx
FSSB interface amplifier	Jumper between pins 11 and 12.	JFx

4.10 BRAKE CONTROL FUNCTION

(1) Overview

This function prevents the tool from dropping vertically when a servo alarm or emergency stop occurs. The function prevents the motor from being immediately deactivated, instead keeping the motor activated for the period specified in the corresponding parameter, until the mechanical brake is fully applied.

(2) Hardware configuration

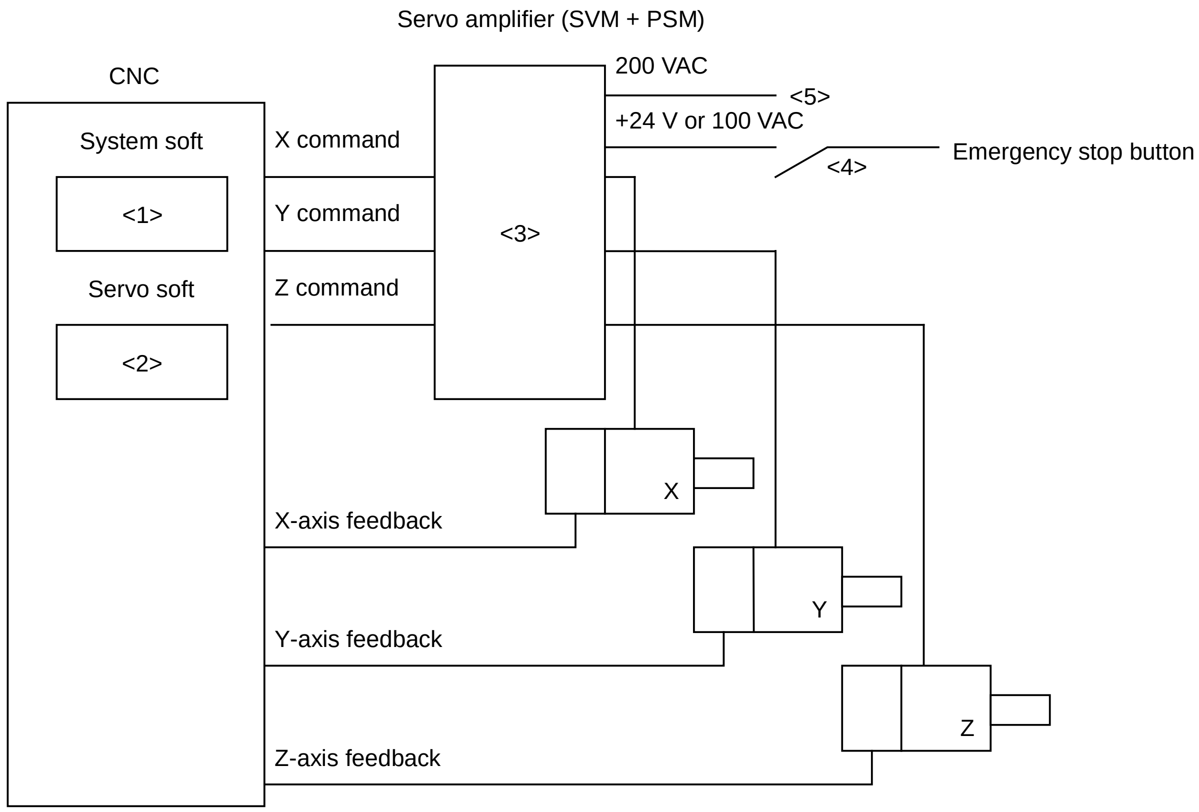


Fig. 4.10 (a) Example of configuration

The numbers of the following descriptions correspond to those in the figure:

<1> Applicable system soft
Any system soft can be used.

<2> Applicable servo soft
Any servo soft can be used.

<3> Servo amplifier
Use a single-axis servo amplifier (SVM1 or single-axis SVU, SVUC, or C-series amplifier for an axis) to which the brake control function is applied. See NOTE below.
For an axis to which the brake control function is not applied, any servo amplifier can be used.

NOTE

When brake control is applied for a two-, or three-axis amplifier, set the brake contrrol parameters for all the axes to be controlled. If an alarm is generated for any of the axes connected to the two- or three-axis amplifier, brake control does not operate effectively.

<4> Emergency stop button

(α servo system)

If the +24 V supply to PSM is cut, the brake control function cannot operate.

To maintain the +24 V supply longer than the brake control function is applied, connect a timer to the emergency stop button and the +24 V contact signal.

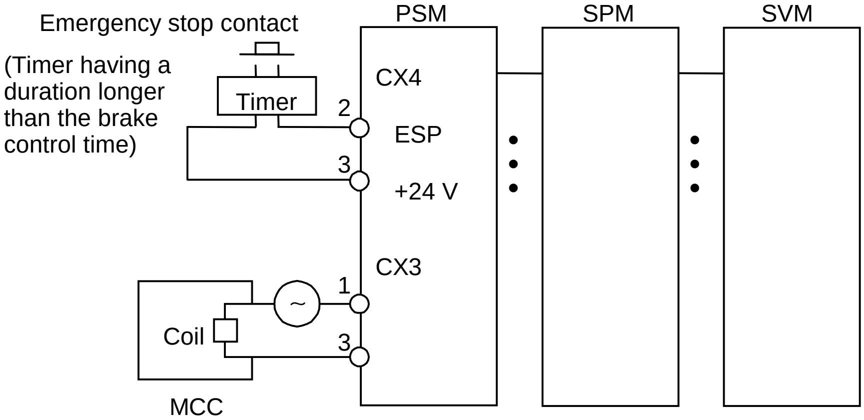


Fig. 4.10 (b) α series amplifier

(C-series amplifier)
If the 100 VAC supply to the servo amplifier is cut, the brake control function cannot operate.
To maintain the 100-VAC supply longer than the brake control function is applied, connect a timer to the emergency stop button and the 100-VAC contact signal.

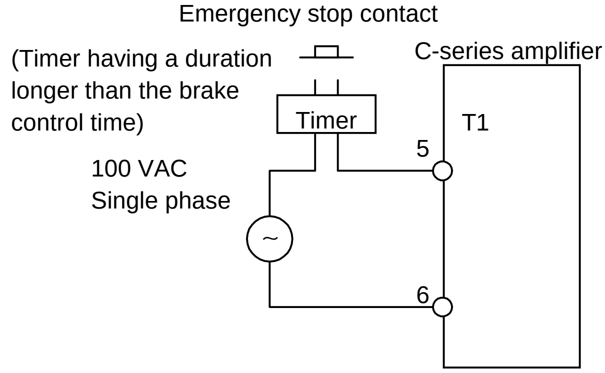


Fig. 4.10 (c) C-series amplifier

<5> 200 VAC
If the 200 VAC supply to the servo amplifier is cut, the brake control function cannot operate. Generally, the servo amplifier's 200-VAC supply is cut when the NC is turned off. The brake control function cannot be enabled.
To cause the brake control function to work effectively even at a power break, apply the power brake machine protection function.

(3) Setting parameters

<1> Brake control function enable/disable bit

		#7	#6	#5	#4	#3	#2	#1	#0
1883	8X05		BRKC						
2005	–								

BRKC (#6) 1: The brake control function is enabled.

<2> Activation delay

1976	8X83	Brake control timer
2083	–	

[Increment system] msec
[Valid data range] 0 to 16000
(Example)
To specify an activation delay of 200 ms, set the brake control timer usually with 200 (appropriately). Do not set it with 500 or greater. Also set the timer connected to the emergency stop contact with the same value as set in the parameter.

(4) Detailed operation

Suppose that there is a machine (with the FANUC CNC) having horizontal and vertical axes of motion. When a servo alarm(*) occurs on the horizontal axis but no error occurs on the vertical axis, the MCCs of the amplifiers for all axes are turned off. When the emergency stop button is pressed, the MCCs of the amplifiers for all axes are turned off.
Standard machines have a mechanical brake that prevents the tool from dropping vertically in such cases. The mechanical brake may actually function according to the timing shown in Fig. 4.10 (d). If this occurs, the tool will drop vertically, causing the tool or workpiece to be damaged.

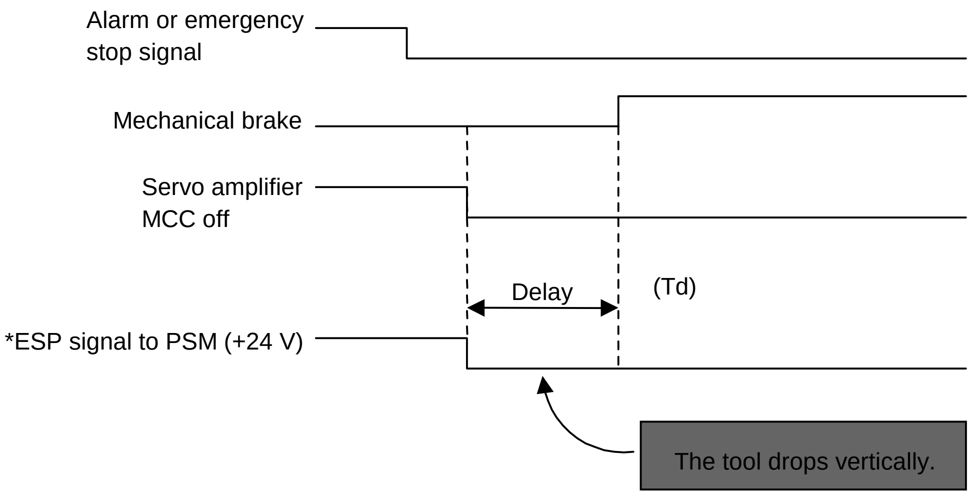


Fig. 4.10 (d)

This function changes the timing to force MCC off, using a software timer, thus preventing the tool from dropping. Fig. 4.10 (e) shows the timing diagram.

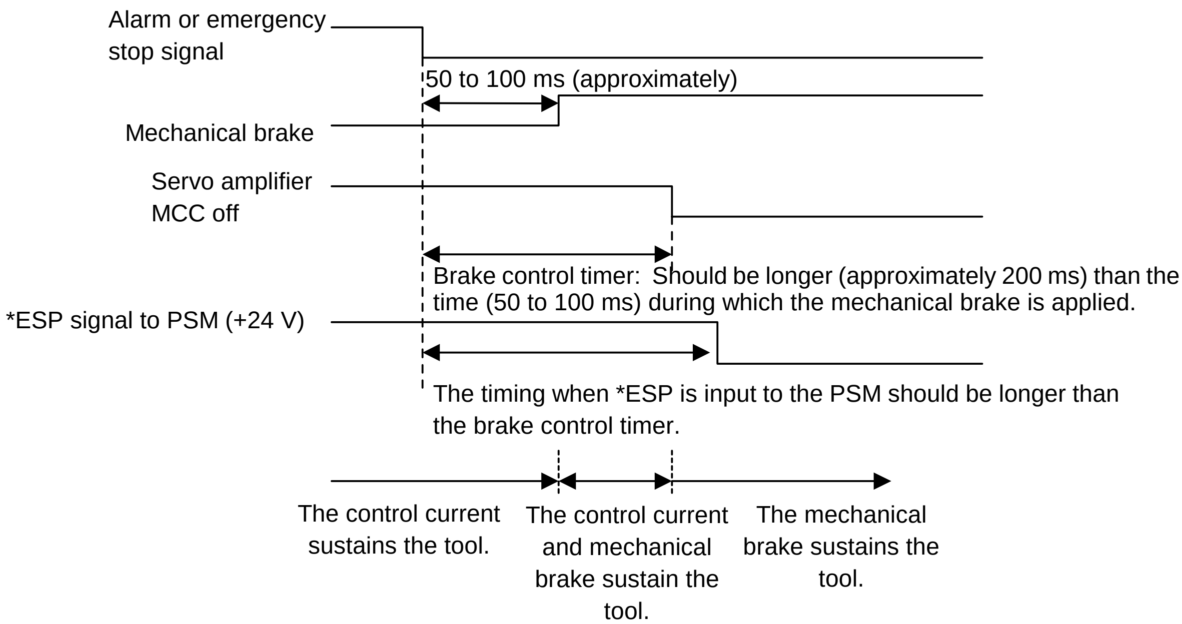


Fig. 4.10 (e)

> **NOTE**
>
> (*) The servo alarm mentioned in the above description refers to a servo alarm detected by the software (OVC alarm, motor overheat alarm, software disconnection alarm, etc.), an alarm detected by the servo amplifier, or a servo alarm detected by the CNC (excessive error).
> If a servo alarm occurs on the axis using this function, no brake control is performed on the axis (except for a motor overheat alarm).

4.11 STOP DISTANCE REDUCTION FUNCTION

The functions described below prevent the tool from colliding with the machine or workpiece by reducing the distance required for the motor to come to a stop if a usual emergency stop condition occurs or if a separate detector disconnection alarm, overheat alarm, or OVC alarm is issued.

4.11.1 Emergency Stop Distance Reduction Function Type 1

(1) Overview

This function reduces the stop distance by resetting the velocity command for a servo motor to 0 at a position where an emergency stop signal is detected for the servo motor.

(2) Series and editions of applicable servo software

Series 9041/A(01) and subsequent editions (Series 0-C, 15-A)
Series 9046/B(02) and subsequent editions (Series 0-C, 15-A)
Series 9060/L(12) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9066/A(01) and subsequent editions (Series 20, 21, Power Mate)
Series 9070/C(03) and subsequent editions (Series 15-B, 16-B, 18-B)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/A(01) and subsequent editions (Series 16*i*, 18*i*, 21*i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*)

(3) Setting parameters

[Parameter setting for <u>other than</u> the Series 904x (Series 15-B, 15*i*, 16, 18, 21)]

		#7	#6	#5	#4	#3	#2	#1	#0
1959	–								DBST
2017	–								

DBST (#0) Specifies whether to enable emergency stop distance reduction function type 1 as follows:
1: To enable
0: To disable

[Parameter setting for the Series 9046 and 9041 (Series 0-C, 15-A)]

		#7	#6	#5	#4	#3	#2	#1	#0
1884	8X06							DBST	
–	–								

DBST (#1) Specifies whether to enable emergency stop distance reduction function type 1 as follows:
1: To enable
0: To disable

To use the emergency stop distance reduction function, enable the brake control function for all axes.

(Brake control function)

		#7	#6	#5	#4	#3	#2	#1	#0
1883	8X05		BRKC						
2005	–								

BRKC (#6) Specifies whether to enable brake control function as follows:
1: To enable
0: To disable

1976	8X83	Brake control timer
2083	–	

[Increment system] ms
[Setting value] 50

(4) Timing diagram

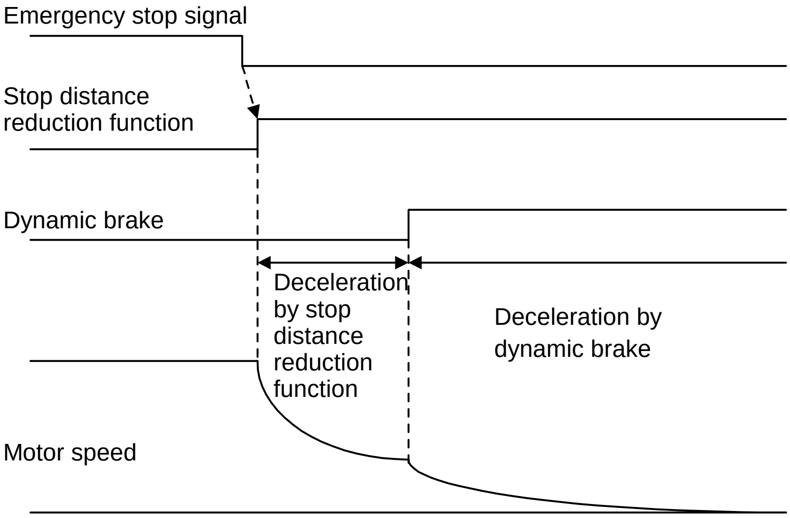


Fig. 4.11.1 (a) Timing diagram of stop distance reduction function

(5) Connecting an amplifier

<1> α series amplifier

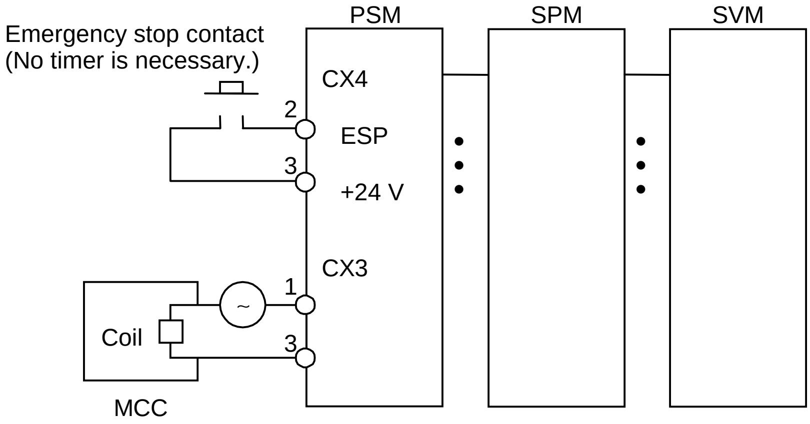


Fig. 4.11.1 (b) α series amplifier

<2> C-series amplifier

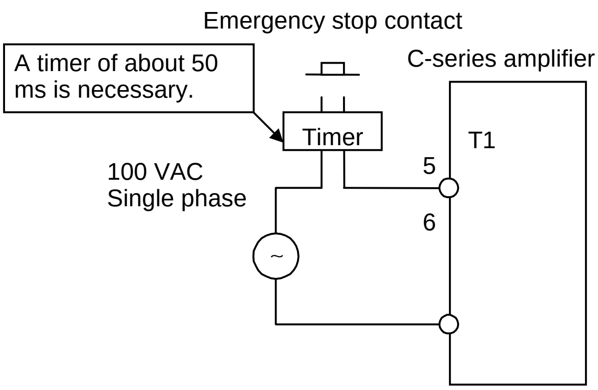
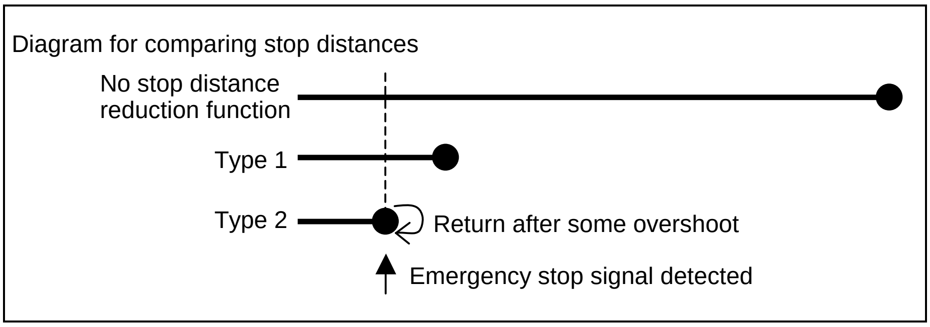


Fig. 4.11.1 (c) C-series amplifier

4.11.2 Emergency Stop Distance Reduction Function Type 2

(1) Overview

This function returns a servo motor to a position where an emergency stop signal is detected for the servo motor, thereby assuring a shorter stop distance than with emergency stop distance reduction function type 1.
Combining the function with a power-break machine protection function that uses a power-break backup module makes effective use of it.



(2) Series and editions of applicable servo software

Series 9080/Y(25) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/L(12) and subsequent editions (Series 16*i*, 18*i*, 21*i*)
Series 90A0/I(09) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*)

(3) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1744	–	DBS2							
2204	–								

DBS2 (#7) Specifies whether to enable emergency stop distance reduction function type 2 as follows:
1: To enable
0: To disable

NOTE 1
1. Like type 1, type 2 requires that the brake control parameter be set.
2. The method of connecting the amplifier for type 2 is the same as for type 1.
3. If both type 1 and type 2 function bits are set, type 2 function is assumed.

NOTE 2

To reduce the stop distance at a power break, make the following preparations:

1. Connect a power break backup module.
2. Connect a 200 ms (approximate) timer to the *ESP signal line of the PSM.
3. Enable this function.
4. Set the brake control timer with 200 ms.

4.11.3 Separate Detector Hardware Disconnection Stop Distance Reduction Function

(1) Overview

This function reduces the stop distance by resetting the velocity command for a servo motor to 0 when the separate detector for the servo motor encounters a hardware disconnection condition. It also causes the other axes to stop sooner than they would when a usual alarm occurs.

(2) Series and editions of applicable servo software

Series 9080/O(15) and subsequent editions (Series 16-C, 18-C)
Series 9090/F(06) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/I(09) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Series and editions of applicable system software

[Series 15*i*]
All series/all editions
[Series 16-C]
Series B0B1/edition 16 (M series)
Series B1B1/edition 13 (T series)
[Series 18-C]
Series BDB1/edition 14 (M series)
Series BEB1/edition 14 (T series)
[Series 16*i*]
Series B0F1/edition 05 (M series)
Series B1F1/edition 05 (T series)
[Series 18*i*]
Series BDF1/edition 05 (M series)
Series BEF1/edition 05 (T series)
[Series 21*i*]
Series DDF1/edition 04 (M series)
Series DEF1/edition 04 (T series)

If this function is used with other system software, a separate detector disconnection alarm and an "abnormal-load detection alarm" occur simultaneously. (For the Series 15-B, this phenomenon occurs in all editions.)

(4) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1745	–			HD2O	HDIS				
2205	–								

HDIS (#4) Specifies whether to enable separate detector hardware disconnection stop distance reduction function as follows:
1: To enable
0: To disable

HD2O (#5) Specifies whether to apply the separate detector hardware disconnection stop distance reduction function to axes subjected to synchronization control, as follows:
1: To apply
0: Not to apply

NOTE 1

When applying this function to axes under synchronization control (including simplified synchronization), follow the steps below:

1 Change the servo axis setting (No. 1023) for two axes subjected to simplified synchronization so that the two axes can be controlled on 1DSP.
2 Set HD2O (bit 5) to 1 for both axes under synchronization control.

NOTE 2

1. This function is implemented using part of the "abnormal-load detection function" option. So, using it requires that option.
2. Usually, when a separate detector disconnection alarm occurs for an axis, not only this axis but also the others are brought to an emergency stop. If an abnormal-load detection group function (not supported in the Series 15) is set up, however, only the axes in the same group as the axis for which an alarm condition has occurred are brought to an emergency stop.
3. If the value (No. 1738 for the Series 15 or No. 1880 for the Series 16 and others) specified as an interval between the detection of an abnormal load and the occurrence of an emergency stop is small, it may impossible to keep the sufficient stop time. The value should be at least greater than or equal to the one specified in the brake control timer parameter (there is no problem with a setting value of 0, because it means 200 ms).

4.11.4 OVL and OVC Alarm Stop Distance Reduction Function

(1) Overview

This function reduces the stop distance for a servo motor when an OVL (motor overheat or amplifier overheat) or OVC alarm condition is detected for the servo motor. It also causes the other axes to stop sooner than they would when a usual alarm occurs.

(2) Series and editions of applicable servo software

Series 9080/Y(25) and subsequent editions (Series 16-C, 18-C)
Series 90A0/I(09) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*)

(3) Series and editions of applicable system software

Completely same as those described in (3) in Subsec. 4.11.3.
If this function is specified in any system software that does not support it, not only the OVC or OVL alarm condition but also an "abnormal-load detection alarm" condition occurs simultaneously.

(4) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
2600	–	OVQK							
2212	–								

OVQK (#7) Specifies whether to enable OVL and OVC alarm stop distance reduction function as follows:
1: To enable
0: To disable

> **NOTE**
> 1 When using this function, you need not be ware of axes subjected to synchronization.
> 2 This function also is implemented using part of the "abnormal-load detection function" option. So, you should observe the cautions stated in NOTE 2 of Subsec. 4.11.3.

4.11.5 Overall Use of the Stop Distance Reduction Functions

To sum up, setting up the following parameters as stated can reduce the stop distance for an emergency stop, separate detector hardware disconnection, and OVL and OVC alarm occurrence.

<1> Specify the abnormal-load detection option.
<2> Specify emergency stop distance reduction function type 2.
<3> For full-closed loop axes, specify the separate detector hardware disconnection distance reduction function. Also if they are subjected to synchronization control, set the **HD2O** bit.
<4> Specify the OVL and OVC alarm stop distance reduction function.
<5> Set the brake control function bit and the brake control timer.

Optional function

4.12 ABNORMAL-LOAD DETECTION FUNCTION

4.12.1 Abnormal-load Detection Function

(1) Overview

When a tool collides with the machine or workpiece, or when a tool is faulty or damaged, a load torque greater than that experienced during normal feed is imposed.
This function monitors the load torque to the motor at servo high-speed sampling intervals. If it detects an abnormal torque, it brings the axis to an emergency stop by issuing an alarm, or reverses the motor by an appropriate amount.
In addition, the function enables the PMC to be used to switch the speed at warning occurrence or load fluctuation.

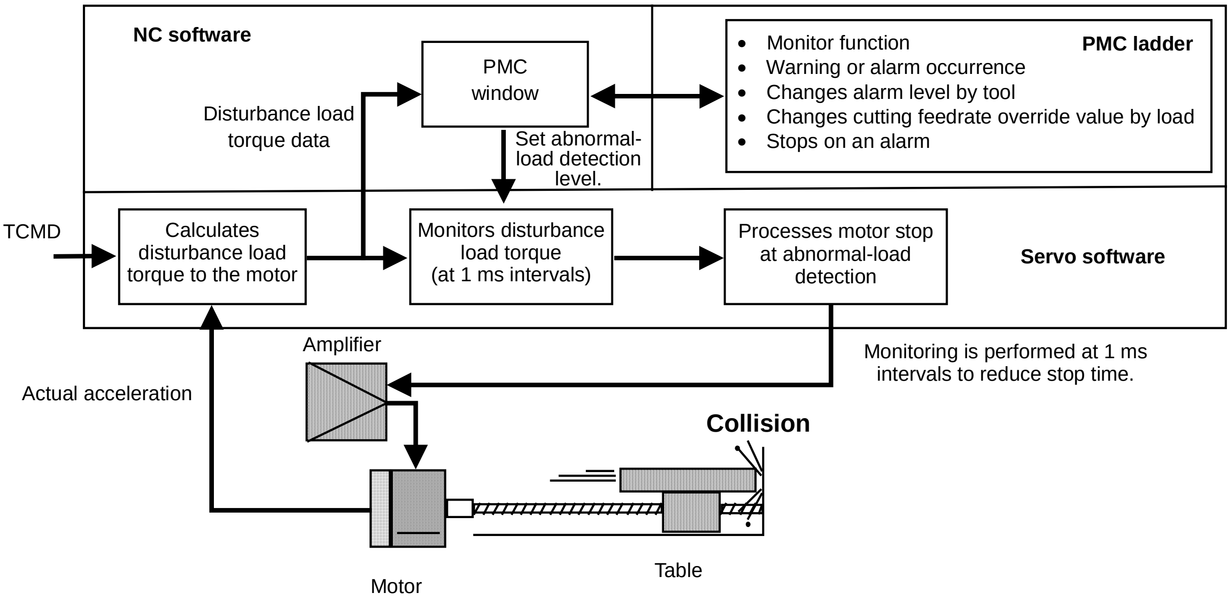


Fig. 4.12.1 Overview of abnormal-load detection

(2) Series and editions of applicable servo software

Series 9060/I(09) and subsequent editions (Series 15-B, 16-A, 18-A, 20, 21, Power Mate)
Series 9065/A(01) and subsequent editions (Power Mate-E)
Series 9066/G(07) and subsequent editions (Series 20, 21, Power Mate)
Series 9080/G(07) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/all editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/all editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Parameter adjustment methods

<1> Connect a check board to enable the motor velocity and torque command to be observed with an oscilloscope or personal computer.
The measurement channels of the check board should be as follows:
Digital and analog (for A06B-6057-H630): Channel 1
Digital (for A06B-6057-H620)
Odd-numbered axis specified in parameter No. 1023: DIP switch 0001
Even-numbered axis specified in parameter No. 1023: DIP switch 0011
Analog (for A06B-6057-H602)
Odd-numbered axis in parameter No. 1023: CH2
Even-numbered axis in parameter No. 1023: CH4
(See Sec. 4.19 for detailed descriptions about how to use the check board.)

<2> Switch on the NC.

<3> Enable the abnormal-load detection function.

		#7	#6	#5	#4	#3	#2	#1	#0
1958	–								ABNT
2016	1016								

ABNT (#0) Specifies whether to enable the abnormal-load detection function as follows:
1: To enable
0: To disable

<4> Also set the following parameter bit.

		#7	#6	#5	#4	#3	#2	#1	#0
1957	–			TDOU					
2015	1015								

TDOU (#5) Specifies whether to output an estimated disturbance value to the check board as follows:
1: To output an estimated disturbance value to the torque command output channel
0: The torque command output channel is used according to the standard specification.

Setting the above parameter causes an estimated disturbance value, rather than the torque command, to be output to the check board.

Moreover, **be sure to set** also the following parameters.

[For Series 9080, 9090, and 90A0]
(This function is supported in the Series 9080/G(07) and subsequent editions, Series 9090/C(03) and subsequent editions, and Series 90A0/A(01) and subsequent editions.)

		#7	#6	#5	#4	#3	#2	#1	#0
1740	–						IQOB		
2200	1200								

[For Series 9065 and 9066]
(This function is supported in the Series 9065/A(01) and subsequent editions, and Series 9066/G(07) and subsequent editions.)

		#7	#6	#5	#4	#3	#2	#1	#0
	–							IQOB	
2009	1009								

IQOB Specifies whether to eliminate influence of control voltage saturation when estimating disturbance, as follows:

1: To eliminate influence of control voltage saturation when estimating disturbance

0: Not to take influence of control voltage saturation when estimating disturbance into consideration

Set up the parameters related to the observer.

1862	–	Observer gain
2050	1050	

[Typical setting] 956 → To be changed to 3559.

1863	–	Observer gain
2051	1051	

[Typical setting] 510 → To be changed to 3329.

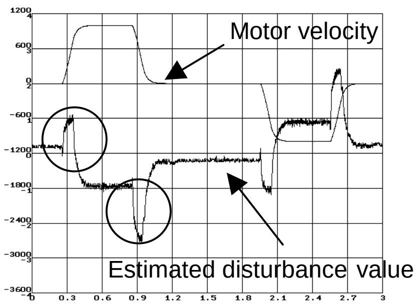
NOTE

When this function is used together with the observer (bit 2 of Nos. 1808, 2003, and 1003 = 1), keep them at the typical setting.
This setting delays the rising of the estimated disturbance value slightly, but it does not pose any problem in almost any case.

<5> Make adjustments on the **POA1** observer parameter.

Run the servo motor at a rapid traverse rate (abut 1000 rpm) linearly back and forth, and observe the motor velocity and estimated disturbance value.

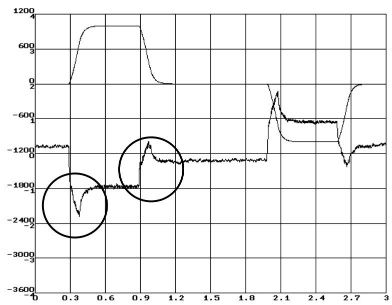
The waveforms observed before adjustment has either of the trends shown below:



Insufficient POA1 value

At acceleration: Undershoot on estimated disturbance value

At deceleration: Overshoot on estimated disturbance value



Excessive POA1 value

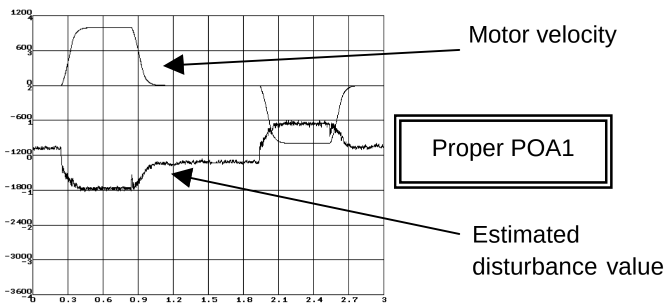
At acceleration: Overshoot on estimated disturbance value

At deceleration: Undershoot on estimated disturbance value

Make adjustments on the **POA1** parameter so that neither an overshoot nor an undershoot will not be observed on the estimated disturbance value at acceleration/deceleration. After adjustment, the waveforms shown below should be obtained.

(A clear waveform like the one shown below may not be obtained in some machines. In such machines, find the POA1 value that can minimize the overshoot and undershoot by watching the estimated disturbance waveform at acceleration/deceleration.)

1859	**–**	**Observer parameter (POA1)**
2047	**1047**	



(For those who want to know details)

The observer estimates a disturbance torque by subtracting the torque required for acceleration/deceleration from the entire torque. The torque required for acceleration/deceleration is calculated using a motor model. The POA1 parameter corresponds to the inertia of the motor model. If the parameter value differs from the actual value, it is impossible to estimate a correct disturbance torque. To detect an abnormal load correctly, therefore, you must adjust the value of this parameter.

An estimated disturbance value when a usual condition is supposed to be related only to frictional torque (for the horizontal axis), and proportional to the velocity. Therefore, a program, like the one used for adjustment, that merely repeats simple acceleration/deceleration is supposed to generate a trapezoidal estimated disturbance torque waveform like a velocity waveform.

NOTE

The POA1 parameter is related to the load inertia ratio parameter ("velocity gain" on the servo screen) through the inside of the software. When the load inertia ratio parameter is changed, the POA1 parameter must also be changed. So, first determine the load inertia ratio (velocity gain) when adjusting the servo.

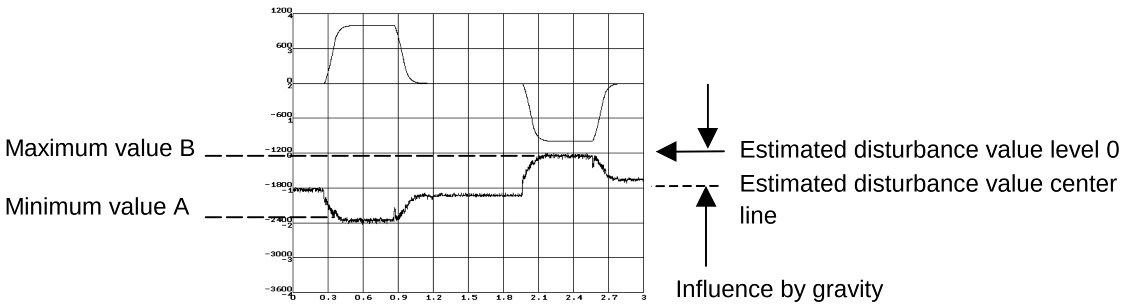
If you must change the load inertia ratio (velocity gain) after the POA1 parameter is determined, re-set the POA1 parameter using the following expression.

$$\text{(New POA1 value)} = \text{(Previous POA1 value)} \times \frac{\text{Load inertia ratio value set after adjustment} + 256}{\text{Load inertia ratio value set before adjustment} + 256}$$

$$= \text{(Previous POA1 value)} \times \frac{\text{Velocity gain set after adjustment (\%)}}{\text{Velocity gain set before adjustment (\%)}}$$

<6> For the vertical axis, adjust the torque offset. (This is unnecessary for the horizontal axis.)

For the vertical axis, the estimated disturbance value is not centered at level 0. Torque offset adjustment is done to center the estimated disturbance value at level 0.



1980	–	Torque offset parameter
2087	1087	

In the above example, the influence by gravity is about –1 (A). So, set the torque offset parameter as follows:

1. When the motor is running at a constant velocity, read the minimum and maximum estimated disturbance values.
2. Setting the minimum and maximum values as A (A) and B (A) (both are signed values), respectively, the parameter value can be obtained from the following expression (for digital).

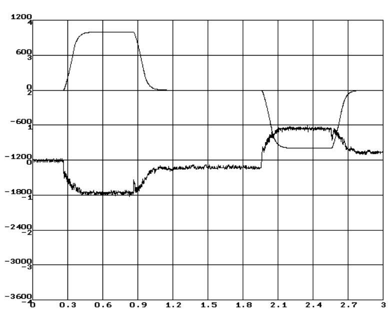
   Torque offset parameter = –(A + B)/(maximum amplifier current value) × 3641

   Let the minimum and maximum values be A(V) and B(V) (both with a sign), respectively, when measuring an estimated disturbance with the analog check board. The value to be set in the parameter is obtained using the following expression:

   Torque offset parameter = –(A + B) × 828

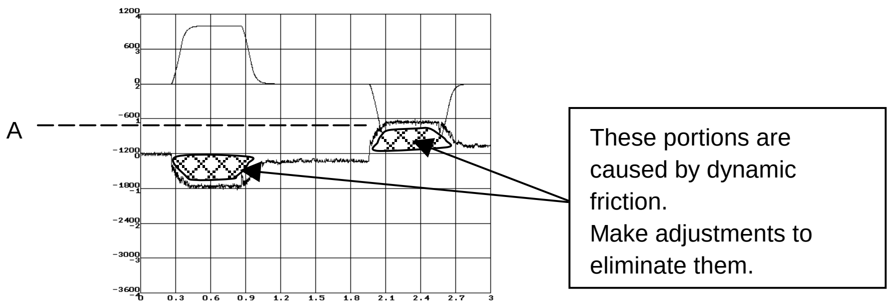
   Example)

   If you read the minimum and maximum values as –1.9 A and –0.1 A in the above chart (the amplifier used is rated at 40 A maximum), the torque offset parameter = –[(–1.9) + (–0.1)]/40 × 3641 = 182. The following chart applies when the parameter is set with 182.



<7> Compensate for dynamic friction.

The dynamic friction-caused component of the estimated disturbance value is nearly proportional to the velocity. Let us deduce a proportional multiplier from the dynamic friction component at 1000 rpm, and use it to cancel the dynamic friction component.



First, read the estimated disturbance value at a constant rotation speed of 1000 rpm. Set the dynamic friction compensation value parameter according to the read value.

1727	–	**Dynamic friction compensation value**
2116	1116	

This parameter is designed to be set directly with the value read using an analog check board. It can be set in 10 mV units.

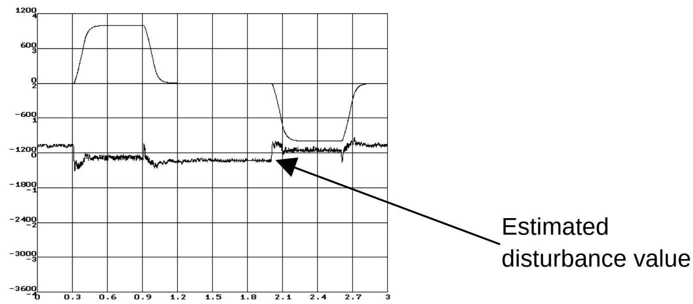
To set the parameter with a value read using a digital check board, convert it to analog form, using the following expression.

Letting the read value be A (Ap):

Dynamic friction compensation value

$= A/(\text{maximum amplifier current}) \times 440$

The estimated disturbance value after dynamic friction compensation appears as follows:



Example)

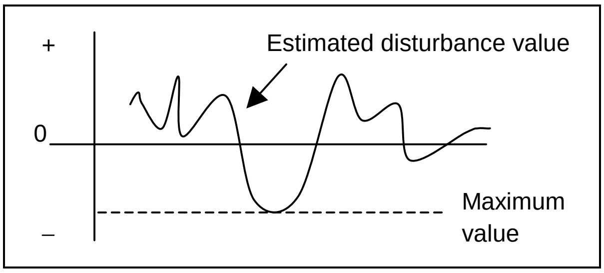
Assuming that the current at 1000 rpm be 1 A (the amplifier used is rated at 40 A maximum):

Dynamic friction compensation parameter

$= 1/40 \times 440 = 11$

In passing, the estimated disturbance value observed using the analog check board is supposed to be 110 mV.

<8> Set an abnormal-load detection alarm level.
Perform several different operations (sample machining program, simultaneous all-axis rapid traverse acceleration/deceleration, etc.), and observe estimated disturbance values, and measure the maximum (absolute) value.
Then, set up an alarm level.

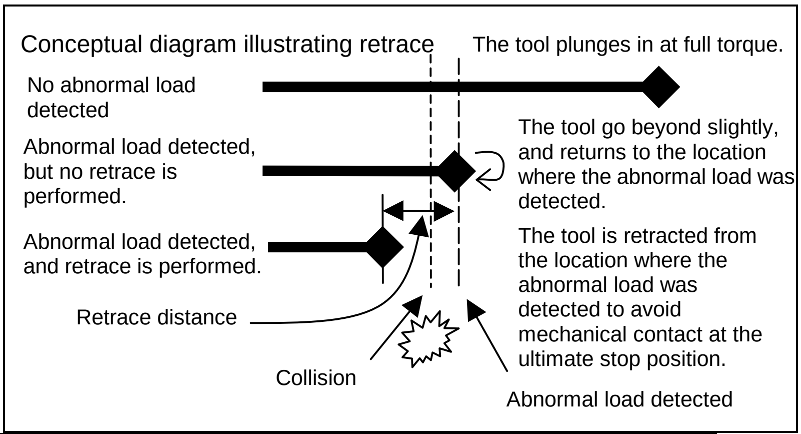


1997	–	Abnormal-load detection alarm level
2104	1104	

Alarm level conversion uses the following expression.
[When the digital check board is used]
Alarm level = maximum estimated disturbance value (A)/ maximum amplifier current (A) × 7282 + (500 to 1000 approximately)
[When the analog check board is used]
Alarm level = maximum estimated disturbance (V)/4.4 × 7282 + (500 to 1000 approximately)

NOTE
1 Add some margin (usually about 500 to 1000) to the alarm level to be set.
2 If the "abnormal-load detection alarm level" parameter is reset to 0, no abnormal-load alarm detection is performed.

<9> Set a distance to be retraced at abnormal-load detection.
If the retrace amount parameter is 0, the motor stops at the point where an abnormal load was detected. To retract the tool from the location of collision quickly, set the retrace distance parameter.



1996	–	Retrace distance
2103	1103	

[Increment system] Detection unit
[Setting value] Approximately 3 mm

NOTE
When the tool is moving faster or slower than the velocity listed below, the tool will not go back even if this parameter is set. It stops at the location where an abnormal load was detected.
Let the value set in the retrace distance parameter be A:
A/8 × detection unit × 1000 [mm/min] or lower:
Stop at the location where an abnormal load was detected.
A/8 × detection unit × 1000 [mm/min] or higher:
Stop after going back.

<10> Run the machine with the alarm level set up.
If the abnormal-load detection function works incorrectly, increase the alarm level.
<11> Nullify the estimated load torque output from the check board. Now adjustment is completed.

4.12.2 Unexpected Disturbance Detection Performed Separately for Cutting and Rapid Traverse

(1) Overview

An improvement has been made so that the alarm threshold for unexpected disturbance detection can be set separately for rapid traverse and cutting.

(2) Series and editions of applicable servo software

Series 9066/H(08) and subsequent editions (Series 20, 21, Power Mate)
Series 9080/J(10) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/A(01) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

A threshold can be set separately for cutting and rapid traverse by setting the following bit when the unexpected disturbance detection function is used:

		#7	#6	#5	#4	#3	#2	#1	#0
1740	–						ABG0		
2200	–								

Alarm thresholds for unexpected disturbance detection are set in the following parameters:

1997	–	Unexpected disturbance detection threshold for cutting (same as the conventional setting)
2104	–	

[Valid data range] 0 to 7282

1765	–	Unexpected disturbance detection threshold for rapid traverse
2142	–	

[Valid data range] 0 to 7282

NOTE

1 When the threshold for cutting is 0, unexpected disturbance detection is not performed during cutting. When the threshold for rapid traverse is 0, unexpected disturbance detection is not performed during rapid traverse. When both parameters are 0, unexpected disturbance detection is not performed at any time.
2 If bit 3 of parameter No. 1800 is 1, the unexpected disturbance detection threshold for cutting is always used. Switching to the threshold for rapid traverse cannot be performed.

4.13 FUNCTION FOR OBTAINING CURRENT OFFSETS AT EMERGENCY STOP

(1) Overview

A current offset is an offset value arising from an analog offset voltage associated with an current detector. If such an offset value is not obtained correctly, the feedback current of the motor is adversely affected, resulting in slight irregularities in the rotation of the motor (four times/revolution).
At present, a current offset is obtained once when the power to the NC is turned on as standard. The offset value varies, depending on the temperature of the current detector. Use this function to cope with such variations in time.

(2) Series and editions of applicable servo software

Series 9080/G(07) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, Power Mate *i*)

(3) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1741	–								CROFS
2201	–								

CROFS (#0) 1: Enables the current offset to be obtained upon the occurrence of an emergency stop.

4.14 LINEAR MOTOR PARAMETER SETTING

4.14.1 Procedure for Setting the Initial Parameters of Linear Motors

(1) Overview

The following describes the procedure for setting the digital servo parameters to enable the use of a FANUC linear motor.

(2) Series and editions of applicable servo software

Series 9066/D(04) and subsequent editions (Power Mate-D)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/A(01) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(3) Setting parameters

The position and speed of a linear motor are detected by connecting a linear encoder to the position detection circuit (A860-0333-T001, A860-0333-T002).
The procedure for setting the linear motor parameters depends on the signal pitch of the scale being used. So, check the signal pitch first.

Table 4.14.1 (a) Examples of usable linear encoders (incremental)

Scale maker	Signal pitch (μm)	Model
HEIDENHAIN	20	LS486, LS186, etc.
HEIDENHAIN	40	LB382, LIDA185, etc.
HEIDENHAIN	2	LIP481
HEIDENHAIN	4	LF481, LIF181, etc.
HEIDENHAIN	100	LB381
Mitsutoyo	20	AT402
Optodyne	40.513167	LDS
Rennyshore	20	RGBF

Table 4.14.1 (b) Usable linear encoders (absolute)

Scale maker	Resolution (μm)	Model
HEIDENHAIN	0.1	LC191F
Mitsutoyo	0.5	AT352

Refer to the "Fanuc Linear Motor Series Descriptions" (B-65222EN) for details.

Parameter setting procedure (1)

Procedure (1) can be used to initialize the parameters (such as current gain) necessary to drive a linear motor. After initialization, it is necessary to set the parameters that depend on the signal pitch of the scale. So, follow procedure (2) below.

1804	–	**Initialization bit**
2000	–	

Specify as follows:
When a scale other than LB381 is used: 00000000
When LB381 is used: 00000001
(Also refer to the descriptions about setting of the number of velocity pulses and the number of position pulses.)

1806	–	**AMR**
2001	–	

Specify 00000000.

1879	–	**Movement direction**
2022	–	

111: Forward as viewed from the magnetic pole detector side
–111: Backward as viewed from the magnetic pole detector side

1874	–	**Motor number**
2020	–	

The following five different linear motor models are available as of May, 1999. Their drawing numbers and model numbers are listed below.

Model name	1500A	3000B	6000B	9000B	15000C
Motor drawing number	0410	0411	0412	0413	0414
Motor model number	90	91	92	93	94

NOTE) The 15000C is supported by Series 9080/R(18) and subsequent editions, and Series 90A0/D(04) and subsequent editions.

Parameter setting procedure (2)

Procedure (2) can be used to specify the parameters that depend on the signal pitch of the scale. Set the parameters according to Table 4.14.1 (2).

1876	–	**Number of velocity pulses (PULCO)**
2023	–	

(Parameter calculation expression)

PULCO = 5000 × 20/(scale signal pitch [μ])

1891	–	**Number of position pulses (PPLS)**
2024	–	

(Parameter calculation expression)

PPLS = 16000 × 20/(scale signal pitch [μ])

1705	–	**AMR conversion coefficient 1**
2112	–	

(Parameter calculation expression)

NOTE) The current motor pole interval is 60 mm.

AMR conversion coefficient 1 = 512 × (60 [mm]/scale signal pitch [μ])

1761	–	**AMR conversion coefficient 2**
2138	–	

Usually specify 0 in this parameter. If AMR conversion coefficient 1 exceeds 32,767 or is not an integer, use AMR conversion coefficient 2.

(Parameter calculation expression)

NOTE) The current motor pole interval is 60 mm.

$$(\text{AMR conversion coefficient 1}) \times 2^{(\text{AMR conversion coefficient 2})} = 60000 \times (512/\text{scale signal pitch } [\mu])$$

1977	–	**Flexible feed gear numerator**
2084	–	

1978	–	**Flexible feed gear denominator**
2085	–	

Use a unified detection unit for the flexible feed gear (FFG) parameters according to Tables 4.14.1 (c) and 4.14.1 (d).

(Parameter calculation expression)

$$\text{FFG} = \frac{5}{128} \times \frac{(\text{scale signal pitch } [\mu]/20)}{(\text{detection unit } [\mu])}$$

Table 4.14.1 (c) Setting parameters for detection unit of 1 μ (incremental)

Signal pitch	PLC0	Number of velocity pulses	Number of position pulses	AMR conversion coefficient 1	AMR conversion coefficient 2	FFG numerator	FFG denominator
20	0	5000	16000	1536	0	5	128
40	0	2500	8000	768	0	5	64
2(*1)	1	5000	(*2)	15360	0	1	256
4(*1)	1	2500	8000	7680	0	1	128
100	0	1000	3200	1200	8	25	128
40.513167	0	2468	7899	1481	9	301	3804

Table 4.14.1 (d) Setting parameters for detection unit of 1 μ (absolute)

Model	PLC0	Number of velocity pulses	Number of position pulses	AMR conversion coefficient 1	AMR conversion coefficient 2	FFG numerator	FFG denominator
LC191F	0	1953	6250	600	0	1	10
AT352(*3)	0	391	1250	120	0	1	2

*1 If the number of position/velocity pulses does not fit one word, set the following bit to 1.

		#7	#6	#5	#4	#3	#2	#1	#0
1804	–								PLC0
2000	–								

PLC0 (#0) Specifies whether to use the number of velocity or position pulses without modifying them, as follows:

0: Not to modify

1: Multiply by 10 ← To be set

*2 Because the number of position pulses exceeds 130,000, specify the position pulse conversion coefficient (supported by Series 90A0/N(14) and subsequent editions).

2628	–	Position pulse conversion coefficient (PSMPYL)
2185	–	

Bit for multiplying the number of position/velocity pulses by ten (PLC0) = 1

Number of pulses (PPLS) = 8000

Position pulse conversion coefficient (PSMPYL) = 2

Regard 160,000 pulses as: (8000*2)*10

*3-a Because the velocity loop proportional gain overflows, set the following bit to 1 (supported by Series 90A0/I(09) and subsequent editions).

		#7	#6	#5	#4	#3	#2	#1	#0
1740	–		P2EX						
2200	–								

P2EX (#6) Velocity loop proportional gain (PK2V)

0: Standard format

1: Changes the format ← To be set

*3-b Because the dead zone compensation parameter overflows internally, change it as follows:

1866	–	Dead zone compensation (tilt) (PDDP)
2054	–	

PDDP Dead zone compensation (tilt)
1894 (typical value for linear motor) → 1500

Parameter setting procedure (3)

Procedure (3) is intended to fine-tune an incremental scale after it is installed and adjusted mechanically. Usually, mechanical scale adjustment is enough for linear motors.
Parameter setting based on procedure (3) is absolutely of supplemental nature. It should be used only for tuning purposes or if the scale cannot be positioned correctly because of a mechanical cause.
Basically, the following parameter setting is not necessary for absolute scales, because they do not use a magnetic pole detector (Hall sensor). (However, it can be done if fine tuning is required because of a mechanical cause.)

1762	–	AMR offset
2139	–	

Specifies an activating phase (AMR offset) for phase Z.

[Increment system] Degrees
[Valid data range] –45 to 45

Fine-tune the activating phase according to the procedure below.

1) Connect the servo check board to the CNC.
2) Set the 7-segment LEDs at CH1 on the check board with:
   Axis number specified in parameter No. 1023 at AXIS
   5 at DATA
3) To measure the activating phase, set the following parameter.

1726	–	Parameter for internal data measurement
2115	–	

System other than Series 90A0:
 326 for an odd-numbered axis and 966 for an even-numbered axis
Series 90A0:
 326 for an odd-numbered axis and 2374 for an even-numbered axis
Under this condition, the activating phase is output from CH1 on the check board.
To use a digital check board to measure data with a personal computer, set up "SD" (servo adjustment software) as stated below. The displayed value is in degree units ("360 degrees" is displayed as "360").

DOS prompt > SD INIT [Enter]	
o (Origin of position)	
F9 (System setting)	
0	(CH0)
2 [Enter]	(TCMD)
639.84375 [Enter]	(A)
F10	(Return to main menu.)

NOTE) See Sec. 4.19 for explanations about how to use the SD software.
In addition, the analog voltage from the check board can be observed using an oscilloscope. In output conversion, 2.5 V corresponds to 360 degrees.

4) Run the linear motor using a JOG operation for example, and observe the behavior of the activating phase (AMR) before, at the moment, and after phase Z is captured. (See Figs. 4.14.1 (a) and (b).)
The activating phase changes to 0 (or 360) degrees at the moment phase Z is captured. Measure the value just before it changes, and let this value be A.

5) Set the AMR offset parameter with A (or A − 360).

NOTE) The valid data range for the parameter is between −45 and +45. If A gets out of the valid data range, it is necessary to re-adjust the mounting position of the scale. When A is measured in analog voltage form, the voltage range for A is between 0 and 0.3 V and between 2.2 and 2.5 V.

6) Observe the activating phase (AMR) by following step 4) again, and make sure that the activating phase changes continuously at the rising portion of phase Z.
Reset the parameter set at step 3) to 0.

7) Switch the power off and on again. Now parameter setting is completed.

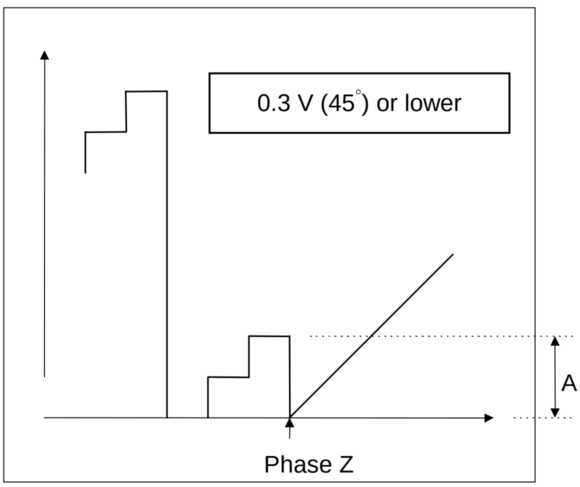


Fig. 4.14.1 (a) If the offset is set with a positive number

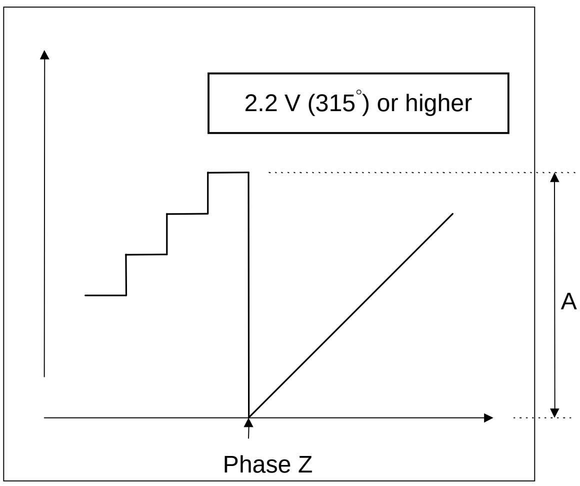


Fig. 4.14.1 (b) If the offset is set with a negative number

Parameter setting procedure (4)

Procedure (4) can be used to set parameters according to the cooling method used for linear motors.

Change the following parameters as listed in Table 4.14.1 (f). For self-cooling linear motors, the parameters need not be set here, because they are set up at initialization in procedure (1).

1877	–	**OVC alarm parameter (POVC1)**
2062	–	

1878	–	**OVC alarm parameter (POVC2)**
2063	–	

1893	–	**OVC alarm parameter (POVCLMT)**
2065	–	

1979	–	**Current rating parameter (RTCURR)**
2086	–	

Table 4.14.1 (f) Setting OVC and current rating parameters by cooling method

Model	Cooling method	Continuous thrust (N)	POVC1	POVC2	POVCLMT	RTCURR
1500A	Self-cooling	355	32698	873	2590	1184
3000B	Self-cooling	600	32698	873	2590	1184
3000B	Air-cooled	720	32667	1257	3729	1421
3000B	Water-cooled	1200	32490	3481	10358	2369
6000B	Self-cooling	1200	32698	873	2589	1184
6000B	Air-cooled	1440	32667	1257	3729	1421
6000B	Water-cooled	2400	32490	3481	10358	2369
9000B	Self-cooling	1800	32708	744	2207	1093
9000B	Air-cooled	2160	32682	1071	3177	1311
9000B	Water-cooled	3600	32531	2968	8826	2186
15000C	Self-cooling	3000	32730	471	1396	869
15000C	Air-cooled	3600	32714	678	2010	1043
15000C	Water-cooled	7000	32563	2557	7601	2029

Parameter setting procedure (5)

Procedure (5) supplements descriptions about application of level-up HRV for linear motors. (→ See Sec. 4.3, "Level-up HRV Control.")

When level-up HRV is applied to increase the current loop gain of a linear motor, it is necessary to set the following parameter, because linear motors have a higher current gain compared with rotational motors. This parameter setting must be done whenever the absolute value of the current loop proportional gain (PK2) becomes higher than 16000 (as a rule of thumb) after application of level-up HRV.

		#7	#6	#5	#4	#3	#2	#1	#0
1750	–						PK12S2		
2210	–								

PK12S2 (#2) Specifies whether to use the quadruple current loop gain function (supported by Series 90A0/D(04) and subsequent editions).

0: Not to use

1: To use ← To be set

When setting this function to ON, re-set the current gain parameters (PK1 and PK2) to one-fourth.

Table 4.14.1 (g) Current gain parameter setting when level-up HRV is applied

Model name	Typical setting			→	Setting after level-up HRV is applied		
	PK12S2	PK1	PK2		PK12S2	PK1	PK2
1500A	0	1890	–7180	→	0	1512	–11488
3000B	0	4804	–14453		1	961	–5782
6000B	0	4804	–13138		1	961	–5253
9000B	0	5036	–16000		1	1008	–6400
15000C	1	1420	–5600		1	1136	–8960

(4) Invalid-parameter alarm when linear motors are used

The following invalid-parameter alarm checks are added when linear motors are used (they are not issued for rotational motors).

- No separate detector can be used for linear motors. (Full-closed loop setting results in an alarm being issued.)
  NOTE) The invalid-parameter alarm detail No. is A043 (10043 on the diagnosis screen).
- If no AMR conversion coefficient is set, an alarm is issued. (Even when the scale is not relocated after the motor is replaced, the AMR conversion coefficients must be re-set, because initialization accompanying motor replacement causes the AMR coefficients to be erased.)
  NOTE) The invalid-parameter alarm detail No. is 1123.

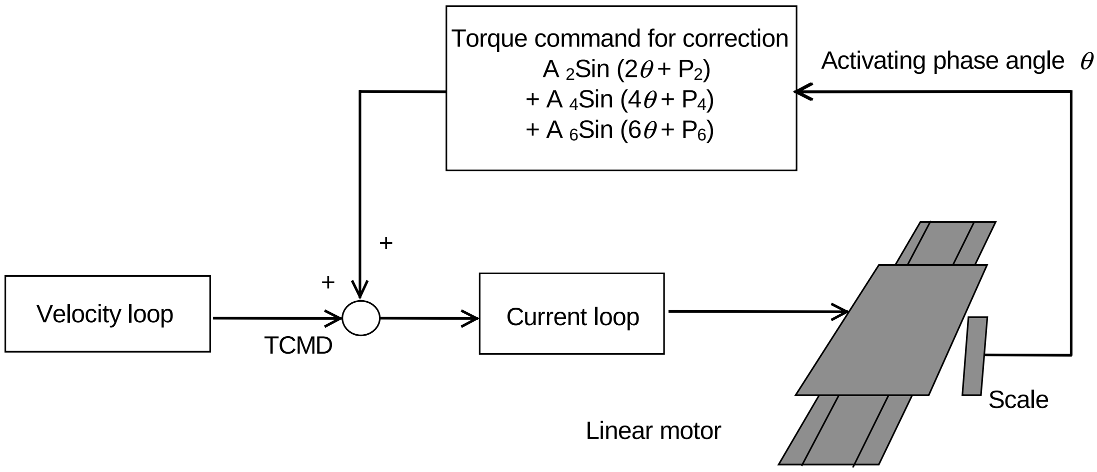
- The valid AMR offset data range is between –45 (degrees) and +45 (degrees). If a value out of this range is specified in the parameter, an invalid-parameter alarm is issued.
  NOTE) The invalid-parameter alarm detail No. is 1393.

> **CAUTION**
> When an AMR conversion coefficient is not set, an alarm is issued. If it is set, but incorrect, no alarm is issued. In this case, the linear motor fails to drive correctly immediately after it passes phase Z. It may move within one pole-to-pole span (60 mm) in the worst case.

4.14.2 Linear Motor Thrust Ripple Correction

(1) Overview

A linear motor has 10-mm, 15-mm, or 30-mm "ripples" that result from its structure (in the case of 60 mm magnetic pole pair), which tend to aggravate the motor feed irregularity. The occurrence of these ripples depends solely on the motor position. So, the feed irregularity can be improved by correcting the current command using servo software.



(2) Series and editions of applicable servo software

Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9081/C(03) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/A(01) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)
(The Series 9066 does not support this function.)

(3) Setting parameters

1753	–	Correction of two thrust ripples per magnetic pole pair
2130	–	Correction gain (high-order 8 bits) Correction phase (low-order 8 bits)

1754	–	Correction of four thrust ripples per magnetic pole pair
2131	–	Correction gain (high-order 8 bits) Correction phase (low-order 8 bits)

1755	–	Correction of six thrust ripples per magnetic pole pair
2132	–	Correction gain (high-order 8 bits) Correction phase (low-order 8 bits)

The way thrust ripples occur varies from one motor (rather than model) to another. Therefore, the correction parameters must be determined specifically for each individual motor. This can be done using "SD" (servo adjustment software) as a measurement tool.
The torque command ripples which occur at a specific position during low-speed motor operation are assumed to be the ripples specific to the motor at that position. A torque command having the same ripples as these specific ripples is created to enable correction.
Follow the procedure described below to measure the activating phase angle and torque command necessary to determine the correction parameters.
The following procedure use terms "odd-numbered axis" and "even-numbered axis" in relation to axis numbers specified in parameter No. 1023 (common to the FS15 and FS16).

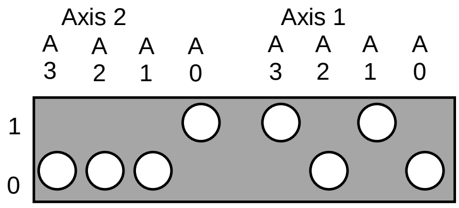
<1> Series 90A0: Does not require step <1>. Go to step <2>.
Series 9080 and 9090: To measure an odd-numbered axis, set a dummy bit to 1 for the even-numbered axis paired with it.
<u>If a linear motor is used in tandem control, however, do not set a dummy bit for the paired axis</u>.

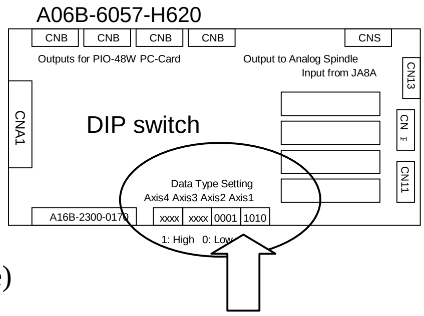
		#7	#6	#5	#4	#3	#2	#1	#0
1953	–								SERD
2009	–								

SERD (#0) Specifies whether to enable the dummy serial feedback function.
0: To disable
<u>1: To enable ← To be set</u>
NOTE) Do not forget to restore the previous setting after parameter setting is completed.

<2>-a When using A06B-6057-H620 (digital check board), set the DIP switches on the check board as follows:

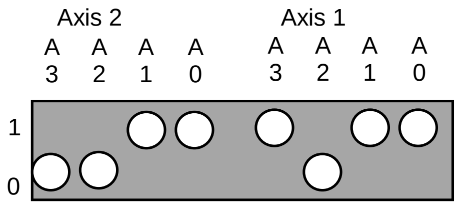
To measure an odd-numbered axis:





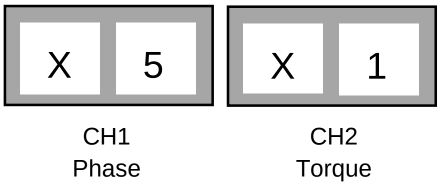
AXIS2: 1 (torque) AXIS1: 10 (phase)

To measure an even-numbered axis:



AXIS2: 3 (torque) AXIS1: 11 (phase)

<2>-b When using A06B-6057-H630 (one-piece analog/digital type), set up the 7-segment LED digits on the check board as shown below:



NOTE) Letter X stands for an axis number specified in parameter No. 1023.

<3> To measure the activating phase angle, set the following parameter.

1726	–	**Parameter for internal data measurement**
2115	–	

Series 9080/D(04) and previous editions:
1456 (for both odd- and even-numbered axes)
Series 9080/E(05) and subsequent editions, Series 9081, and Series 9090:
1328 (for both odd- and even-numbered axes)
Series 90A0:
704 for odd-numbered axis and 2752 for even-numbered axis

Steps <2> and <3> enable CH0 and CH1 of the SD software to be used to measure the motor activating phase angle (CH0) and torque command (CH1).

<4> Start the "SD" software, and make the following setting.

```
DOS prompt > SD INIT [Enter]
o   (Origin of position)
F9  (System setting)
0                    (CH0)
2 [Enter]            (TCMD)
1.0 [Enter]          (1.0A)
1                    (CH1)
2 [Enter]            (TCMD)
40 [Enter]           (Maximum current for servo amplifier to be used)
F10           (Return to main menu.)

(Ctrl)T       (XTYT mode selected)
F2  (Data number)
9000 [Enter]  (Number of data items to be measured)
```

NOTE) This description uses the 3000B as an example. It differs from other models only in the current rating of the servo amplifier.

<5> When determining the correction parameters, set the velocity gain to a rather low value.

<6> Cause the linear motor to reciprocate at F1200 (mm/min), using a stroke of over 200 mm or longer.

<7> Pressing the F1 key (to start measurement) at regular speed displays the data shown below. (Check that the activating phase angle-based sine waveform changes from negative to positive at three points or more.)

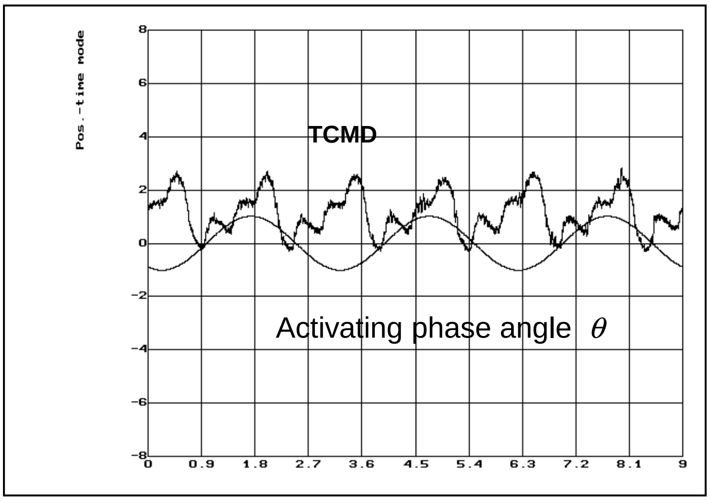
CAUTION

Measurement direction varies with the setting of the direction-of-movement parameter.

When the setting is 111: Measurement is performed during forward movement.

When the setting is –111: Measurement is performed during backward movement.

Measurement in the wrong direction hinders correct calculation of the correction parameter.



<8> Pressing CTRL+L causes the correction parameter values to be calculated as shown below. Enter the displayed parameter values. Usually, use the correction parameter values displayed on the top row.
The parameter values displayed on the middle and bottom rows are used for special parameter setting.

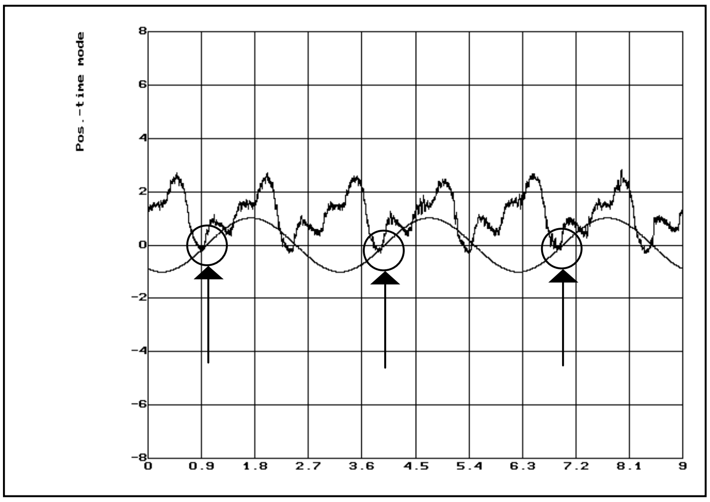
Middle row: To be used when either quadruple ripple correction or quadruple TCMD output is selected.

Bottom row: To be used when both quadruple ripple correction and quadruple TCMD output are selected.

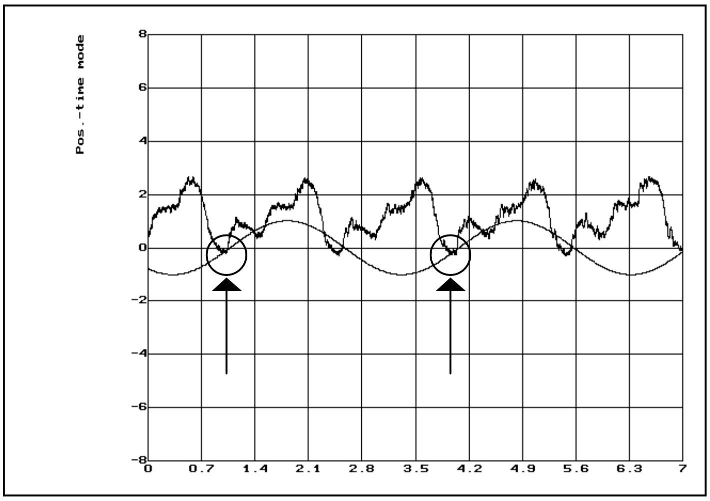
```
<< Normal torque ripple compensation >>
   FS15B / FS16C    Parameter
2: #1753 / #2130 -> -25425 (   156:   175)
4: #1754 / #2131 ->  22774 (    88:   246)
6: #1755 / #2132 ->  20504 (    80:    24)

<< Compensation Value x 4 mode >> No.1743 B6=1 (FS15) / No.2203 B6=1 (FS16) or
<< TCMD Serial-Out x 4 mode    >> No.1743 B5=1 (FS15) / No.2203 B5=1 (FS16) ~~
2: #1753 / #2130 ->  10159 (    39:   175)
4: #1754 / #2131 ->   5878 (    22:   246)
6: #1755 / #2132 ->   5144 (    20:    24)

<< Compensation Value x 4 mode >> No.1743 B6=1 (FS15) / No.2203 B6=1 (FS16) and
<< TCMD Serial-Out x 4 mode    >> No.1743 B5=1 (FS15) / No.2203 B5=1 (FS16) ~~~
2: #1753 / #2130 ->   2479 (     9:   175)
4: #1754 / #2131 ->   1526 (     5:   246)
6: #1755 / #2132 ->   1304 (     5:    24)
```

Example of measurement

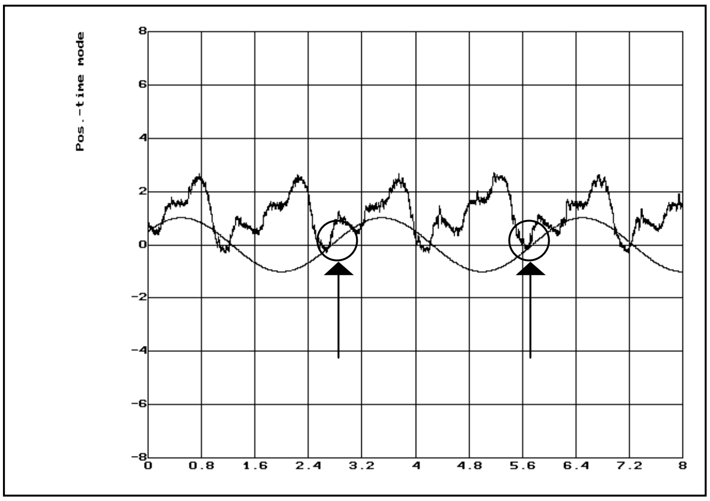
(a) Measured waveform where parameter value calculation is possible



(b) Measured waveform where parameter value calculation is impossible (No. 1)
Two activating phase angle-based sine waves cannot be acquired because of insufficient measurement time.



(c) Measured waveform where parameter value calculation is impossible (No. 2)
Two activating phase angle-based sine waves cannot be acquired because of an inappropriate measurement start position.



4.15 TORQUE CONTROL FUNCTION

(1) Overview

In PMC axis control, the torque control function can be used. The servo motor produces a torque as specified by the NC. Note that the user can switch between position control and torque control.

(2) Control types

Two types of torque control are supported: type 1 and type 2. The two types are explained below.

(i) Torque control type 1
The motor produces a torque according to a torque command specified by the PMC. A servo alarm is issued if the speed of the motor exceeds the excessive speed alarm level specified by the PMC.
A block diagram of torque control type 1 is shown below.

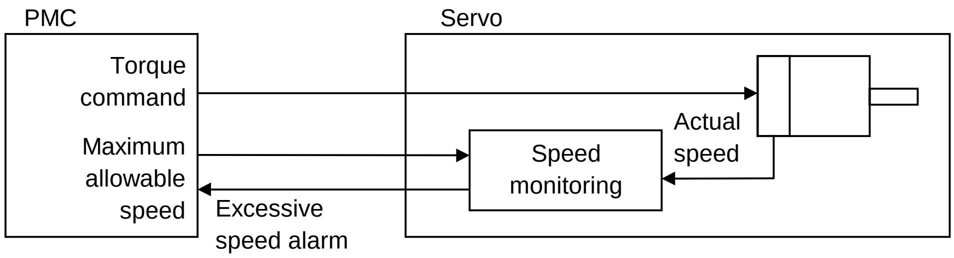


Fig. 4.15 (a) Torque control type 1

(ii) Torque control type 2
The motor produces a torque according to a torque command specified by the PMC.
When the motor is loaded, it produces a torque according to a torque command. When it is not loaded, it rotates at a constant (allowable) speed.

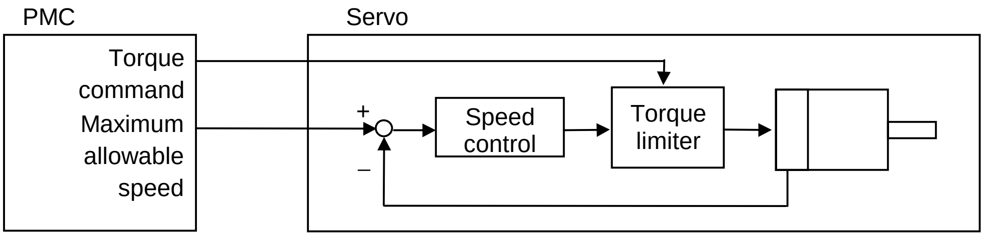


Fig. 4.15 (b) Torque control type 2

NOTE) Basically, torque control type 2 performs speed control to cause the limiter to operate on a command from the speed controller according to a torque command specified by the PMC. This causes the motor to produce a torque that matches the torque command when it is loaded and to rotate at a constant (allowable) speed when it is not loaded.

(3) Series and editions of applicable servo software

(i) Torque control type 1
Series 9066/E(05) and subsequent editions (Power Mate-H)
Series 9080/G(07) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*, 16*i*)

(ii) Torque control type 2
Series 9066/E(05) and subsequent editions (Power Mate-H)
Series 9080/S(19) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/I(09) and subsequent editions (Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90A0/D(04) and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(4) Setting parameters

This manual describes servo-related parameters only.

NOTE
For details about the setting of the torque control function for each CNC, refer to "PMC Axis Control" in the respective CNC Connection Manuals (Functions).
The ordering information for each connection manual is as follows:

Series 15*i*
Connection Manual (Function) B-63323EN-1
Series 16*i*,18*i*,21*i*
Connection Manual (Function) B-63003EN-1
Power Mate *i*
Connection Manual B-63713EN-1
Series 15-B
Connection Manual (BMI Interface) B-62073E-1

(a) Setting for torque control type 1

		#7	#6	#5	#4	#3	#2	#1	#0
1951	–	FRCAXS							
2007	–								

FRCAXS (#7) Torque control is:
0: Not exercised
1: Exercised ← To be set

1998	–	Torque constant
2105	–	

This parameter is used to specify a motor-specific torque constant. The units are as follows:

0.00001 Nm/torque command for a rotary motor

0.001 Nm/torque command for a linear motor

When the initial parameter setting function (Sec. 2.1) is used, a motor-specific value is set automatically.

(b) Setting for torque control type 2

		#7	#6	#5	#4	#3	#2	#1	#0
1808	–					PIEN			
2007	–								

PIEN (#3) The velocity control method to be used is:

0: I-P control

1: P-I control ← To be set

		#7	#6	#5	#4	#3	#2	#1	#0
1951	–	FRCAXS							
2007	–								

FRCAXS (#7) Torque control is:

0: Not exercised

1: Exercised ← To be set

		#7	#6	#5	#4	#3	#2	#1	#0
1743	–				FRCAX2				
2203	–								

FRCAX2 (#4) Torque control type 2 is:

0: Not exercised

1: Exercised ← To be set

(Usually, use type 2.)

1998	–	Torque constant
2105	–	

This parameter is used to specify a motor-specific torque constant. The units are as follows:

0.00001 Nm/torque command for a rotary motor

0.001 Nm/torque command for a linear motor

When the initial parameter setting function (Sec. 2.1) is used, a motor-specific value is set automatically.

4.16 USAGE OF THE SERVO SOFTWARE FOR SUPER-PRECISION MACHINING

(1) Overview

For servo systems used for super-precision machines, a special setting may be required in addition to the conventional settings of 1 μm and 0.1 μm as detection unit.
In the cases described below, the super-precision function of the Series 9081 digital servo software must be used.

1	When the position detection unit of the laser or scale is 0.01 μm or 0.001 μm, and the number of position pulses per motor revolution is 130,000 or more

In this case, a servo parameter causes an overflow in the digital servo system, so that the Series 9081 must be used. For an explanation of how to make this setting, see (3) in this section.

Example)

When the amount of travel per motor revolution is 4 mm, and 0.01-μm position detection is performed (when the number of position pulses per motor revolution is 400,000)

2	When an amplifier with a smaller capacity than a regular amplifier is used to place emphasis on smooth feed rather than maximum motor torque

In this case, the current loop and velocity loop parameters must be modified. With the Series 9081, the required conversions can be made only by setting a conversion coefficient parameter.
For an explanation of how to make this setting, see (4) in this section.

Example)

When the α3/3000 (usually driven by a 40-A amplifier) is driven using the 12-A amplifier designed for the α2/2000

3	When a reduced voltage is applied to the amplifier to place emphasis on smooth feed rather than maximum motor speed

In this case, the current loop parameter must be modified. With the Series 9081, required conversions can be made only by setting a bit parameter.
For an explanation of how to make this setting, see (5) in this section.

Example)

When the supply voltage for driving the motor is changed from 200 V to 60 V (In this case, an amplifier modification is also required.)

4 When the position detection unit of the laser or scale is 0.001 μm, and the number of position pulses per motor revolution exceeds 1,000,000 (resolution of serial pulse coder A)

In this case, the number of position feedback pulses becomes greater than the number of velocity feedback pulses (1,000,000 pulses for αA1000 or serial pulse coder A), so that stable positioning cannot be performed. In such a system, a separate velocity detector must also be used as described in (6) of this section.

Example)

When the amount of travel per motor revolution is 5 mm, and 0.001-μm position detection is performed (when the number of position pulses per motor revolution is 5,000,000)

(2) Series and editions of applicable servo software

Series 9081/C(03) and subsequent editions (Series 15-B,16-C,18-C)

(3) Using a separate position detector with 130,000 pulses per motor revolution

(a) In this case, a servo parameter causes an overflow in the digital servo system, so that the number of velocity pulses and the number of position pulses must be set as follows:

1732	–	**Conversion coefficient for the number of feedback pulses (SBPDNL)**
2121	–	

The value specified in this parameter is used to divide the number of velocity pulses and the number of position pulses to produce a value not exceeding 32,767. For this parameter, set as small a value as possible.

[Typical setting] 100 or 1,000

1876	–	**Number of velocity pulses (PULCO)**
2023	–	

When a Serial A or αA1000 built-in pulse coder is used, set $\frac{8,192}{\text{SBPDNL}}$.

1891	–	Number of position pulses (PPLS)
2024	–	

When a Serial A or αA1000 built-in pulse coder is used, set the following:

$$\frac{\text{Number of feedback pulses from separate detector/motor revolution}}{8{,}192} \times \text{PULCO}$$

		#7	#6	#5	#4	#3	#2	#1	#0
1804	–								PLC0
2000	–								

PLC0 (#0) The number of velocity pulses and the number of position pulses are:
0: Used as is ← To be set
1: Used after multiplication by 10

Example of setting

When the Series 15-B and serial pulse coder A are used, and a 0.01-μm separate position detector is used with a machine having a travel of 4 mm per motor revolution
No. 1804#0 = 0
No. 1732 = 100
No. 1876 = 8,192 ÷ 100 = 82
No. 1891 = (400,000 ÷ 8,192) × 82 = 4,004

NOTE
When PMC velocity control is used, and a very small value is set as the number of velocity pulses (PULCO), the difference between a specified velocity and actual velocity may become large. In such a case, set the number of velocity pulses as described in (b) below.

(b) Notes on using PMC velocity control

When PMC velocity control is used, and a very small value is set as the number of velocity pulses (PULCO), the difference between a specified velocity and actual velocity may become large. In such a case, modify the settings as described below.

		#7	#6	#5	#4	#3	#2	#1	#0
1741	–				SPVCMD				
2201	–								

SPVCMD (#7) The setting of the number of velocity pulses when the conversion coefficient (SBPDNL) is not used is:

0: Disabled

1: Enabled ← To be set

1876	–	Number of velocity pulses (PULCO)
2023	–	

When a Serial A or αA1000 built-in pulse coder is used, set 8,192.

Example of setting

> Make the following modifications when PMC velocity control is used in the example of (a) of (3) above:
> No. 1741#4 = 1
> No. 1876 = 8,192

(4) Using a smaller-current amplifier

By using a smaller-current amplifier instead of the normal amplifier, the current detection resolution can be increased, hence smoother control can be achieved.

Note, however, that the maximum torque of the motor becomes smaller as a result of reducing the maximum current.

To enable this modification, set the following parameter:

1733	–	Detection resistance conversion coefficient (SBAMPL)
2122	–	

Set the following:

$$\frac{\text{Maximum current of amplifier that is actually used}}{\text{Maximum current of amplifier that is usually used}} \times 100$$

Example of setting

> When the α3/3000 (normally driven by a 40-A amplifier) is driven using the amplifier designed for the α2/2000 (12 A maximum)
> No. 1733 = (12/40) × 100 = 30

(5) Changing the amplifier input voltage

By maintaining the supply voltage to the servo amplifier control unit at 200 V (the regular voltage) and changing the supply voltage to the inverter to 60 V (normally 200 V), the voltage command resolution can be increased, enabling finer control to be exercised.

For this purpose, a power transformer (A06B-6047-H011 for the Japanese market, or A06B-6047-H021 for overseas markets) is used.

Note, however, that the maximum speed of the motor is reduced as the voltage decreases.

Moreover, the amplifier must be modified.

The C series servo amplifier must be modified according to modification specification #J008.

The α series servo unit (SVU) must be modified according to modification specification #J003.

The α series servo unit (SVUC) must be modified according to modification specification #J001.

Note that modification specifications for the α series servo unit are available only for the following amplifiers:

SVU: A06B-6089-H101 to H105, H201 to H210
SVUC: A06B-6090-H002 to H008, H222 to H226

To enable this modification, set the following parameter:

		#7	#6	#5	#4	#3	#2	#1	#0
1884	–							SBSMAP	
2006	–								

SBSMAP (#7) An amplifier input voltage change from 200 V to 60 V is:
0: Not made
1: Made ← To be set

Example of setting

When the amplifier input voltage is reduced from 200 V to 60 V (Series 15-B)
No. 1884#1 = 1

(6) Using a separate position detector (1,000,000 pulses or more per motor revolution)

Optional function

When a machine is used for which the number of feedback pulses from a separate position detector per motor revolution exceeds 1,000,000, stable control cannot be achieved if serial pulse coder A or the αA1000 (pulse coder built into the motor) is used as the velocity detector.
In this case, a velocity detector with a greater number of pulses is required. When a velocity detector with a greater number of pulses is used, a special system, like that shown Fig. 4.16, must be configured.
This function is option.

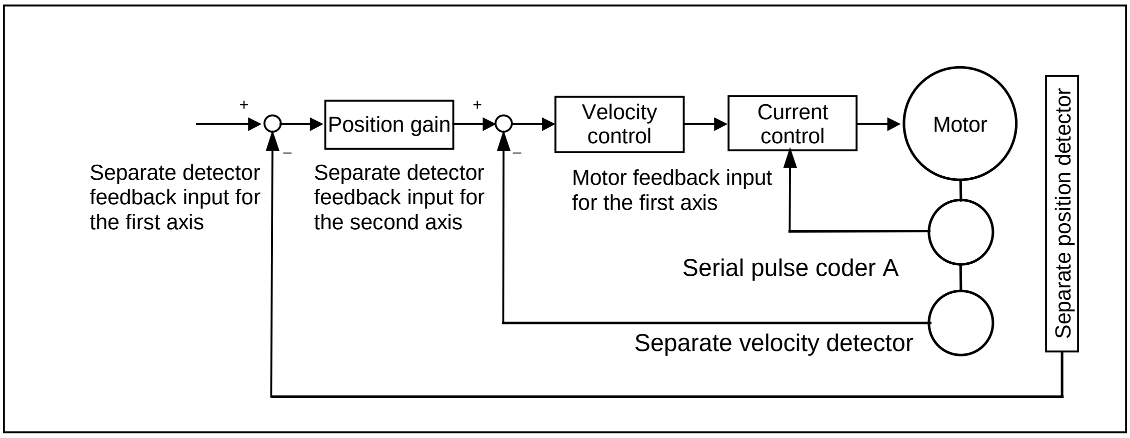


Fig. 4.16 Special system for super-precision machining

Thus, the one axis of this system is driven using the normal two axes.
To configure a system like that described above, modify the settings of the following parameters.

Function bits

Series 15-B	Series 16-C, 18-C	Function bit	Axis	Funciton
No. 1807	–	#3 = 1	First axis and second axis	Enables a separate position detector.
No. 1815	No. 1815	#1 = 1	First axis and second axis	Enables a separate position detector.
No. 1953	No. 2009	#0 = 1	Second axis	Enables dummy bits.
No. 1884	No. 2006	#3 = 1	First axis	Enables the system.
No. 1709	No. 2019	#4 = 1	First axis	Enables the system.

1732	–	**Conversion coefficient for the number of feedback pulses (SBPDNL)**
2121	–	

The value specified in this parameter is used to divide the number of velocity pulses and the number of position pulses to produce a value not greater than 32,767. For this parameter, set as small a value as possible.

[Typical setting] 100 or 1,000

1876	–	**Number of velocity pulses (PULCO)**
2023	–	

Set the following:

$$\frac{\text{Number of feedback pulses from a separate velocity detector per motor revolution}}{\text{SBPDNL}}$$

1891	–	**Number of position pulses (PPLS)**
2024	–	

Set the following:

$$\frac{\text{Number of feedback pulses from a separate position detector per motor revolution}}{\text{SBPDNL}}$$

		#7	#6	#5	#4	#3	#2	#1	#0
1804	–								PLC0
2000	–								

PLC0 (#0) The number of velocity pulses and the number of position pulses are:
0: Used as is ← To be set
1: Used after multiplication by 10

Example of setting

When a separate velocity detector of 3,000,000 pulses/revolution and separate position detector of 1,000,000 pulses/revolution are used (Series 15-B)
No. 1807#3 = 1 (first axis, second axis)
No. 1815#1 = 1 (first axis, second axis)
No. 1953#0 = 1 (second axis)
No. 1884#3 = 1 (first axis)
No. 1709#4 = 1 (first axis)
No. 1732 = 1,000
No. 1876 = 3,000,000/1,000 = 3,000
No. 1891 = 1,000,000/1,000 = 1,000
No. 1804#0 = 0 (first axis)

Optional function

4.17 TANDEM CONTROL FUNCTION

(1) Overview

If a single motor is not capable of producing sufficient torque to drive a large table, for example, tandem control allows two motors to produce movement along one axis.
A motor of the same specification is used for both the main motor and sub-motor.
Only the main motor is responsible for positioning. The sub-motor only produces a torque. In this way, double the torque can be obtained (load sharing mode).
By applying a preload torque to produce tension between the main motor and sub-motor, the backlash between gears can be reduced (anti-backlash mode).
Tandem control is used to run linked linear motors and motors with a winding tandem (α300, α400, etc.).

(2) Applicable servo software series and editions

Series 9060/F(06) and subsequent editions (Series 15-B, 16-A, 18-A, Power Mate)
Series 9080/A(01) and subsequent editions (Series 15-B, 16-C, 18-C)
Series 9090/C(03) and subsequent editions (Series 16*i*-A, 18*i*-A, Power Mate *i*)
Series 90A0/A(01) and subsequent editions (Series 15*i*-A, 16*i*-A, 18*i*-A, Power Mate *i*)

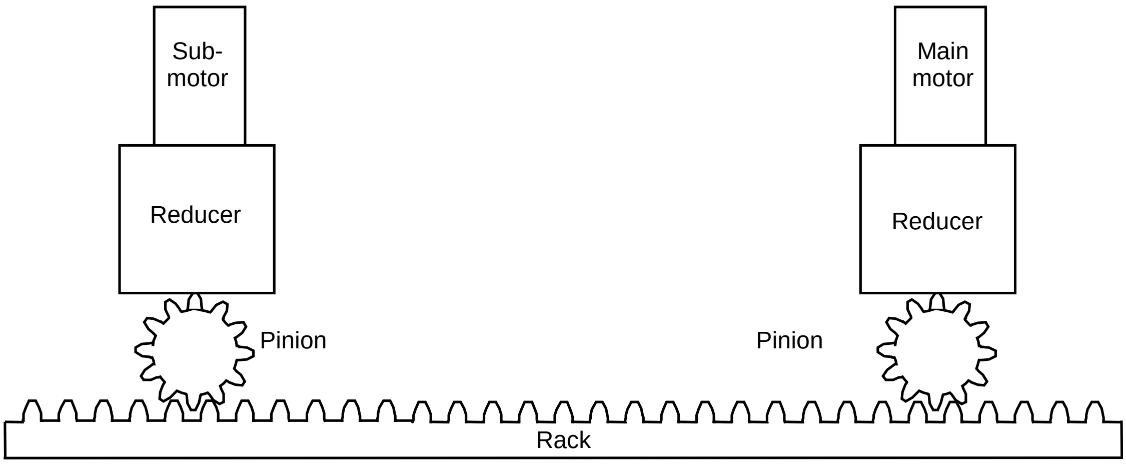


Fig. 4.17 (a) Example of tandem control application (1)

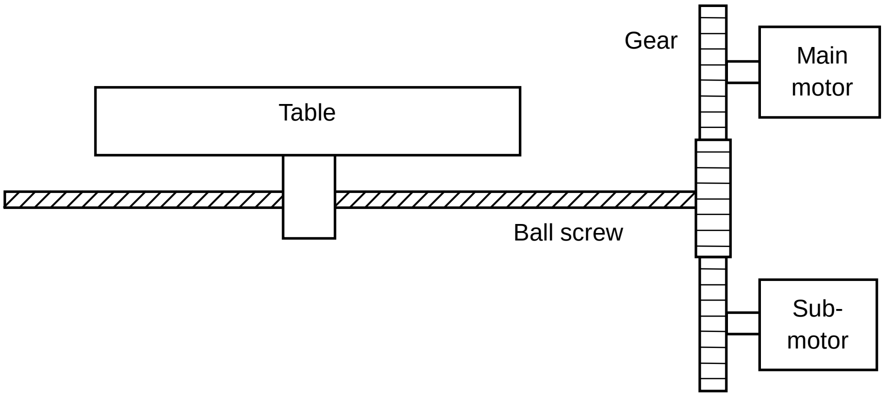


Fig. 4.17 (b) Example of tandem control application (2)

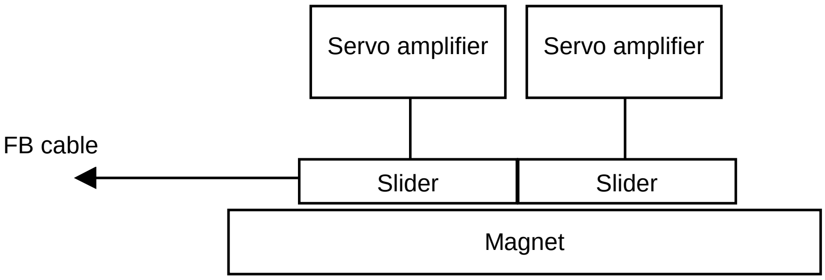


Fig. 4.17 (c) Example of exercising tandem control (linking linear motors)

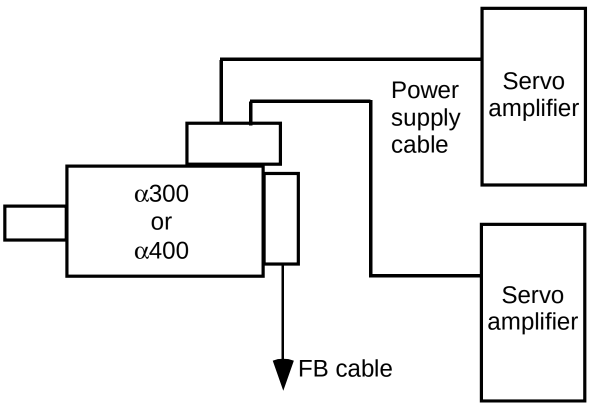


Fig. 4.17 (d) Example of exercising tandem control (winding tandem)

(3) Start-up procedure

To start tandem control, follow the procedure below.

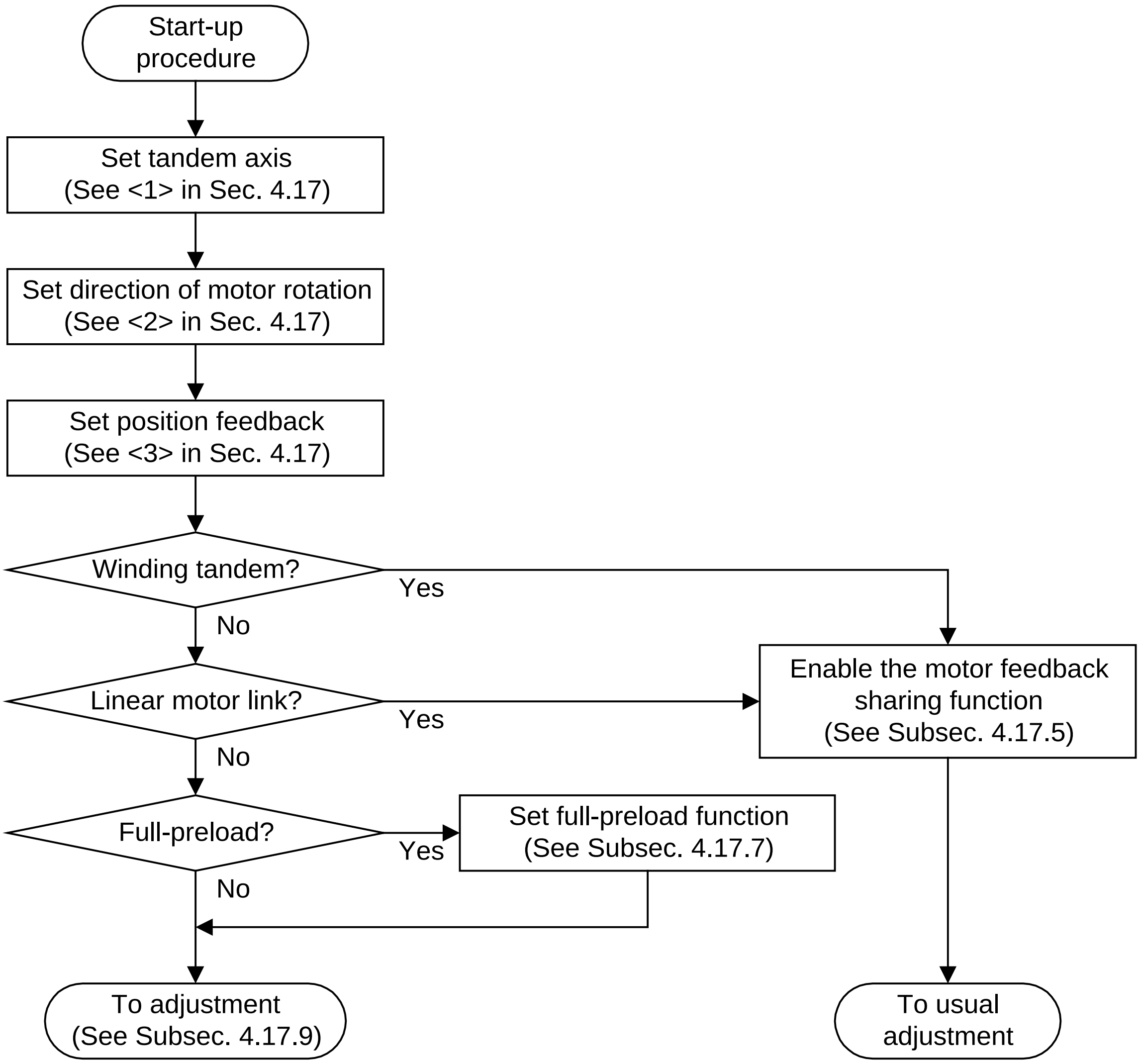


Fig. 4.17 (e) Start-up procedure flowchart

<1> Tandem axis setting

Tandem control is an optional function.
Refer to the Parameter Manual of CNC for details.

		#7	#6	#5	#4	#3	#2	#1	#0
1817	–		TANDEM						
1817	–								

TANDEM (#6) 1: Enables tandem control. (Set this parameter for the main- and sub-axes.)

–	–	Number of CNC controlled axes (for Series 16 only)
1010	–	

As with the PMC axis, specify a number obtained by subtracting the number of tandem sub-axes from the number of controlled axes.
If an invalid-parameter alarm is issued, check whether the value set in this parameter is correct.

1021	–	Parallel-axis name (for Series 15 only)
–	–	

Specify 77 and 83 for the main axis and sub-axis, respectively.

1023	–	Servo axis arrangement
1023	–	

This parameter specifies servo axis arrangement.
Set an odd number for a main axis, and the subsequent even number for the sub-axis.
If 3 is set for a main axis, for example, set 4 for the sub-axis.

NOTE
Specify a tandem sub-axis after a CNC-controlled axis (command axis) (by referencing the following examples of setting).

Example of tandem axis setting

(1) For Series 16 (★ indicates a tandem axis.)
Number of controlled axes = 6
Number of CNC-controlled axes (No. 1010) = 3

	Axis number	Axis name	Servo axis arrangement No. 1023	Tandem No. 1817#6	Position display No. 3115#0	Remark
★	1	X	1	1	0	CNC axis (main axis)
★	2	Y	3	1	0	CNC axis (main axis)
	3	Z	5	0	0	CNC axis
★	4	A	2	1	1	Tandem control sub-axis (sub-X-axis)
★	5	B	4	1	1	Tandem control sub-axis (sub-X-axis)
	6	C	6	0	0	PMC axis

(2) For Series 15 (★ indicates a tandem axis.)

	Axis number	Axis name	Servo axis arrangement No. 1023	Tandem No. 1817#6	Parallel axis No. 1021	Remark
★	1	X_M	1	1	77	CNC axis (main axis)
★	2	Y_M	3	1	77	CNC axis (main axis)
	3	Z	5	0	0	CNC axis
	4	A	6	0	0	CNC axis
	5	B	7	0	0	CNC axis
★	6	X_S	2	1	83	Tandem control sub-axis (sub-X-axis)
★	7	Y_S	4	1	83	Tandem control sub-axis (sub-X-axis)

<2> Direction of motor rotation

1879	–	Direction of motor rotation (DIRCT)
2022	–	

Main axis: With a forward direction specified, 111 specifies that the main axis motor rotates counterclockwise as viewed from the motor shaft side, while –111 specifies the opposite direction.

Sub-axis: To cause the sub-axis motor to rotate in the same direction as for the main axis, specify the same value for both the sub-axis and the main axis because of their mechanical structure. To cause the sub-axis motor to reverse, specify a value whose sign is opposite to that for the normal direction. For winding tandem, be sure to specify the values with the same sign.

<3> Position feedback setting

Specify position feedback for both main axis and sub-axis. (See Subsec. 4.17.9 for a concrete example.)

NOTE) Assume position feedback shown in Fig. 4.17.9 (a) not only for the main axis but also for the sub-axis.

	Series 16	Series 15
☐ Semi-closed or full-closed loop setting	No. 1815#1	No. 1815#1 No. 1807#1
☐ DMR setting	No. 1816	No. 1816
☐ CMR setting	No. 1820	No. 1820
☐ Setting the reference counter capacity	No. 1821	No. 1896
☐ Setting the high-resolution pulse coder	No. 2000#0	No. 1804#0
☐ Setting the number of velocity detection pulses	No. 2023	No. 1876
☐ Setting the number of position detection pulses	No. 2024	No. 1891
☐ Flexible feed gear (numerator) setting	No. 2084	No. 1977
☐ Flexible feed gear (denominator) setting	No. 2085	No. 1978

(4) Descriptions of servo parameters for adjustment

The load inertia ratio to be specified for axes subjected to tandem control differs from that for ordinary axes.

1875	–	Load inertia ratio (LDINT)
2021	–	

[Standard setting] (Load inertia/motor inertia) × 256

(NOTE) In typical tandem control, the total load inertia of the machine is borne by two motors. So, calculate the load inertia for the above formula as follows:

(Load inertia) = (Total load inertia of machine)/2

When the full preload function is used, the motor on the driving side is required to bear the total load inertia of the machine and the motor inertia of the other motor. So, calculate the load inertia for the above formula as follows:

(Load inertia) = (Total load inertia of machine) + (Motor inertia)

Example of setting The example shown in Fig. 4.17 (a) is used. Assume that the inertia of each section applied to the motor shaft as follows:

- Inertias of the reducers of the main- and sub-axes: J_{1m}, J_{1s}
- Inertias of the pinions of the main- and sub-axes: J_{2m}, J_{2s}
- Inertia of the rack: J_3

(Total load inertia of the machine) = $J_{1m} + J_{2m} + J_3 + J_{1s} + J_{2s}$

When the total load inertia of the machine is double that of the motor inertia, for example, set the following:

When typical tandem control is used:

(Load inertia ratio) = (2/2) × 256 = 256

When the full preload function is used:

(Load inertia ratio) = (2 + 1) × 256 = 768

The result obtained from the above formula may cause oscillation due to the mechanical structure. In such a case, set a smaller value.

○ Notes on stable tandem control operation

To ensure stable tandem control operation, the machine must be capable of performing back-feed.

Back-feed is the moving of the sub-motor from the main motor, or vice versa, through the connected transmission feature. When the back-feed capability is disabled, unstable operation results. In this case, machine adjustment becomes necessary.

The user can check whether the back-feed capability is enabled. To make this check in the case of the example shown in Figs. 4.17 (a) and (b), turn the main motor with the power line for the sub-motor disconnected, and check that the main motor can be turned with one-third or less of the rated torque of the motor (See (2) in Subsec. 4.17.9).

4.17.1 Preload Function

By applying an offset to the torque controlled by position (velocity) feedback, torques of opposite directions can be applied to the main- (main motor) and sub-axes (sub-motor) to maintain tension at all times. This function can reduce the backlash between the main- and sub-axes, caused by the tandem connection of two motors through gears. However, this function does not reduce the backlash between the ball screw and table, which are a feature of the machine system.

For example, set preload +Pre for the main axis and preload -Pre for the sub-axis. Then, torques are produced as shown below.

If a torque is required during acceleration/deceleration, a torque of the same direction is produced with the two motors. (Load sharing mode)

If no torque is required, for example, during stop state, preload torques produce tension between the two axes. (Anti-backlash mode)

For an application which requires only anti-backlash mode, use the full preload function, described in Subsec. 4.17.7.

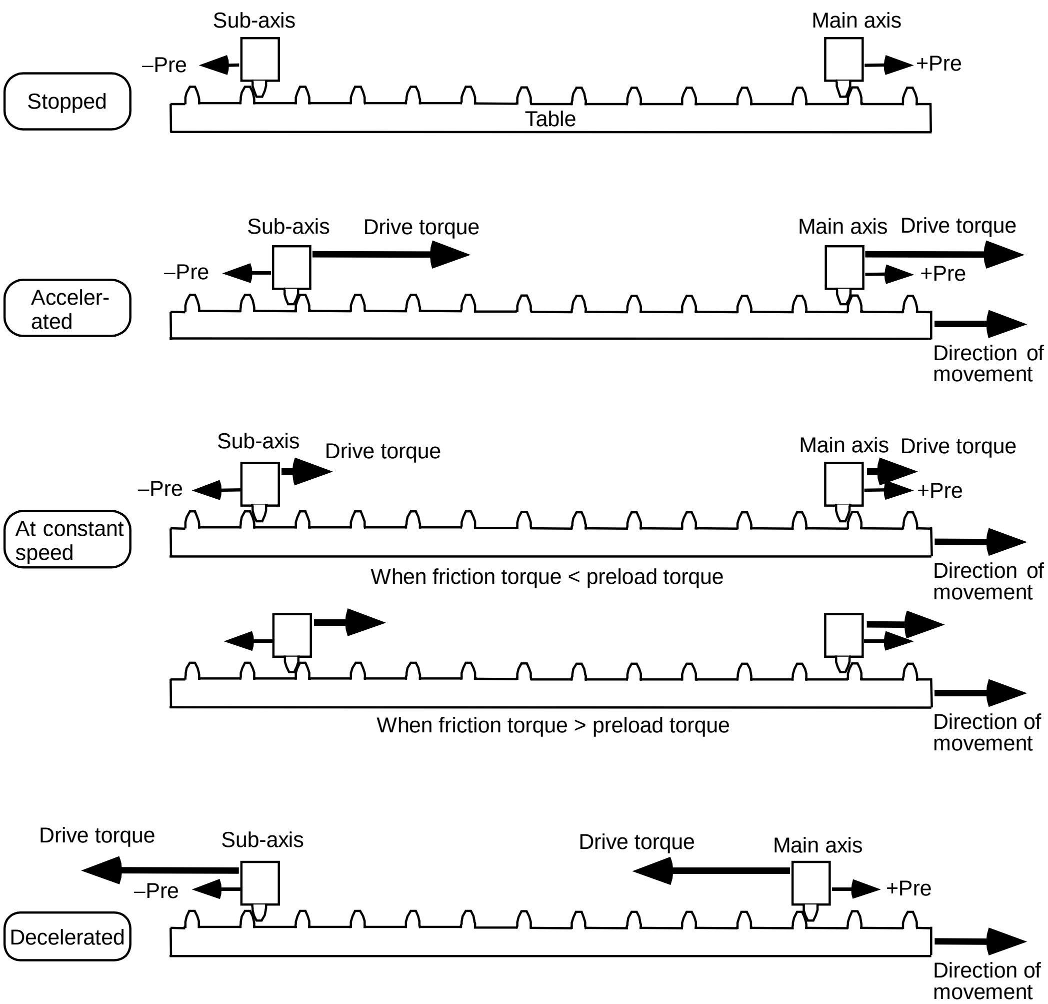


Fig. 4.17.1 (a) Changes of torque during movement

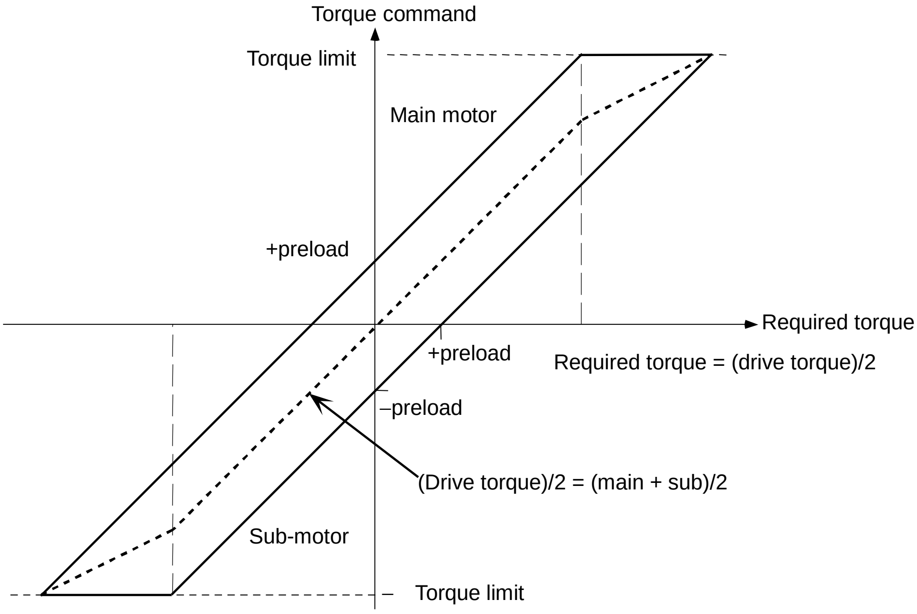


Fig. 4.17.1 (b) Relationship between required torque and torque command for each motor

1980	**–**	**Preload value (PRLOAD)**
2087	**–**	

Set this parameter for the main- and sub-axes.

CAUTION

Set a value that is as small as possible but greater than the static friction torque. A set preload torque is applied to each motor at all times. So, set a value that does not exceed the rated static torque of each motor. As a guideline, specify a value equal to one-third of the rated static torque.

As shown in Fig. 4.17.11 (a) in Subsec. 4.17.11, a preload torque is added in any case. So, set the preload torque directions as follows:

- When the rotation directions of the main axis and sub-axis are the same: Different signs
- When the rotation directions of the main axis and sub-axis are different: Same sign

Example of setting

For the α22/3000 (Servo module SVM1-130)
When a preload torque of 5 Nm is to be applied, the torque constant is 0.68 Nm/Arms according to the specifications of the servo motor. So, the peak value is 0.48 Nm/Ap. The torque is converted to a current value as follows:

$$5/0.48 = 10.4 \text{ Ap.}$$

The amplifier limit is 130 Ap, so that the value to be set is:

$$10.4/130 \times 7282 = 583$$

So, set 583 for the main axis, and –583 for the sub-axis (when the directions of rotation of the two motors are the same).
When movement of the table is stopped, check whether the system is in tension. If not, increase this value gradually.

WARNING

When two motors are not connected, always set a preload value of 0.
The sub-axis motor may rotate at extremely high speed, which is very dangerous.

4.17.2 Damping Compensation Function

To enable more stable tandem control, a torque offset can be applied to the sub-axis, or to both the main- and sub-axes to eliminate a difference in speed, if any, between the main- and sub-axes.
This function is particularly useful for controlling the vibration (with a frequency of several Hz to 30 or 40 Hz) that may occur in a machine system with a low spring rigidity.

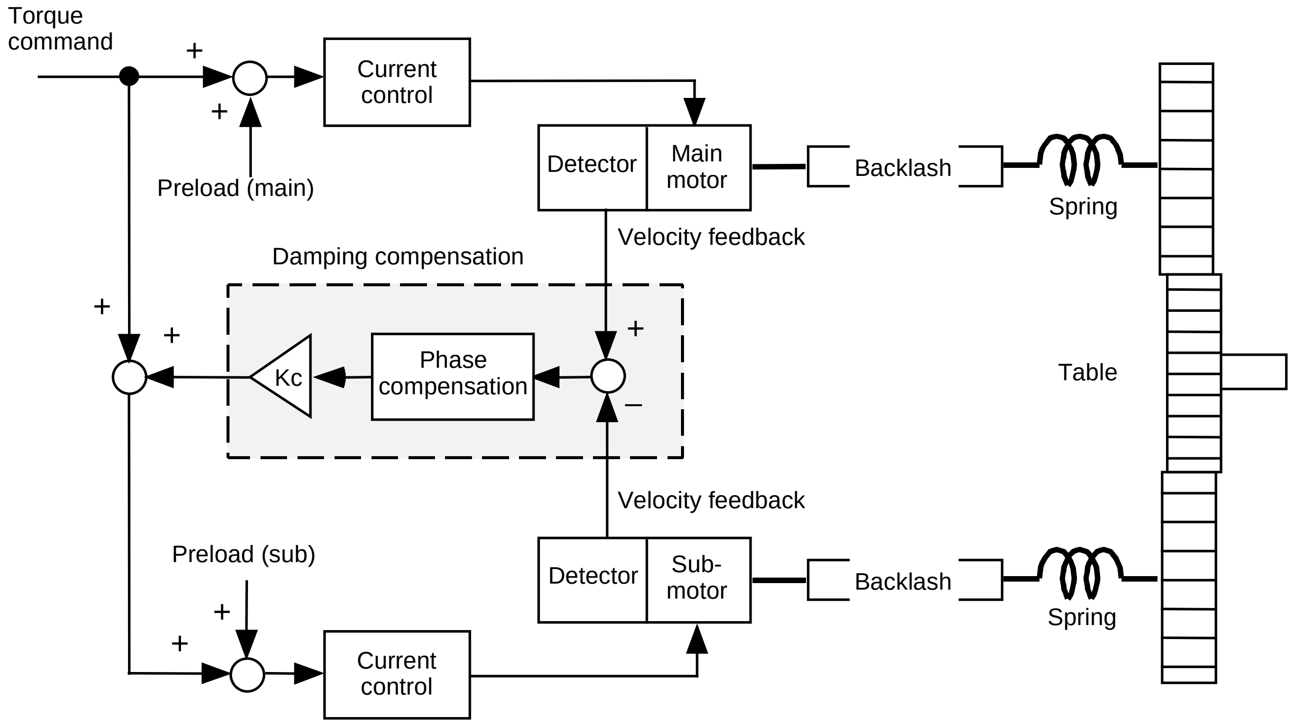


Fig. 4.17.2 (a) Damping compensation function

		#7	#6	#5	#4	#3	#2	#1	#0
1952	–	LAXDMP							
2008	–								

LAXDMP (#7) 1: Enables the damping compensation function for the main- and sub-axes.
When LAXDMP (#7) = 0, the damping compensation function is enabled for the sub-axis only.
Usually, set this bit to 1. (Set this parameter for the main axis only.)

(Series 9060/P(16) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03)and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

1721	–	**Damping compensation gain Kc (ABPGL)**
2036	–	

Set this parameter for the main axis only.

[Valid data range] 0 to 32767

[Setting method] $Kc \times 32768$ $(0 \le Kc < 0.5)$

A function bit is not supported for the damping compensation function; the damping compensation function is enabled at all times. When 0 is set in this parameter, the damping compensation function is ineffective.

(Series 9060/N(14) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

1721	–	**Damping compensation phase coefficient α (ABPHL)**
2036	–	

Set this parameter for the sub-axis only.

[Valid data range] 51 to 512

[Setting method] $\alpha \times 512$ $(0.1 \le \alpha \le 1.0)$

When 0 is set in this parameter, this setting is internally handled as 512 ($\alpha = 1$), When $\alpha = 1$, phase compensation is not performed. Instead, the set value is output to Kc as is.

(Series 9060/P(16) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

(Example of adjustment) The speeds of the motors are checked using the check board (when the motors rotate in the same direction).

This function may be useful when the oscillation frequencies (several Hz to 30 or 40 Hz) are the same, and the phases are opposite as shown below.

NOTE

1 When the directions of rotation of the main motor and sub-motor are different, the phase relationship is reversed.
2 When the phase difference is not 180°, the phase coefficient α must be adjusted. Start with 512, then decrease the value gradually.

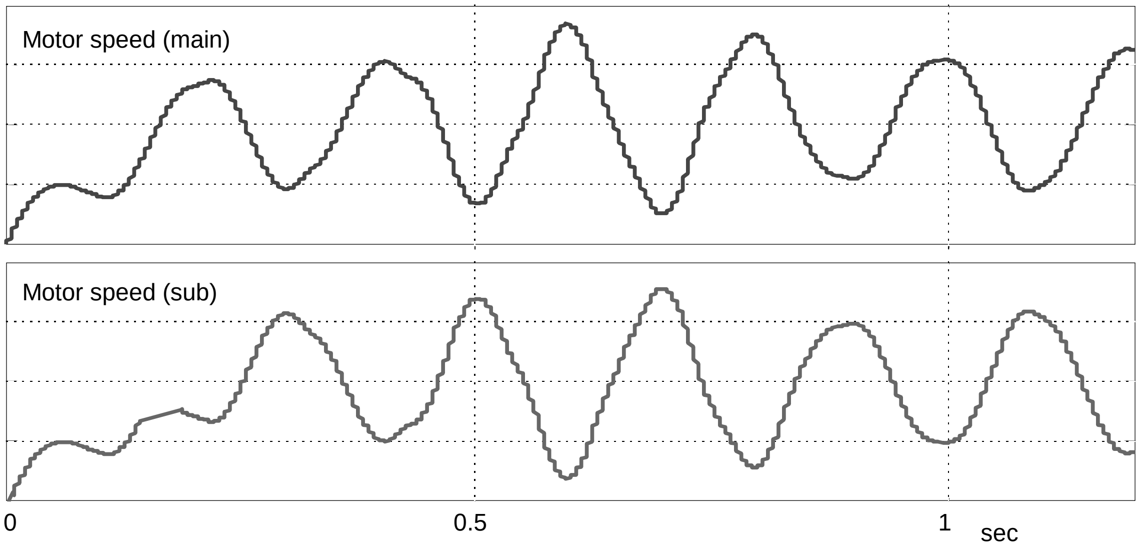


Fig. 4.17.2 (b) Motor speed vibration

● Adjustment procedure for damping compensation

P Enable the velocity feedback averaging function.
[No. 1952#2 (Series 15), No. 2008#2 (Series 16) = 1]

2 Set an adequate preload value.
[No. 1980 (Series 15), No. 2087 (Series 16)]
Set a value slightly larger than the load applied during movement.

3 If dual-position feedback function is used, set a time constant of 200 [No. 1973 (Series 15), No. 2080 (Series 16)].
Adjust the setting of the parameter to ensure stable axis movement.

4 Set 0 or 512 as phase coefficient α.
[Sub-axis No.1721 (Series 15), No. 2036 (Series 16)]
If 512 is set, the value may have to be reduced when the vibration phase difference between the motors is other than 180°. (See Fig. 4.17.2 (b).)

5 Set a damping gain of 3277.
[Main axis No. 1721 (Series 15), No. 2036 (Series 16)]
To reduce the vibration, this value must be increased or decreased. Be careful not to increase this value excessively. Otherwise, high-frequency vibration will occur.
When adjusting this parameter, apply the maximum axis load.

6 Repeat steps 2 through 5 until smooth movement is achieved.

4.17.3 Velocity Feedback Averaging Function

As can be seen from the tandem control block diagram shown in Fig. 4.17.11 (a) in Subsec. 4.17.11, velocity control is not applied to the sub-axis motor. For this reason, the sub-axis may vibrate and become unstable due to a backlash such as, for example, in the gears, in a machine with a large backlash. In such a case, the machine can be made stable by applying velocity control to the sub-axis as well. This function is referred to as the velocity feedback averaging function.

		#7	#6	#5	#4	#3	#2	#1	#0
1952	–						VFBAVE		
2008	–								

VFBAVE (#2) 1: Enables the velocity feedback averaging function. Usually, set this bit to 1. (Set this parameter for the main axis only.)
(Series 9060/F(06) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

NOTE
For some machines, a position deviation may change largely at low averaging precision, depending on the direction of movement.
This problem will not happen in the following editions because the averaging precision has been improved.
Series 9090/K(11) and subsequent editions, and 90A0/G(07) and subsequent editions

4.17.4 Servo Alarm 2-axis Simultaneous Monitor Function

If an alarm occurs in either of two axis motors used to operate a machine in concert as in synchronization control or tandem control, it is necessary to stop the other axis immediately so as to prevent the machine from being twisted.
This function monitors two axes simultaneously for servo alarm conditions. If an alarm condition is detected in either of the two axes, the function can promptly turn off activation (Mcc) for the other axis.
This function is not confined to tandem axes. It can be used also axes under synchronization control.

		#7	#6	#5	#4	#3	#2	#1	#0
1951	–								EXP2AX
2007	–								

EXP2AX (#0) 1: Enables the servo alarm two-axis monitor function.
(Set this parameter for the main axis only.)
(Series 9080/K(11) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

4.17.5 Motor Feedback Sharing Function

To achieve improved thrust, two linear motors may be connected in series.
When linear motors are connected in series, one position feedback signal, which is originally available for the main axis, is to be shared by the sub-axis as well. In this case, the motor feedback sharing function can be used.
This function can also be used when a motor (α300, α400) with the wire tandem specification is used.

> **NOTE**
> When using this function in a full-closed loop system, the main axis shares its separate detector feedback loop with the sub-axis.

		#7	#6	#5	#4	#3	#2	#1	#0
1960	–	PFBCPY							
2018	–	1							

PFBCPY (#7) 1: The motor feedback signal for the main axis is shared by the sub-axis motor.
(Set this parameter for the sub-axis only.)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

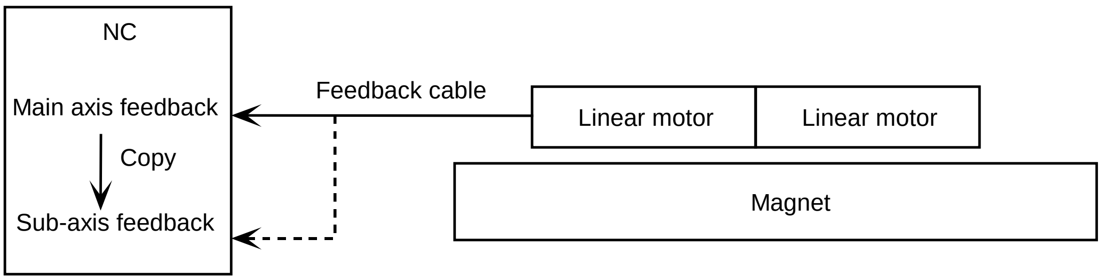


Fig. 4.17.5 Motor feedback sharing function

4.17.6 Full-closed Loop Feedback Sharing Function

When applying synchronization control or tandem control, you may need to use one separate detector feedback loop for both the main and sub-axes. The loop can be branched out by hardware, but a problem like noise may arise. Using this function enables the software to cause one separate detector feedback loop to be shared between the main and sub-axes.

		#7	#6	#5	#4	#3	#2	#1	#0
1940	–							FULLCP	
2200	–								

FULLCP (#1) 1: Sub-axis separate detector feedback is shared by the main and sub-axes.
(Set this parameter for the sub-axis only.)
(Series 90A0/I(09) and subsequent editions)

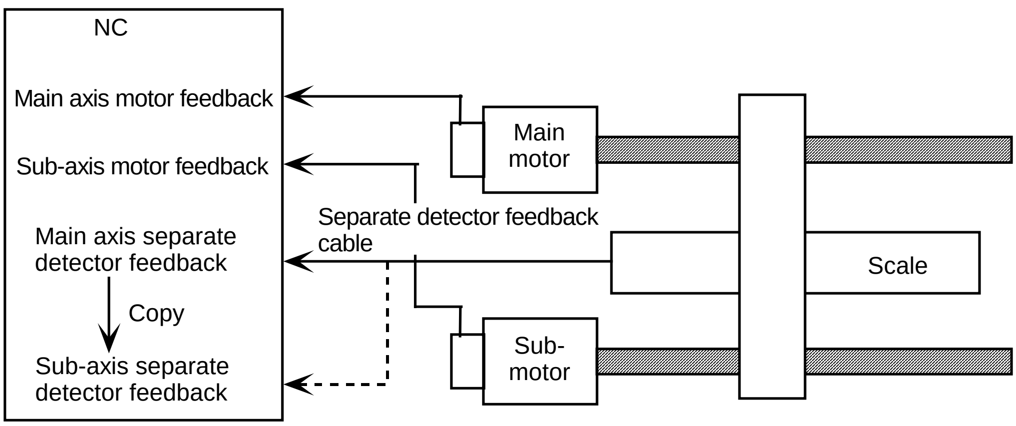


Fig. 4.17.6 Full-closed loop feedback sharing function

4.17.7 Full Preload Function

(1) Overview

In tandem control, special preload torques of opposite directions, as shown in Fig. 4.17.7 (a), are applied to the main motor and sub-motor to establish tension in the system.
With these special torques, the rack and pinions can be kept in tension at all times, as shown in Fig. 4.17.7 (b). This function is referred to as the full preload function.
However, this function is basically designed to be used together with the position feedback switch function. So, it is supported by the following editions in the Series 16. For the Series 15, there is no limitation on the supporting editions.

16*i*-MA: B0F1/13 16*i*-TA: B1F1/12 18*i*-MA: BDF1/13
18*i*-TA: BEF1/12
16-MC: B0B1/20 16-TC: B1B1/17 18-MC: BDB1/18
18-TC: BEB1/18

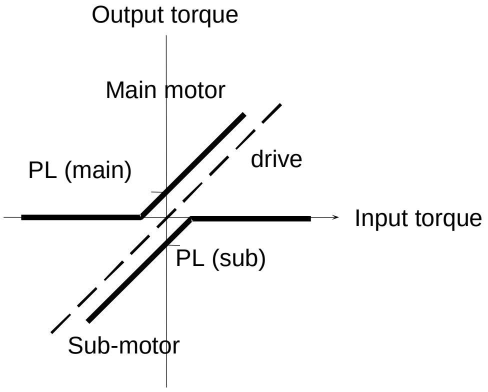


Fig. 4.17.7 (a) Full preload function

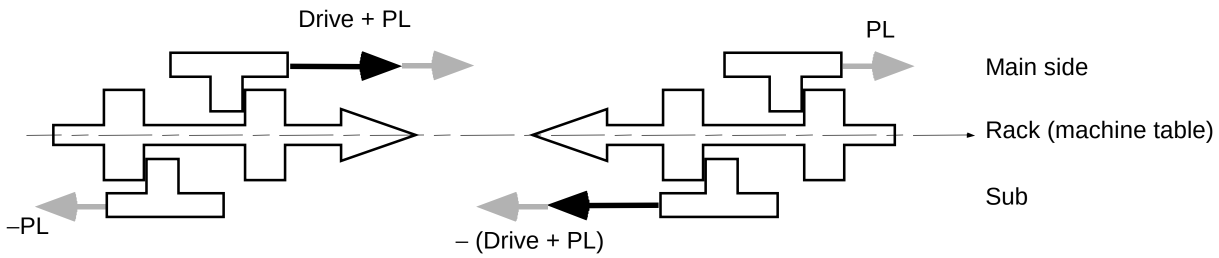


Fig. 4.17.7 (b) Relationship between full preloads and backlash (conceptual)

○ Servo block diagram (full preload function)

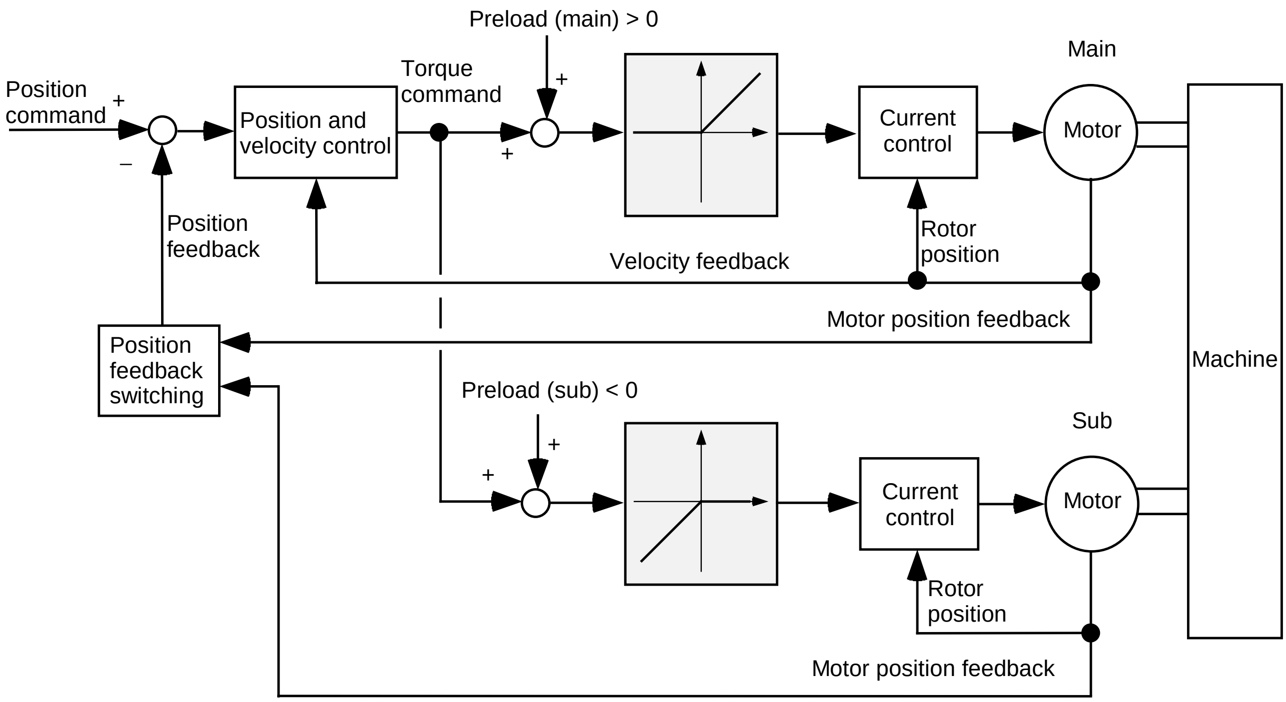


Fig. 4.17.7 (c) Servo block diagram (full preload function)

(2) Parameters for the full preload function

		#7	#6	#5	#4	#3	#2	#1	#0
1952	–					SPPRLD			
2008	–								

SPPRLD (#3) 1: Enables the full preload function.
(Set this parameter for the main axis only.)
(Series 9060/N(14) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

> **CAUTION**
> Always set this bit while the system is in the emergency stop state. After rewriting this bit, always turn the power to the NC off, then back on.

		#7	#6	#5	#4	#3	#2	#1	#0
1952	–				SPPCHG				
2008	–								

SPPCHG (#4) Specifies the motor output torque polarities:

1: Outputs only the negative polarity to the main axis, and only the positive polarity to the sub-axis.

0: Outputs only the positive polarity to the main axis, and only the negative polarity to the sub-axis.

(Set this parameter for the main axis only.)

NOTE) A motor torque with a positive polarity is a torque that is produced counter clockwise as viewed from the shaft.

See Fig. 4.17.7 (d).

(Series 9060/N(14) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

○ Preload torque signs to be set when the full preload function is used

The polarity of a preload value must always be the same as that of the output torque. So, set the polarities as follows:

When SPPCHG = 0	Main-side preload value ≥ 0
	Sub-side preload value ≤ 0
When SPPCHG = 1	Main-side preload value ≤ 0
	Sub-side preload value ≥ 0

CAUTION

Always set this bit while the system is in the emergency stop state. After rewriting this bit, always turn the power to the NC off, then back on.

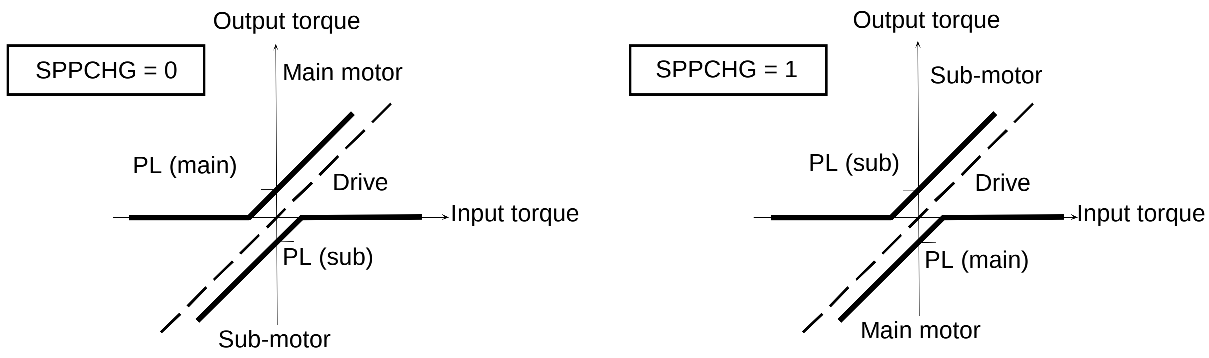


Fig. 4.17.7 (d) Torque output polarity switching and signs of preload values (PL)

(3) Changing the torque output polarity with the full preload function

When the full preload function is used together with synchronous tandem control as shown in Fig. 4.17.7 (e), set the torque output polarity with the parameter bit SPPCHG (No. 1952#4, No. 2008#4) so that the main motor on the master side and that on the slave side produce torques in the same direction.

CAUTION

In the example shown in Fig. 4.17.7 (e), the main motor on the master side faces the main motor on the slave side. This means that if the same torque output polarity is set, the two main motors will produce opposing torques, resulting in twisting of the machine. In such a case, set the output polarities so that the output polarity on the master side is opposite to that on the slave side.

That is, to prevent the machine from twisting, the output polarities of the motors must be determined according to the structure of the machine.

Table 4.17.7(a) Example of setting (1)

Synchronous axis	Tandem axis	Motor name	SPPCHG	Preload value
Master	Main	X_m	0	+
	Sub	X_2		–
Slave	Main	X_3	1	–
	Sub	X_4		+

Another example is given below.

Table 4.17.7(b) Example of setting (2)

Synchronous axis	Tandem axis	Motor name	SPPCHG	Preload value
Master	Main	X_m	1	–
	Sub	X_2		+
Slave	Main	X_3	0	+
	Sub	X_4		–

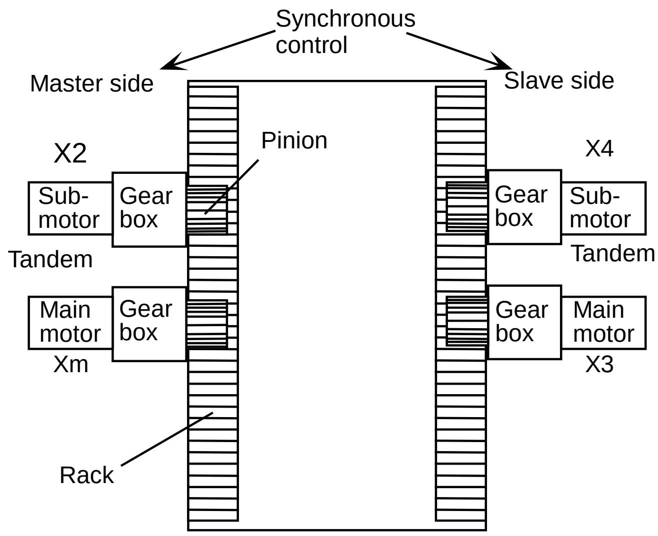


Fig. 4.17.7 (e) Synchronous tandem control

(4) Checking whether the full preload function is operating normally

- Observe Tcmd on the main- and sub-axes with the check board. The results are output to ch2 (main axis) and ch4 (sub-axis).
- After adjusting the damping compensation gain to 0, apply an acceleration/deceleration command. If the Tcmd value on the main side is positive, and the Tcmd value on the sub-side is negative, the full preload function is operating normally (when SPPCHG = 0).

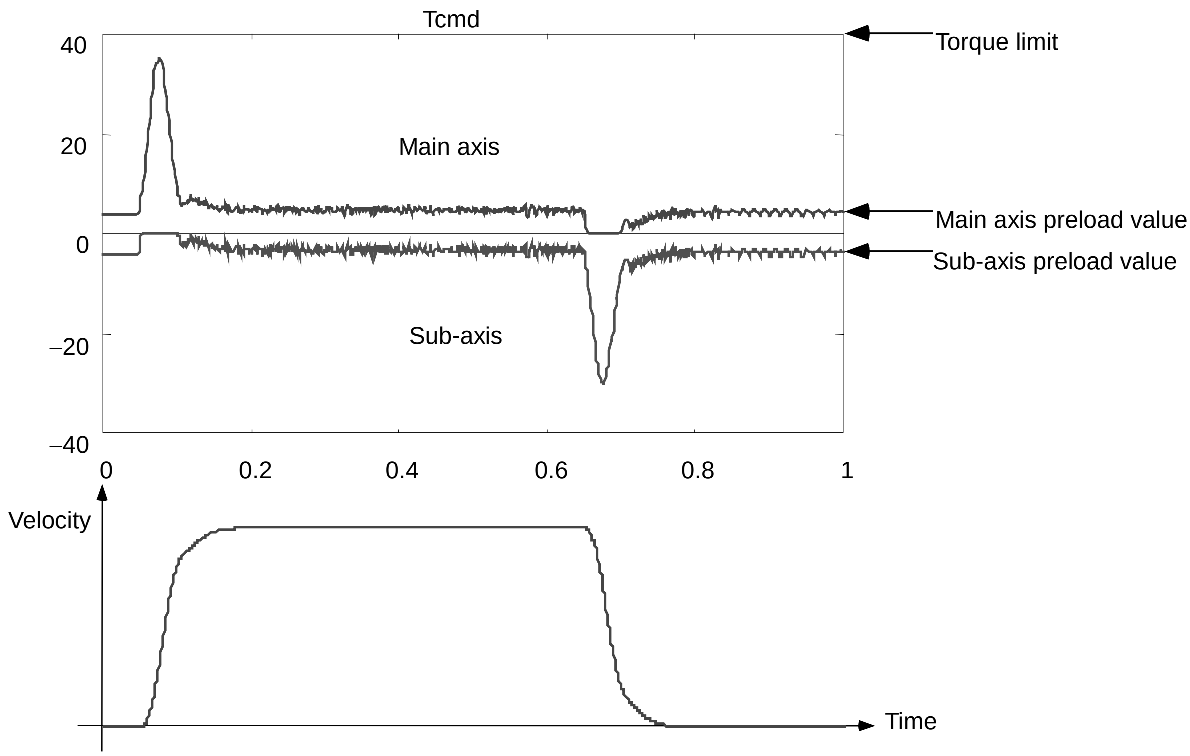


Fig. 4.17.7 (f) Tcmd at acceleration/deceleration time (when the full preload function is used)

4.17.8 Position Feedback Switching Function

When the full preload function is enabled, low servo rigidity can result in vibration, as shown in Fig. 4.17.8 (a), only in the case of driving by the sub-axis. In such a case, stable operation can be achieved by using the position feedback switching function.

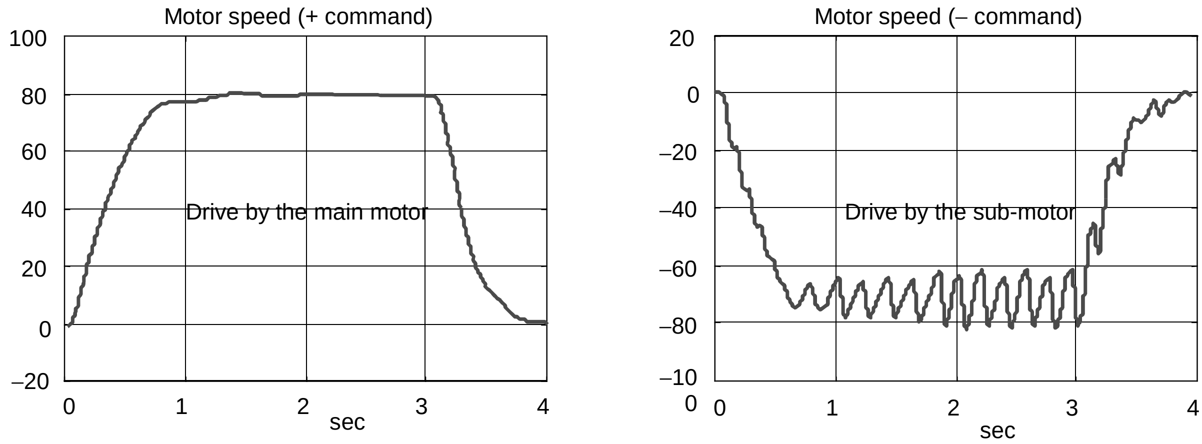


Fig. 4.17.8 (a) Motor speeds with plus-direction and minus-direction commands

		#7	#6	#5	#4	#3	#2	#1	#0
1952	–		PFBSWC						
2008	–								

PFBSWC (#6)
1: Switches position feedback according to the direction of a torque command.
0: Always uses main axis position feedback.
(Set this parameter for the main axis only.)

(Series 9060/P(16) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

CAUTION
Always set this bit while the system is in the emergency stop state. After rewriting this bit, always turn the power to the NC off, then back on.

1737	–	Position feedback switching time constant τ (JITEI)
2126	–	

Set this parameter for the main axis only. Set 0 for this parameter for the sub-axis.

[Valid data range] 0 to 4096

[Method of setting] $\{1 - \exp(-1\ \text{ms}/\tau)\} \times 4096$

[Standard setting] 0

When $\tau = \infty$: Parameter = 0

When τ = 50 ms: Parameter = 81

When τ = 0: Parameter = 4096

> **NOTE**
> This parameter is valid only when PFBSWC = 1.

● Notes on the position feedback switching function

- Reference position return operation and positioning are performed with the main axis only. Note, however, that during movement (command ≠ 0), position feedback on the driving side is used for position control. (A switching time constant is to be specified with the parameter.)
- Adjust the switching time constant if a shock is observed at the time of position feedback switching.
- Basically, the position feedback switching function assumes setting of semi-closed loop mode.
  When the position feedback switching function is to be used with full-closed loop mode, divide the scale signal into two to apply the same signal to both the main and sub-sides.
  Moreover, set full-closed loop mode for the main and sub-sides as well.

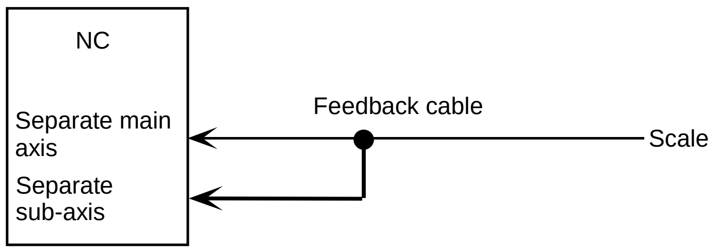


Fig. 4.17.8 (b) Cable on the scale side when the position feedback switching function is used (full-closed loop)

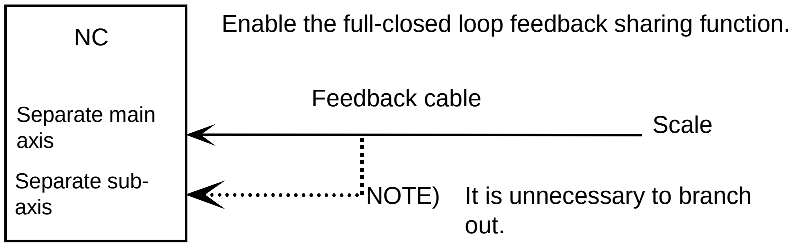


Fig. 4.17.8 (c) Example of using the full-closed loop feedback sharing function together with the position feedback switch function

4.17.9 Adjustment

(1) Examples of parameter setting

This section gives examples of parameter setting.

<1> Full-closed loop system using a 1-µm increment system, 8080P/motor revolution for scale feedback, a scale detection unit of 0.5 µm/P, and an α 64 pulse coder (conventional tandem)

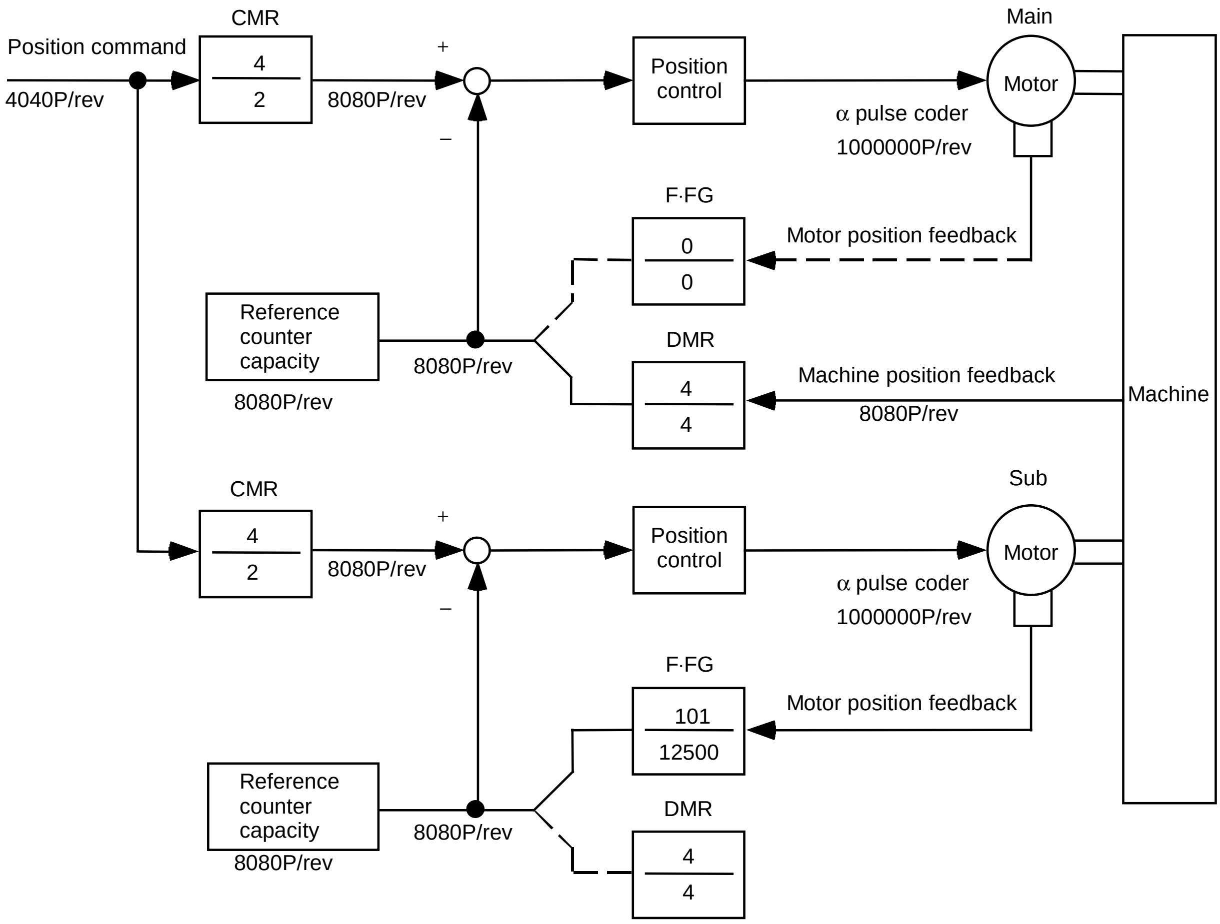


Fig. 4.17.9 (a) Example of position feedback setting

	Series 16	Series 15	Main	Sub
• Tandem axis	No. 1817#6	No. 1817#1	1	1
• Full-closed loop	No. 1815#1	No. 1815#1	1	0
		No. 1807#3	1	0
• DMR	No. 1816	No. 1816	01110000	01110000
• CMR	No. 1820	No. 1820	4	4
• Reference counter capacity	No. 1821	No. 1896	8080	8080
• High-resolution pulse coder	No. 2000#0	No. 1804#0	0	0
• Number of velocity detection pulses	No. 2023	No. 1876	8192	8192
• Number of position detection pulses	No. 2024	No. 1891	8080	12500
• Flexible feed gear	No. 2084	No. 1977	0	101
• Flexible feed gear	No. 2085	No. 1978	0	12500

<2> Semi-closed loop system using a 1-μ° increment system, rotary axis with a gear reduction ratio of 1/984, and an α 64 pulse coder (conventional tandem)

	Series 16	Series 15	Main	Sub
• Tandem axis	No. 1817#6	No. 1817#1	1	1
• Semi-closed loop	No. 1815#1	No. 1815#1	0	0
		No. 1807#3	0	0
• DMR	No. 1816	No. 1816	01110000	01110000
• CMR	No. 1820	No. 1820	2	2
• Reference counter capacity	No. 1821	No. 1896	15000	15000
• High-resolution pulse coder	No. 2000#0	No. 1804#0	0	0
• Number of velocity detection pulses	No. 2023	No. 1876	8192	8192
• Number of position detection pulses	No. 2024	No. 1891	12500	12500
• Flexible feed gear	No. 2084	No. 1977	3	3
• Flexible feed gear	No. 2085	No. 1978	8200	8200

(NOTE) $\frac{360000/984}{1000000} = \frac{36}{98400} = \frac{3}{8200}$

<3> Assuming a semi-closed loop system with an increment system of 0.1 μm, 10 mm stroke per motor revolution, and α300 motor (winding tandem):

	Series 16	Series 15	Main	Sub
• Tandem axis	No. 1817#6	No. 1817#1	1	1
• DMR	No. 1816	No. 1816	01110000	01110000
• CMR	No. 1820	No. 1820	2	2
• Reference counter capacity	No. 1821	No. 1896	100000	100000
• High-resolution pulse coder	No. 2000#0	No. 1804#0	1	1
• Motor feedback sharing function	No. 2018#7	No. 1960#7	0	1
• Number of velocity detection pulses	No. 2023	No. 1876	819	819
• Number of position detection pulses	No. 2024	No. 1891	1250	1250
• Flexible feed gear	No. 2084	No. 1977	10	10
• Flexible feed gear	No. 2085	No. 1978	100	100

(2) Back-feed confirmation method

(a) Check whether back-feed is possible when the machine is connected and the power line is removed.
If back-feed is impossible, unstable control will result, and machine adjustment such as a gear box adjustment will be necessary.
<1> Making a check manually
First, turn the shaft of the main motor manually to check that the sub-motor turns. Next, turn the shaft of the sub-motor manually to check that the main motor turns. If these checks are successful, back-feed is possible.
<2> Making a check using NC commands
After checking (b) and (c) below, remove the sub-motor power line. Then, enter a plus (+) command or minus (−) command to rotate the main motor. Check that the main motor can be turned with one-third or less of its rated static torque. When this check is successful, back-feed is possible.

(b) With the machine connected, activate the motors. At this time, release the emergency stop state after reducing the torque limit by a factor of about 10.
Check the motor current on the servo adjustment screen. If the current increases gradually, the directions of rotation of the main- and sub-motors may not be set correctly.

(c) Check the operation by entering a plus (+) command and minus (−) command.
If the error persists due to friction load, increase the torque limit.

(d) If the operation is normal, return the torque limit to its original value, then set a preload value.

(3) Adjustment items

If vibration occurs:

- Check the position feedback setting (<3> in Sec. 4.17).
- Check Vcmd (CH1), Tcmd (CH2 and CH4), and the speeds (CH5 and CH6) using the check board.

(a) A higher gear reduction ratio tends to produce more backlash, such that unstable operation will result from the sub-axis running between backlashes.

→ Enable the velocity feedback averaging function.

(No. 1952#2 = 1) Series 15
(No. 2008#2 = 1) Series 16

(b) The main axis and sub-axis vibrate at the same frequency (several Hz to 30 or 40 Hz) as a result of the spring rigidity being low.
(The twist rigidity is proportional to the second power of the gear reduction ratio, so that the frequency is probably a lower resonant frequency.)

→ Enable damping compensation.
(See the adjustment procedure described in Subsec. 4.17.2.)

(No. 1952#2 = 1) Series 15
(No. 2008#2 = 1) Series 16

(c) The operation of a full-closed-loop system is unstable.

→ Check the position feedback setting (<3> in Sec. 4.17.) If the parameters are set correctly, place the system in semi-closed loop mode, then adjust the system to achieve stable operation.
Then, return the system to full-closed loop mode. If the operation is still unstable, apply a function such as the dual position feedback function.

(d) In the stop state, no tension is established between the main axis and sub-axis.

→ Set a preload value of 0, and check the torque in the stop state.
Then, set a preload value greater than the stop-state torque.

(No. 1980) Series 15
(No. 2087) Series 16

(e) Position-dependent vibration occurs.

→ Change the feedrate to determine whether the vibration frequency is constant or proportional to the feedrate.
If the vibration frequency is proportional to the feedrate, position-dependent vibration is occurring. Check position-related items such as the number of gear teeth.

4.17.10 Notes on Tandem Control

(1) Tandem control and synchronous control selection criteria

Two control methods are supported to enable the control of one axis using two motors: tandem control and synchronous control. The synchronous control method controls the position of the master axis and slave axis by using the same command. If a position feedback difference occurs between the two motors, control is applied by correcting the slave axis. The servo system applies position control separately to the master and slave axes.

The tandem control method exercises position control over the main axis only; this method exercises torque control over the sub-axis only. (For clarity, the terms master and slave are used for synchronous control, while main and sub are used for tandem control.)

When building a machine system, select a suitable control method, paying careful attention to the differences between the control methods.

In general, apply the following guideline:

- When the machine system is rigid or supports back-feed, select tandem control.
- When the machine system exhibits effects such as twisting, or does not support back-feed, select synchronous control (for example, when a gantry type machine or worm wheel is used).

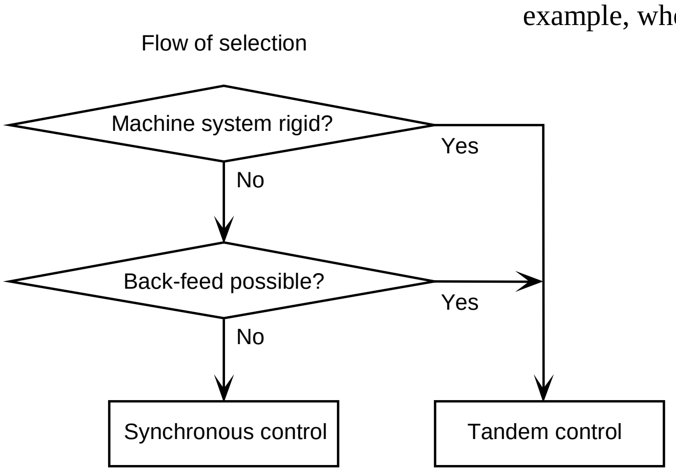


Fig. 4.17.10 (a) Flow of selection

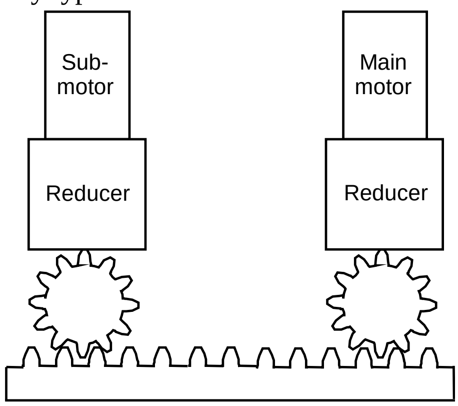


Fig. 4.17.10 (c) Example of tandem control (machine system supporting back-feed)

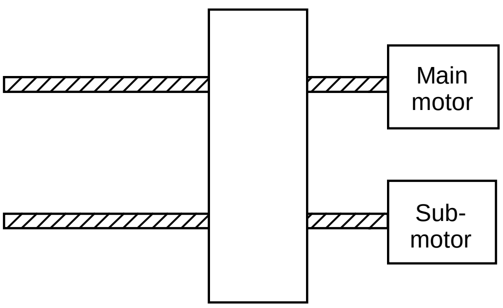


Fig. 4.17.10 (b) Example of synchronous control (machine system not supporting back-feed)

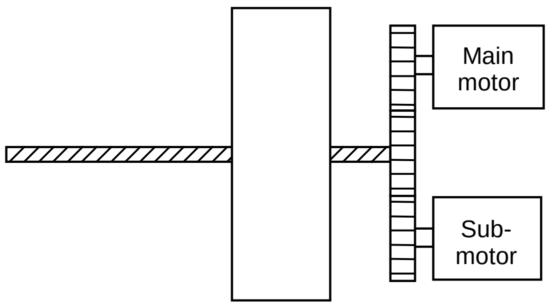


Fig. 4.17.10 (d) Example of tandem control (rigid machine system)

(2) Notes on high-speed processing of velocity loop proportionals

(Torque command) High-speed processing of velocity loop proportionals can be used for tandem control in the following editions:

Series 90A0/I(09) and subsequent editions

In other editions, using high-speed processing of proportionals requires that first velocity command tandem control be enabled, then the proportionals high-speed processing function be enabled.

(Reference)

The name of control varies with the level on which commands are shared. The term "synchronization control" is used when position commands are shared. The term "velocity command tandem control" is used when velocity commands are shared. The terms "torque command tandem control" and "tandem control" are used when torque commands are shared.

		#7	#6	#5	#4	#3	#2	#1	#0
1952	–			VCMDTM					
2008	–								

VCMDTM (#5) 1: Enables velocity command tandem control.
(Set this parameter for the main axis only.)

(Series 9060/N(14) and subsequent editions)
(Series 9080/A(01) and subsequent editions)
(Series 9090/C(03) and subsequent editions)
(Series 90A0/A(01) and subsequent editions)

CAUTION

Usually this bit should be kept at 0.
This function cannot be used together with ordinary tandem control.
Velocity command tandem control does not require preload setting for establishing tension.
This bit should be set at an emergency stop. After it is set, be sure to switch the NC power off and on again.

4.17.11 Block Diagrams

(1) Tandem control

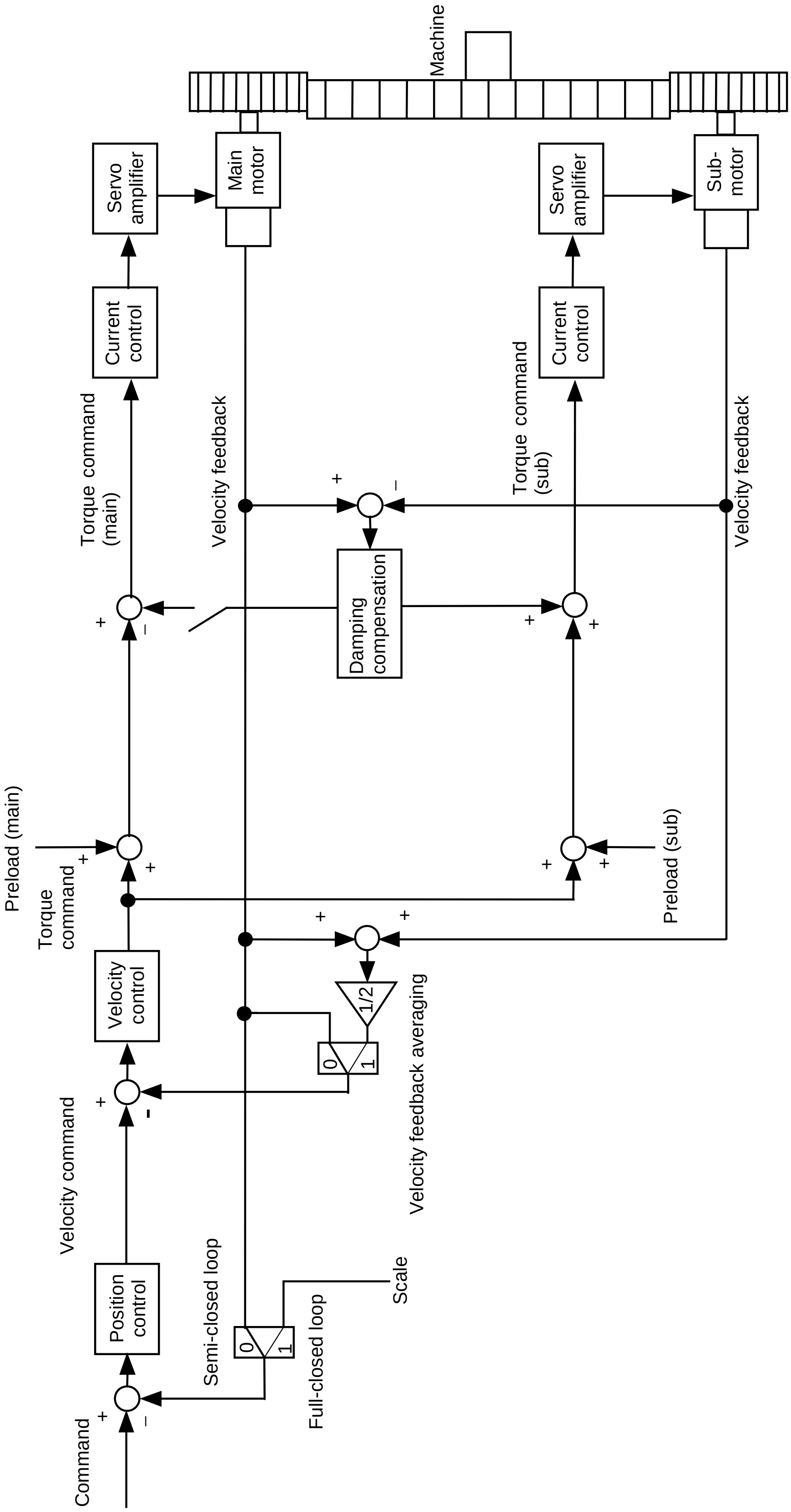


Fig. 4.17.11 (a) Tandem control (typical)

(2) Tandem control (with full preload function)

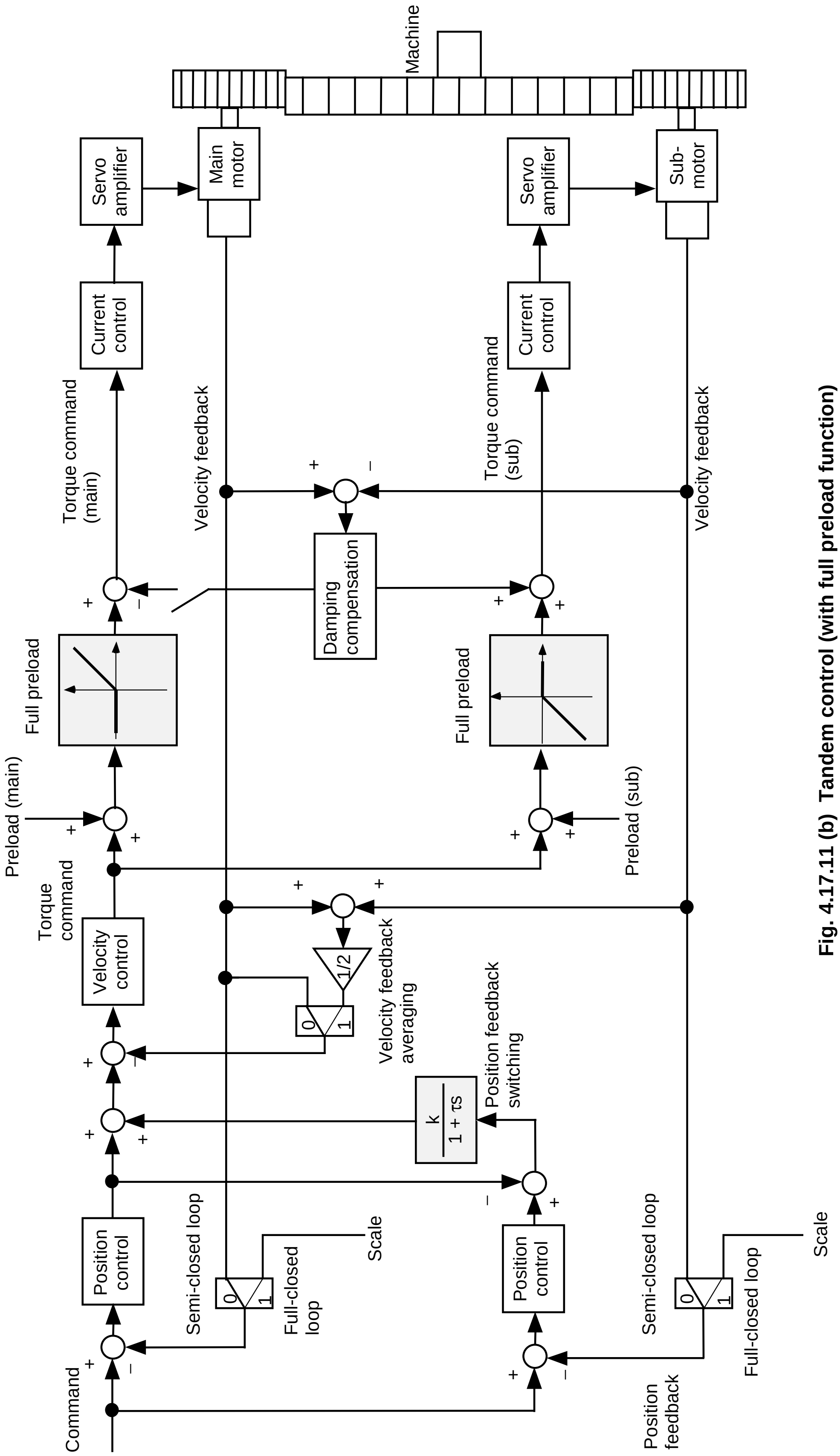


Fig. 4.17.11 (b) Tandem control (with full preload function)

4.18 SERVO AUTO TUNING

(1) Overview

The FANUC auto tuning system uses a personal computer to automatically determine servo-related parameter values. Data such as the move commands required for auto tuning is sent to the NC from the personal computer via the RS-232C interface (DNC operation). Servo data (such as position and velocity data) generated during operation is fed to the personal computer via an interface board manufactured by FANUC; the optimum parameter values for the system are determined by analyzing the data and comparing with a specified figure. The parameter values determined by the auto tuning function are sent to the NC via the RS-232C interface.

(2) Scope

This system allows the adjustments described below to be made.

<1> Velocity loop gain adjustment
The velocity loop gain parameter is automatically adjusted to an optimum value by gradually increasing the gain while monitoring the resonance of the machine system.

<2> Automatic estimation of machine inertia
By repeatedly accelerating/decelerating a machine, the inertia of that machine can be automatically estimated to determine the values of the parameters related to machine inertia. Thus, the acceleration torque of the machine can be separated from the friction torque to facilitate backlash acceleration and unexpected disturbance detection adjustments.

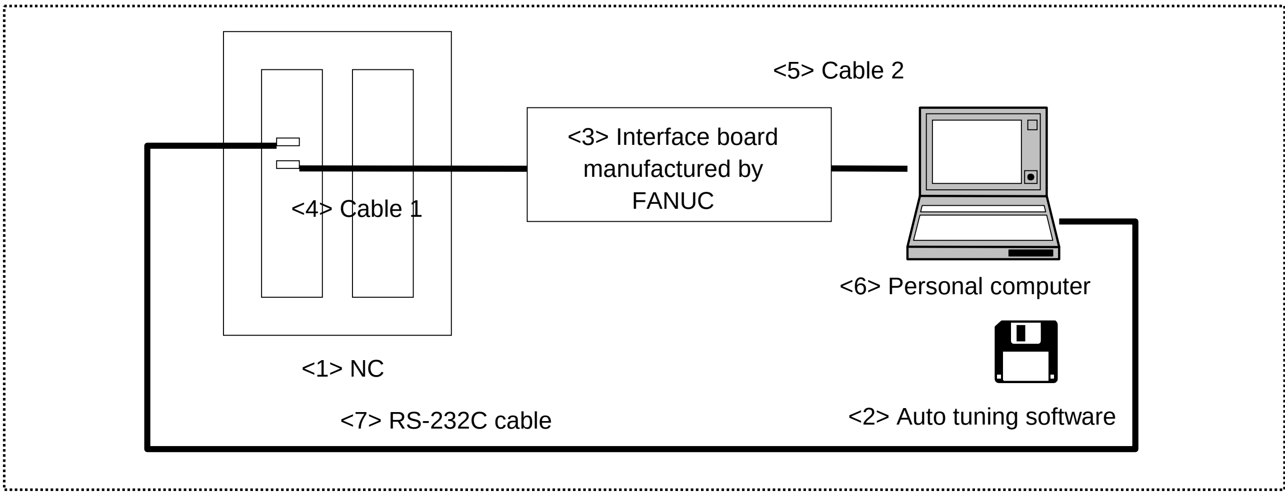
<3> Feed-forward coefficient adjustment
The advanced preview feed-forward coefficient is automatically adjusted to allow the user to eliminate figure errors caused by servo system delay while viewing a circular trace error. (To enable this adjustment, the advanced preview control option is required.)

<4> Quadrant protrusion compensation adjustment
The two-stage backlash acceleration function is adjusted to eliminate quadrant protrusion in circular cutting at both low and high speeds. (To enable this adjustment, the advanced preview control option is not required.)

<5> Measurement of machine system velocity loop frequency characteristics
Even without the use of a special measuring instrument, the frequency characteristics (gain diagram) of a velocity loop involving a machine system can be measured easily.

<6> Creation of initial parameter values
Initial digital servo parameter values can be automatically created using the personal computer. The initial parameters include those parameters that are set on the servo setting screen of the NC, which are automatically set by entering data such as the gear reduction ratio, the motor used, and so forth on the personal computer.

(3) System configuration



(a) Items to be purchased from FANUC

<1> NC

The auto tuning function can be used with the following combinations of system software and servo software (as of May, 1999):

NC name	System software	Servo software
Series 15*i*	All versions can be used.	Series 90A0/A(01) and later
Series 15-B	A0C1/N, A0C2/Q and later AAC1/K, AAC2/G and later A1C2/F A2C1/F, A2C2/F and later A6C1/F, A6C2/G and later A0D1/A, A0D2/B and later AAD1/A, AAD2/C and later A1D2/A A2D1/A, A2D2/A and later A6D1/A, A6D2/B and later	Series 9060/W(23) and later, or Series 9070/H(08) and later, or Series 9080/A(01) and later
Series 16*i* (C52)	All versions can be used.	Series 9090/A(01) and later
Series 16*i* (C543)	B0F1/14 and later, or B1F1/13 and later	Series 90A0/A(01) and later
Series 16-A	B005/24 and later, or B105/18 and later	Series 9060/W(23) and later
Series 16-B	B0A1/13 and later, or B1A1/12	Series 9070/H(08) and later, or Series 9080/A(01) and later
	B7A1/04 and later (Series 16-PB) B8A1/05 and later (Series 16-LB)	
Series 16-C	All versions can be used.	Series 9080/A(01) and later
Series 18*i* (C52)	All versions can be used.	Series 9090/A(01) and later
Series 18*i* (C543)	BDF1/14 and later, or BEF1/13 and later	Series 90A0/A(01) and later
Series 18-A	BD03/20 and later, or BE03/17 and later	Series 9060/W(23) and later

NC name	System software	Servo software
Series 18-B	BDA1/03 and later, or BEA1/04 and later	Series 9070/H(08) and later, or Series 9080/A(01) and later
Series 18-C	All versions can be used.	Series 9080/A(01) and later
Series 21*i* (C52)	All versions can be used.	Series 9090/A(01) and later
Series 21*i* (C543)	DDF1/08 and later, or DEF1/08 and later	Series 90A0/A(01) and later
Series 21-TB	DE01/06 and later	Series 9060/W(23) and later
Series 21-MB	D201/09 and later DDA1/01 and later	Series 9060/W(23) and later

The following servo software can also be used:

- Series 9081/C(03) and later
- Series 9066/F(06) and later

<2> Auto tuning software produced by FANUC

- For NEC PC9801-series
  Specification: A08B-9000-J900
- For IBM PC/AT compatible machines
  Specification: A08B-9001-J900
  (As of May, 1999, the latest edition is Edition 1.6.)

<3> Interface board manufactured by FANUC
Specification: A06B-6057-H630

<4> Cable 1 (for connection between the NC and interface board)
The required cable varies from one NC to another. For detailed descriptions about connection, see Sec. 4.19, "Servo Check Board Operating Procedure."

<5> Cable 2

NOTE

Only when a NEC PC9801-series PC is used, the cable below (for connection between the interface board and PIO48W manufactured by Contech) is to be purchased from FANUC.
For a desktop personal computer
Specification: A06B-6050-K870
For a notebook-sized personal computer
Specification: A06B-6050-K869

(b) Items to be provided by the customer

<1> Cable 2

> **NOTE**
>
> Only when a IBM PC/AT-compatible machine is used, a commercially available cable (for connection between the interface board and printer port), shorter than 2 meters, must be provided.

<2> Personal computer

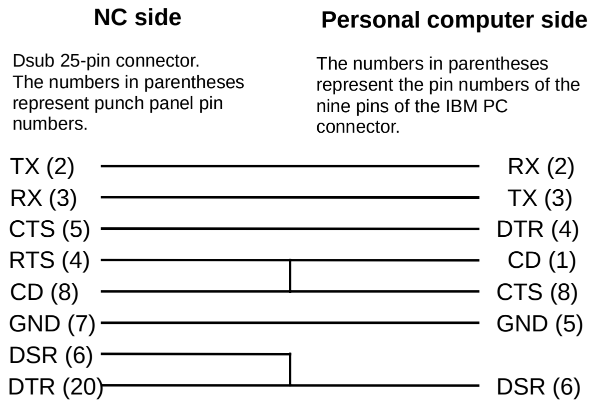
- A NEC PC9801 series or IBM PC/AT-compatible machine can be used.

> **NOTE**
>
> 1 When a NEC PC9801 series PC is used, one of the following I/O expansion boards is required:
> For a desktop personal computer:
> PIO-48W (98) manufactured by Contech
> For a notebook-sized personal computer:
> PIO 48W (9N) manufactured by Contech
>
> NOTE) If a PC9801-series notebook personal computer has no expansion bus connector, it cannot be used.
>
> 2 When a IBM PC/AT-compatible machine is used, the personal computer must be equipped with a bidirectional printer port.
>
> NOTE) Whether the NEC PC98NX series can be used has not been checked.

- The auto tuning system requires a 486SX CPU, 33-MHz, or better. For efficient use, a 486DX2 CPU running at 50 MHz, or better, is recommended.
- The auto tuning software is compatible with MS-DOS® Version 3.0 and later. Note that the auto tuning software is not compatible with Windows®. Use the software in MS-DOS mode.
  (When Windows® 95 is used, the software cannot be used in a DOS window. Therefore, when starting up the personal computer, press the F8 key, then select the DOS prompt only mode.)
  As of May, 1999, the compatibility of the software with the following machines has been confirmed:
- NEC: PC9821Na
- IBM: ThinkPad 235 (Windows® 98),
  535X (Windows® 95)
- Fujitsu: FMV575D4, FMV BIBLO
- Toshiba: DynaBook SS PORTEGE3010
  (Windows® 98)

<3> RS-232C cable

- When a NEC PC9801-series PC is used, a commercially available reverse cable such as the PC-98HA-16 can be used.
- When a IBM PC/AT-compatible machine is used, manufacture the following cable:



(4) Interface board setting procedure

Channel setting for an interface board varies with its type.

(a) Interface board (A06B-6057-H630) supporting eight axes
Set the 7-segment LED digits as shown below:

- For automatic adjustment of the first to fourth axes

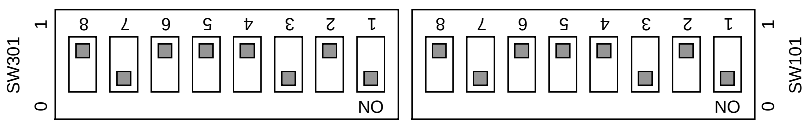
15	25	35	45
CH1	**CH2**	**CH3**	**CH4**

- For automatic adjustment of the fifth to eighth axes

55	65	75	85
CH1	**CH2**	**CH3**	**CH4**

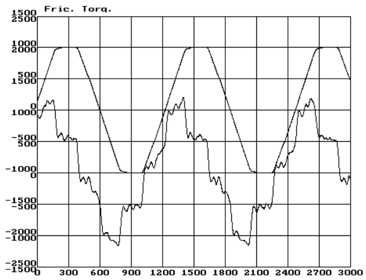
NOTE
This board can be used to make automatic adjustments for any two axes on the same printed-circuit board of an NC. If one of the two axes is any of the first to fourth axes, and the other is any of the fifth to eighth axes, it is necessary to make a special axis setting.

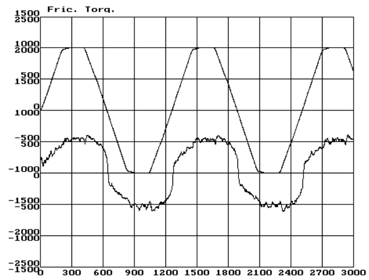
(b) Conventional interface board (A06B-6057-H620)
Set the DIP switches on the interface board as shown below.



For details of usage, refer to MANUAL.TXT, included on the floppy disk on which the auto tuning software is supplied.

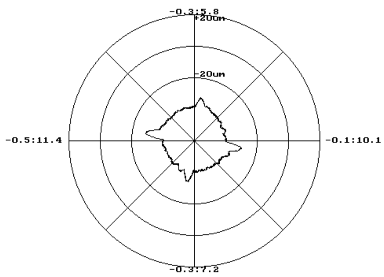
(5) Examples of usage

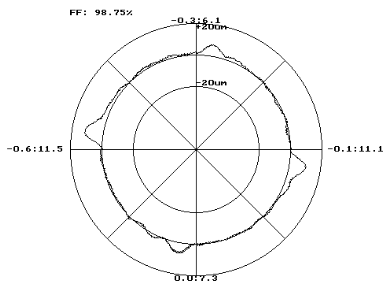




Before inertia estimation
(Up: TSA, Low: Friction torque)

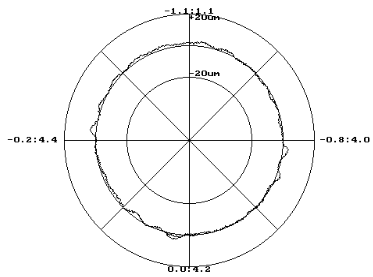
After inertia estimation



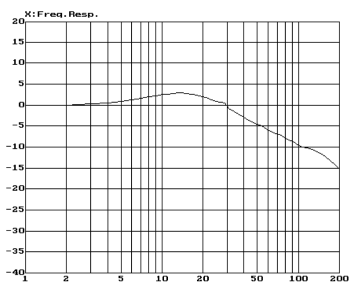


Circle before feed-forward adjustment

Circle after feed-forward adjustment



Circle after backlash acceleration adjustment



Frequency characteristic measurement results

4.19 SERVO CHECK BOARD OPERATING PROCEDURE

(1) Overview

The servo check board enables digital control values used in a digital servo section to be observed from the outside. The digital control values can be observed in either analog or digital form. Analog outputs can be observed directly with an oscilloscope, and digital outputs can be observed with a personal computer.

(2) Servo check board configuration

The following table lists the signals that can be observed with the servo check board, and the number of supported axes.

Table 4.19 (a) Servo check board specification

Name	Specification	Output interface	Number of supported axes	Number of output channels	
A	A06B-6057-H630	Analog and digital	8	4 (optional)	
B	A06B-6057-H620	Digital only	4	4 (optional)	(*)
C	A06B-6057-H602	Analog only	2	8 (fixed)	(*)

* Servo check board A (one-piece analog/digital type) is upward-compatible, that is, can be replaced, with digital check board B and analog check board C.

The method for connecting the servo check board with a CNC varies with the type of the CNC.
The following table lists the ordering information for adapters and cables required to connect the check board.

Table 4.19 (b) Adapters and cables required to connect the servo check board to each CNC

CNC	Required adapters and cables	Ordering information
Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*	Adapter board + dedicated *i* series cable Straight cable	A02B-0236-K822 A06B-6050-K872
Series 15-B, 16, 18, 20, 21-TB, 21-MB	Adapter board (required only for check board C) Straight cable	A02B-0120-C211 A06B-6050-K872
Series 0-C, 15-A, 21-TA, Power Mate	Reverse-insertion-prevented cable	A06B-6050-K871
Power Mate - H	Straight cable	A06B-6050-K872
Power Mate - E	Dedicated Power Mate-E adapter board Reverse-insertion-prevented cable	A02B-0168-K201 A06B-6050-K871
β amplifier with I/O link	Dedicated adapter board + cable Reverse-insertion-prevented cable	A06B-6093-K021 A06B-6050-K871

(3) Servo check board connection

> **CAUTIONS FOR CONNECTION**
> When connecting the servo check board to an NC, keep the NC power supply switched off.

(a) Connection between check board A (one-piece analog/digital type) and each CNC

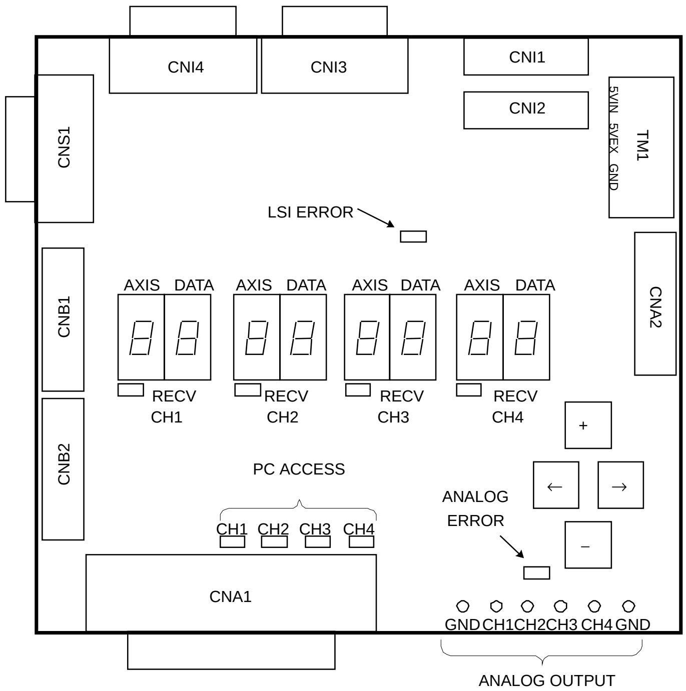
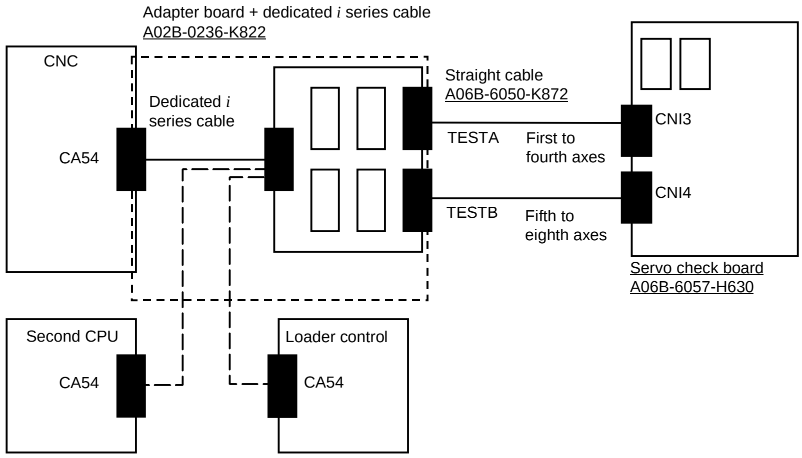
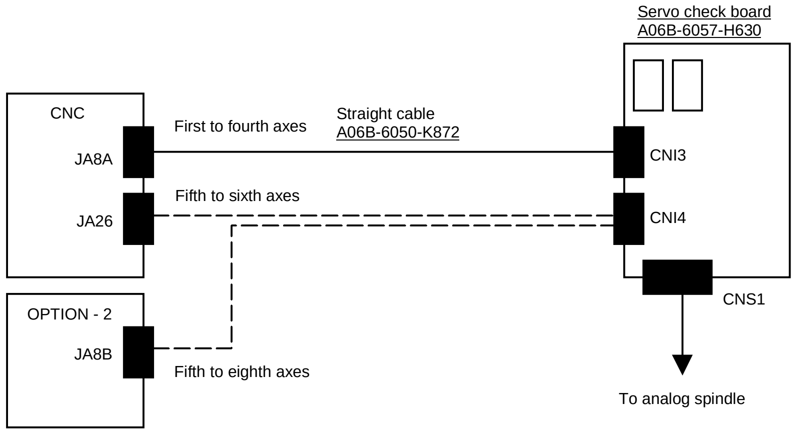


Fig. 4.19 (a) Connector layout on servo check board A (A06B-6057-H630)

Series 15*i* ,16*i*, 18*i*, 21*i*, Power Mate *i*



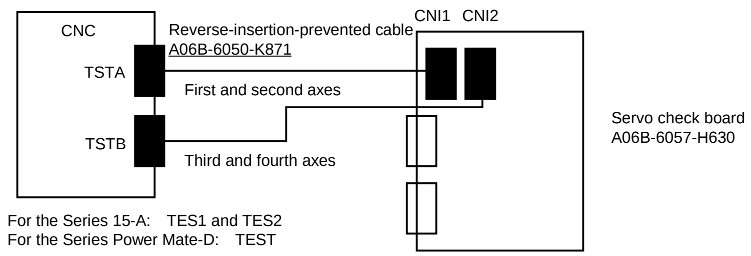
Series 15-B, 16, 18, 20, 21-TB, 21-MB



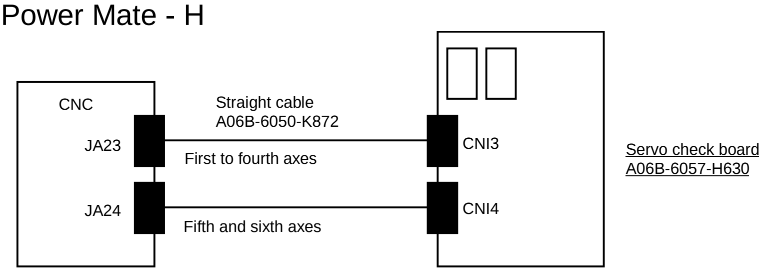
NOTE) To observe data for the fifth and sixth axes using the 6-axis main board in the Series 16-B, 16-C, 18-B, or 18-C, connect between JA26 and CNI4.

NOTE) To use the option 2 board for the Series 16-B, 16-C, 18-B, or 18-C, connect between JA8B and CNI4.

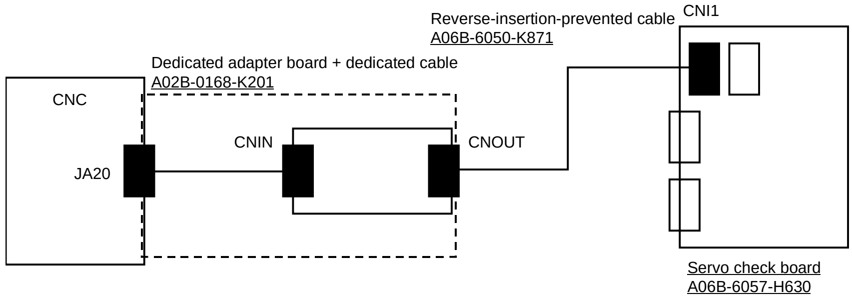
Series 0-C, 15-A, 21-TA, Power Mate



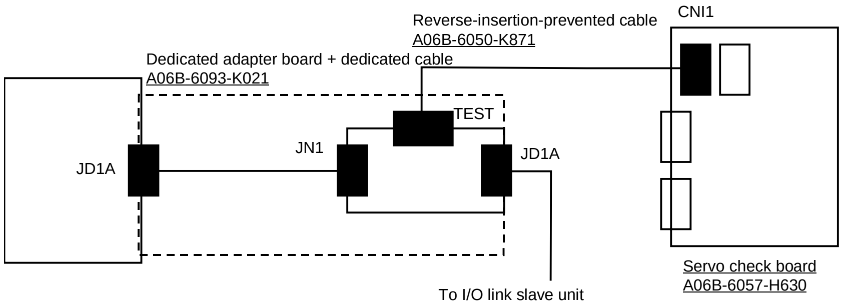
Power Mate - H



Power Mate - E



β amplifier with I/O link



(b) Connection between servo check board B (interface board supporting automatic adjustment) and each CNC

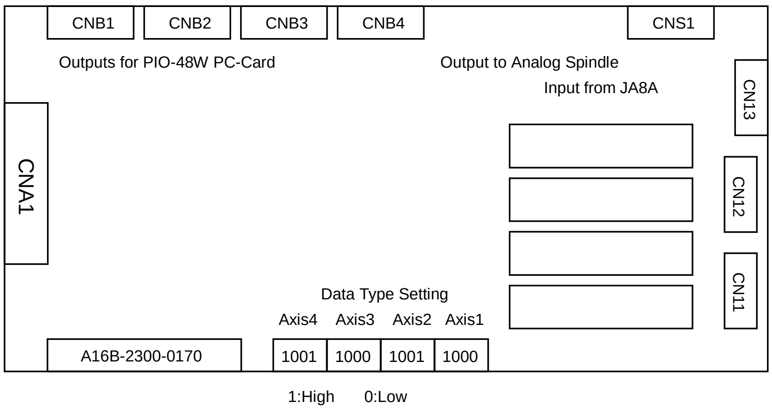
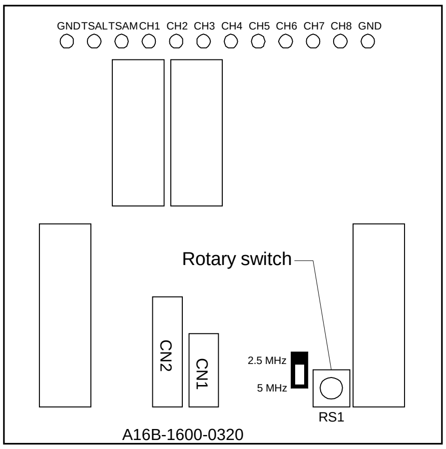


Fig. 4.19 (b) Connector layout on servo check board B (A06B-6057-H620)

NOTE) The connection method for servo check board B is the same as for servo check board A (to be connected to CNI1, CNI2, or CNI3).
However, servo check board B does not have CNI4 for the fifth to eighth axes, so it is impossible to observe data on the first to fourth axes and data on the fifth to eighth axes simultaneously.

(c) Connection between servo check board C (analog check board) and each CNC



NOTE
Install a jumper pin on the 5 MHz side at S1 (clock) on the check board.

Do not use check pins TSAL and TSAM.

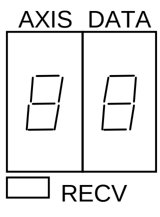
Fig. 4.19 (c) Connector layout on servo check board C (A06B-6057-H602)

NOTE) The connection method for servo check board C is the same as for servo check board A (use a reverse-insertion-prevented cable to connect the CNC or adapter board to connector CN2).

(4) Selecting signals for observation

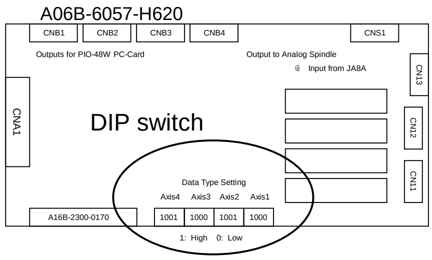
(a) Servo check board A (one-piece analog/digital type)
On servo check board A, a pair of two 7-segment LED digits is used to select the axis and data type for signals to be observed.
Set the AXIS digit with the axis number (1 to 8) set in parameter No. 1023.
Also set the DATA digit with the type of data to be observed (the table below).
Data is not output for an axis unless the RECV LED lights for that axis.

DATA	Data type
0	Velocity command (VCMD)
1	Torque command (TCMC) or estimated load torque
2	Speed (SPEED)
4	Position (POS)
5	Automatic adjustment data
6	Automatic adjustment data 2

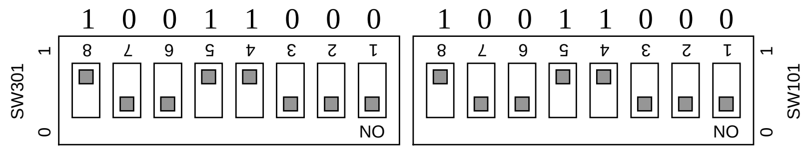


(b) Servo check board B (digital type)
Set the DIP switches as explained below.

Set DIP switches 1 and 0 according to the directions printed on the printed-circuit board.



Example of setting with the DIP switches on your side as shown at the right.



Data for the third and fourth axis is selected. Data for the first and second axis is selected.

NOTE) The terms "L axis" and "M axis" refer to an axis assigned an odd number specified in parameter No. 1023 and an axis assigned an even number that follows directly that odd number, respectively.

Data type	L axis				M axis				
Velocity command (VCMD)							○		1
	○	○	○	○	○	○		○	0
Torque command/ estimated load				○			○	○	1
	○	○	○		○	○			0
Speed (SPEED)		○				○		○	1
	○		○	○	○		○		0

Data type	L axis				M axis				
Position (POS)	○				○			○	1
		○	○	○		○	○		0
Adjustment	○		○		○		○	○	1
		○		○		○			0
Adjustment 2	○	○			○	○		○	1
			○	○			○		0

(c) Servo check board C (analog type)
Output data is permanently assigned to each check pin as listed below.
The rotary switch on the printed-circuit board is kept at 0 for usual use.

NOTE) The terms "L axis" and "M axis" refer to an axis assigned an odd number specified in parameter No. 1023 and an axis assigned an even number that follows directly that odd number, respectively.

		Check pin							
		CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
Rotary switch	0	L axis VCMD	L axis TCMD	M axis VCMD	M axis TCMD	L axis SPEED	M axis SPEED	–	–
	1	↑	↑	↑	↑	L axis POS	M axis POS	L axis adjust-ment	M axis adjust-ment
	2	↑	↑	↑	↑	L axis adjust-ment 2	M axis adjust-ment 2	–	–

(5) VCMD signal

When the feed-forward function is not used, the VCMD signal conveys a velocity command.
With this signal, it is possible to measure very slight vibration in the motor and its motion irregularity.
When the feed-forward function is used, the VCMD signal represents a positional deviation rather than a velocity command. So the signal can be used to measure vibration in the motor and irregularity in the feed distance of the tool driven by the motor.
The signal conversion type for the VCMD signal can be switched using parameters.
This switching is used, if the signal waveform is hard to observe because of the VCMD signal being reciprocating within ±5 V.

		#7	#6	#5	#4	#3	#2	#1	#0
1956	8X12			VCM2	VCM1				
2012	1012								

Parameters for rotational motor

VCM2	VCM1	Specified rotation speed/5 V
0	0	0.9155 rpm
0	1	14 rpm
1	0	234 rpm
1	1	3750 rpm

Parameters for linear motor

VCM2	VCM1	Specified velocity/5 V
0	0	0.075 m/min
0	1	1.2 m/min
1	0	19.2 m/min
1	1	307.2 m/min

Using an oscilloscope to see the movement of the entire signal in DC mode, then its magnified image in AC mode enables you to check very slight vibration in the motor and its motion irregularity.

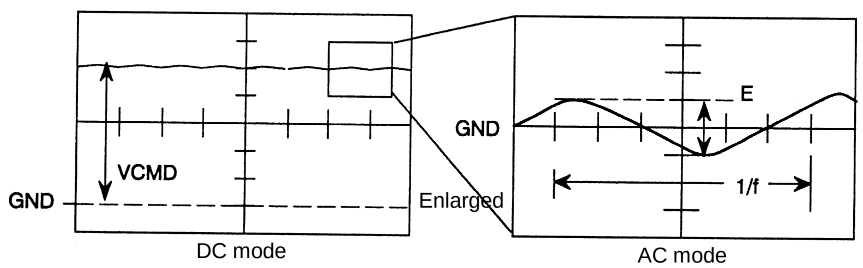


Fig. 4.19 (d) Waveform of the VCMD signal

The following table lists the number of positional deviation pulses for a VCMD voltage of 5 V.

Table 4.19 (c) Number of positional deviation pulses for a VCMD voltage of 5 V for semi-closed loop

VCM2	VCM1	Number of positional deviation pulses for a VCMD voltage of 5 V
0	0	15,258 × FFG/Kp
0	1	244,133 × FFG/Kp
1	0	3,906,133 × FFG/Kp
1	1	62,498,133 × FFG/Kp

Kp: Position gain (s^{-1})
FFG: Flexible feed gear (numerator/denominator)

Table 4.19 (d) Number of positional deviation pulses for a VCMD voltage of 5 V for full-closed loop

VCM2	VCM1	Number of positional deviation pulses for a VCMD voltage of 5 V
0	0	0.0153 × (number of positional feedback occurrences per motor revolution)/Kp
0	1	0.2441 × (number of positional feedback occurrences per motor revolution)/Kp
1	0	3.96061 × (number of positional feedback occurrences per motor revolution)/Kp
1	1	62.5 × (number of positional feedback occurrences per motor revolution)/Kp

Kp: Position gain (s^{-1})

Table 4.19 (e) Number of positional deviation pulses for a VCMD voltage of 5 V when a linear motor is in use

VCM2	VCM1	Number of positional deviation pulses for a VCMD voltage of 5 V
0	0	1,250/(A × Kp)
0	1	20,000/(A × Kp)
1	0	320,000/(A × Kp)
1	1	5,120,000/(A × Kp)

Kp: Position gain (s^{-1})
A: Detection unit (μm)

(Example)

Assume the following conditions:
Position gain = 30 (s^{-1}), semi-closed loop, detection unit of 1 μm/pulse, flexible feed gear = 1/100,
VCM2 = 0, VCM1 = 1 (VCMD waveform signal calculation parameters)
If a waveform with E = 0.3 V and I/f = 20 ms is observed:

Number of positional deviation pulses for a VCMD voltage of 5 V = 244133/100/30 = 81 pulses

Table vibration = 81 × 0.3/5 = 4.88 μm
Vibration frequency = 50 Hz

(6) TCMD signal

The TCMD signal conveys a torque command for the motor.
When a motor is running at high speed, its actual currents (IR and IS) may differ from the rating because of back electromotive force.
The output voltage of the signal becomes 4.44 V at maximum current.
A higher signal voltage may be observed in a motor in which the actual current limit function is enabled, however.

Table 4.19 (f) TCMD waveform conversion

Maximum current	Ap/V	Applicable servo motor
12 Ap	2.7	β0.5/3000, β1/3000, β2/3000, α1/3000, α2/2000, α2/3000
20 Ap	4.5	β3/3000, β6/2000, αC3/2000, αC6/2000, αC12/2000, αM2/3000, αM2.5/3000, α3/3000HV, α6/3000HV
40 Ap	9	α2.5/3000, α3/3000, α6/2000, α12/2000, α22/1500, αC22/1500, αL3/3000, αM3/3000, αM6/3000HV, αM9/3000HV, α12/3000HV, α22/3000HV (driven with 40 A), α30/3000HV (driven with 40 A) 1500A, 3000B
60 Ap	14	α22/3000HV, α30/3000HV, αM22/3000HV, αM30/3000HV
80 Ap	18	α6/3000, α30/1200, α12/3000, α22/2000, αL6/3000, αL9/3000, αM6/3000, αM9/3000, αM6/3000HV 6000B
130 Ap	29	α22/3000, α30/2000, α30/3000, α40/2000, α40/2000FAN, αL25/3000, αL50/3000, αM22/3000, αM30/3000, αM40/3000, 9000B
240 Ap	55	α65/2000, 15000C
360 Ap	82	α100/2000, α150/2000, αM40/3000FAN *α300/2000, α400/2000 (Winding tandem)

Effective current (RMS) = TCMD signal output (Ap) $\times$ 0.71

* For motors with a winding tandem, the current per amplifier is calculated as listed above, but their actual torque is doubled.

(7) SPEED signal

The SPEED signal conveys the rotation speed of the motor.

Signal conversion	3750 rpm/5 V

Linear motor

Signal conversion	307.2 (m/min)/5 V

When the SPEED signal is latched at 5 V, check whether the following parameter is set with a value.

1983 (Series 15-A) 1726 (Series 15)	**8x90**	**Must be kept at 0.**
2115	**1115**	

NOTE) Setting this parameter with a value other than 0 disables the SPEED signal output.

(8) Acquiring signals using a personal computer

Servo check boards A and B, listed in Table 4.19 (a), have a digital output interface. Using the servo adjustment software (SD) enables them to collect servo data such as position and speed through the interface into a personal computer.

(a) Connection between a servo check board and a personal computer (IBM PC/AT compatible)
Connect servo check board connector CNA1 to the printer port of a personal computer. The printer port must support bidirectional communication mode. (Measurement is impossible in ECP mode.)

Windows® does not support the servo adjustment software (SD). Use it in full-screen mode or MS-DOS mode.

(b) Basic operating instructions
<1> Enter "SD INIT" at a DOS prompt. The software starts with all its states initialized, and its main screen appears (if the name of the software's executable file is "SD.EXE").
The main screen lets you measure and view data.
Entering "CTRL + letter" switches the drawing mode. Select a drawing mode suitable for the data to be observed. (Pressing the ? key displays a list of the available drawing modes.)

Drawing mode examples:
CTRL + X: XY mode (XY display)
CTRL + T: XTYT mode (time axis display)

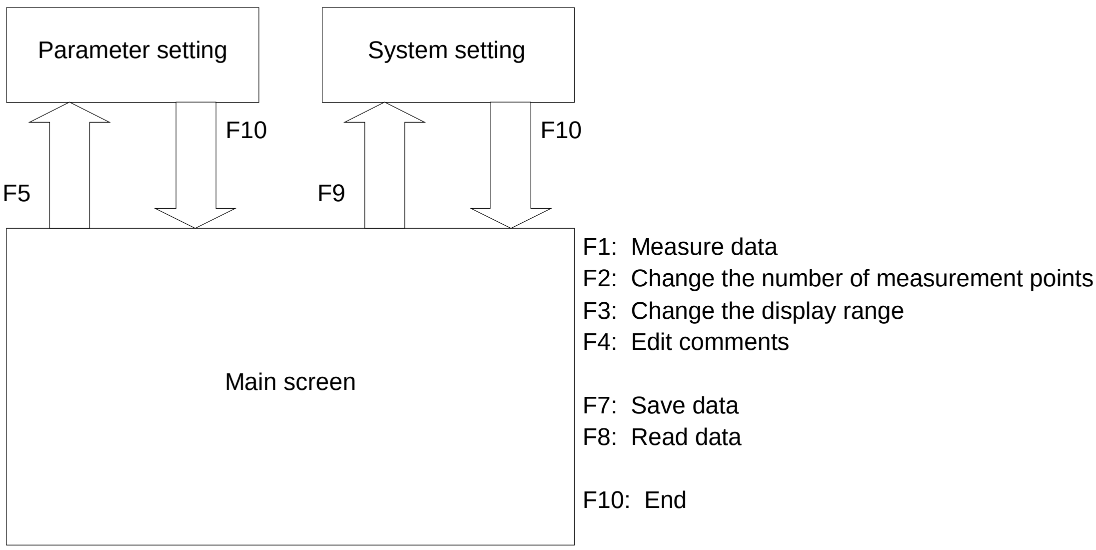


Fig. 4.19 (e) Servo adjustment software basic configuration and key manipulation

<2> To change the type of data to be measured and the unit of conversion for it, press the F9 key on the main screen to display the system setting screen.

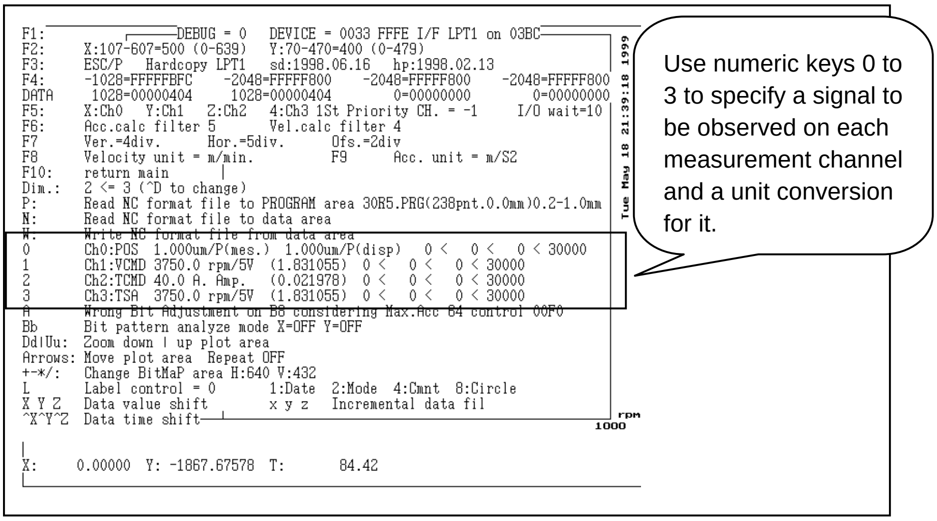


Fig. 4.19 (f) System setting screen

Data output on CH1 to CH4 of the check board corresponds to channels 0 to 3 on the SD software. To change the setting, press numeric key 0 to 3. Select a data type (0: position, 1: velocity command, 2: torque command, 3: rotation speed) from the display at the bottom of the screen, then specify the unit of conversion for the data.
Conversion values (except for position data) can be set up according to descriptions in (5) to (7).

Table 4.19 (g) Meaning of measurement data conversion values and example setting

Type	Display at the bottom of the screen	Meaning of conversion values	Example	Input value
POS	1 pulse = X?	Detection unit (in mm units)	1 μm	0.001
VCMD	5 V = X rpm?	What rpm corresponds to VCMD of 5 V?	VCM2 = 1 VCM1 = 1	3750 (Note)
TCMD	X Ap. Amp.?	Maximum amplifier current (A)	40 A	40
SPEED (number of revolutions)	5 V = X rpm?	What rpm corresponds to SPEED of 5 V?	–	Constantly 3750 (rotational motor)

> **NOTE**
> To observe the VCMD signal as the number of positional deviation pulses, input conversion values listed in Tables 4.19 (c) to (e).

To exit the system setting screen, press the F10 key.

<3> To specify measurement intervals, press the F5 key to display the parameter setting screen.
Pressing numeric keys 1, 2, 5, and 0 can change the setting. Usually select 1 ms.

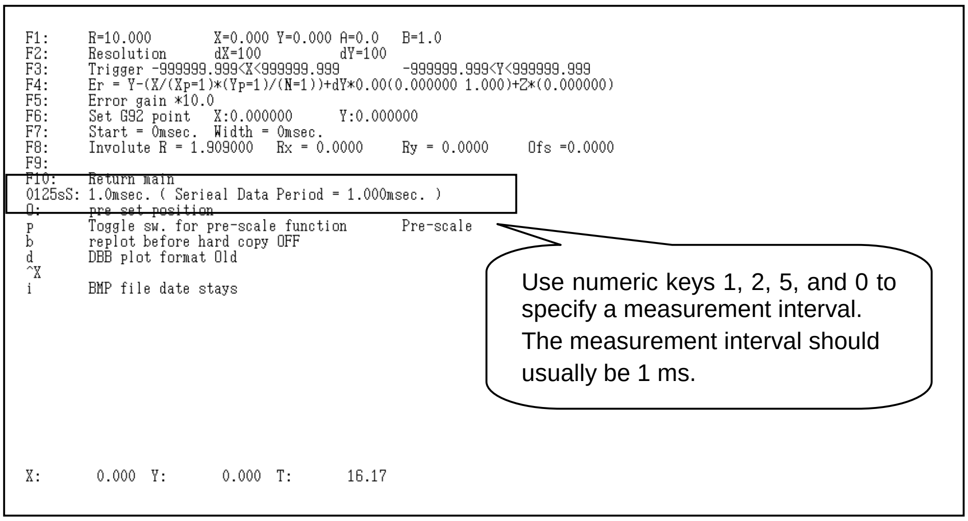


Fig. 4.19 (g) Parameter setting screen

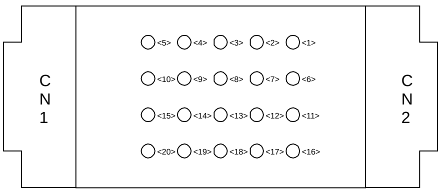
To return to the main screen after parameter setting, press the F10 key.

(9) Check pin board

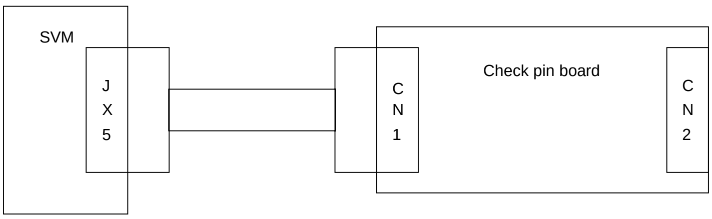
Unlike conventional servo amplifiers, the servo amplifier module (SVM) does not have a check pin. To observe signals in the servo amplifier with an oscilloscope, connect the following check pin board to the connector of the amplifier.

Ordering information	Description	
A06B-6071-K290	Printed-circuit board	A20B-1005-0340
	Cable (20 cm)	A660-2042-T031#L200R0

(a) Printed-circuit board outline drawing



(b) Connectors to be used



(c) Pin numbers and signal meanings

Pin number	Signal name	Signal meaning
<1>		
<2>	+3.3V	+3.3 V supply voltage
<3>	IRL	L axis phase-R motor current conversion signal
<4>	ISL	L axis phase-S motor current conversion signal
<5>	IRM	M axis phase-R motor current conversion signal
<6>	ISM	M axis phase-S motor current conversion signal
<7>	IRN	N axis phase-R motor current conversion signal
<8>	ISN	N axis phase-S motor current conversion signal
<9>	0V	GND
<10>		

Pin number	Signal name	Signal meaning
<11>	+24VC	+24 V supply voltage
<12>	+15VC	+15 V supply voltage
<13>	–15VC	–15 V supply voltage
<14>	+5V	+5 V supply voltage
<15>	ITL	L axis phase-T motor current conversion signal
<16>		
<17>	ITM	M axis phase-T motor current conversion signal
<18>		
<19>	ITN	N axis phase-T motor current conversion signal
<20>		

NOTE

1. If the SVM does not have an axis corresponding to a pin on the check pin board, no signal is output to the pin.
2. The voltage output using the motor current conversion signal represents the actual current (sine wave) flowing through the motor (4.0 V is output at maximum current). This voltage cannot be measured with a voltmeter (such as a VOM); use an oscilloscope.

5 DETAILS OF PARAMETERS

5.1 DETAILS OF Series 0-C AND 15-A SERVO PARAMETERS (9041, 9046 SERIES)

The descriptions of parameters follow.
For parameters for which a specification method is not described, do not change the parameters from the values set up automatically during servo parameter initialization.
The parameters in the upper row apply to Series 0-C, and those in the lower row, to Series 15-A.

	#7	#6	#5	#4	#3	#2	#1	#0
8X00 / 1804							DGPR	PLC0

PLC0 (#0) Specifies the detection unit as follows: ⇒ See Subsec. 2.1.2.
0: 1 μm or semi-closed loop
1: Full-closed loop with 0.1 μm
Setting bit 0 of parameter No. 8X00 (PLC0) to 1 for the Series 0-C applies a 10-fold weight to the following parameters.

No. 8X23	Number of velocity feedback pulses	Set value × 10
No. 8X24	Number of position feedback pulses	Set value × 10
Nos. 0004 to 0503	Reference counter capacity	Set value × 10
Nos. 0504 to 0507	Limit to the position deviation during movement	Set value × 10
Nos. 0508 to 0592	Grid shift value	Set value × 10
Higher than No. 0592	Limit to the position deviation at stop	Set value × 10

DGPR (#1) When power is switched on, the motor-specific digital servo parameter is: ⇒ See Subsec. 2.1.2
0: Specified
1: Not performed
After a motor ID No. is set in parameter Nos. 8X20 and 1874 (motor type), if DGPR is set to 0, the motor-specific parameter is set to a standard value when power is switched on. DGPR is also set to 1 simultaneously.

	#7	#6	#5	#4	#3	#2	#1	#0
8X01 / 1806	AMR7	AMR6	AMR5	AMR4	AMR3	AMR2	AMR1	AMR0

AMR0 to AMR7 (#0 to #7) Set AMR values according to the number of pulses output from the pulse coder of the motor.

AMR								
7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	α pulse coder, and serial pulse coder A other than the following models
0	0	0	0	0	0	1	1	AC3-0S, 4-0S
1	0	0	0	0	0	1	0	AC5-0

	#7	#6	#5	#4	#3	#2	#1	#0
8X02 / 1807					PFSE			

PFSE (#3) The separate detector is: ⇒ See Subsec. 2.1.2.
0: Not used
1: Used
This parameter must be set only for Series 15-A.
For Series 0-C, specifying parameter No. 0037 specifies this parameter automatically.

	#7	#6	#5	#4	#3	#2	#1	#0
8X03 / 1808	VOFS	OVSC	BLEN	NPSP	PIEN	OBEN	TGAL	

TGAL (#1) Software disconnection alarm detection level is:
0: Set to a standard value
1: Lowered to a value specified separately

Related parameters: 8X64 (Series 0-C) and 1892 (Series 15-A)

OBEN (#2) The velocity control observer is:
0: Not used
1: Used

⇒ See Subsec. 4.5.2.
Related parameters: 8X47 (Series 0-C), 1859 (Series 15-A), 8X50 (Series 0-C), 1862 (Series 15-A), 8X51 (Series 0-C), and 1863 (Series 15-A)

PIEN (#3) Velocity control is:
0: Set to I-P
1: Set to PI

NPSP (#4) The N–pulse suppress function is: ⇒ See Subsec. 4.4.4.
0: Not used
1: Used

BLEN (#5) The backlash acceleration function is:
0: Not used
1: Used

⇒ See Subsecs. 4.6.4 and 4.6.5.
Related parameters: 8X48 (Series 0-C) and 1860 (Series 15-A)

OVSC (#6) The overshoot compensation function is:
0: Not used
1: Used

⇒ See Sec. 4.7.
Related parameters: 8X45 (Series 0-C) and 1857 (Series 15-A)

VOFS (#7) The VCMD offset function is:
0: Not used
1: Used

	#7	#6	#5	#4	#3	#2	#1	#0
8X04 / 1809		DLY0						

DLY0 (#6) The PWM dead zone is set to:
0: 8 μs
1: 16 μs
Always set this bit to 1 when using the S series servo amplifier, α series large-size servo amplifier (SVMI-240, -360), and α series HV servo amplifier.

	#7	#6	#5	#4	#3	#2	#1	#0
8X05 / 1883	SFCM	BRKC					FEED	

FEED (#1) The feed forward function is:
0: Not used
1: Used

⇒ See Subsecs. 4.6.1, 4.6.2, and 4.6.3.
Related parameters :
8X68 (Series 0-C) and 1961 (Series 15-A)

BRKC (#6) The vertical axis brake control function is:
0: Not used
1: Used

⇒ See Sec. 4.10.
Related parameters :
8X83 (Series 0-C) and 1976 (Series 15-A)

SFCM (#7) The static friction compensation function is:
0: Not used
1: Used

⇒ See Subsec. 4.6.6.
Related parameters :
8X03 (Series 0-C), 1808 (Series 15-A), 8X72 (Series 0-C), 1965 (Series 15-A), 8X73 (Series 0-C), and 1966 (Series 15-A)

	#7	#6	#5	#4	#3	#2	#1	#0
8X06 / 1884		DCBE		ACCF		PKVE	DBST	FCBL

FCBL (#0) Specifies whether to reflect backlash compensation pulses to the position as follows:
0: To reflect
1: Not to reflect
If this parameter is set to 1, quadrant protrusions caused by backlash can be reduced even in a closed loop system. Generally, in a closed loop system, backlash compensation is not set. If FCBL is set to 1, however, protrusions can be reduced without position deviation.

⇒ See Subsecs. 4.6.4 and 4.6.5.

DBST (#1)	The emergency stop distance reduction function type 1 is: 0: Not used 1: Used	⇒ See Subsec. 4.11.1. Related parameters: 8X05 (Series 0-C), 1883 (Series 15-A), 8X83 (Series 0-C), and 1976 (Series 15-A)
PKVE (#2)	The velocity dependent current loop gain variable function is: 0: Not used 1: Used	Related parameters: 8X74 (Series 0-C) and 1967 (Series 15-A)
ACCF (#4)	Specifies the amount of velocity feedback data to be used as follows: 0: Velocity feedback for the latest 2 ms 1: Velocity feedback for the latest 1 ms	Related parameters: 8X67 (Series 0-C), 1895 (Series 15-A), 8X76 (Series 0-C), and 1969 (Series 15-A)
DCBE (#6)	During deceleration, back electromotive force compensation is: 0: Not used 1: Used	

	#7	#6	#5	#4	#3	#2	#1	#0
8X09	BLST	BLCU		K2VC		ADBL		SERD
1953								

SERD (#0)	The dummy serial feedback function is: 0: Not used 1: Used If this parameter is specified for axes to which a servo amplifier or motor is not connected, alarms related to pulse coders and amplifiers are ignored.	⇒ See Subsec. 4.9.1.
ADBL (#2)	The new backlash acceleration function is: 0: Not used 1: Used	Related parameters: 8X48 (Series 0-C), 1860 (Series 15-A), 8X87 (Series 0-C), and 1980 (Series 15-A)
K2VC (#4)	The function for changing the proportional gain in the stop state is: 0: Not used 1: Used	⇒ See Subsec. 4.4.3. Related parameters: 8X89 (Series 0-C) and 1982 (Series 15-A)
BLCU (#6)	The function for enabling the backlash acceleration function only during cutting is : 0: Not used 1: Used	⇒ See Subsecs. 4.6.4 and 4.6.5.
BLST (#7)	The backlash acceleration stop function is : 0: Not used 1: Used	⇒ See Subsec. 4.6.4. Related parameters: 8X82 (Series 0-C) and 1975 (Series 15-A)

	#7	#6	#5	#4	#3	#2	#1	#0
8X10	**POLE**	**SSG1**	**PGTW**		**BLTE**		**RCCL**	
1954	**–**	**MVFB**	**–**		**BLTE**		**RCCL**	

The upper row is for the Series 9046.
The lower row is for the Series 9041.

RCCL (#1) The actual current-based variable torque limit function is:
0: Not used
1: Used

Reletad parameters:
8X52 (Series 0-C) and 1864 (Series 15-A)

BLTE (#3) Multiplication of the backlash acceleration amount by 10 is: (For high-resolution pulse coders)
0: Disabled
1: Enabled

PGTW (#5) The position gain switch function is: ⇒ See Subsec. 4.8.1.
0: Not used
1: Used

SSG1 (#6) The low-speed integration function is: ⇒ See Subsec. 4.8.2.
0: Not used
1: Used
This bit functions with the Series 9046 only.

MVFB (#6) The machine speed feedback function is: ⇒ See Subsec. 4.5.1.
0: Not used
1: Used
This bit functions with the Series 9041 only.

POLE (#7) The punch laser function is:
0: Not used
1: Used
This bit functions with the Series 9046 only.

	#7	#6	#5	#4	#3	#2	#1	#0
8X11	**DPFB**		**PGEX**					
1955								

PGEX (#5) The position gain range is: ⇒ See Subsec. 2.1.5.
0: Not expanded
1: Expanded by 8 times

DPFB (#7) The dual position feedback function is: ⇒ See Subsec. 4.5.4.
0: Not used
1: Used

	#7	#6	#5	#4	#3	#2	#1	#0
8X12 / 1956			VCM2	VCM1			MSFE	

MSFE (#1) The machine speed feedback function is:
0: Not used
1: Used

⇒ See Subsec. 4.5.1.
Related parameters:
8X88 (Series 0-C) and 1981 (Series 15-A)

VCM1, 2 (#4, #5) The VCMD waveform is converted according to the table below.

⇒ See (5) in Sec. 4.19.

VCM2	VCM1	Number of velocity command revolution/ 5V
0	0	0.9155 rpm
0	1	14 rpm
1	0	234 rpm
1	1	3750 rpm

✰: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 0-C	Series 15-A		
8X20	1874	Motor No. Motor number that can be specified → 2.1.5 (6)	→ 2.1.2 Initial setting
8X21	1875	Load inertia ratio (LDINT) $\frac{\text{Load inertia}}{\text{Rotor inertia}} \times 256$ Increase velocity loop gain parameters PK1V and PK2V by (1 + LDINT/256) times	Adjust for individual machines separately.
8X22 8X23 8X24	1879 1876 1891	Motor rotation direction Number of velocity pulses Number of position pulses	→ 2.1.2 Initial setting
8X40 8X41 8X42	1852 1853 1854	Current loop gain (PK1) Current loop gain (PK2) Current loop gain (PK3)	★ Motor-specific ★ Motor-specific ★ Motor-specific
8X43	1855	Velocity loop integral gain (PK1V)	✰ Motor-specific Adjust for individual machines separately.
8X44	1856	Velocity loop proportional gain (PK2V)	
8X45	1857	Velocity loop incomplete integral gain (PK3V)	✰ Motor-specific → 4.7
8X46	1858	Velocity loop gain (PK4V)	★ Motor-specific
8X47	1859	Observer parameter (POA1)	★ Motor-specific
8X48	1860	Backlash acceleration amount	✰ → 4.6.4
8X49	1861	Maximum dual position feedback amplitude	✰ → 4.5.4
8X50 8X51	1862 1863	Observer gain (POK1) Observer gain (POK2)	★ Motor-specific
8X52	1864	Final clamp value for the actual-current limit	★ Motor-specific
8X53	1865	Current dead-zone compensation (PPMAX)	★ Motor-specific
8X54	1866	Current dead-zone compensation (PDDP) The standard setting for α motors is 1894. To drive the α motor with an S Series amplifier, change it to 3787.	★ Motor-specific

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 0-C	Series 15-A		
8X55 8X56 8X57 8X58 8X59	1867 1868 1869 1870 1871	Current dead-zone compensation (PHYST) Backelectromotive force compensation (EMFCMP) Current-phase control (PVPA) Current-phase control (PALPH) Backelectromotive force compensation (EMFBAS)	★ Motor-specific
8X60	1872	Torque limit The standard setting represents the maximum current of the amplifier.	★ Motor-specific
8X61 8X62 8X63	1873 1877 1878	Backelectomotive force compensation (EMFCMP) Overload protection coefficient (POVC1) Overload protection coefficient (POVC2)	★ Motor-specific
8X64	1892	Software disconnection alarm level	★ Motor-specific → 3.2
8X65	1893	Overload protection coefficient (POVCLMT)	★ Motor-specific
8X66	1894	250 μsec acceleration feedback	☆ → 4.4.1
8X67	1895	Torque command filter	☆ → 4.5.3
8X68	1961	Feed-forward coefficient	☆ → 4.6.1
8X69	1962	Velocity feed-forward coefficient	☆ → 4.6.1
8X70	1963	Backlash acceleration timing	☆ → 4.6.4
8X71	1964	Time during which backlash acceleration is effective	☆ → 4.6.4
8X72	1965	Static friction compensation amount	☆ → 4.6.6
8X73	1966	Stop time determination parameter	☆ → 4.6.6
8X74	1967	Velocity-dependent current-loop gain	★ Motor-specific
8X76	1969	~~1-msec acceleration feedback gain~~ (Basically, do not use this parameter.)	☆ An alternative function is available. → 4.4.1
8X77	1970	Overshoot protection counter	☆ → 4.7
 8X79 8X80 8X81	 1972 1973 1974	Series 9046 (Response to standard and high-speed positioning) Limit speed for enabling low-speed integration during acceleration Limit speed for enabling low-speed integration during deceleration Position gain switching speed	 ☆ → 4.8.2 ☆ → 4.8.2 ☆ → 4.8.1
 8X78 8X79 8X80 8X81	 1971 1972 1973 1974	Series 9041 (Response to dual position feedback) Conversion coefficient (numerator) Conversion coefficient (denominator) Primary delay time constant Zero width	☆ → 4.5.4
8X82	1975	Backlash acceleration stop	☆ → 4.6.4
8X83	1976	Brake control timer (msec)	☆ → 4.10
8X84 8X85	1977 1978	Flexible feed gear (numerator) Flexible feed gear (denominator)	→ 2.1.2 Initial setting
8X86	1979	Rated current parameter	★ Motor-specific
8X87	1980	Torque offset (For the Series 9041 and 9046, this parameter must be specified only when the new-type backlash acceleration function is used.)	☆
8X88	1981	Machine speed feedback gain	☆ → 4.5.1
8X89	1982	Base pulse for backlash acceleration	☆ → 4.6.4
8X97	1990	Static friction compensation stop parameter	☆ → 4.6.6
8X98	1991	Current-phase compensation coefficient	★ Motor-specific
8X99	1992	N-pulse suppression level	★ → 4.4.4

5.2 DETAILS OF THE SERVO PARAMETERS FOR Series 15, 16, 18, 20, 21, Power Mate (SERIES 9060, 9064, 9065, 9066, 9070, 9080, 9081, 9090, AND 90A0)

The descriptions of parameters follow.
For parameters for which a specification method is not described, do not change the parameters from the values set up automatically during servo parameter initialization.
The parameter in the top left cell applies to Series 15; the one in the bottom left cell, to Series 16, 18, 20, 21, Power Mate; and the one in the bottom right cell, to Power Mate-E.

★: Do not change.

		#7	#6	#5	#4	#3	#2	#1	#0
1804	–				PGEX	PRMC		DGPR	PLC0
2000	1000								

PLC0 (#0) Specifies whether to multiply the number of velocity and position pulses by ten internally as follows: ⇒ See Subsec. 2.1.2.
0: Not to multiply by ten
1: To multiply by ten

DGPR (#1) When power is switched on, the motor-specific standard servo parameter is: ⇒ See Subsec. 2.1.2.
0: Specified
1: Not specified

PRMC (#3) ★: Do not change.

PGEX (#4) The position gain range is: ⇒ See Subsec. 2.1.5.
0: Not expanded
1: Expanded by 8 times

		#7	#6	#5	#4	#3	#2	#1	#0
1806	–	AMR7	AMR6	AMR5	AMR4	AMR3	AMR2	AMR1	AMR0
2001	1001								

AMR0 to ARM7 (#0 to #7) Specify the AMR value according to the pulse coder model for the motor.

AMR								
7	6	5	4	3	2	1	0	
0	0	0	0	0	0	0	0	α pulse coder, and serial pulse coder A other than the following models
0	0	0	0	0	0	1	1	AC3-0S, 4-0S
1	0	0	0	0	0	1	0	AC5-0

		#7	#6	#5	#4	#3	#2	#1	#0
1807	–	VFSE				PFSE			
2002	1002								

		#7	#6	#5	#4	#3	#2	#1	#0
1815								OPT	
1815									

OPT (#1) A separate position detector is: ⇒ See Subsec. 2.1.2.
0: Used
1: Not used
This bit is not supported by the Power Mate-E.

PFSE (#3) A separate position detector is:
0: Not used
1: Used
Set this parameter with the Series 15 only.
With the Series 16, 18, 20, and 21, this parameter is automatically set by setting OPT = 1.

VFSE (#3) A separate position detector is: ⇒ See Subsec. 2.1.2.
0: Not used
1: Used
This parameter is automatically set by setting OPT = 1.
When a separate position detector is used with the Power Mate-E:
Set PFSE = VFSE = 1.
When no separate position detector is used with the Power Mate-E:
Set PFSE = VFSE = 0.

		#7	#6	#5	#4	#3	#2	#1	#0
1808	–	VOFS	OVSC	BLEN	NPSP	PIEN	OBEN	TGAL	
2003	1003								

TGAL (#1) The software disconnection alarm detection level is:
0: Standard setting
1: Lower sensitivity specified elsewhere

Related parameters:
1892 (Series 15), 2064 (Series 16), and 1064 (Power Mate-E)

OBEN (#2) The velocity control observer function is:
0: Not used
1: Used

⇒ See Subsec. 4.5.2.
Related parameters:
1859 (Series 15), 2047 (Series 16), 1047 (Power Mate-E), 1862 (Series 15), 2050 (Series 16), 1050 (Power Mate-E), 1863 (Series 15), 2051 (Series 16), and 1051 (Power Mate-E)

PIEN (#3) The velocity control method to be used is:
0: I-P
1: PI

NPSP (#4) The N pulse suppression function is:
0: Not used
1: Used

⇒ See Subsec. 4.4.4.
Related parameters:
1992 (Series 15), 2099 (Series 16), and 1099 (Power Mate-E)

BLEN (#5) The backlash acceleration function is:
0: Not used
1: Used

⇒ See Subsecs. 4.6.4 and 4.6.5.
Related parameters:
1860 (Series 15), 2048 (Series 16), and 1048 (Power Mate-E) etc.

OVSC (#6) The overshoot compensation function is:
0: Not used
1: Used

⇒ See Sec. 4.7.
Related parameters:
1857 (Series 15), 2045 (Series 16), and 1045 (Power Mate-E)

VOFS (#7) The VCMD offset function is:
0: Not used
1: Used

Related parameters:
1970 (Series 15), 2077 (Series 16), and 1077 (Power Mate-E)

		#7	#6	#5	#4	#3	#2	#1	#0
1809			DLY0			TRW1	TRW0	TIB0	TIA0
2004	1004								

TIA0 (#0)
TIB0 (#1)
TRW0 (#2)
TRW1 (#3)

TRW1	TRW0	TIB0	TIA0	
0	1	1	0	For conventional control/HRV control
0	0	1	1	For level-up HRV control

DLY0 (#6) The PWM dead zone is:
0: Set to 8 μs
1: Set to 16 μs
This parameter must always be 1 for S Series servo amplifiers, α series Large type servo amplifier (SVM1-240 or -360), or α series HV servo amplifiers.

			#7	#6	#5	#4	#3	#2	#1	#0
1883	–		SFCM	BRKC					FEED	
2005	1005									

FEED (#1) The feed forward function is:
0: Not used
1: Used

⇒ See Subsecs. 4.6.1, 4.6.2, and 4.6.3.
Related parameters:
1961 (Series 15), 2068 (Series 16), 1068 (Power Mate-E), 1985 (Series 15), and 2092 (Series 16)

BRKC (#6) The vertical-axis brake control function is:
0: Not used
1: Used

⇒ See Sec. 4.10.
Related parameters:
1976 (Series 15), 2083 (Series 16), and 1083 (Power Mate-E)

SFCM (#7) The static friction compensation function is:
0: Not used
1: Used

⇒ See Subsec. 4.6.6.
Related parameters:
1808 (Series 15), 2003 (Series 16), 1003 (Power Mate-E), 1965 (Series 15), 2072 (Series 16), 1072 (Power Mate-E), 1966 (Series 15), 2073 (Series 16), and 1073 (Power Mate-E)

			#7	#6	#5	#4	#3	#2	#1	#0
1884	–			DCBE		ACCF	SPVE	PKVE	SBSM	FCBL
2006	1006									

FCBL (#0) During full-closed feedback, backlash compensation is:
0: Applied to the position
1: Not applied to the position

⇒ See Subsecs. 4.6.4 and 4.6.5.

SBSM (#1) An amplifier whose input voltage is 200 V (standard) or 60 V is used:
0: Uses an amplifier whose input voltage is 200 V (standard).
1: Uses an amplifier whose input voltage is 60 V.

⇒ See Sec. 4.16.

PKVE (#2) Speed-dependent current loop gain variable function is:
0: Not used
1: Used ← ★: Do not change

Related parameters:
1967 (Series 15), 2074 (Series 16), and 1074 (Power Mate-E)

SPVE (#3) A separate position detector is:
0: Not used
1: Used

⇒ See Sec. 4.16.

ACCF (#4) Specifies the amount of velocity feedback data to be used as follows:
0: Velocity feedback for the latest 2 ms
1: Velocity feedback for the latest 1 ms

DCBE (#6) At deceleration, back electromotive force compensation is:
0: Invalidated
1: Validated ← ★: Do not change

		#7	#6	#5	#4	#3	#2	#1	#0
1951	–	FRCA	FAD						
2007	–								

FAD (#6) The fine acceleration/deceleration function is:
0: Not used
1: Used

⇒ See Subsec. 4.8.3.
Related parameters:
1702 (Series 15) and 2109 (Series 16)

NOTE
After this bit is set, the power must be turned off, then back on.

FRCA (#7) Torque control function is:
0: Not used
1: Used

⇒ See Sec. 4.15.

		#7	#6	#5	#4	#3	#2	#1	#0
1952	–	LAXD	PFBS	VCTM	SPPC	SPPR	VFBA	TNDM	
2008	–								

TNDM (#1) This bit is automatically set to 1 when bit 6 (tandem axis) of parameter No. 1817 is set to 1.
(In the Series 15, this bit is kept at 0.)
This bit cannot be set directly.

VFBA (#2) 1: Enables the velocity feedback averaging function.
(Usually, set this bit to 1. Set this parameter for the main axis only.)

⇒ See Subsec. 4.17.3.

SPPR (#3) 1: Enables the full preload function.
(Set this parameter for the main axis only.)

CAUTION
Always set this bit while the system is in the emergency stop state. After rewriting this bit, the power to the NC must be turned off, then back on.
⇒ See Subsec. 4.17.7.

SPPC (#4) The motor output torque polarities are as follows:

0: Outputs only the positive polarity to the main axis, and outputs only the negative polarity to the sub-axis.

1: Outputs only the negative polarity to the main axis, and outputs only the positive polarity to the sub-axis.

(Set this parameter for the main axis only.)

CAUTION

Always set this bit while the system is in the emergency stop state. After rewriting this bit, the power to the NC must be turned off, then back on.

⇒ See Subsec. 4.17.7.

VCTM (#5) 1: Enables velocity command tandem control.

(Set this parameter for the main axis only.)

NOTE

Usually, set this bit to 0. This function cannot be used together with tandem control. Moreover, set a preload value of 0.

PFBS (#6) 1: Switches position feedback according to the direction of a torque command.

(Set this parameter for the main axis only.)

CAUTION

Always set this bit while the system is in the emergency stop state. After rewriting this bit, the power to the NC must be turned off, then back on.

⇒ See Subsec. 4.17.8.

LAXD (#7) 0: Enables damping compensation for the sub-axis only.

1: Enables damping compensation with both the main axis and sub-axis.

Usually, set this bit to 1. (Set this parameter for the main axis only.)

⇒ See Subsec. 4.17.2.

		#7	#6	#5	#4	#3	#2	#1	#0
1953	–	BLST	BLCU				ADBL	IQOB	SERD
2009	1009								

SERD (#0) The dummy serial feedback function is: ⇒ See Subsec. 4.9.1.
0: Not used
1: Used

IQOB(#1) 1: Eliminates the effect of voltage saturation in unexpected disturbance detection. ⇒ See Subsec. 4.12.1.
This bit functions with the Series 9066 only. With other series, setting bit 2 of parameter No. 2200 has the same effect. With the Series 9066, set either bit.

ADBL (#2) The new backlash acceleration function is:
0: Not used
1: Used
Related parameters: 1860 (Series 15), 2048 (Series 16), 1048 (Power Mate-E), 1980 (Series 15), 2087 (Series 16), and 1087 (Power Mate-E)

BLCU(#6) The function that validates the backlash acceleration function only at cutting is: ⇒ See Subsecs. 4.6.4 and 4.6.5.
0: Invalidated
1: Validated

BLST (#7) The backlash acceleration stop function is: ⇒ See Subsec. 4.6.4.
0: Not used
1: Used
Related parameters: 1975 (Series 15), 2082 (Series 16), and 1082 (Power Mate-E)

		#7	#6	#5	#4	#3	#2	#1	#0
1954	–	POLE		HBBL	HBPE	BLTE	LINE		
2010	1010								

LINE (#2) 1: Controls a linear motor. ⇒ See Subsec. 4.14.1.
This bit is set automatically when the parameters of the linear motor are initialized. Check that this bit is set before the linear motor is driven.
This bit is not supported by the Power Mate-E.

BLTE (#3) The function to multiply the backlash acceleration amount by 10 is: ⇒ See Subsecs. 4.6.2 and 4.6.4.
0: Invalidated
1: Validated

HBPE (#4) A pitch error compensation is added to the error counter of: ⇒ See Subsec. 4.5.4.
0: Full-closed loop ← Standard setting
1: Semi-closed loop

HBBL (#5) A backlash compensation amount is added to the error counter of: ⇒ See Subsec. 4.5.4.
0: Semi-closed loop ← Standard setting
1: Full-closed loop

POLE (#7) The punch/laser switching function is:
0: Not used
1: Used

		#7	#6	#5	#4	#3	#2	#1	#0
1955	–			RCCL					
2011	1011								

RCCL (#5) The actual current torque limit variable function is:
0: Not used
1: Used ← ★: Do not change

Related parameters: 1995 (Series 15), 2102 (Series 16), and 1102 (Power Mate-E)

		#7	#6	#5	#4	#3	#2	#1	#0
1956	–	STNG		VCM2	VCM1			MSFE	
2012	1012								

MSFE (#1) The machine speed feedback function is: ⇒ See Subsec. 4.5.1.
0: Not used
1: Used

Related parameters: 1981 (Series 15), 2088 (Series 16), and 1088 (Power Mate-E)

VCM1 (#4) The VCMD waveform signal conversion on the check board is switched.

VCM2 (#5) Switches the VCMD waveform conversion value according to the following list: ⇒ See (5) in Sec. 4.19.

VCM2	VCM1	Number of velocity command revolution/5 V
0	0	0.9155 rpm
0	1	14 rpm
1	0	234 rpm
1	1	3750 rpm

STNG (#7) In velocity command mode, a software disconnection alarm is:
0: Detected
1: Ignored

		#7	#6	#5	#4	#3	#2	#1	#0
1707	–	APTG							
2013	1013								

APTG (#7) The α pulse coder software disconnection monitor is: ⇒ See Sec. 3.2.
0: Not ignored
1: Ignored

			#7	#6	#5	#4	#3	#2	#1	#0
1957	–		BZNG	BLAT	TDOU				SSG1	PGTW
2015	1015									

PGTW (#0) The position gain switching function is:
0: Not used
1: Used

⇒ See Subsec. 4.8.1.
Related parameters:
1713 (Series 15), 2028 (Series 16), and 1028 (Power Mate-E)

SSG1 (#1) The integration function for low speed is:
0: Not used
1: Used

⇒ See Subsec. 4.8.2.
Related parameters:
1714 (Series 15), 2029 (Series 16), 1029 (Power Mate-E), 1715 (Series 15), 2030 (Series 16), and 1030 (Power Mate-E)

TDOU (#5) Switches the check board output data as follows:
0: TCMD is output.
1: Estimated load torque is output.

⇒ See Subsec. 4.6.5 and 4.12.1.

BLAT (#6) The two-stage backlash acceleration function is:
0: Not used
1: Used

⇒ See Subsec. 4.6.5.
Related parameters:
1860 (Series 15), 2048 (Series 16), 1724 (Series 15), and 2039 (Series 16)

BZNG (#7) When a separate detector is used, the battery alarm for the built-in pulse coder is:
0: Not ignored
1: Ignored

			#7	#6	#5	#4	#3	#2	#1	#0
1958	–						K2VC			ABNT
2016	1016									

ABNT (#0) The unexpected disturbance detection function (option) is:
0: Not used
1: Used

⇒ See Subsec. 4.12.1.
Related parameters:
1997 (Series 15), 2104 (Series 16), and 1104 (Power Mate-E)

K2VC (#3) The function for changing the proportional gain in the stop state is:
0: Not used
1: Used

⇒ See Subsec. 4.4.3.
Related parameters:
1730 (Series 15) and 2119 (Series 16)

		#7	#6	#5	#4	#3	#2	#1	#0
1959	–	PK25	OVCR	RISC	HTNG				DBST
2017	1017								

DBST (#0) The stop distance reduction function (type 1) during emergency stop is:
0: Not used
1: Used
This bit is not supported by the Power Mate-E.
⇒ See Subsec. 4.11.1.
Related parameters:
1883 (Series 15), 2005 (Series 16), 1976 (Series 15), and 2083 (Series 16)

HTNG (#4) In velocity command mode, the hardware disconnection alarm of a separate detector is:
0: Detected
1: Ignored

RISC (#5)
0: When RISC is used, the feed-forward response characteristics remain as is.
1: When RISC is used, the feed-forward response characteristics are improved.
This bit is not supported by the Power Mate-E.
⇒ See Subsec. 4.6.3.

OVCR (#6)
0: The OVC alarm (type 1) is improved.
1: The OVC alarm (type 2) is improved.
⇒ See Sec. 4.2.

PK25 (#7) Velocity loop high cycle management is:
0: Not used
1: Used
This bit is not supported by the Power Mate-E.
⇒ See Subsec. 4.4.2.

		#7	#6	#5	#4	#3	#2	#1	#0
1960	–	PFBC						MOVO	REVS
2018	–								

REVS (#0) The direction of the serial type scale signal is:
0: Reversed
1: Not reversed
This bit is valid in the Series 9080, 9090, and 90A0.
⇒ See Subsec. 2.1.4.

MOVO (#1) The observer stop time disable function is:
0: Not used
1: Used
⇒ See Subsec. 4.5.2.

PFBC (#7)
1: The motor feedback signal for the main axis is shared by the sub-axis. (Set this parameter for the sub-axis only.)
⇒ See Subsec. 4.17.5.

			#7	#6	#5	#4	#3	#2	#1	#0
1709	–		DPFB			SPSY				
2019	1019									

SPSY (#4) A separate velocity detector is:
0: Not used
1: Used

⇒ See Sec. 4.16.

DPFB(#7) The dual position feedback function (option) is:
0: Not used
1: Used

⇒ See Subsec. 4.5.4.
Related parameters:
1971 (Series 15), 2078 (Series 16), 1078 (Power Mate-E), 1972 (Series 15), 2079 (Series 16), 1079 (Power Mate-E), 1973 (Series 15), 2080 (Series 16), and 1080 (Power Mate-E)

			#7	#6	#5	#4	#3	#2	#1	#0
1740	–			P2EX			ABGO	IQOB		OVSP
2200	1200									

OVSP (#0) A feedback mismatch alarm is:
0: Detected
1: Not detected

IQOB (#2) 1: Eliminates the effect of voltage saturation on unexpected disturbance detection.
When the Series 9066 is used, setting bit 1 of parameter No. 2009 has the same effect. Set either bit.

⇒ See Subsec. 4.12.1.

ABGO (#3) 1: When an unexpected disturbance is detected, a threshold is set separately for cutting and rapid traverse.
This bit is not supported by the Power Mate-E.

⇒ See Subsec. 4.12.2.
Related parameters:
1997 (Series 15), 2104 (Series 16), 1765 (Series 15), and 2142 (Series 16)

P2EX (#6) The velocity loop proportional gain (PK2V) format is:
0: Standard format
1: Converted format

⇒ See Supplement 2 of Subsec. 2.1.5.

		#7	#6	#5	#4	#3	#2	#1	#0
1741	–		CPEE		SPVC			RNLV	CROF
2201	–								

CROF (#0) The function for obtaining current offsets upon an emergency stop is:
0: Not used
1: Used

⇒ See Sec. 4.13.

RNLV (#1) Specifies the detection level for the feedback mismatch alarm as follows:
0: 600 rpm
1: 1000 rpm

SPVC (#4) Without using the conversion coefficient (SBPDNL), the number of velocity pulses is:
0: Not set
1: Set

⇒ See Sec. 4.16.
Related parameters:
1732 (Series 15) and 2121 (Series 16)

CPEE (#6) The actual current display peak hold function is:
0: Not used
1: Used

		#7	#6	#5	#4	#3	#2	#1	#0
1742	–				DUAL	OVS1	PIAL	VGCG	FAG0
2202	–								

FAG0 (#0) The fine acceleration/deceleration function, used separately for cutting and rapid traverse, is:
0: Not used
1: Used

Related parameters:
1702 (Series 15), 2109 (Series 16), 1766 (Series 15), 2143 (Series 16), 1951 (Series 15), and 2007 (Series 16)

NOTE
After this bit is set, the power must be turned off, then back on.
⇒See Subsecs. 3.4.2 and 4.8.3.

VGCG (#1) The cutting/rapid traverse-specific velocity loop gain switch function is:
0: Not used
1: Used

⇒ See Subsecs. 3.4.2 and 4.5.7.
Related parameters:
1858 (Series 15), 2046 (Series 16), 1700 (Series 15), and 2107 (Series 16)

PIAL (#2) When rapid traverse is selected by the cutting/rapid traverse-specific velocity loop gain switch function, the 1/2PI function is:
0: Automatically disabled
1: Always enabled

⇒ See Subsec. 4.5.7.

OVS1 (#3) 1: Overshoot compensation is valid only once after the termination of a move command. ⇒ See Sec. 4.7.

DUAL (#4) Zero width is determined: ⇒ See Subsec. 4.5.4.
0: Only by setting = 0
1: By setting
Related parameters: 1974 (Series 15) and 2081 (Series 16)

		#7	#6	#5	#4	#3	#2	#1	#0
1743	–				FRC2		1/2PI		
2203	–								

CRPI (#2) The current loop 1/2PI function is: ⇒ See Subsec. 4.5.7.
0: Not used
1: Used

FRC2 (#4) Torque control type 2 is: ⇒ See Sec. 4.15.
0: Not exercised
1: Exercised

		#7	#6	#5	#4	#3	#2	#1	#0
1744	–	ERC0		PGW2					
2204	–								

PGW2 (#5) Position gain switch type 2 is: ⇒ See Subsec. 4.8.1.
0: Not used
1: Used
Related parameters: 1713 (Series 15) and 2028 (Series 16)

ERC0 (#7) Emergency stop distance reduction function type 2 is: ⇒ See Subsec. 4.11.2.
0: Not used
1: Used

		#7	#6	#5	#4	#3	#2	#1	#0
1745	–						FLDY		
2205	–								

FLDY (#2) The dummy separate detector function is: ⇒ See Subsec. 4.9.1.
0: Not used
1: Used

		#7	#6	#5	#4	#3	#2	#1	#0
1746	–	HSSR							
2206	–								

HSSR (#7) High-speed data output to the check board is: ⇒ See Subsecs. 3.4.1 and 4.5.6.
0: Not performed
1: Performed

		#7	#6	#5	#4	#3	#2	#1	#0
1747	–					PD50			
2207	–								

PD50 (#3) Specifies a value for the stop-time variable proportional gain function as follows:
0: 75% down
1: 50% down

⇒ See Subsec. 4.4.3.
Related parameters:
1730 (Series 15) and 2119 (Series 16)

		#7	#6	#5	#4	#3	#2	#1	#0
1749	–						FADL		
2209	–								

FADL (#2) 0: FAD bell-shaped type
1: FAD linear type

⇒ See Subsec. 4.8.3.
Related parameters:
1702 (Series 15) and 2109 (Series 16)

> **NOTE**
> After this bit is set, the power must be turned off, then back on.
> ⇒See Subsec. 4.8.3.

		#7	#6	#5	#4	#3	#2	#1	#0
1750	–						PKGA		
2210	–								

PKGA (#2) The quadruple current loop gain function is:
0: Not used
1: Used

⇒ See Subsec. 4.14.1.

		#7	#6	#5	#4	#3	#2	#1	#0
1751	–							PHCP	
2211	–								

PHCP (#1) The deceleration phase delay compensation function is:
0: Not used
1: Used

Related parameters:
1756 (Series 15), 2133 (Series 16), 1757 (Series 15), and 2134 (Series 16)

		#7	#6	#5	#4	#3	#2	#1	#0
2600	–	OVQK							
2212	–								

OVQK (#7) When an OVC or OVL alarm occurs, the stop distance reduction function is:
0: Not used
1: Used

⇒ See Subsec. 4.11.4.

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number			Details	
Series 15	Series 16, 18, 20, 21, Power Mate	Power Mate-E		
1874	2020	1020	Motor No. Motor number that can be specified → 2.1.5 (6)	→ 2.1.2 Initial setting
1875	2021	1021	Load inertia ratio (LDINT) $\frac{\text{Load inertia}}{\text{Rotor inertia}} \times 256$ Increase velocity loop gain parameters PK1V and PK2V by (1 + LDINT/256) times	Adjust for individual machines separately.
1879 1876 1891	2022 2023 2024	1022 1023 1024	Rotation direction of the motor Number of velocity pulse Number of position pulse	→ 2.1.2 Initial setting
1713 1714 1715	2028 2029 2030	1028 1029 1030	Velocity enabling position gain switching Acceleration-time velocity enabling integration function for low speed Deceleration-time velocity enabling integration function for low speed	→ 4.8.1 → 4.8.2 → 4.8.2
1718 1719	2033 2034	–	Number of position feedback pulses Vibration-damping control gain	→ 4.5.5
1721	2036	–	Tandem control/damping compensation gain (main axis) Tandem control/damping compensation phase coefficient (sub-axis)	→ 4.17.2
1724	2039	–	Stage 2 acceleration amount for two-stage backlash acceleration	→ 4.6.5
1852 1853 1854	2040 2041 2042	1040 1041 1042	Current loop gain (PK1) Current loop gain (PK2) Current loop gain (PK3)	★ Motor-specific ★ Motor-specific ★ Motor-specific
1855	2043	1043	Velocity loop integral gain (PK1V)	☆ Motor-specific Adjust for individual machines separately.
1856	2044	1044	Velocity loop proportional gain (PK2V)	
1857	2045	1045	Velocity loop incomplete integral gain (PK3V)	☆ Motor-specific → 4.7
1858	2046	1046	Velocity loop gain (PK4V)	★ Motor-specific
1859	2047	1047	Observer parameter (POA1) This parameter is adjusted when the unexpected disturbance detection and two-stage backlash functions are used. NOTE: If the velocity gain (load inertia ratio) is changed, this parameter must be re-adjusted.	☆ Motor-specific → 4.6.5, 4.12
1860	2048	1048	Backlash acceleration amount	☆ → 4.6.4
1861	2049	1049	Maximum dual position feedback amplitude	☆ → 4.5.4
1862 1863	2050 2051	1050 1051	Observer gain (POK1) Observer gain (POK2) When only the unexpected disturbance detection function is used, these parameters must be changed.	☆ Motor-specific → 4.12
1864	2052	1052	Not used	★

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number			Details	
Series 15	Series 16, 18, 20, 21, Power Mate	Power Mate-E		
1865	2053	1053	Current dead-zone compensation (PPMAX)	★ Motor-specific
1866	2054	1054	Current dead-zone compensation (PDDP) The standard setting for α motors is 1894. To drive the α motor with an S Series amplifier, change it to 3787.	★ Motor-specific
1867	2055	1055	Current dead-zone compensation (PHYST)	★ Motor-specific
1868	2056	1056	Back electromotive force compensation/variable current gain at deceleration (EMFCMP)	
1869	2057	1057	Current phase compensation/phase D current at high-speed (PVPA)	Conventional control/HRV control
1870	2058	1058	Current phase compensation/phase D current limit (PALPH)	
1871	2059	1059	Back electromotive force compensation (EMFBAS)	
1872	2060	1061	Torque limit The standard setting represents the maximum current of the amplifier.	★ Motor-specific
1873	2061	1061	Back electromotive force compensation (EMFCMP)	★ Motor-specific
1877	2062	1062	Overload protection coefficient (POVC1)	
1878	2063	1063	Overload protection coefficient (POVC2)	
1892	2064	1064	Software disconnection alarm level	★ Motor-specific → 3.2
1893	2065	1065	Overload protection coefficient (POVCLMT)	★ Motor-specific
1894	2066	1066	250 μsec acceleration feedback	☆ → 4.4.1
1895	2067	1067	Torque command filter	☆ → 4.5.3
1961	2068	1068	Feed-forward coefficient	☆ → 4.6.1 to 4.6.3
1962	2069	1069	Velocity feed-forward coefficient	☆ → 4.6.1 to 4.6.3
1963	2070	1070	Backlash acceleration timing	☆ → 4.6.4
1964	2071	1071	Time during which backlash acceleration is effective	☆ → 4.6.4
1965	2072	1072	Static friction compensation amount	☆ → 4.6.6
1966	2073	1073	Stop time determination parameter	☆ → 4.6.6
1967	2074	1074	Current loop gain variable with velocity	★ Motor-specific
1969	2076	1076	~~1-msec acceleration feedback gain~~ (Basically, do not use this parameter.)	☆ An alternative function is available. → 4.4.1
1970	2077	1077	Overshoot protection counter	☆ → 4.7
1971	2078	1078	Dual position feedback conversion coefficient (numerator)	☆ → 4.5.4
1972	2079	1079	Dual position feedback conversion coefficient (denominator)	
1973	2080	1080	Dual position feedback primary delay time constant	
1974	2081	1081	Dual position feedback zero width	
1975	2082	1082	Backlash acceleration stop amount	☆ → 4.6.4
1976	2083	1083	Brake control timer (msec)	☆ → 4.10

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number			Details	
Series 15	Series 16, 18, 20, 21, Power Mate	Power Mate-E		
1977 1978	2084 2085	1084 1085	Flexible feed gear (numerator) Flexible feed gear (denominator)	→ 2.1.2 Initial setting
1979	2086	1086	Rated current parameter	★ Motor-specific
1980	2087	1087	Torque offset Tandem control/Preload value	☆ → 4.6.5 and 4.12 ☆ → 4.17.1
1981	2088	1088	Machine speed feedback gain	☆ → 4.5.1
1982	2089	1089	Base pulse for backlash acceleration	☆ → 4.6.4
1984	2091	1091	Nonlinear control parameter	☆
1985	2092	–	Advanced control feed-forward coefficient	☆ → 4.6.2
1990	2097	1097	Static friction compensation stop parameter	☆ → 4.6.6
1991	2098	1098	Current phase compensation coefficient	★ Motor-specific
1992	2099	1099	N-pulse suppression level	★ → 4.4.4
1994	2101	–	Overshoot compensation valid level	☆ → 4.7
1995	2102	1102	Final clamp value for the actual-current limit	★ Motor-specific
1996	2103	1103	Track back amount applied when an unexpected disturbance is detected	☆ → 4.12
1997	2104	1104	Unexpected disturbance detection threshold (cutting when switching is used)	☆ → 4.12
1998	2105	1105	Torque constant	☆ → 4.15
1700	2107	–	Velocity loop gain override	☆ → 3.4.2
1702	2109	–	Fine acceleration/deceleration time constant (rapid traverse when switching is used)	☆ → 3.4.2 and 4.8.3
1703	2110	–	Magnetic saturation compensation	★ Motor-specific
1704	2111	–	Torque limit at deceleration	★ Motor-specific
1705	2112	–	Linear motor AMR conversion coefficient 1	☆ → 4.14
1706	2113	–	Notch filter center frequency	☆ → 3.4.1 and 4.5.7
1725	2114	–	Stage 2 acceleration amount override for two-stage backlash acceleration	→ 4.6.5
1726	2115	–	For internal data output: Usually to be kept at 0.	
1727	2116	1116	Unexpected disturbance detection dynamic friction cancel	→ 4.12
1729	2118	–	Dual position feedback Semi-closed/full-closed error overestimation level	→ 4.5.4
1730	2119	–	Function for changing the proportional gain in the stop state: Stop level	→ 4.4.3
 1732 1733	 2121 2122	–	Series 9081 (supporting ultra-precision) Conversion coefficient for number of feedback pulses Detection resistance conversion coefficient	→ 4.16
1737	2126	–	Tandem control/position feedback switching time constant	→ 4.17.8
1735	2127	–	Non-interference control coefficient (NINTCT)	★ Motor-specific
1736	2128	–	Decrease-in-magnetic-flux coefficient (MFWKCE)	★ Motor-specific
1752	2129	–	Decrease-in-magnetic-flux coefficient (MFWKBL)	★ Motor-specific

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number			Details	
Series 15	Series 16, 18, 20, 21, Power Mate	Power Mate-E		
1753 1754 1755	2130 2131 2132	–	Correction of two thrust ripples per magnetic pole pair Correction of four thrust ripples per magnetic pole pair Correction of six thrust ripples per magnetic pole pair	☆ → 4.14
1756	2133	–	Deceleration phase delay compensation coefficient (PHDLY1)	★ Motor-specific
1757	2134	–	Deceleration phase delay compensation coefficient (PHDLY2)	★ Motor-specific
1760	2137	–	Stage 1 acceleration amount override for two-stage backlash acceleration	→ 4.6.5
1761 1762	2138 2139	–	Linear motor AMR conversion coefficient 2 Linear motor AMR offset	→ 4.14
1765	2142	–	Unexpected disturbance detection threshold in rapid traverse	→ 4.12.2
1766	2143	–	Fine acceleration/deceleration time constant 2 (in cutting)	→ 3.4.2, 4.8.3
1767	2144	–	Position feed-forward coefficient for cutting	→ 3.4.2, 4.8.3
1768	2145	–	Velocity feed-forward coefficient for cutting	→ 3.4.2, 4.8.3
1769	2146	–	Two-stage backlash acceleration end timer	→ 4.6.5
1771	2148	–	Deceleration decision level (HRV control) Usually to be kept at 0.	Usually adjustment is not needed.
1777	2154	–	Static friction compensation function. Decision level for movement restart after stop.	→ 4.6.6
1779	2156	–	Torque command filter (at cutting)	→ 3.4.2, 4.5.3
1785	2162	–	Second overload protection coefficient (POVC21)	★ Motor-specific
1786	2163	–	Second overload protection coefficient (POVC22)	★ Motor-specific
1787	2164	–	Second overload protection coefficient (POVCLMT2)	★ Motor-specific
1788	2165	–	Maximum amplifier current	★ Motor-specific
1790	2167	–	Stage 2 acceleration amount offset for two-stage backlash acceleration	→ 4.6.5
2620	2177	–	Damping filter limit bandwidth	→ 3.4.1, 4.5.7
2621	2178	–	Rapid traverse position gain	→ 3.4.2
2623	2180	–	Linear motor thrust ripple correction. Phase delay compensation.	→ 4.14.3
2628	2185	–	Position pulse conversion coefficient → Supplement 1 of Subsec. 2.1.5	→ 2.1.2 Initial setting

6 PARAMETER LIST

6.1 FOR Series 0-C AND 15-A

July 1999

Series 9046 (compatible with standard and high-speed positioning)
Series 9041 (compatible with dual position feedback)

		Motor model	α3HV	α6HV	α12HV	α22HV	α30HV	αC3	αC6	αC12	αC22	α0.5
		Motor specification	0171	0172	0176	0177	0178	0121	0126	0141	0145	0113
		Motor model										β0.5
		Motor specification										0113
98.04.14		Motor type No.	1	2	3	4	5	7	8	9	10	13
Symbol	Parameter No.											
	FS15-A	FS0-C										
	1808	8☐03	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	8☐04	01000110	01000110	01000110	01000110	01000110	00000110	00000110	00000110	00000110	00000110
	1883	8☐05	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8☐06	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000000	01000000	01000100
	1951	8☐07	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8☐08	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8☐09	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8☐10	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000010
	1955	8☐11	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8☐12	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8☐40	687	828	730	800	1100	1600	1800	3000	2330	220
PK2	1853	8☐41	–2510	–3129	–3038	–3190	–3886	–5059	–6105	–9750	–6831	–540
PK3	1854	8☐42	–2617	–2638	–2638	–2694	–2663	–2608	–2641	–2687	–2694	–2556
PK1V	1855	8☐43	107	127	188	271	293	107	127	251	271	9
PK2V	1856	8☐44	–955	–1141	–1683	–2426	–2625	–955	–1140	–2245	–2426	–79
PK3V	1857	8☐45	0	0	0	0	0	0	0	0	0	0
PK4V	1858	8☐46	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	8☐47	3972	3326	2254	1564	1446	3974	3329	1690	1564	–4789
BLCMP	1860	8☐48	0	0	0	0	0	0	0	0	0	0
RESERV	1861	8☐49	0	0	0	0	0	0	0	0	0	0
POK1	1862	8☐50	956	956	956	956	956	956	956	956	956	956
POK2	1863	8☐51	510	510	510	510	510	510	510	510	510	510
RESERV	1864	8☐52	3843	3842	3843	3843	3842	3843	3844	3842	3842	3844
PPMAX	1865	8☐53	21	21	21	21	21	21	21	21	21	21
PDDP	1866	8☐54	3787	3787	3787	3787	3787	1894	1894	1894	1894	1894
PHYST	1867	8☐55	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	8☐56	2500	4000	3500	3500	4000	3046	4381	4000	4000	1200
PVPA	1869	8☐57	2200	2500	2400	2000	1700	2100	1800	2400	2400	2000
PALPH	1870	8☐58	70	70	70	60	52	42	48	42	43	77
PPBAS	1871	8☐59	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	8☐60	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	8☐61	120	120	120	120	120	120	120	120	120	120
POVC1	1877	8☐62	32686	32637	32568	32370	32359	32686	32637	32412	32370	32585
POVC2	1878	8☐63	1031	1639	2505	4981	5110	1030	1636	4446	4981	2288
TGALMLV	1892	8☐64	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	8☐65	3059	4866	7445	14847	15235	3056	4858	13245	14847	6797
PK2VAUX	1894	8☐66	0	0	0	0	0	0	0	0	0	0
FILTER	1895	8☐67	0	0	0	0	0	0	0	0	0	0
FALPH	1961	8☐68	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	8☐69	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	8☐70	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	8☐71	0	0	0	0	0	0	0	0	0	0
RESERV	1965	8☐72	0	0	0	0	0	0	0	0	0	0
RESERV	1966	8☐73	0	0	0	0	0	0	0	0	0	0
AALPH	1967	8☐74	0	0	4000	4000	4000	4000	4000	0	0	1000
MODEL	1968	8☐75	0	0	0	0	0	0	0	0	0	0
WKAC	1969	8☐76	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	8☐77	0	0	0	0	0	0	0	0	0	0
RESERV	1971	8☐78	0	0	0	0	0	0	0	0	0	0
RESERV	1972	8☐79	0	0	0	0	0	0	0	0	0	0
RESERV	1973	8☐80	0	0	0	0	0	0	0	0	0	0
RESERV	1974	8☐81	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	8☐82	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	8☐83	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	8☐84	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	8☐85	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	8☐86	1287	1623	2008	2836	2872	1286	1622	2678	2836	1918
TDPLD	1980	8☐87	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	8☐88	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	8☐89	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	8☐90	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	8☐91	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	8☐92	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	8☐93	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	8☐94	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	8☐95	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	8☐96	0	0	0	0	0	0	0	0	0	0
RESERV	1990	8☐97	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	8☐98	5145	5145	5170	10250	15370	12800	17920	17920	12800	5160
ONEPSL	1992	8☐99	400	400	400	400	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

		Motor model	α3/3	α6/2	α6/3	α12/2	α12/3	α22/2	α22/3	α30/2	α30/3	αM3
		Motor specification	0123	0127	0128	0142	0143	0147	0148	0152	0153	0161
		Motor model										
		Motor specification										
98.04.14		Motor type No.	15	16	17	18	19	20	21	22	23	24
Symbol	Parameter No.											
	FS15-A	FS0-C										
	1808	8□03	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001000
	1809	8□04	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	8□05	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8□06	01000100	01000000	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100
	1951	8□07	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8□08	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8□09	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8□10	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000010
	1955	8□11	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8□12	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8□40	1314	2282	943	3121	1324	2195	881	3173	1305	672
PK2	1853	8□41	–3268	–4660	–2956	–4953	–3671	–4490	–2759	–5522	–3431	–2065
PK3	1854	8□42	–3052	–3052	–2633	–3052	–3052	–3052	–3052	–3052	–3052	–3052
PK1V	1855	8□43	87	99	91	188	165	203	214	144	240	53
PK2V	1856	8□44	–781	–887	–818	–1683	–1474	–1821	–1921	–1293	–2153	–471
PK3V	1857	8□45	0	0	0	0	0	0	0	0	0	0
PK4V	1858	8□46	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	8□47	4858	4279	4639	2254	2574	2084	1976	2935	1763	–806
BLCMP	1860	8□48	0	0	0	0	0	0	0	0	0	0
RESERV	1861	8□49	0	0	0	0	0	0	0	0	0	0
POK1	1862	8□50	956	956	956	956	956	956	956	956	956	956
POK2	1863	8□51	510	510	510	510	510	510	510	510	510	510
RESERV	1864	8□52	3843	3843	3843	3844	3844	3843	3843	3843	3842	3847
PPMAX	1865	8□53	21	21	21	21	21	21	21	21	21	21
PDDP	1866	8□54	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	8□55	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	8□56	2000	3500	3000	4000	2500	4000	3000	5000	4500	2500
PVPA	1869	8□57	2200	2000	2800	2000	2200	2000	2200	2600	2000	2400
PALPH	1870	8□58	64	41	80	38	64	40	64	46	59	70
PPBAS	1871	8□59	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	8□60	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	8□61	120	120	120	120	120	120	120	120	120	120
POVC1	1877	8□62	32713	32689	32698	32568	32614	32543	32518	32668	32493	32697
POVC2	1878	8□63	690	991	877	2505	1922	2811	3128	1245	3443	886
TGALMLV	1892	8□64	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	8□65	2045	2940	2601	7445	5709	8358	9305	3695	10245	2627
PK2VAUX	1894	8□66	0	0	0	0	0	0	0	0	0	0
FILTER	1895	8□67	0	0	0	0	0	0	0	0	0	0
FALPH	1961	8□68	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	8□69	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	8□70	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	8□71	0	0	0	0	0	0	0	0	0	0
RESERV	1965	8□72	0	0	0	0	0	0	0	0	0	0
RESERV	1966	8□73	0	0	0	0	0	0	0	0	0	0
AALPH	1967	8□74	3000	0	0	2000	2000	2000	2000	2000	1000	3000
MODEL	1968	8□75	0	0	0	0	0	0	0	0	0	0
WKAC	1969	8□76	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	8□77	0	0	0	0	0	0	0	0	0	0
RESERV	1971	8□78	0	0	0	0	0	0	0	0	0	0
RESERV	1972	8□79	0	0	0	0	0	0	0	0	0	0
RESERV	1973	8□80	0	0	0	0	0	0	0	0	0	0
RESERV	1974	8□81	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	8□82	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	8□83	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	8□84	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	8□85	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	8□86	1052	1261	1187	2008	1758	2127	2245	1414	2355	1193
TDPLD	1980	8□87	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	8□88	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	8□89	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	8□90	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	8□91	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	8□92	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	8□93	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	8□94	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	8□95	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	8□96	0	0	0	0	0	0	0	0	0	0
RESERV	1990	8□97	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	8□98	0	10265	30	12800	5145	7680	2585	10240	5145	25
ONEPSL	1992	8□99	400	400	400	400	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

		Motor model	αM6	αM9	α22/1.5	α30/1.2	α40/FAN	α40/2	0E	5E	E1/3	E2/3
		Motor specification	0162	0163	0146	0151	0158	0157	0105	0106	0101	0102
		Motor model							β3/3	β6/2	β1/3	β2/3
		Motor specification							0033	0034	0031	0032
98.04.14		Motor type No.	25	26	27	28	29	30	33	34	35	36
Symbol	Parameter No.											
	FS15-A	FS0-C										
	1808	8□03	00001000	00001000	00000000	00000000	00000000	00000000	00001000	00001000	00001000	00001000
	1809	8□04	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	8□05	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8□06	01000100	01000100	01000000	01000000	01000100	01000100	01000000	01000000	01000000	01000000
	1951	8□07	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8□08	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8□09	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8□10	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000010	00000000	00000010
	1955	8□11	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8□12	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8□40	950	748	2330	5060	1832	1832	275	990	359	704
PK2	1853	8□41	–2582	–2402	–6381	–9923	–5994	–5994	–1006	–3544	–1129	–2401
PK3	1854	8□42	–3052	–2632	–2694	–2705	–2700	–2700	–2622	–2632	–2564	–2596
PK1V	1855	8□43	38	61	271	147	201	201	144	144	102	62
PK2V	1856	8□44	–328	–550	–2426	–1313	–1801	–1801	–2587	–2587	–916	–1111
PK3V	1857	8□45	0	0	0	0	0	0	0	0	0	0
PK4V	1858	8□46	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	8□47	–1156	–690	1564	2891	2107	2107	1467	1467	4141	3415
BLCMP	1860	8□48	0	0	0	0	0	0	0	0	0	0
RESERV	1861	8□49	0	0	0	0	0	0	0	0	0	0
POK1	1862	8□50	956	956	956	956	956	956	956	956	956	956
POK2	1863	8□51	510	510	510	510	510	510	510	510	510	510
RESERV	1864	8□52	3847	3844	3843	3843	3842	3842	3840	3072	0	3072
PPMAX	1865	8□53	21	21	21	21	21	21	21	21	21	21
PDDP	1866	8□54	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	8□55	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	8□56	3500	3000	4000	8000	6637	6637	3000	3200	2500	3300
PVPA	1869	8□57	2400	2700	2400	3600	2200	2200	3200	2000	2100	2700
PALPH	1870	8□58	70	83	43	38	48	48	80	57	71	78
PPBAS	1871	8□59	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	8□60	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	8□61	120	120	120	120	120	120	120	120	120	120
POVC1	1877	8□62	32727	32692	32370	32665	32361	32579	32456	32456	32617	32540
POVC2	1878	8□63	516	955	4981	1283	5090	2358	3897	3897	1884	2850
TGALMLV	1892	8□64	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	8□65	1529	2832	14847	3809	15175	7007	11600	11600	5594	8474
PK2VAUX	1894	8□66	0	0	0	0	0	0	0	0	0	0
FILTER	1895	8□67	0	0	0	0	0	0	0	0	0	0
FALPH	1961	8□68	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	8□69	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	8□70	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	8□71	0	0	0	0	0	0	0	0	0	0
RESERV	1965	8□72	0	0	0	0	0	0	0	0	0	0
RESERV	1966	8□73	0	0	0	0	0	0	0	0	0	0
AALPH	1967	8□74	3000	0	0	0	2000	2000	0	0	0	0
MODEL	1968	8□75	0	0	0	0	0	0	0	0	0	0
WKAC	1969	8□76	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	8□77	0	0	0	0	0	0	0	0	0	0
RESERV	1971	8□78	0	0	0	0	0	0	0	0	0	0
RESERV	1972	8□79	0	0	0	0	0	0	0	0	0	0
RESERV	1973	8□80	0	0	0	0	0	0	0	0	0	0
RESERV	1974	8□81	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	8□82	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	8□83	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	8□84	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	8□85	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	8□86	910	1238	2836	1436	2867	1948	2506	2506	1740	2142
TDPLD	1980	8□87	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	8□88	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	8□89	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	8□90	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	8□91	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	8□92	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	8□93	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	8□94	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	8□95	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	8□96	0	0	0	0	0	0	0	0	0	0
RESERV	1990	8□97	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	8□98	5145	0	5120	12800	12800	12800	–1476	30	80	–2786
ONEPSL	1992	8□99	400	400	400	400	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

98.04.14 Symbol	Parameter No. FS15-A	FS0-C										
		Motor model	50S	60S	70S	5-0	4-0S	3-0S	2-0SP	1-0SP	5S	6S
		Motor specification	0331	0332	0333	0531	0532	0533	0371	0372	0314	0316
		Motor model	α65/2	α100/2	α150/2					α2/2		
		Motor specification	0331	0332	0333					0372		
		Motor type No.	39	40	41	42	43	44	45	46	48	49
	1808	8□03	00001000	00001000	00001000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1809	8□04	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	8□05	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8□06	01010100	01010100	01010100	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	8□07	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8□08	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8□09	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8□10	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	8□11	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8□12	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8□40	999	1451	1334	457	460	736	390	1170	1500	750
PK2	1853	8□41	–3600	–6000	–5297	–999	–730	–1500	–1053	–2289	–2781	–2000
PK3	1854	8□42	–1957	–2259	–2723	–1873	–2373	–2374	–2480	–2485	–3052	–2596
PK1V	1855	8□43	168	130	145	30	58	53	111	91	151	216
PK2V	1856	8□44	–1502	–1165	–1295	–300	–517	–477	–997	–812	–1355	–1932
PK3V	1857	8□45	0	0	0	0	0	0	0	0	0	0
PK4V	1858	8□46	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	8□47	2526	3259	2931	0	–733	–795	3806	4674	2801	1964
BLCMP	1860	8□48	0	0	0	0	0	0	0	0	0	0
RESERV	1861	8□49	0	0	0	0	0	0	0	0	0	0
POK1	1862	8□50	956	956	956	956	956	956	956	956	956	956
POK2	1863	8□51	510	510	510	510	510	510	510	510	510	510
RESERV	1864	8□52	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	8□53	21	21	21	21	21	21	21	21	21	21
PDDP	1866	8□54	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	8□55	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	8□56	4444	4884	6668	0	629	1129	1589	2147	2403	5000
PVPA	1869	8□57	2800	2800	3040	2330	1861	2330	2330	1864	2330	3750
PALPH	1870	8□58	57	57	57	57	46	57	57	46	57	64
PPBAS	1871	8□59	20	20	20	0	0	0	0	0	0	0
TQLIM	1872	8□60	6560	6560	6560	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	8□61	120	120	120	0	120	120	120	120	120	120
POVC1	1877	8□62	32419	32499	32281	32514	32543	32576	32623	32627	32677	32485
POVC2	1878	8□63	4365	3358	6086	3173	2817	2401	1811	1766	1142	3536
TGALMLV	1892	8□64	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	8□65	13002	9990	18168	9437	8375	7136	5377	5245	3388	10522
PK2VAUX	1894	8□66	0	0	0	0	0	0	0	0	0	0
FILTER	1895	8□67	1100	1100	1100	0	0	0	0	0	0	0
FALPH	1961	8□68	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	8□69	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	8□70	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	8□71	0	0	0	0	0	0	0	0	0	0
RESERV	1965	8□72	0	0	0	0	0	0	0	0	0	0
RESERV	1966	8□73	0	0	0	0	0	0	0	0	0	0
AALPH	1967	8□74	400	400	400	0	0	0	0	0	0	0
MODEL	1968	8□75	0	0	0	0	0	0	0	0	0	0
WKAC	1969	8□76	15	15	15	0	0	0	0	0	0	0
OSCTPL	1970	8□77	0	0	0	0	0	0	0	0	0	0
RESERV	1971	8□78	0	0	0	0	0	0	0	0	0	0
RESERV	1972	8□79	0	0	0	0	0	0	0	0	0	0
RESERV	1973	8□80	0	0	0	0	0	0	0	0	0	0
RESERV	1974	8□81	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	8□82	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	8□83	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	8□84	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	8□85	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	8□86	2653	2326	3137	2261	2129	1966	1706	1685	1354	1966
TDPLD	1980	8□87	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	8□88	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	8□89	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	8□90	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	8□91	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	8□92	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	8□93	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	8□94	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	8□95	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	8□96	0	0	0	0	0	0	0	0	0	0
RESERV	1990	8□97	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	8□98	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	8□99	400	400	400	400	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

		Motor model	10S	20S/1.5	20S	30S	30/2	40	0L(C)	5L(C)	6L(C)	7L(C)
		Motor specification	0315	0505	0502	0590	0506	0581	0561	0562	0564	0571
		Motor model							αL3	αL6	αL9	αL25
		Motor specification							0561	0562	0564	0571
98.04.14		Motor type No.	50	51	52	53	54	55	56	57	58	59
Symbol	Parameter No.											
	FS15-A	FS0-C										
	1808	8□03	00000000	00000000	00000000	00000000	00000000	00000000	00001000	00001000	00001000	00001000
	1809	8□04	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	8□05	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8□06	00000000	00000000	00000000	00000000	00000000	00000000	01000100	01000100	01000100	01000100
	1951	8□07	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8□08	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8□09	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8□10	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	8□11	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8□12	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8□40	2591	1131	1261	3414	705	1511	1600	1360	850	590
PK2	1853	8□41	–5540	–2477	–2577	–7650	–2716	–5829	–4508	–4000	–2300	–1600
PK3	1854	8□42	–2623	–2649	–2646	–2663	–2669	–2672	–2614	–2647	–2652	–2685
PK1V	1855	8□43	260	458	298	201	375	282	18	17	34	92
PK2V	1856	8□44	–2328	–4103	–2666	–1797	–3356	–2526	–159	–156	–309	–823
PK3V	1857	8□45	0	0	0	0	0	0	0	0	0	0
PK4V	1858	8□46	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	8□47	1630	925	1424	2112	1131	1502	–2382	–2429	–1229	4611
BLCMP	1860	8□48	0	0	0	0	0	0	0	0	0	0
RESERV	1861	8□49	0	0	0	0	0	0	0	0	0	0
POK1	1862	8□50	956	956	956	956	956	956	956	956	956	956
POK2	1863	8□51	510	510	510	510	510	510	510	510	510	510
RESERV	1864	8□52	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	8□53	21	21	21	21	21	21	21	21	21	21
PDDP	1866	8□54	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	8□55	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	8□56	5520	3549	2731	5456	1961	3478	2000	2000	1240	4500
PVPA	1869	8□57	3500	2797	2600	7200	2330	2800	2330	2330	2330	3000
PALPH	1870	8□58	64	52	57	50	57	43	57	57	57	64
PPBAS	1871	8□59	0	0	0	0	0	0	5	5	5	5
TQLIM	1872	8□60	7282	7282	6918	6918	6554	7282	5462	5462	7282	7282
EMFLMT	1873	8□61	120	120	120	120	120	120	120	120	120	120
POVC1	1877	8□62	32539	32155	32386	32530	32254	32340	32695	32698	32614	32489
POVC2	1878	8□63	2864	7659	4771	2971	6421	5355	912	877	1928	3482
TGALMLV	1892	8□64	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	8□65	8515	22907	14219	8834	19176	15972	2706	2602	5727	10360
PK2VAUX	1894	8□66	0	0	0	0	0	0	0	0	0	0
FILTER	1895	8□67	0	0	0	0	0	0	0	0	0	0
FALPH	1961	8□68	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	8□69	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	8□70	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	8□71	0	0	0	0	0	0	0	0	0	0
RESERV	1965	8□72	0	0	0	0	0	0	0	0	0	0
RESERV	1966	8□73	0	0	0	0	0	0	0	0	0	0
AALPH	1967	8□74	0	0	0	0	0	0	3000	3000	4000	4000
MODEL	1968	8□75	0	0	0	0	0	0	0	0	0	0
WKAC	1969	8□76	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	8□77	0	0	0	0	0	0	0	0	0	0
RESERV	1971	8□78	0	0	0	0	0	0	0	0	0	0
RESERV	1972	8□79	0	0	0	0	0	0	0	0	0	0
RESERV	1973	8□80	0	0	0	0	0	0	0	0	0	0
RESERV	1974	8□81	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	8□82	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	8□83	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	8□84	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	8□85	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	8□86	1768	3801	2285	1801	2654	2941	1210	1187	1761	2369
TDPLD	1980	8□87	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	8□88	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	8□89	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	8□90	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	8□91	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	8□92	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	8□93	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	8□94	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	8□95	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	8□96	0	0	0	0	0	0	0	0	0	0
RESERV	1990	8□97	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	8□98	0	0	0	0	0	0	0	0	0	50
ONEPSL	1992	8□99	400	400	400	400	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

			10L(C)	2-0SP/3	1-0SP/3	0S	5S/3	10S/3	20S/3	30S/3	0L(L)	5L(L)
		Motor model	10L(C)	2-0SP/3	1-0SP/3	0S	5S/3	10S/3	20S/3	30S/3	0L(L)	5L(L)
		Motor specification	0572	0371	0373	0313	0514	0317	0318	0319	0561	0562
		Motor model	αL50	α1/3	α2/3							
		Motor specification	0572	0371	0373							
98.04.14		Motor type No.	60	61	62	63	64	65	66	67	68	69
Symbol	Parameter No.											
	FS15-A	FS0-C										
	1808	8□03	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	8□04	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	8□05	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8□06	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100
	1951	8□07	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8□08	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8□09	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8□10	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	8□11	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8□12	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8□40	700	390	450	600	672	1090	542	708	1600	1360
PK2	1853	8□41	−2000	−1053	−900	−1600	−1574	−2360	−1377	−1811	−4508	−4000
PK3	1854	8□42	−2701	−2480	−2503	−2517	−2526	−2625	−2654	−2664	−2614	−2647
PK1V	1855	8□43	116	111	128	126	136	287	305	346	18	17
PK2V	1856	8□44	−1035	−997	−1146	−1127	−1215	−2571	−2734	−3097	−159	−156
PK3V	1857	8□45	0	0	0	0	0	0	0	0	0	0
PK4V	1858	8□46	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235
POA1	1859	8□47	3666	3806	3311	3366	3124	1476	1388	1226	−2382	−2429
BLCMP	1860	8□48	0	0	0	0	0	0	0	0	0	0
RESERV	1861	8□49	0	0	0	0	0	0	0	0	0	0
POK1	1862	8□50	956	956	956	956	956	956	956	956	956	956
POK2	1863	8□51	510	510	510	510	510	510	510	510	510	510
RESERV	1864	8□52	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	8□53	21	21	21	21	21	21	50	50	21	21
PDDP	1866	8□54	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	8□55	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	8□56	4800	2800	2520	2520	2520	3780	5400	6000	2000	2000
PVPA	1869	8□57	3200	2330	2330	2330	2330	2330	2330	2200	2330	2330
PALPH	1870	8□58	64	57	57	57	57	57	57	57	57	57
PPBAS	1871	8□59	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	8□60	7282	7282	7282	7282	7282	7282	7282	7282	5462	5462
EMFLMT	1873	8□61	120	120	120	120	120	120	120	120	120	120
POVC1	1877	8□62	32237	32623	32519	32712	32694	32578	32495	32470	32695	32698
POVC2	1878	8□63	6640	1811	3112	706	924	2381	3410	3723	912	877
TGALMLV	1892	8□64	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	8□65	19834	5377	9256	2094	2740	7075	10144	11081	2706	2602
PK2VAUX	1894	8□66	0	0	0	0	0	0	0	0	0	0
FILTER	1895	8□67	0	0	0	0	0	0	0	0	0	0
FALPH	1961	8□68	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	8□69	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	8□70	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	8□71	0	0	0	0	0	0	0	0	0	0
RESERV	1965	8□72	0	0	0	0	0	0	0	0	0	0
RESERV	1966	8□73	0	0	0	0	0	0	0	0	0	0
AALPH	1967	8□74	4000	1680	2940	4000	2100	2520	4000	0	3000	3000
MODEL	1968	8□75	0	0	0	0	0	0	0	0	0	0
WKAC	1969	8□76	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	8□77	0	0	0	0	0	0	0	0	0	0
RESERV	1971	8□78	0	0	0	0	0	0	0	0	0	0
RESERV	1972	8□79	0	0	0	0	0	0	0	0	0	0
RESERV	1973	8□80	0	0	0	0	0	0	0	0	0	0
RESERV	1974	8□81	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	8□82	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	8□83	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	8□84	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	8□85	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	8□86	3277	1706	2239	1064	1218	1814	2344	2450	1210	1187
TDPLD	1980	8□87	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	8□88	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	8□89	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	8□90	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	8□91	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	8□92	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	8□93	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	8□94	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	8□95	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	8□96	0	0	0	0	0	0	0	0	0	0
RESERV	1990	8□97	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	8□98	0	50	0	0	0	0	15	0	0	0
ONEPSL	1992	8□99	400	400	400	400	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

98.04.14		Motor model	6L(L)	7L(L)	10L(L)	6S/3	40S/2	0T/3	5T	5T/3	10T	10T/3
		Motor specification	0564	0571	0572		0583	0381	0382	0383	0384	0385
		Motor model Motor specification Motor type No.	70	71	72	73	78	79	80	81	82	83
Symbol	Parameter No. FS15-A	FS0-C										
	1808	8□03	00001000	00001000	00001000	00001000	00001000	00001000	00000000	00001000	00000000	00001000
	1809	8□04	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	8□05	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8□06	01000100	01000100	01000100	01000100	01000100	01000100	00000000	01000100	00000000	01000100
	1951	8□07	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8□08	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8□09	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8□10	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	8□11	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8□12	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8□40	850	590	700	1000	892	701	670	456	600	409
PK2	1853	8□41	–2300	–1600	–2000	–2400	–2877	–2038	–1600	–1019	–1153	–946
PK3	1854	8□42	–2652	–2685	–2701	–2459	–2666	–2390	–2473	–2498	–2550	–2543
PK1V	1855	8□43	34	119	150	135	280	260	287	209	450	349
PK2V	1856	8□44	–309	–1070	–1346	–1205	–2511	–2329	–2568	–1877	–4034	–3124
PK3V	1857	8□45	0	0	0	0	0	0	0	0	0	0
PK4V	1858	8□46	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	8□47	–1229	3547	2820	3148	1512	1630	1478	2022	941	1215
BLCMP	1860	8□48	0	0	0	0	0	0	0	0	0	0
RESERV	1861	8□49	0	0	0	0	0	0	0	0	0	0
POK1	1862	8□50	956	956	956	956	956	956	956	956	956	956
POK2	1863	8□51	510	510	510	510	510	510	510	510	510	510
RESERV	1864	8□52	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	8□53	21	21	21	21	50	21	21	21	21	21
PDDP	1866	8□54	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	8□55	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	8□56	1240	4500	4800	3200	4800	4008	4400	3684	4590	4008
PVPA	1869	8□57	2330	3000	3200	2300	3200	4200	4000	3000	3335	2330
PALPH	1870	8□58	57	64	64	64	60	43	64	64	57	57
PPBAS	1871	8□59	5	5	5	5	5	5	0	5	0	5
TQLIM	1872	8□60	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	8□61	120	120	120	120	120	120	120	120	120	120
POVC1	1877	8□62	32614	32299	31875	32693	32345	32703	32669	32714	32532	32625
POVC2	1878	8□63	1928	5867	11158	940	5290	819	1235	674	2948	1788
TGALMLV	1892	8□64	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	8□65	5727	17509	32767	2787	15775	2428	3665	1998	8766	5308
PK2VAUX	1894	8□66	0	0	0	0	0	0	0	0	0	0
FILTER	1895	8□67	0	0	0	0	0	0	0	0	0	0
FALPH	1961	8□68	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	8□69	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	8□70	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	8□71	0	0	0	0	0	0	0	0	0	0
SFCCM	1965	8□72	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	8□73	0	0	0	0	0	0	0	0	0	0
AALPH	1967	8□74	4000	4000	4000	3200	3333	3158	0	2105	0	3421
MODEL	1968	8□75	0	0	0	0	0	0	0	0	0	0
PKMOL	1969	8□76	0	0	0	0	0	0	0	0	0	0
OSCTP	1970	8□77	0	0	0	0	0	0	0	0	0	0
RESERV	1971	8□78	0	0	0	0	0	0	0	0	0	0
RESERV	1972	8□79	0	0	0	0	0	0	0	0	0	0
RESERV	1973	8□80	0	0	0	0	0	0	0	0	0	0
RESERV	1974	8□81	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	8□82	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	8□83	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	8□84	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	8□85	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	8□86	1761	3079	4261	1228	2923	1147	1409	1040	2179	1696
TDPLD	1980	8□87	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	8□88	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	8□89	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	8□90	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	8□91	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	8□92	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	8□93	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	8□94	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	8□95	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	8□96	0	0	0	0	0	0	0	0	0	0
RESERV	1990	8□97	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	8□98	0	50	0	0	0	0	0	0	0	0
ONEPSL	1992	8□99	400	400	400	400	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

		Motor model	0-0SP/3	0S/1.5	5S/1.5	6S/1	10S/1	20S/0.5
		Motor specification	0374	0515	0516	0520	0504	0500
		Motor model	α2.5/3					
		Motor specification	0374					
98.04.14		Motor type No.	84	85	86	87	88	89
Symbol	Parameter No.							
	FS15-A	FS0-C						
	1808	8□03	00001000	00000000	00000000	00000000	00000000	00000000
	1809	8□04	01000110	01000110	01000110	01000110	01000110	01000110
	1883	8□05	00000000	00000000	00000000	00000000	00000000	00000000
	1884	8□06	01000100	01000100	01000100	01000000	01000000	00000000
	1951	8□07	00000000	00000000	00000000	00000000	00000000	00000000
	1952	8□08	00000000	00000000	00000000	00000000	00000000	00000000
	1953	8□09	00000000	00000000	00000000	00000000	00000000	00000000
	1954	8□10	00000000	00000000	00000000	00000000	00000000	00000000
	1955	8□11	00000000	00000000	00000000	00000000	00000000	00000000
	1956	8□12	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	8□40	294	1275	800	1008	2420	3500
PK2	1853	8□41	–990	–3600	–2447	–3840	–6600	–11616
PK3	1854	8□42	–2455	–2544	–3052	–2584	–2640	–2662
PK1V	1855	8□43	70	142	212	215	364	298
PK2V	1856	8□44	–898	–1268	–1896	–1927	–3261	–2666
PK3V	1857	8□45	0	0	0	0	0	0
PK4V	1858	8□46	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	8□47	4228	2992	2001	1970	1164	1424
BLCMP	1860	8□48	0	0	0	0	0	0
RESERV	1861	8□49	0	0	0	0	0	0
POK1	1862	8□50	956	956	956	956	956	956
POK2	1863	8□51	510	510	510	510	510	510
RESERV	1864	8□52	0	0	0	0	0	0
PPMAX	1865	8□53	21	21	21	21	21	21
PDDP	1866	8□54	3787	3787	3787	3787	3787	3787
PHYST	1867	8□55	319	319	319	319	319	319
EMFCMP	1868	8□56	1971	2000	6000	5500	6500	2000
PVPA	1869	8□57	2330	3500	3650	4500	4600	6200
PALPH	1870	8□58	57	83	83	83	83	83
PPBAS	1871	8□59	5	5	5	5	5	5
TQLIM	1872	8□60	7282	7282	7282	7282	7282	7282
EMFLMT	1873	8□61	120	120	120	120	120	120
POVC1	1877	8□62	32569	32696	32589	32487	32320	32384
POVC2	1878	8□63	2482	903	2234	3517	5601	4805
TGALMLV	1892	8□64	4	4	4	4	4	4
POVCLMT	1893	8□65	7376	2679	6636	10466	16711	14321
PK2VAUX	1894	8□66	0	0	0	0	0	0
FILTER	1895	8□67	0	0	0	0	0	0
FALPH	1961	8□68	0	0	0	0	0	0
VFFLT	1962	8□69	0	0	0	0	0	0
ERBLM	1963	8□70	0	0	0	0	0	0
PBLCT	1964	8□71	0	0	0	0	0	0
SFCCM	1965	8□72	0	0	0	0	0	0
PSPTL	1966	8□73	0	0	0	0	0	0
AALPH	1967	8□74	2917	1000	3500	0	0	0
MODEL	1968	8□75	0	0	0	0	0	0
PKMOL	1969	8□76	0	0	0	0	0	0
OSCTP	1970	8□77	0	0	0	0	0	0
RESERV	1971	8□78	0	0	0	0	0	0
RESERV	1972	8□79	0	0	0	0	0	0
RESERV	1973	8□80	0	0	0	0	0	0
RESERV	1974	8□81	0	0	0	0	0	0
BLENDL	1975	8□82	0	0	0	0	0	0
MOFCTL	1976	8□83	0	0	0	0	0	0
SDMR1	1977	8□84	0	0	0	0	0	0
SDMR2	1978	8□85	0	0	0	0	0	0
RTCURR	1979	8□86	1998	1205	1896	1961	2478	2294
TDPLD	1980	8□87	0	0	0	0	0	0
MCNFB	1981	8□88	0	0	0	0	0	0
BLBSL	1982	8□89	0	0	0	0	0	0
ROBSTL	1983	8□90	0	0	0	0	0	0
ACCSPL	1984	8□91	0	0	0	0	0	0
ADFF1	1985	8□92	0	0	0	0	0	0
VMPK3V	1986	8□93	0	0	0	0	0	0
BLCMP2	1987	8□94	0	0	0	0	0	0
AHDRTL	1988	8□95	0	0	0	0	0	0
RADUSL	1989	8□96	0	0	0	0	0	0
RESERV	1990	8□97	0	0	0	0	0	0
DEPVPL	1991	8□98	50	0	0	0	0	0
ONEPSL	1992	8□99	400	400	400	400	400	400

NOTE) DPFMX and PDPCH are not used with the Series 9046. With the Series 9041, PDPCL, DPFEX, and DPFZW are used for INTSP1, INTSP2, and PTWNSP, respectively. For details, see Appendix A.

6.2 PARAMETERS FOR STANDARD CONTROL

July 1999

Series 9070 (for Series 15-B, 16, 18)
Series 9060 (for Series 20, 21, Power Mate)
Series 9064 (for Power Mate-E)

95.08.07			Motor model	α3HV	α6HV	α12HV	α22HV	α30HV	αC3	αC6	αC12	αC22	α0.5
			Motor specification	0171	0172	0176	0177	0178	0121	0126	0141	0145	0113
			Motor model										β0.5
			Motor specification										0113
			Motor type No.	1	2	3	4	5	7	8	9	10	13
Symbol	Parameter No. FS15-B	FS16~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000000	01000000	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000
PK1	1852	2040	1040	687	828	730	800	1100	1600	1800	3000	2330	220
PK2	1853	2041	1041	–2510	–3129	–3038	–3190	–3886	–5059	–6105	–9750	–6831	–540
PK3	1854	2042	1042	–2617	–2638	–2638	–2694	–2663	–2608	–2641	–2687	–2694	–2556
PK1V	1855	2043	1043	107	127	188	271	293	107	127	251	271	9
PK2V	1856	2044	1044	–955	–1141	–1683	–2426	–2625	–955	–1140	–2245	–2426	–79
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	3972	3326	2254	1564	1446	3974	3329	1690	1564	–4789
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	1894	1894	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	2500	4000	3500	3500	4000	3046	4381	4000	4000	1200
PVPA	1869	2057	1057	2200	2500	2400	2000	1700	2100	1800	2400	2400	2000
PALPH	1870	2058	1058	70	70	70	60	52	42	48	42	43	77
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32686	32637	32568	32370	32359	32686	32637	32412	32370	32585
POVC2	1878	2063	1063	1031	1639	2505	4981	5110	1030	1636	4446	4981	2288
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	3059	4866	7445	14847	15235	3056	4858	13245	14847	6797
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
RESERV	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
RESERV	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	12288	8192	16288	16288	12192	16288	20384	8192	8192	17384
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1287	1623	2008	2836	2872	1286	1622	2678	2836	1918
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	5145	5145	5170	10250	15370	12800	17920	17920	12800	5160
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	205	325	527	684	921	205	326	395	684	29
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0

			Motor model	α3/3	α6/2	α6/3	α12/2	α12/3	α22/2	α22/3	α30/2	α30/3	αM3
			Motor specification	0123	0127	0128	0142	0143	0147	0148	0152	0153	0161
			Motor model										
			Motor specification										
95.08.07			Motor type No.	15	16	17	18	19	20	21	22	23	24
Symbol	Parameter No.												
	FS15-B	FS16~PM	PM-E										
	1808	2003	1003	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001000
	1809	2004	1004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000000	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000
PK1	1852	2040	1040	1314	2282	943	3121	1324	2195	881	3173	1305	672
PK2	1853	2041	1041	–3268	–4660	–2956	–4953	–3671	–4490	–2759	–5522	–3431	–2065
PK3	1854	2042	1042	–3052	–3052	–2633	–3052	–3052	–3052	–3052	–3052	–3052	–3052
PK1V	1855	2043	1043	87	99	91	188	165	203	214	144	240	53
PK2V	1856	2044	1044	–781	–887	–818	–1683	–1474	–1821	–1921	–1293	–2153	–471
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	4858	4279	4639	2254	2574	2084	1976	2935	1763	–806
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	2000	3500	3000	4000	2500	4000	3000	5000	4500	2500
PVPA	1869	2057	1057	2200	2000	2800	2000	2200	2000	2200	2600	2000	2400
PALPH	1870	2058	1058	64	41	80	38	64	40	64	46	59	70
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32713	32689	32698	32568	32614	32543	32518	32668	32493	32697
POVC2	1878	2063	1063	690	991	877	2505	1922	2811	3128	1245	3443	886
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	2045	2940	2601	7445	5709	8358	9305	3695	10245	2627
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
RESERV	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
RESERV	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	15288	12288	12288	18384	18384	14288	14288	14288	9192	31672
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1052	1261	1187	2008	1758	2127	2245	1414	2355	1193
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	10265	30	12800	5145	7680	2585	10240	5145	25
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	251	419	454	527	601	911	864	1870	1123	221
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0

			Motor model	αM6	αM9	α22/1.5	α30/1.2	α40/FAN	α40/2	0E	5E	E1/3	E2/3
			Motor specification	0162	0163	0146	0151	0158	0157	0105	0106	0101	0102
			Motor model							β3/3	β6/2	β1/3	β2/3
			Motor specification							0033	0034	0031	0032
95.08.07			Motor type No.	25	26	27	28	29	30	33	34	35	36
Symbol	Parameter No.												
	FS15-B	FS16~PM	PM-E										
	1808	2003	1003	00001000	00001000	00000000	00000000	00000000	00000000	00001100	00001100	00001100	00001100
	1809	2004	1004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	01000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000100	00000100	00000100	00000100
	1884	2006	1006	01000100	01000100	01000000	01000000	01000100	01000100	01000000	01000000	01000000	01000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00000000	00100000
PK1	1852	2040	1040	950	748	2330	5060	1832	1832	275	990	359	704
PK2	1853	2041	1041	–2582	–2402	–6381	–9923	–5994	–5994	–1006	–3544	–1129	–2401
PK3	1854	2042	1042	–3052	–2632	–2694	–2705	–2700	–2700	–2622	–2632	–2564	–2596
PK1V	1855	2043	1043	38	61	271	147	201	201	144	144	102	62
PK2V	1856	2044	1044	–328	–550	–2426	–1313	–1801	–1801	–2587	–2587	–916	–1111
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	–1156	–690	1564	2891	2107	2107	1467	1467	4141	3415
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	1894	1894	1894	1894	1894	1894	1894	3787	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	3500	3000	4000	8000	6637	6637	3000	3200	2500	3300
PVPA	1869	2057	1057	2400	2700	2400	3600	2200	2200	3200	2000	2100	2700
PALPH	1870	2058	1058	70	83	43	38	48	48	80	57	71	78
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32727	32692	32370	32665	32361	32579	32456	32456	32617	32540
POVC2	1878	2063	1063	516	955	4981	1283	5090	2358	3897	3897	1884	2850
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	1529	2832	14847	3809	15175	7007	11600	11600	5594	8474
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
RESERV	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
RESERV	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	31672	16384	12288	12288	10192	10192	0	0	0	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	910	1238	2836	1436	2867	1948	2506	2506	1740	2142
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	5145	0	12800	12800	12800	12800	–1476	30	80	–2786
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	15000	15000	15000	15000	12000	0	12000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	581	653	684	1842	1756	1756	107	215	51	83
LP24PA	1999	2106	1106	0	0	0	0	0	0	12923	12923	12923	14203

			Motor model	50S	60S	70S	5-0	4-0S	3-0S	2-0SP	1-0SP	5S	6S
			Motor specification	0331	0332	0333	0531	0532	0533	0371	0372	0314	0316
			Motor model	α65/2	α100/2	α150/2					α2/2		
			Motor specification	0331	0332	0333					0372		
95.08.07			Motor type No.	39	40	41	42	43	44	45	46	48	49
Symbol	Parameter No. FS15-B	FS16~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01010100	01010100	01010100	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	999	1451	1334	457	460	736	390	1170	1500	750
PK2	1853	2041	1041	–3600	–6000	–5297	–999	–730	–1500	–1053	–2289	–2781	–2000
PK3	1854	2042	1042	–1957	–2259	–2723	–1873	–2373	–2374	–2480	–2485	–3052	–2596
PK1V	1855	2043	1043	168	130	145	30	58	53	111	91	151	216
PK2V	1856	2044	1044	–1502	–1165	–1295	–300	–517	–477	–997	–812	–1355	–1932
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	2526	3259	2931	0	–733	–795	3806	4674	2801	1964
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	4444	4884	6668	0	629	1129	1589	2147	2403	5000
PVPA	1869	2057	1057	2800	2800	3040	2330	1861	2330	2330	1864	2330	3750
PALPH	1870	2058	1058	57	57	57	57	46	57	57	46	57	64
PPBAS	1871	2059	1059	20	20	20	0	0	0	0	0	0	0
TQLIM	1872	2060	1060	6560	6560	6560	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	0	120	120	120	120	120	120
POVC1	1877	2062	1062	32419	32499	32281	32514	32543	32576	32623	32627	32677	32485
POVC2	1878	2063	1063	4365	3358	6086	3173	2817	2401	1811	1766	1142	3536
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	13002	9990	18168	9437	8375	7136	5377	5245	3388	10522
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	1100	1100	1100	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
RESERV	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
RESERV	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	400	400	400	0	0	0	0	0	0	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	15	15	15	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	2653	2326	3137	2261	2129	1966	1706	1685	1354	1966
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	2243	3791	4217	3	10	21	51	104	390	403
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0

			Motor model	10S	20S/1.5	20S	30S	30/2	40	0L(C)	5L(C)	6L(C)	7L(C)
			Motor specification	0315	0505	0502	0590	0506	0581	0561	0562	0564	0571
			Motor model							αL3	αL6	αL9	αL25
			Motor specification							0561	0562	0564	0571
95.08.07			Motor type No.	50	51	52	53	54	55	56	57	58	59
Symbol	Parameter No. FS15-B	FS16~PM	PM-E										
	1808	2003	1003	00000000	00000000	00000000	00000000	00000000	00000000	00001000	00001000	00001000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	00000000	00000000	00000000	00000000	00000000	00000000	01000100	01000100	01000100	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	2591	1131	1261	3414	705	1511	1600	1360	850	590
PK2	1853	2041	1041	–5540	–2477	–2577	–7650	–2716	–5829	–4508	–4000	–2300	–1600
PK3	1854	2042	1042	–2623	–2649	–2646	–2663	–2669	–2672	–2614	–2647	–2652	–2685
PK1V	1855	2043	1043	260	458	298	201	375	282	18	17	34	92
PK2V	1856	2044	1044	–2328	–4103	–2666	–1797	–3356	–2526	–159	–156	–309	–823
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	1630	925	1424	2112	1131	1502	–2382	–2429	–1229	4611
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	5520	3549	2731	5456	1961	3478	2000	2000	1240	4500
PVPA	1869	2057	1057	3500	2797	2600	7200	2330	2800	2330	2330	2330	3000
PALPH	1870	2058	1058	64	52	57	50	57	43	57	57	57	64
PPBAS	1871	2059	1059	0	0	0	0	0	0	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	6918	6918	6554	7282	5462	5462	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32539	32155	32386	32530	32254	32340	32695	32698	32614	32489
POVC2	1878	2063	1063	2864	7659	4771	2971	6421	5355	912	877	1928	3482
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	8515	22907	14219	8834	19176	15972	2706	2602	5727	10360
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
RESERV	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
RESERV	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	0	0	0	0	0	0	3000	3000	4000	4000
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1768	3801	2285	1801	2654	2941	1210	1187	1761	2369
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	0	0	0	0	0	0	0	0	50
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	598	577	888	1860	995	1709	218	445	451	930
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0

95.08.07			Motor model	10L(C)	2-0SP/3	1-0SP/3	0S/3	5S/3	10S/3	20S/3	30S/3	0L(L)	5L(L)
			Motor specification	0572	0371	0373	0313	0514	0317	0318	0319	0561	0562
			Motor model	αL50	α1/3	α2/3							
			Motor specification	0572	0371	0373							
			Motor type No.	60	61	62	63	64	65	66	67	68	69
Symbol	Parameter No. FS15-B	FS16~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	700	390	450	600	672	1090	542	708	1600	1360
PK2	1853	2041	1041	–2000	–1053	–900	–1600	–1574	–2360	–1377	–1811	–4508	–4000
PK3	1854	2042	1042	–2701	–2480	–2503	–2517	–2526	–2625	–2654	–2664	–2614	–2647
PK1V	1855	2043	1043	116	111	128	126	136	287	305	346	18	17
PK2V	1856	2044	1044	–1035	–997	–1146	–1127	–1215	–2571	–2734	–3097	–159	–156
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	3666	3806	3311	3366	3124	1476	1388	1226	–2382	–2429
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	50	50	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	4800	2800	2520	2520	2520	3780	5400	6000	2000	2000
PVPA	1869	2057	1057	3200	2330	2330	2330	2330	2330	2330	2200	2330	2330
PALPH	1870	2058	1058	64	57	57	57	57	57	57	57	57	57
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	5462	5462
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32237	32623	32519	32712	32694	32578	32495	32470	32695	32698
POVC2	1878	2063	1063	6640	1811	3112	706	924	2381	3410	3723	912	877
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	19834	5377	9256	2094	2740	7075	10144	11081	2706	2602
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
RESERV	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
RESERV	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	4000	1680	2940	4000	2100	2520	4000	0	3000	3000
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	3277	1706	2239	1064	1218	1814	2344	2450	1210	1187
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	50	0	0	0	0	15	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	1345	51	74	247	435	541	866	1079	218	445
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0

			Motor model	6L(L)	7L(L)	10L(L)	6S/3	40S/3	0T/3	5T	5T/3	10T	10T/3
			Motor specification	0564	0571	0572		0583	0381	0382	0383	0384	0385
			Motor model										
			Motor specification										
95.08.07			Motor type No.	70	71	72	73	78	79	80	81	82	83
Symbol	Parameter No.												
	FS15-B	FS16~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00001000	00000000	00001000	00000000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000100	01000100	01000100	01000100	00000000	01000100	00000000	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	850	590	700	1000	892	701	670	456	600	409
PK2	1853	2041	1041	–2300	–1600	–2000	–2400	–2877	–2038	–1600	–1019	–1153	–946
PK3	1854	2042	1042	–2652	–2685	–2701	–2459	–2666	–2390	–2473	–2498	–2550	–2543
PK1V	1855	2043	1043	34	119	150	135	280	260	287	209	450	349
PK2V	1856	2044	1044	–309	–1070	–1346	–1205	–2511	–2329	–2568	–1877	–4034	–3124
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	–1229	3547	2820	3148	1512	1630	1478	2022	941	1215
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	50	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787	3787	3787	3787	3787
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	1240	4500	4800	3200	4800	4008	4400	3684	4590	4008
PVPA	1869	2057	1057	2330	3000	3200	2300	3200	4200	4000	3000	3335	2330
PALPH	1870	2058	1058	57	64	64	64	60	43	64	64	57	57
PPBAS	1871	2059	1059	5	5	5	5	5	5	0	5	0	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32614	32299	31875	32693	32345	32703	32669	32714	32532	32625
POVC2	1878	2063	1063	1928	5867	11158	940	5290	819	1235	674	2948	1788
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	5727	17509	32767	2787	15775	2428	3665	1998	8766	5308
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCM	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	4000	4000	4000	3200	3333	3158	0	2105	0	3421
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
PKMOL	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTP	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1761	3079	4261	1228	2923	1147	1409	1040	2179	1696
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	50	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	451	715	1034	647	1719	269	433	593	483	624
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0

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Symbol	Parameter No. FS15-B	FS16~PM	PM-E						
			Motor model	0-0SP/3	0S/1.5	5S/1.5	6S/1	10S/1	20S/0.5
			Motor specification	0374	0515	0516	0520	0504	0585
			Motor model	α2.5/3					
			Motor specification	0374					
			Motor type No.	84	85	86	87	88	89
	1808	2003	1003	00001000	00000000	00000000	00000000	00000000	00000000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000100	01000000	01000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	294	1275	800	1008	2420	3500
PK2	1853	2041	1041	–990	–3600	–2447	–3840	–6600	–11616
PK3	1854	2042	1042	–2455	–2544	–3052	–2584	–2640	–2662
PK1V	1855	2043	1043	70	142	212	215	364	298
PK2V	1856	2044	1044	–898	–1268	–1896	–1927	–3261	–2666
PK3V	1857	2045	1045	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	4228	2992	2001	1970	1164	1424
BLCMP	1860	2048	1048	0	0	0	0	0	0
RESERV	1861	2049	1049	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787
PHYST	1867	2055	1055	319	319	319	319	319	319
EMFCMP	1868	2056	1056	1971	2000	6000	5500	6500	2000
PVPA	1869	2057	1057	2330	3500	3650	4500	4600	6200
PALPH	1870	2058	1058	57	83	83	83	83	83
PPBAS	1871	2059	1059	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120
POVC1	1877	2062	1062	32569	32696	32589	32487	32320	32387
POVC2	1878	2063	1063	2482	903	2234	3517	5601	4764
TGALMLV	1892	2064	1064	4	4	4	4	4	4
POVCLMT	1893	2065	1065	7376	2679	6636	10466	16711	14198
PK2VAUX	1894	2066	1066	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0
SFCCM	1965	2072	1072	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0
AALPH	1967	2074	1074	2917	1000	3500	0	0	0
MODEL	1968	2075	1075	0	0	0	0	0	0
PKMOL	1969	2076	1076	0	0	0	0	0	0
OSCTP	1970	2077	1077	0	0	0	0	0	0
RESERV	1971	2078	1078	0	0	0	0	0	0
RESERV	1972	2079	1079	0	0	0	0	0	0
RESERV	1973	2080	1080	0	0	0	0	0	0
RESERV	1974	2081	1081	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0
RTCURR	1979	2086	1086	1998	1205	1896	1961	2478	2284
TDPLD	1980	2087	1087	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0
RESERV	1990	2097	1097	0	0	0	0	0	0
DEPVPL	1991	2098	1098	50	0	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0
ABVOF	1996	2103	1103	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0
TRQCST	1998	2105	1105	131	219	279	404	427	888
LP24PA	1999	2106	1106	0	0	0	0	0	0

6.3 PARAMETERS FOR HRV CONTROL

July 1999

Series 90A0 (for Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 9090 (for Series 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 9080, 9081 (for Series 15-B, 16-C, 18-C)
Series 9066 (for Series 20, 21, Power Mate)
Series 9065 (for Power Mate-E)

			Motor model	α3HV	α6HV	α12HV	α22HV	α30HV	αC3	αC6	αC12	αC22	α0.5/3
			Motor specification	0171	0172	0176	(40A)	(40A)	0121	0126	0141	0145	0113
			Motor model				0177	0178					β0.5/3
			Motor specification										0113
99.04.30			Motor type No.	1	2	3	4	5	7	8	9	10	13
Symbol	Parameter No.												
	FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000000	01000000	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00100000	00100000	00100000	00000000	00000000	00000000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	687	828	730	800	1100	1600	1800	3000	2330	220
PK2	1853	2041	1041	–2510	–3129	–3038	–3190	–3886	–5059	–6105	–9750	–6831	–540
PK3	1854	2042	1042	–2617	–2638	–2638	–2694	–2663	–2608	–2641	–2687	–2694	–2556
PK1V	1855	2043	1043	107	127	188	271	293	107	127	251	271	9
PK2V	1856	2044	1044	–955	–1141	–1683	–2426	–2625	–955	–1140	–2245	–2426	–79
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	3972	3326	2254	1564	1446	3974	3329	1690	1564	–4789
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	1894	1894	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	2500	4000	3500	3500	4000	3046	4381	4000	4000	1200
PVPA	1869	2057	1057	2200	–7692	–6922	–6671	–4113	–6405	–3858	–3094	–3872	2000
PALPH	1870	2058	1058	70	–1920	–1700	–3000	–3400	–250	–2500	–4000	–2800	77
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32686	32637	32568	32370	32359	32686	32637	32412	32370	32585
POVC2	1878	2063	1063	1031	1639	2505	4981	5110	1030	1636	4446	4981	2288
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	3059	4866	7445	14847	15235	3056	4858	13245	14847	6797
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	0	8192	16288	16288	12192	16288	11192	8192	8192	17384
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1287	1623	2008	2836	2872	1286	1622	2678	2836	1918
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	5145	5145	5170	10250	15370	12800	17920	17920	12800	5160
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	15000	15000	15000	0	0	0	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	205	325	527	684	921	205	326	395	684	29
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	2568	0	0	2592	2576	16	24	16	24	0
DETQLM	1704	2111	1111	6244	3870	5140	3915	3147	0	5220	0	2660	7790
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	1700	300	3420	700	900	2729	3326	4520	3298	400
MFWKCE	1736	2128	1128	3333	4286	2857	2667	3636	4000	6500	6000	7000	0
MFWKBL	1752	2129	1129	2578	2076	2073	2574	1813	1048	1047	785	1042	0
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	1134	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	25	25	45	45	45	25	25	25	45	12

			Motor model	α3/3	α6/2	α6/3	α12/2	α12/3	α22/2	α22/3	α30/2	α30/3	αM3
			Motor specification	0123	0127	0128	0142	0143	0147	0148	0152	0153	0161
			Motor model										
			Motor specification										
99.04.30			Motor type No.	15	16	17	18	19	20	21	22	23	24
Symbol	Parameter No.												
	FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001000
	1809	2004	1004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000000	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00000000	00100000	00100000	00100000	00000000	00100000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000000	00000000	00000010	00000010	00000010	00000010	00000000
PK1	1852	2040	1040	1183	2054	754	3121	1324	1975	881	3173	1175	538
PK2	1853	2041	1041	–2941	–4194	–2363	–4953	–3671	–4041	–2759	–5522	–3088	–1652
PK3	1854	2042	1042	–3052	–3052	–2633	–3052	–3052	–3052	–3052	–3052	–3052	–3052
PK1V	1855	2043	1043	87	99	91	188	165	203	214	144	240	53
PK2V	1856	2044	1044	–781	–887	–818	–1683	–1474	–1821	–1921	–1293	–2153	–471
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	4858	4279	4639	2254	2574	2084	1976	2935	1763	–806
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	2000	3500	–12820	–6440	–6400	4000	3000	–12840	4500	2500
PVPA	1869	2057	1057	–7690	–6415	–3845	–5135	–7683	–3590	–3845	–3097	–3845	2400
PALPH	1870	2058	1058	–800	–1600	–650	–1500	–540	–2000	–650	–1120	–650	70
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32713	32689	32698	32568	32614	32543	32518	32668	32493	32697
POVC2	1878	2063	1063	690	991	877	2505	1922	2811	3128	1245	3443	886
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	2045	2940	2601	7445	5709	8358	9305	3695	10245	2627
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	3000	8192	0	10192	18384	18384	14288	14288	9192	3000
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1052	1261	1187	2008	1758	2127	2245	1414	2355	1193
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	10265	30	12800	5145	7680	2585	10240	5145	25
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	0	15000	15000	15000	0	15000	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	251	419	454	527	601	911	864	1870	1123	221
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	32	32	32	0	24	0	24	20	0	24
DETQLM	1704	2111	1111	6214	3960	5170	5220	0	3468	5170	4040	3890	5220
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	2047	2729	1706	4037	2615	2956	1663	4989	2000	1990
MFWKCE	1736	2128	1128	1500	5000	1000	5000	2500	6000	2000	6000	6000	2000
MFWKBL	1752	2129	1129	1812	1556	2076	1045	1552	1300	2571	1044	2588	2588
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	0	0	3880	5160	3880	5160	0
PHDLY2	1757	2134	1134	0	0	0	0	0	12820	12840	12820	12840	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	40	40	80	45	85	85	135	135	135	40

			Motor model	αM6	αM9	α22/1.5	α30/1.2	α40/FAN	α40/2	αE3/3	αE6/2	αE1/3	αE2/3
			Motor specification	0162	0163	0146	0151	0158	0157	0105	0106	0101	0102
			Motor model							β3/3	β6/2	β1/3	β2/3
			Motor specification							0033	0034	0031	0032
99.04.30			Motor type No.	25	26	27	28	29	30	33	34	35	36
Symbol	Parameter No.												
	FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00001000	00001000	00000000	00000000	00000000	00000000	00001000	00001000	00001000	00001000
	1809	2004	1004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000000	01000000	01000100	01000100	01000000	01000000	01000000	01000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00000000	00000000	00000000	00100000	00100000	00100000	00100000	00000000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000010	00000000	00000000	00000010	00000010	00000010	00000010	00000000	00000010
PK1	1852	2040	1040	950	748	2330	5060	1649	1649	629	990	359	704
PK2	1853	2041	1041	–2582	–2402	–6381	–9923	–5395	–5395	–2093	–3544	–1129	–2401
PK3	1854	2042	1042	–3052	–2632	–2694	–2705	–2700	–2700	–2622	–2632	–2564	–2596
PK1V	1855	2043	1043	38	61	271	147	201	201	144	144	102	62
PK2V	1856	2044	1044	–328	–550	–2426	–1313	–1801	–1801	–2587	–2587	–916	–1111
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	–1156	–690	1564	2891	2107	2107	1467	1467	4141	3415
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	3500	3000	4000	8000	–12820	–12820	3000	3200	2500	3300
PVPA	1869	2057	1057	–3590	–6407	–3872	–2078	–3855	–3855	–10250	–6420	2100	–10250
PALPH	1870	2058	1058	–1440	–1600	–2800	–1800	–2400	–2400	–1600	–1600	71	–1600
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32727	32692	32370	32665	32361	32579	32456	32456	32617	32540
POVC2	1878	2063	1063	516	955	4981	1283	5090	2358	3897	3897	1884	2850
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	1529	2832	14847	3809	15175	7007	11600	11600	5594	8474
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	31672	12288	12288	12288	14288	14288	0	0	0	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	910	1238	2836	1436	2867	1948	2506	2506	1740	2142
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	5145	0	12800	12800	12800	12800	-1476	30	80	-2786
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	0	0	0	15000	15000	15000	12000	0	12000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	581	653	684	1842	1756	1756	107	215	51	83
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	24	32	24	28	20	20	0	0	0	0
DETQLM	1704	2111	1111	5220	5220	2660	0	3920	3920	2640	3890	7784	7740
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	2729	853	3298	7846	3326	3326	0	0	0	0
MFWKCE	1736	2128	1128	2500	2000	7000	9500	7000	7000	0	5000	0	3000
MFWKBL	1752	2129	1129	1298	2570	1042	788	1300	1300	0	2064	0	4128
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	5140	0	0	20	20	6164	2573	0	5140
PHDLY2	1757	2134	1134	0	12840	0	0	12840	12840	12840	12850	0	12840
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	80	85	47	85	135	135	25	25	12	12

			Motor model	α300/1.2	α400/1.2	50S	60S	70S	5-0	4-0S	3-0S	2-0SP	1-0SP
			Motor specification	0335	0336	0331	0332	0333	0531	0532	0533	0371	0372
			Motor model			α65/2	α100/2	α150/2					α2/2
			Motor specification			0331	0332	0333					0372
99.04.30			Motor type No.	37	38	39	40	41	42	43	44	45	46
Symbol	Parameter No.												
	FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00000000	00000000	00000000	00000000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	00000000	00000000	00010000	00010000	00010000	00000000	00000000	00000000	00000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00100000	00100000	00000000	00000000	00000000	00000000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	2405	3562	790	1578	1574	457	460	736	390	1170
PK2	1853	2041	1041	–6299	–8240	–3473	–4761	–4809	–999	–730	–1500	–1053	–2289
PK3	1854	2042	1042	–2698	–2702	–2714	–2714	–2718	–1873	–2373	–2374	–2480	–2485
PK1V	1855	2043	1043	106	105	121	102	120	30	58	53	111	91
PK2V	1856	2044	1044	–952	–938	–1085	–916	–1072	–300	–517	–477	–997	–812
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	3985	4045	3498	4141	3541	0	–733	–795	3806	4674
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787	3787	3787	3787	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	0	0	4444	4884	6668	0	629	1129	1589	2147
PVPA	1869	2057	1057	–3105	–2103	–4617	–4617	–3849	2330	1861	2330	2330	–7690
PALPH	1870	2058	1058	–2700	–4000	–1620	–1620	–1890	57	46	57	57	–1000
PPBAS	1871	2059	1059	0	0	20	20	20	0	0	0	0	0
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	0	120	120	120	120
POVC1	1877	2062	1062	32330	32309	32482	32529	32332	32514	32543	32576	32623	32627
POVC2	1878	2063	1063	5480	5732	3569	2987	5452	3173	2817	2401	1811	1766
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	16346	17105	10622	8881	16262	9437	8375	7136	5377	5245
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	1100	1100	1100	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	12288	8192	28672	20480	20480	0	0	0	0	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	15	15	15	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	2450	2506	2398	2193	2968	2261	2129	1966	1706	1685
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	15000	15000	0	0	0	0	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	10282	13644	2438	4103	4548	3	10	21	51	104
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	16	16	12	0	0	0	0	0	0	0
DETQLM	1704	2111	1111	0	0	2148	0	0	0	0	0	0	6194
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	8000	0	0	0	0	0	0	0	0	4800
MFWKCE	1736	2128	1128	21000	21000	3600	4800	3500	0	0	0	0	2500
MFWKBL	1752	2129	1129	1054	798	1551	1294	1033	0	0	0	0	1806
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	1134	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	245	245	245	365	365	2	4	4	12	12

			Motor model	5S	6S	10S	20S/1.5	20S	30S	30/2	40	7L(C)	10L(C)
			Motor specification	0314	0316	0315	0505	0502	0590	0506	0581	0571	0572
			Motor model									αL25	αL50
			Motor specification									0571	0572
99.04.30			Motor type No.	48	49	50	51	52	53	54	55	59	60
Symbol	Parameter No.												
	FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00100000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	1500	750	2591	1131	1261	3414	705	1511	574	700
PK2	1853	2041	1041	–2781	–2000	–5540	–2477	–2577	–7650	–2716	–5829	–2254	–2000
PK3	1854	2042	1042	–3052	–2596	–2623	–2649	–2646	–2663	–2669	–2672	–2700	–2701
PK1V	1855	2043	1043	151	216	260	458	298	201	375	282	92	116
PK2V	1856	2044	1044	–1355	–1932	–2328	–4103	–2666	–1797	–3356	–2526	–825	–1035
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	2801	1964	1630	925	1424	2112	1131	1502	4599	3666
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787	3787	3787	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	2403	5000	5520	3549	2731	5456	1961	3478	4500	4800
PVPA	1869	2057	1057	2330	3750	3500	2797	2600	7200	2330	2800	–7692	–6430
PALPH	1870	2058	1058	57	64	64	52	57	50	57	43	–2200	–3300
PPBAS	1871	2059	1059	0	0	0	0	0	0	0	0	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	6918	6918	6554	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32677	32485	32539	32155	32386	32530	32254	32340	32476	32214
POVC2	1878	2063	1063	1142	3536	2864	7659	4771	2971	6421	5355	3644	6929
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	3388	10522	8515	22907	14219	8834	19176	15972	10844	20705
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	0	0	0	0	0	0	0	0	24576	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1354	1966	1768	3801	2285	1801	2654	2941	2423	3349
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	0	0	0	0	0	0	0	50	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0	0	0	15000	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	390	403	598	577	888	1860	995	1709	928	1343
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	0	0	0	0	0	0	0	0	20	24
DETQLM	1704	2111	1111	0	0	0	0	0	0	0	0	50	0
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	0	0	0	0	0	0	0	0	0	2402
MFWKCE	1736	2128	1128	0	0	0	0	0	0	0	0	2000	4000
MFWKBL	1752	2129	1129	0	0	0	0	0	0	0	0	2567	2321
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	1134	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	40	45	45	45	85	85	0	0	135	135

99.04.30			Motor model	2-0SP/3	1-0SP/3	0S/3	5S/3	10S/3	20S/3	30S/3	αL3	αL6	αL9
			Motor specification	0371	0373	0313	0514	0317	0318	0319	0561	0562	0564
			Motor model	α1/3	α2/3						(HRV)	(HRV)	(HRV)
			Motor specification	0371	0373								
			Motor type No.	61	62	63	64	65	66	67	68	69	70
Symbol	Parameter No. FS15-B	FS16-C–PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	1004	00000110	00000110	01000110	01000110	01000110	01000110	01000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000100	01000100	01000100	01000100	01000100	00000000	00000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00000000	00000000	00000000	00000000	00000000	00100000	00100000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000010	00000110	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	390	530	600	672	1090	542	708	757	855	737
PK2	1853	2041	1041	−1053	−1653	−1600	−1574	−2360	−1377	−1811	−3394	−3610	−2588
PK3	1854	2042	1042	−2480	−2490	−2517	−2526	−2625	−2654	−2664	−2652	−2676	−2673
PK1V	1855	2043	1043	111	128	126	136	287	305	346	18	17	35
PK2V	1856	2044	1044	−997	−1146	−1127	−1215	−2571	−2734	−3097	−158	−155	−309
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235
POA1	1859	2047	1047	3806	3311	3366	3124	1476	1388	1226	−2395	−2455	−1227
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	50	50	21	21	21
PDDP	1866	2054	1054	1894	1894	3787	3787	3787	3787	3787	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	2800	2520	2520	2520	3780	5400	6000	2000	2000	1240
PVPA	1869	2057	1057	2330	−6156	2330	2330	2330	2330	2200	0	0	−10249
PALPH	1870	2058	1058	57	−1200	57	57	57	57	57	0	0	−800
PPBAS	1871	2059	1059	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32623	32519	32712	32694	32578	32495	32470	32693	32696	32607
POVC2	1878	2063	1063	1811	3112	706	924	2381	3410	3723	940	894	2010
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	5377	9256	2094	2740	7075	10144	11081	2787	2653	5970
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	1680	8194	4000	2100	2520	4000	0	16384	28672	20480
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1706	2239	1064	1218	1814	2344	2450	1228	1198	1798
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	50	0	0	0	0	15	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	0	0	0	0	0	15000	15000	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	51	74	247	435	541	866	1079	219	450	450
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	0	0	0	0	0	0	0	64	64	16
DETQLM	1704	2111	1111	7715	7780	0	0	0	0	0	2650	2620	5160
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	785	2300	0	0	0	0	0	2000	2500	2500
MFWKCE	1736	2128	1128	0	3000	0	0	0	0	0	0	0	2500
MFWKBL	1752	2129	1129	0	3088	0	0	0	0	0	0	0	2586
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	7710	7710	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	1134	12830	12830	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	12	12	40	80	85	135	135	40	85	85

			Motor model	7L(L)	10L(L)	6S/3	40S/2	0T/3	5T	5T/3	10T	10T/3	0-0SP/3
			Motor specification	0571	0572		0583	0381	0382	0383	0384	0385	0374
			Motor model										α2.5/3
			Motor specification										0374
99.04.30			Motor type No.	71	72	73	78	79	80	81	82	83	84
Symbol	Parameter No. FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00000000	00001000	00000000	00001000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	01000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000100	01000100	01000100	00000000	01000100	00000000	01000100	01000100
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	590	700	1000	892	701	670	456	600	409	368
PK2	1853	2041	1041	–1600	–2000	–2400	–2877	–2038	–1600	–1019	–1153	–946	–990
PK3	1854	2042	1042	–2685	–2701	–2459	–2666	–2390	–2473	–2498	–2550	–2543	–2455
PK1V	1855	2043	1043	119	150	135	280	260	287	209	450	349	70
PK2V	1856	2044	1044	–1070	–1346	–1205	–2511	–2329	–2568	–1877	–4034	–3124	–898
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	3547	2820	3148	1512	1630	1478	2022	941	1215	4228
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	50	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	3787	3787	3787	3787	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	4500	4800	3200	4800	4008	4400	3684	4590	4008	1971
PVPA	1869	2057	1057	3000	3200	2300	3200	4200	4000	3000	3335	2330	2330
PALPH	1870	2058	1058	64	64	64	60	43	64	64	57	57	57
PPBAS	1871	2059	1059	5	5	5	5	5	0	5	0	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32299	31875	32693	32345	32703	32669	32714	32532	32625	32569
POVC2	1878	2063	1063	5867	11158	940	5290	819	1235	674	2948	1788	2482
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	17509	32767	2787	15775	2428	3665	1998	8766	5308	7376
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	4000	4000	3200	3333	3158	0	2105	0	3421	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	3079	4261	1228	2923	1147	1409	1040	2179	1696	1998
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	50	0	0	0	0	0	0	0	0	50
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	715	1034	647	1719	269	433	593	483	624	131
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	0	0	0	0	0	0	0	0	0	0
DETQLM	1704	2111	1111	0	0	0	0	0	0	0	0	0	7730
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	0	0	0	0	0	0	0	0	0	500
MFWKCE	1736	2128	1128	0	0	0	0	0	0	0	0	0	0
MFWKBL	1752	2129	1129	0	0	0	0	0	0	0	0	0	0
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	1134	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	0	0	85	135	40	40	85	45	85	40

99.04.30			Motor model	0S/1.5	5S/1.5	6S/1	10S/1	20S/0.5	1500A	3000B	6000B	9000B	15000C
			Motor specification	0515	0516	0520	0504	0585	0410	0411	0412	0413	0414
			Motor model										
			Motor specification										
			Motor type No.	85	86	87	88	89	90	91	92	93	94
Symbol	Parameter No. FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00000000	00000000	00000000	00000000	00000000	00001000	00001000	00001000	00001000	00001000
	1809	2004	1004	01000110	01000110	01000110	01000110	01000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	01000100	01000100	01000000	01000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000100	00000100	00000100	00000100	00000100
	1955	2011	1011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	1275	800	1008	2420	3500	1890	4804	4804	5036	1420
PK2	1853	2041	1041	–3600	–2447	–3840	–6600	–11616	–7180	–14453	–13138	–16000	–5600
PK3	1854	2042	1042	–2544	–3052	–2584	–2640	–2662	–2647	–2660	–2660	–2660	–2663
PK1V	1855	2043	1043	142	212	215	364	298	19	16	16	14	10
PK2V	1856	2044	1044	–1268	–1896	–1927	–3261	–2666	–260	–214	–214	–195	–131
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	2992	2001	1970	1164	1424	–4371	–5321	–5321	–5849	–8681
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	3787	3787	3787	3787	3787	1894	1894	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	2000	6000	5500	6500	2000	0	0	0	0	0
PVPA	1869	2057	1057	3500	3650	4500	4600	6200	0	0	0	0	0
PALPH	1870	2058	1058	83	83	83	83	83	0	0	0	0	0
PPBAS	1871	2059	1059	5	5	5	5	5	0	0	0	0	0
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	1062	32696	32589	32487	32320	32387	32670	32670	32670	32685	32712
POVC2	1878	2063	1063	903	2234	3517	5601	4764	1222	1222	1222	1041	703
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	2679	6636	10466	16711	14198	3626	3626	3626	3087	2086
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	1000	3500	0	0	0	0	0	0	0	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1205	1896	1961	2478	2284	1402	1402	1402	1293	1063
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	219	279	404	427	888	227	455	911	1481	3104
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	0	0	0	0	0	0	0	0	0	0
DETQLM	1704	2111	1111	0	0	0	0	0	0	0	0	0	0
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	0	0	0	0	0	0	0	0	0	0
MFWKCE	1736	2128	1128	0	0	0	0	0	0	0	0	0	0
MFWKBL	1752	2129	1129	0	0	0	0	0	0	0	0	0	0
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	1134	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	25	25	25	25	25	45	45	85	135	245

			Motor model Motor specification	αM2 0376	αM2.5 0377	αM22 0165	αM30 0166	α22/3HV (60A)	α30/3HV (60A)	αM6HV 0182	αM9HV 0183	αM22HV 0185	αM30HV 0186
			Motor model Motor specification					0177	0178				
99.04.30			Motor type No.	98	99	100	101	102	103	104	105	106	107
Symbol	Parameter No. FS15-B	FS16-C~PM	PM-E										
	1808	2003	1003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	1004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	1005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	1006	00000000	00000000	00000000	00000000	01000100	01000100	00000000	00000000	00000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00100000	00100000	00000000	00000000	00000000	00100000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000010	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	600	400	555	736	1050	1100	783	542	430	648
PK2	1853	2041	1041	–1957	–1154	–2698	–2623	–3811	–4300	–2832	–2277	–2470	–2532
PK3	1854	2042	1042	–2476	–2547	–2686	–2696	–2694	–2663	–2607	–2640	–2682	–2692
PK1V	1855	2043	1043	31	56	97	128	181	195	37	66	94	161
PK2V	1856	2044	1044	–274	–500	–867	–1142	–1618	–1750	–329	–595	–845	–1444
PK3V	1857	2045	1045	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	–1383	–759	4378	3322	2346	2168	–1154	6373	4490	2628
BLCMP	1860	2048	1048	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	1050	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	1051	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	1055	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1056	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	1057	–9230	–8722	–7695	–3870	–7696	–3852	–7690	–6408	–5135	–5130
PALPH	1870	2058	1058	–1400	–1800	–2700	–2240	–2240	–1200	–1800	–1800	–2000	–2800
PPBAS	1871	2059	1059	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	1060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	1061	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	1062	32685	32645	32587	32567	32590	32586	32725	32678	32596	32447
POVC2	1878	2063	1063	1041	1535	2260	2514	2221	2279	538	1119	2149	4009
TGALMLV	1892	2064	1064	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1065	3089	4556	6714	7473	6599	6771	1596	3321	6385	11935
PK2VAUX	1894	2066	1066	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	1074	20480	8192	12288	8192	20480	12288	28672	12288	24576	0
MODEL	1968	2075	1075	0	0	0	0	0	0	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0	0	0	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0	0	0	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1086	1293	1570	1907	2012	1890	1915	929	1341	1859	2542
TDPLD	1980	2087	1087	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	1098	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	15000	15000	0	0	15000	15000	15000
ABVOF	1996	2103	1103	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1105	139	143	943	1341	1026	1381	580	603	967	1061
LP24PA	1999	2106	1106	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1110	2600	2584	40	24	2584	2592	40	40	40	24
DETQLM	1704	2111	1111	6440	7780	5220	5220	5145	4658	0	5220	3940	5220
AMRDML	1705	2112	1112	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1127	1322	625	1802	1756	4200	5885	5572	853	4051	2388
MFWKCE	1736	2128	1128	2000	2500	0	3000	2778	4000	0	0	0	2000
MFWKBL	1752	2129	1129	2578	3847	0	2577	1554	1287	0	0	0	2575
LP2GP	1753	2130	1130	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	2590	0	0	0	0	0	0
PHDLY2	1757	2134	1134	0	0	0	12815	0	0	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0	0	0	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	1165	25	25	135	135	60	60	45	45	65	65

99.04.30			Motor model	αM40/3	αM40	α300/2	α400/2
			Motor specification	With FAN	0169	0337	0338
			Motor model	0170			
			Motor specification				
			Motor type No.	108	110	111	112
Symbol	Parameter No.						
	FS15-B	FS16-C~PM	PM-E				
	1808	2003	1003	00001000	00001000	00001000	00001000
	1809	2004	1004	01000110	00000110	01000110	01000110
	1883	2005	1005	00000000	00000000	00000000	00000000
	1884	2006	1006	00000000	00000000	00000000	00000000
	1954	2010	1010	00000000	00000000	00000000	00000000
	1955	2011	1011	00100000	00100000	00100000	00100000
	1956	2012	1012	00000000	00000000	00000000	00000000
	1751	2211	1211	00000000	00000000	00000000	00000000
PK1	1852	2040	1040	1046	822	1368	1465
PK2	1853	2041	1041	–4459	–2254	–4478	–5239
PK3	1854	2042	1042	–2664	–2664	–2700	–2704
PK1V	1855	2043	1043	43	119	107	104
PK2V	1856	2044	1044	–386	–1069	–956	–933
PK3V	1857	2045	1045	0	0	0	0
PK4V	1858	2046	1046	–8235	–8235	–8235	–8235
POA1	1859	2047	1047	–983	3551	3968	4068
BLCMP	1860	2048	1048	0	0	0	0
DPFMX	1861	2049	1049	0	0	0	0
POK1	1862	2050	1050	956	956	956	956
POK2	1863	2051	1051	510	510	510	510
RESERV	1864	2052	1052	0	0	0	0
PPMAX	1865	2053	1053	21	21	21	21
PDDP	1866	2054	1054	3787	1894	3787	3787
PHYST	1867	2055	1055	319	319	319	319
EMFCMP	1868	2056	1056	0	0	0	0
PVPA	1869	2057	1057	–3852	–3873	–4375	–3358
PALPH	1870	2058	1058	–1800	–4950	–1200	–2094
PPBAS	1871	2059	1059	0	0	5	5
TQLIM	1872	2060	1060	7282	7282	7282	7282
EMFLMT	1873	2061	1061	0	0	120	120
POVC1	1877	2062	1062	32613	32279	32326	32299
POVC2	1878	2063	1063	1937	6107	5521	5861
TGALMLV	1892	2064	1064	4	4	4	4
POVCLMT	1893	2065	1065	5752	18231	16468	17492
PK2VAUX	1894	2066	1066	0	0	0	0
FILTER	1895	2067	1067	0	0	0	0
FALPH	1961	2068	1068	0	0	0	0
VFFLT	1962	2069	1069	0	0	0	0
ERBLM	1963	2070	1070	0	0	0	0
PBLCT	1964	2071	1071	0	0	0	0
SFCCML	1965	2072	1072	0	0	0	0
PSPTL	1966	2073	1073	0	0	0	0
AALPH	1967	2074	1074	20480	0	16384	12288
MODEL	1968	2075	1075	0	0	0	0
WKAC	1969	2076	1076	0	0	0	0
OSCTPL	1970	2077	1077	0	0	0	0
PDPCH	1971	2078	1078	0	0	0	0
PDPCL	1972	2079	1079	0	0	0	0
DPFEX	1973	2080	1080	0	0	0	0
DPFZW	1974	2081	1081	0	0	0	0
BLENDL	1975	2082	1082	0	0	0	0
MOFCTL	1976	2083	1083	0	0	0	0
SDMR1	1977	2084	1084	0	0	0	0
SDMR2	1978	2085	1085	0	0	0	0
RTCURR	1979	2086	1086	1453	2588	2459	2535
TDPLD	1980	2087	1087	0	0	0	0
MCNFB	1981	2088	1088	0	0	0	0
BLBSL	1982	2089	1089	0	0	0	0
ROBSTL	1983	2090	1090	0	0	0	0
ACCSPL	1984	2091	1091	0	0	0	0
ADFF1	1985	2092	1092	0	0	0	0
VMPK3V	1986	2093	1093	0	0	0	0
BLCMP2	1987	2094	1094	0	0	0	0
AHDRTL	1988	2095	1095	0	0	0	0
RADUSL	1989	2096	1096	0	0	0	0
SMCNT	1990	2097	1097	0	0	0	0
DEPVPL	1991	2098	1098	0	0	0	0
ONEPSL	1992	2099	1099	400	400	400	400
INPA1	1993	2100	1100	0	0	0	0
INPA2	1994	2101	1101	0	0	0	0
DBLIM	1995	2102	1102	15000	15000	15000	15000
ABVOF	1996	2103	1103	0	0	0	0
ABTSH	1997	2104	1104	0	0	0	0
TRQCST	1998	2105	1105	4330	1563	10238	13661
LP24PA	1999	2106	1106	0	0	0	0
VLGOVR	1700	2107	1107	0	0	0	0
RESERV	1701	2108	1108	0	0	0	0
BELLTC	1702	2109	1109	0	0	0	0
MGSTCM	1703	2110	1110	0	1	16	16
DETQLM	1704	2111	1111	0	4174	0	2660
AMRDML	1705	2112	1112	0	0	0	0
NFILT	1706	2113	1113	0	0	0	0
NINTCT	1735	2127	1127	5116	1848	0	0
MFWKCE	1736	2128	1128	2000	2000	7500	8000
MFWKBL	1752	2129	1129	1287	2051	1307	790
LP2GP	1753	2130	1130	0	0	0	0
LP4GP	1754	2131	1131	0	0	0	0
LP6GP	1755	2132	1132	0	0	0	0
PHDLY1	1756	2133	1133	0	0	0	0
PHDLY2	1757	2134	1134	0	0	0	0
DGCSMM	1782	2159	1159	0	0	0	0
TRQCUP	1783	2160	1160	0	0	0	0
RESERV	1784	2161	1161	0	0	0	0
POVC21	1785	2162	1162	0	0	0	0
POVC22	1786	2163	1163	0	0	0	0
POVCLMT2	1787	2164	1164	0	0	0	0
MAXCRT	1788	2165	1165	365	135	365	365

APPENDIX

A DIFFERENCES BETWEEN THE PARAMETERS FOR THE Series 15-A AND Series 15-B (15*i*-A)

(1) Overview

The Series 15-A and Series 15-B incorporate servo software of different series. For some servo functions, they use different parameter numbers and setting methods.
The servo parameters for the Series 15*i*-A are the same as for the Series 15-B.
The Series 15-A, 15-B, and 15*i*-A are applicable to the following servo ROMs that support the α servo-mechanism:

NC model	Series of servo ROM applicable to the α servo-mechanism
Series 15-A	Series 9041 (supporting dual position feedback) Series 9046 (supporting standard and high-speed positioning)
Series 15-B	Series 9060 (320C25 servo module) Series 9070 (320C51 servo module) Series 9080 (320C52 servo module) Series 9081 (320C52 servo module)
Sereis 15*i*-A	Series 90A0 (320C543 servo card)

The parameter numbers and setting methods differ for the following servo functions:

<1> Dual position feedback function	<2> High-speed positioning function
<3> Feed-forward function	<4> Machine velocity feedback function
<5> Functions for α motor	<6> Function for extending position gain setting range

(2) Details

<1> Dual position feedback function (See Subsec. 4.5.4.)
The Series 15-A and 15-B (15*i*-A) use different numbers for the parameter that enables this function.
For other parameters related to this function, however, the three systems use the same numbers.

Function	Series 15-A (Series 9041)	Series 15-B, 15*i*-A
Enable bit	No. 1955 #7	No. 1709 #7
Maximum amplitude	No. 1861	
Conversion coefficient (numerator/denominator)	No. 1971/No. 1972	
Primary delay time constant	No. 1973	
Zero width	No. 1974	

<2> High-speed positioning function (See Sec. 4.8.)
The Series 15-A and 15-B (15*i*-A) use different parameter numbers for this function.

	Series 15-A (Series 9046)	Series 15-B, 15*i*-A
Low-speed integration		
Enable bit	No. 1954 #6	No. 1957 #1
Disable speed	No. 1972	No. 1714
Enable speed	No. 1973	No. 1715
Position gain switch function		
Enable bit	No. 1954 #5	No.1957 #0
Switching speed	No. 1974	No. 1713

<3> Feed-forward function (See Subsec. 4.6.1.)
<4> Machine speed feedback function (See Subsec. 4.5.1.)
For the functions indicated above, the Series 15-A and 15-B (15*i*-A) use identical parameter numbers and different setting methods.

NC model	Position feed-forward coefficient (No. 1961) Machine speed feedback coefficient (No. 1981)
Series 15-A	Set value = $\alpha \times 4096 \times \dfrac{8192}{\text{Number of position feedback pulses per motor revolution}}$
Series 15-B, Series 15*i*-A	Set value = $\alpha \times 100$ (α: 0 to 1)

NC model	Velocity feed-forward coefficient (No. 1985)
Series 15-A	Set value = $\alpha \times 4096 \times \dfrac{8192}{\text{Number of position feedback pulses per motor revolution}}$
Series 15-B, Series 15*i*-A	Set value = $\alpha \times 10000$ (α: 0 to 1)

NC model	Velocity feed-forward coefficient (No. 1962)
Series 15-A	Set value = $(-PK2V) \times \dfrac{\text{Rotor inertia + load inertia}}{\text{Rotor inertia}} \times \dfrac{0.04 \times 8000}{\text{Number of position feedback pulses per motor revolution}}$
Series 15-B, Series 15*i*-A	Set value = $\dfrac{\text{Rotor inertia + load inertia}}{\text{Rotor inertia}} \times 100$

<5> α motor functions

The Series 15-A and 15-B (15*i*-A) use different parameter numbers and setting methods for these functions.

Function	**Series 15-A (Series 9046)**	**Series 15-B, 15*i*-A**
TCMD-dependent current loop gain change function	No. 1864 (Low-byte)	No. 1967
TCMD-dependent phase-advance compensation function	No. 1991 (common)	
Actual current limit function Enable bit Set value	No. 1954 #1 No. 1864 (High-byte)	No. 1955 #5 No. 1995

<6> Function for extending the position gain setting range

The Series 15-A and 15-B (15*i*-A) use different parameter numbers and setting methods for this function.

Function for extending the position gain setting range		
Function	**Series 15-A**	**Series 15-B, 15*i*-A**
Enable bit	No. 1955 #5	No. 1804 #4
Setting method	The number of position pulses (No. 1891) is multiplied by 8.	Above bit only

B ANALOG SERVO INTERFACE SETTING PROCEDURE

(1) Overview

This section describes how to specify parameters for using the analog servo function with the analog servo interface unit. This analog servo function is supported in the Series 15*i* and Power Mate *i*.

> **CAUTION**
> For analog servo axes, only the feedforward, backlash compensation, pitch error compensation, and position gain switch functions can be used as digital servo functions. The other functions (such as backlash acceleration) cannot be used.

(2) Series and editions of applicable servo software

Series 90A0/E(05) and subsequent edtitions (Series 15*i*, Power Mate *i*)

(3) Setting parameters

1) Setting start: Switch on the CNC power from an emergency stop.
2) Set up the FSSB. Switch the power off and on again.
3) Initialize the servo parameters. Switch the power off and on again.
4) Enable the analog servo interface function. Switch the power off and on again. Now setting is completed.

(4) FSSB setting

a) Connecting the analog servo interface unit requires that the FSSB be set up manually. (The FSSB setting screen cannot be used.)

		#7	#6	#5	#4	#3	#2	#1	#0
Series 15*i*	**1090**								**FMD**
Power Mate *i*	**1902**								

FMD (#0) Specifies the FSSB set mode as follows:
0: Automatic setting mode
1: Manual setting mode ← To be set

b) Directly enter all parameters listed in the following table. Before doing this, understand the meaning of each parameter sufficiently. For detailed descriptions about parameter setting, refer to the respective CNC Connection Manuals and Parameter Manuals. Analog and digital servo axes can be used together as shown in the reference examples below.

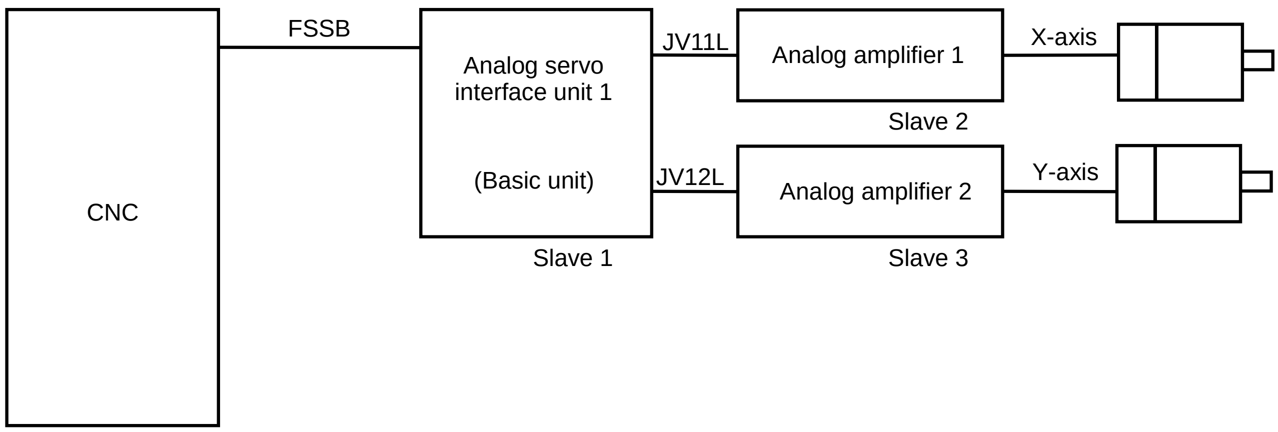
Parameter number		Meaning
Series 15*i*	**Power Mate *i***	
1023	1023	Servo axis number for each axis
1093	1905	(Bit type parameter)
1080 to 1089	1910 to 1919	Conversion table value for slave number
1094	1936	Connector number for interface unit 1
1095	1937	Connector number for interface unit 2

(Reference)

FSSB setting example where an analog servo interface unit is used (The parameter numbers on the upper row in the table apply to the Series 15*i*, and those on the lower row, to the Power Mate *i*.)

[Setting example 1: Two analog servo axes]

Let the analog servo interface unit be slave 1. Assume that analog amplifiers are connected behind the analog servo interface unit, and let them be slaves 2 and 3 sequentially.

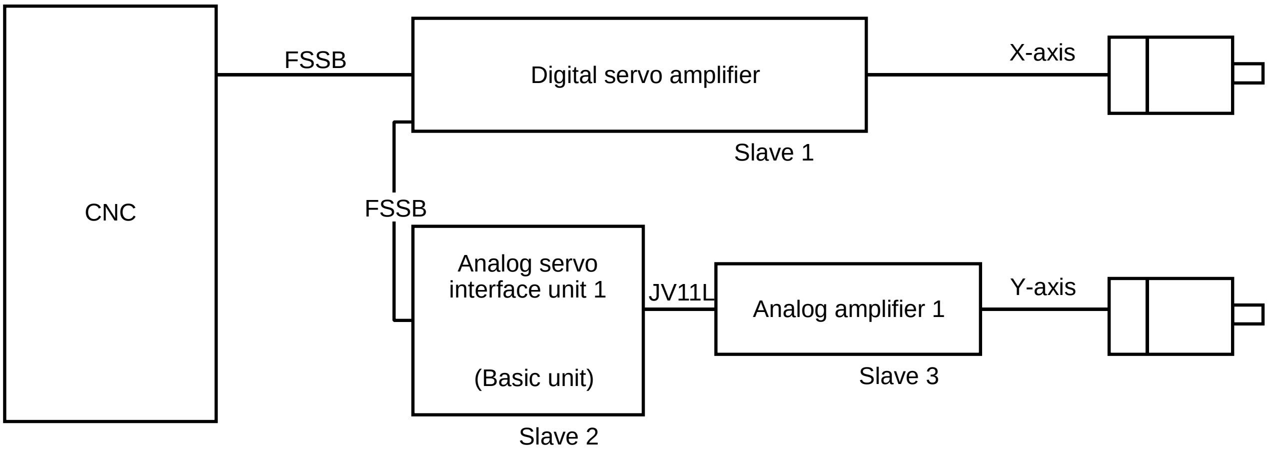


No.	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089
No.	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Set value	16	0	1	40	40	40	40	40	40	40

Axis	No. 1023	No. 1093	No. 1094	No. 1095
Axis	No. 1023	No. 1905	No. 1936	No. 1937
X	1	01000000	0	0
Y	2	01000000	1	0

[Setting example 2: One digital servo axis + one analog servo axis]

The digital servo amplifier and analog servo interface unit are slaves 1 and 2, as in the sequence in which they are connected to the FSSB. Assuming that the axis connected to the analog servo amplifier is behind the analog servo interface unit, it is slave 3.

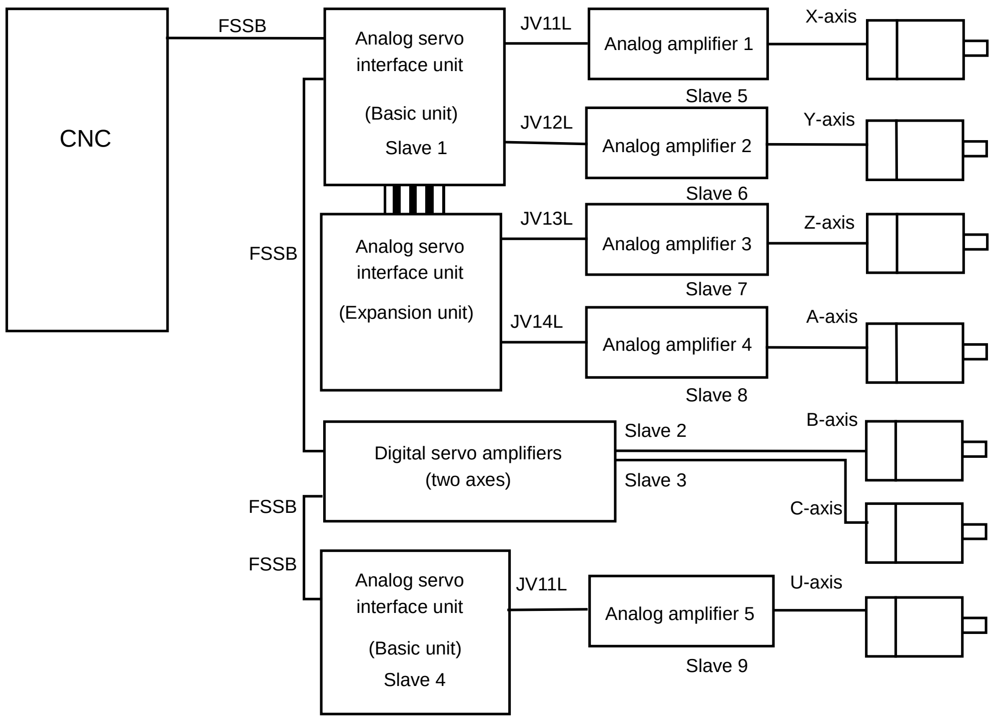


No.	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089
No.	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Set value	0	16	1	40	40	40	40	40	40	40

Axis	No. 1023	No. 1093	No. 1094	No. 1095
Axis	No. 1023	No. 1905	No. 1936	No. 1937
X	1	00000000	0	0
Y	2	01000000	0	0

[Setting example 3: Five analog servo axes + two digital servo axes]

The first analog servo interface unit (including expansion) is slave 1, two digital servo amplifiers are slaves 2 and 3, the second analog servo interface unit is slave 4, as in the sequence in which they are connected to the FSSB. Assuming that the analog amplifiers are connected behind the analog servo interface unit, they are slaves 5 to 9.



No.	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089
No.	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Set value	16	4	5	48	0	1	2	3	6	40

Axis	No. 1023	No. 1093	No. 1094	No. 1095
Axis	No. 1023	No. 1905	No. 1936	No. 1937
X	1	01000000	0	0
Y	2	01000000	1	0
Z	3	01000000	2	0
A	4	01000000	3	0
B	5	00000000	0	0
C	6	00000001*	0	0
U	7	10000000	0	0

NOTE) For a digital servo axis even-numbered in parameter No. 1023, specify a slow interface type between a servo amplifier and servo software (bit 0 of No. 1093/No. 1905 = 1).

(5) Servo parameter initialization

For axes connected to an analog servo circuit, initialize the servo parameters as listed below.

Parameter number		Name	Set value
Series 15*i*	Power Mate *i*		
1804	2000	Initialization bit	00000000
1874	2020	Motor number	50
1806	2001	AMR	00000000
1820	1820	CMR	Perform the same initialization as for digital servo according to your machine tool.
1977	2084	FFG (numerator)	
1978	2085	FFG (denominator)	
1879	2022	Direction of movement	111 (counterclockwise) or –111 (clockwise)
1896	1821	Reference counter	Specify the number of pulses per motor revolution (after FFG) in the same manner as for the digital servo circuit.
1876	2023	Number of velocity pulses	Set value = 1536.797 × E where E is the voltage (V) that corresponds to a velocity command of 1000 rpm.
1891	2024	Number of position pulses	Specify the number of pulses per motor revolution (before FFG) in the same manner as for the digital servo circuit.

(6) Setting the analog servo function

To enable the analog servo function, set the following parameters for the axes to be connected to an analog servo circuit. (It is also necessary to enable the dummy serial feedback function.)

		#7	#6	#5	#4	#3	#2	#1	#0
Series 15*i*	1953				ANALOG				SERD
Power Mate *i*	2009								

SERD (#0) Specifies whether to enable the dummy serial feedback function as follows:

0: To disable

1: To enable ← To be set

ANALOG (#4) Specifies whether to enable the analog servo interface function as follows:

0: To disable

1: To enable ← To be set

Series 15*i*	1788	Maximum amplifier current
Power Mate *i*	2165	

Specify 0 for the axis to be connected to an analog servo circuit.

C PARAMETERS SET WITH VALUES IN DETECTION UNITS

If the detection unit is changed with a CMR or flexible feed gear, it is also necessary to change the parameters that are set with values in detection units. This appendix lists these parameters.
For details of these parameters, refer to the respective CNC parameter manuals.

C.1 PARAMETERS FOR Series 15*i*

No.	Description
1827	Effective area (in-position check) for individual axis
1828	Positional deviation limit for individual axis during movement
1829	Positional deviation limit for individual axis at stop
1830	Positional deviation limit for individual axis with servo off
1832	Positional deviation limit for individual axis with feed at stop
1837	Positional deviation limit during rigid tapping movement
1841	Servo error amount within which reference position return is assumed to be possible
1843	Positional deviation limit with torque limit skipped
1844	Grid shift for reference position shift function
1849	Backlash compensation for individual axis at rapid traverse
1850	Grid shift for individual axis
1851	Backlash compensation for individual axis
1881	Permissible error amount for starting chopping compensation
1896	Mark 1 intervals on linear scale having reference marks
1912	Zero-width synchronization error for each axis
1913	Maximum permissible synchronization error for each axis at rapid traverse
1914	Maximum permissible synchronization error for each axis at stop
1917	Zero-width synchronization error for each axis No.2
1996	Abnormal load detection pull-back amount
5226	Mark 2 intervals on linear scale having reference marks
5227	Distance from origin to reference position on linear scale having reference marks
5423	Pitch error compensation magnification
5433	Second cyclic pitch error compensation magnification
5428	Pitch error compensation (absolute value) at reference position for movement to reference position in direction opposite to origin return direction
5449	Three-dimensional error compensation magnification
5450	Three-dimensional error compensation magnification
5451	Three-dimensional error compensation magnification
5471	Compensation α at compensation point number a for individual axis
5472	Compensation β at compensation point number b for individual axis
5473	Compensation γ at compensation point number c for individual axis
5474	Compensation ε at compensation point number d for individual axis
5504	Compensation point number d for movement axis 1 subjected to straightness compensation
5551	Compensation at compensation point number a for movement axis 1
5552	Compensation at compensation point number b for movement axis 1
5553	Compensation at compensation point number c for movement axis 1
5554	Compensation at compensation point number d for movement axis 1
5561	Compensation at compensation point number a for movement axis 2
5562	Compensation at compensation point number b for movement axis 2
5563	Compensation at compensation point number c for movement axis 2
5564	Compensation at compensation point number d for movement axis 2
5571	Compensation at compensation point number a for movement axis 3
5572	Compensation at compensation point number b for movement axis 3
5573	Compensation at compensation point number c for movement axis 3
5574	Compensation at compensation point number d for movement axis 3
5591	Straightness compensation magnification

No.	Description
5592	Straightness compensation magnification
5593	Straightness compensation magnification
5594	Straightness compensation magnification
5595	Straightness compensation magnification

C.2 PARAMETERS FOR Series 15-B

No.	Description
1827	Effective area (in-position check) for individual axis
1828	Positional deviation limit for individual axis during movement
1829	Positional deviation limit for individual axis at stop
1830	Positional deviation limit for individual axis with servo off
1832	Positional deviation limit for individual axis with feed at stop
1837	Positional deviation limit during rigid tapping movement
1838	Effective area (in-position check) for individual axis at cutting feed
1849	Backlash compensation for individual axis at rapid traverse
1850	Grid shift for individual axis
1851	Backlash compensation for individual axis
1881	Permissible error amount for starting chopping compensation
1885	Software deceleration dog for individual axis
1890	Distance to be moved for feedback pulse check for individual axis
1896	Mark 1 intervals on linear scale having reference marks
1912	Zero-width synchronization error for each axis
1913	Maximum permissible synchronization error for each axis at rapid traverse
1914	Maximum permissible synchronization error for each axis at stop
1917	Zero-width synchronization error for each axis No.2
1941	Error limit for malfunction check A for individual axis (detection unit for malfunction check detector)
1942	Error limit for malfunction check B for individual axis at stop (detection unit for malfunction check detector)
1943	Error limit for malfunction check B for individual axis at rapid traverse (detection unit for malfunction check detector)
1944	Backlash compensation for malfunction check detector for individual axis (detection unit for malfunction check detector)
1996	Abnormal load detection pull-back amount
5226	Mark 2 intervals on linear scale having reference marks
5227	Distance from origin to reference position on linear scale having reference marks
5423	Pitch error compensation magnification
5428	Pitch error compensation (absolute value) at reference position for movement to reference position in direction opposite to origin return direction
5433	Second cyclic pitch error compensation magnification
5471	Compensation α at compensation point number a for individual axis
5472	Compensation β at compensation point number b for individual axis
5473	Compensation γ at compensation point number c for individual axis
5474	Compensation ε at compensation point number d for individual axis
5551	Compensation at compensation point number a for movement axis 1
5552	Compensation at compensation point number b for movement axis 1
5553	Compensation at compensation point number c for movement axis 1
5554	Compensation at compensation point number d for movement axis 1
5561	Compensation at compensation point number a for movement axis 2
5562	Compensation at compensation point number b for movement axis 2
5563	Compensation at compensation point number c for movement axis 2
5564	Compensation at compensation point number d for movement axis 2
5571	Compensation at compensation point number a for movement axis 3
5591	Straightness compensation magnification
5592	Straightness compensation magnification

No.	Description
5593	Straightness compensation magnification
5594	Straightness compensation magnification
5595	Straightness compensation magnification

C.3 PARAMETERS FOR Series 16, 18, AND 21

No.	Description
1821	Reference counter capacity for individual axis
1826	Effective area (in-position check) for individual axis
1827	Effective area (in-position check) for individual axis at cutting feed
1828	Positional deviation limit for individual axis during movement
1829	Positional deviation limit for individual axis at stop
1830	Positional deviation limit for individual axis with servo off
1832	Positional deviation limit for individual axis with feed at stop
1836	Servo error amount within which reference position return is assumed to be possible
1850	Grid shift/reference position shift for individual axis
1851	Backlash compensation for individual axis
1852	Backlash compensation for individual axis at rapid traverse
1876	Inductosyn 1-pitch interval
1877	Inductosyn shift
1882	Mark 2 intervals on linear scale having reference marks
1883	Distance from origin to reference position on linear scale having reference marks
1884	Distance from origin to reference position on linear scale having reference marks
1885	Permissible cumulative movement value during torque control (PMC axis control)
1886	Positional deviation with torque control canceled (PMC axis control)
3623	Pitch error compensation magnification for individual axis
5300	Rigid tapping effective area (in-position check) for tapping axis
5302	Second-spindle rigid tapping effective area (in-position check) for tapping axis
5304	Third-spindle rigid tapping effective area (in-position check) for tapping axis
5310	Rigid tapping positional deviation limit for tapping axis during movement
5312	Rigid tapping positional deviation limit for tapping axis at stop
5314	Rigid tapping positional deviation limit for tapping axis during movement
5350	Second-spindle rigid tapping positional deviation limit for tapping axis during movement
5352	Second-spindle rigid tapping positional deviation limit for tapping axis at stop
5354	Third-spindle rigid tapping positional deviation limit for tapping axis during movement
5356	Third-spindle rigid tapping positional deviation limit for tapping axis at stop
5761	Compensation at compensation point number a for movement axis 1 (straightness compensation)
5762	Compensation at compensation point number b for movement axis 1 (straightness compensation)
5763	Compensation at compensation point number c for movement axis 1 (straightness compensation)
5764	Compensation at compensation point number d for movement axis 1 (straightness compensation)
5771	Compensation at compensation point number a for movement axis 2 (straightness compensation)
5772	Compensation at compensation point number b for movement axis 2 (straightness compensation)
5773	Compensation at compensation point number c for movement axis 2 (straightness compensation)
5774	Compensation at compensation point number d for movement axis 2 (straightness compensation)
5781	Compensation at compensation point number a for movement axis 3 (straightness compensation)
5782	Compensation at compensation point number b for movement axis 3 (straightness compensation)
5783	Compensation at compensation point number c for movement axis 3 (straightness compensation)
5784	Compensation at compensation point number d for movement axis 3 (straightness compensation)
5871	Compensation α at compensation point number a for individual axis (gradient compensation)
5872	Compensation β at compensation point number b for individual axis (gradient compensation)
5873	Compensation γ at compensation point number c for individual axis (gradient compensation)
5874	Compensation ε at compensation point number d for individual axis (gradient compensation)
8313	Limit to difference in positional deviation between master and slave axes (pair under simplified synchronization control)
8315	Maximum compensation for synchronization (pair under simplified synchronization control)
8316	Difference in reference counter between master and slave axes (pair under simplified synchronization control)

No.	Description
8323	Limit to difference in positional deviation between master and slave axes (more than one pair under simplified synchronization control)
8325	Maximum compensation for synchronization (more than one pair under simplified synchronization control)
8326	Difference in reference counter between master and slave axes (more than one pair under simplified synchronization control)

- **Setting data for shifting external machine coordinate systems**

C.4 PARAMETERS FOR Series 0-C

No.	Description
570-	Reference counter capacity for individual axis
500-	Effective area (in-position check) for individual axis
609-	Effective area (in-position check) for individual axis at cutting feed
504-	Positional deviation limit for individual axis during movement
593-	Positional deviation limit for individual axis at stop
405(M) 463(T)	Servo error amount within which reference position return is assumed to be possible
508-	Grid shift/reference position shift for individual axis
535-	Backlash compensation for individual axis (only when arbitrary CMR is in use (ACMR (bit 7 of parameter No. 035) = 1))
686-(M) 673-(T)	Backlash compensation for individual axis at rapid traverse (only when arbitrary CMR is in use (ACMR (bit 7 of parameter No. 035) = 1))
618(M) 400(T)	Rigid tapping effective area (in-position check) for tapping axis
620(M) 402(T)	Rigid tapping positional deviation limit for tapping axis during movement
622(M) 404(T)	Rigid tapping positional deviation limit for tapping axis at stop
475(M)	Limit to difference in positional deviation between master and slave axes

- **Pitch error compensation data and setting data for shifting external machine coordinate systems**

The detection unit is used only when an arbitrary CMR is in use (ACMR (bit 7 of parameter No. 035) = 1). If ACMR = 0, the increment system is used. For the pitch error compensation data, however, it becomes possible to support the detection unit by setting bits 0 and 1 of parameter No. 011 appropriately.

C.5 PARAMETERS FOR THE Power Mate *i*

No.	Description
1821	Reference counter capacity for individual axis
1826	Effective area (in-position check) for individual axis
1827	Effective area (in-position check) for individual axis at cutting feed
1828	Positional deviation limit for individual axis during movement
1829	Positional deviation limit for individual axis at stop
1830	Positional deviation limit for individual axis with servo off
1832	Positional deviation limit for individual axis with feed at stop
1836	Servo error amount within which reference position return is assumed to be possible (when ISC is in use)
1850	Grid shift/reference position shift for individual axis
1851	Backlash compensation for individual axis
1852	Backlash compensation for individual axis at rapid traverse
1872*	Servo positional deviation check value
1882	Mark 2 intervals on linear scale having reference marks
1883	Distance from origin to reference position on linear scale having reference marks
1884	Distance from origin to reference position on linear scale having reference marks
1885	Permissible cumulative movement value during torque control (PMC axis control)
1886	Positional deviation with torque control canceled (PMC axis control)
3623	Pitch error compensation magnification for individual axis (H is optional)
5300(D)	Rigid tapping effective area (in-position check) for tapping axis
5310(D)	Rigid tapping positional deviation limit for tapping axis during movement
5312(D)	Rigid tapping positional deviation limit for tapping axis at stop
5314(D)	Rigid tapping positional deviation limit for tapping axis during movement
5761	Compensation at compensation point number a for movement axis 1 (straightness compensation)
5762	Compensation at compensation point number b for movement axis 1 (straightness compensation)
5763	Compensation at compensation point number c for movement axis 1 (straightness compensation)
5764	Compensation at compensation point number d for movement axis 1 (straightness compensation)
5771	Compensation at compensation point number a for movement axis 2 (straightness compensation)
5772	Compensation at compensation point number b for movement axis 2 (straightness compensation)
5773	Compensation at compensation point number c for movement axis 2 (straightness compensation)
5774	Compensation at compensation point number d for movement axis 2 (straightness compensation)
5781	Compensation at compensation point number a for movement axis 3 (straightness compensation)
5782	Compensation at compensation point number b for movement axis 3 (straightness compensation)
5783	Compensation at compensation point number c for movement axis 3 (straightness compensation)
5784	Compensation at compensation point number d for movement axis 3 (straightness compensation)
8313	Limit to difference in positional deviation between master and slave axes (pair under simplified synchronization control)
8315	Maximum compensation for synchronization (pair under simplified synchronization control)
8316	Difference in reference counter between master and slave axes (pair under simplified synchronization control)
8323(H)	Limit to difference in positional deviation between master and slave axes (more than one pair under simplified control)
8325(H)	Maximum compensation for synchronization (more than one pair under simplified synchronization control)
8326(H)	Difference in reference counter between master and slave axes (more than one pair under simplified synchronization control)

The parameter No. indicated with an asterisk (*) is related to a function unique to the Power Mate.
The parameter No. suffixed with "(D)" are related to the functions dedicated to the Power Mate *i*-D.
The parameter No. suffixed with "(H)" are related to the functions dedicated to the Power Mate *i*-H.

C.6 PARAMETERS FOR THE Power Mate -E

No.	Description
200	Effective area (in-position check)
202	Positional deviation limit during movement
204	Grid shift
221	Backlash compensation
231	Positional deviation limit at stop
321	Servo positional deviation check value
324	Reference counter capacity
329	Positional deviation with at feed at stop

D FUNCTION-SPECIFIC SERVO PARAMETERS

☆ : Parameters set up automatically or cleared at initialization

Parenthesized parameters : Common parameters that are also used for other functions

Parameter number			Meaning		
Series 15	Series 16, 18, 20, 21, Power Mate	Power Mate-E			
[Servo initialization functions]					
1804	2000	1000	Initialization bits		→ 2.1.2
1874	2020	1020	Motor number		
1806	2001	1001	AMR		
1820	1820	100	CMR		
1977 1978	2084 2085	1084 1085	Flexible feed gear (numerator) Flexible feed gear (denominator)		
1879	2022	1022	Move direction		
1876	2023	1023	Number of velocity pulses		
1891	2024	1024	Number of position pulses		
1804#0	2000#0	1000#0	1: Multiplies the number of velocity pulses and position pulses by 10.		
1896	1821	324	Reference counter		
1875	2021	1021	Load inertia ratio		
–	3111#0	–	1: Displays the servo setting screen.		
[Vibration suppression functions in the stop state]					
1894	2066	1066	250 µs acceleration feedback gain	☆	→ 4.4.1
1959#7	2017#7	–	Velocity loop high cycle management function		→ 4.4.2
1958#3	2016#3	–	Function for changing the proportional gain in the stop state		→ 4.4.3
1730	2119	–	Function for changing the proportional gain in the stop state: Stop judgement level		
1747#3	2207#3	–	1: The velocity loop proportional gain in the stop state is 50%.		
1808#4	2003#4	1003#4	N pulse suppression function	☆	→ 4.4.4
1992	2099	1099	N pulse suppression level	☆	
[Machine-resonance suppression functions]					
1956#1	2012#1	1012#1	Machine speed feedback function	☆	→ 4.5.1
1981	2088	1088	Machine speed feedback gain	☆	
1808#2	2003#2	1003#2	Observer function	☆	→ 4.5.2
1859	2047	1047	Observer coefficient (POA1)	☆	
1862	2050	1050	Observer coefficient (POK1)	☆	
1863	2051	1051	Observer coefficient (POK2)	☆	
1960#1	2018#1	–	Function for disabling the observer in the stop state		
1730	2119	–	Function for disabling the observer in the stop state: Stop judgement level		

☆ : Parameters set up automatically or cleared at initialization

Parenthesized parameters : Common parameters that are also used for other functions

Parameter number			Meaning		
Series 15	**Series 16, 18, 20, 21, Power Mate**	**Power Mate-E**			
[Machine-resonance suppression functions]					
1895	2067	1067	Torque command filter coefficient	☆	→ 4.5.3
1779	2156	–	Torque command filter coefficient for rapid traverse		→ 3.4.2
1709#7	2019#7	1019#7	Dual position feedback function (optional function)	☆	→ 4.5.4
1861	2049	1049	Maximum amplitude	☆	
1971	2078	1078	Conversion coefficient (numerator)	☆	
1972	2079	1079	Conversion coefficient (denominator)	☆	
1973	2080	1080	Primary delay time constant	☆	
1974	2081	1081	Zero-point amplitude	☆	
1729	2118	–	Level on which the difference in error between the semi-closed and full-closed modes becomes too large (Only this function can be used without any options.)		
1954#5 1954#4	2010#5 2010#4	1010#5 1010#4	1: The backlash compensation is added to the error count of the closed loop. 1: The pitch error compensation is added to the error count of the semi-closed loop.		
1742#4	2202#4	–	1: Improvement in the zero-width determination		
1718	2033	–	Number of position feedback pulses (vibration-damping control)		→ 4.5.5
1719	2034	–	Vibration-damping control gain		
1706	2113	–	Notch filter attenuation center frequency	☆	→ 4.5.6
2620	2177	–	Notch filter attenuation bandwidth		
1743#2	2203#2	–	Current loop 1/2PI function		→ 4.5.7 → 3.4.2
1742#1 1742#2	2202#1 2202#2	– –	Enables the current loop 1/2PI function for cutting only. (This parameter is also used for the cutting feed/rapid traverse velocity loop gain switch function.) When the above bit is used, the current loop 1/2PI function is left enabled.		
[Shape-error suppression functions]					
[Feed-forward functions]					
1808#3	2003#3	1003#3	PI control	☆	→ 4.6.1 to 4.6.3
1883#1	2005#1	1005#	Feed-forward function	☆	
1961	2068	1068	Feed-forward coefficient	☆	
1962	2069	1069	Velocity feed-forward coefficient	☆	
1985	2092	–	Advanced preview feed-forward coefficient	☆	→ 4.6.2
1959#5	2017#5	–	RISC feed-forward function type 2		→ 4.6.3
1800#3	1800#3	–	Enables feed-forward in rapid traverse.		→ 3.4.2 → 4.8.3
(1742#0)	(2202#0)	–	Switches the feed-forward coefficient between cutting and rapid traverse. (This parameter is also used for the cutting/rapid traverse-specific fine acceleration/deceleration function.)		
1767	2144	–	Position feed-forward coefficient for cutting		
1768	2145	–	Velocity feed-forward coefficient for cutting		
(1985)	(2092)	–	Position feed-forward coefficient for rapid traverse	☆	
(1962)	(2069)	–	Velocity feed forward coefficient for rapid traverse	☆	

✰	:	Parameters set up automatically or cleared at initialization
Parenthesized parameters	:	Common parameters that are also used for other functions

Parameter number			Meaning		
Series 15	**Series 16, 18, 20, 21, Power Mate**	**Power Mate-E**			
[Shape-error suppression functions]					
[Backlash acceleration functions]					
1851	1851	–	Backlash compensation		→ 4.6.4 to 4.6.5
1884#0	2006#0	–	1: Does not reflect the backlash compensation in positions.	✰	
1808#5	2003#5	–	Backlash acceleration function	✰	→ 4.6.4
1860	2048	–	Backlash acceleration amount	✰	
1964	2071	–	Period during which backlash acceleration remains effective	✰	
1953#7	2009#7	–	Backlash acceleration stop	✰	
1975	2082	–	Timing at which the backlash acceleration is stopped	✰	
1953#6	2009#6	–	1: Enables the backlash acceleration function during cutting feed only.	✰	
1957#6 (1808#5)	2015#6 (2003#5)	–	Two-stage backlash acceleration function (The backlash acceleration function is also enabled.)	 ✰	→ 4.6.5
(1860)	(2048)	–	Stage 1 acceleration amount	✰	
1987	2094	–	Stage 1 acceleration amount from negative direction to positive direction	✰	
1760	2137	–	Stage 1 acceleration override		
1975	2082	–	Stage 2 start/end parameter	✰	
1982	2089	–	Stage 2 end scale factor	✰	
1724	2039	–	Stage 2 acceleration amount		
1790	2167	–	Stage 2 offset		
1725	2114	–	Stage 2 acceleration override		
1960#2	2018#2	–	The format of the stage 2 acceleration override is changed.		
1953#6	2009#6	–	1: Enables backlash acceleration only during cutting feed.	✰	
1883#7 (1808#5)	2005#7 (2003#5)	–	Static friction compensation function (The backlash acceleration function is also enabled.)	✰ ✰	→ 4.6.6
(1964)	(2071)	1071	Compensation count	✰	
1965	2072	1072	Static friction compensation	✰	
1966	2073	1073	Stop state judgement parameter	✰	
(1953#7)	(2009#7)	1009#7	Stop of static friction compensation	✰	
1990	2097	1097	Parameter for stopping static friction compensation	✰	
[Overshoot compensation functions]					
1808#6	2003#6	1003#6	Overshoot compensation function	✰	→ 4.7
1857	2045	1045	Velocity loop incomplete integral gain (PK3V)	✰	
1970	2077	1077	Overshoot compensation counter	✰	
1994	2101	–	Overshoot compensation enable level	✰	
1742#3	2202#3	–	Overshoot compensation type 2		

☆ : Parameters set up automatically or cleared at initialization

Parenthesized parameters : Common parameters that are also used for other functions

Parameter number			Meaning		
Series 15	**Series 16, 18, 20, 21, Power Mate**	**Power Mate-E**			
[High-speed positioning functions]					
1957#0	2015#0	1015#0	Position gain switch function		→ 4.8.1
1714	2029	1029	Limit speed for enabling position gain switching		
1744#1	2204#1	–	1: Increases the increment system for the effective switch velocity to 10 times.		
1957#0 1744#5	2015#0 2204#5	–	Position gain switch function type 2		
1957#1	2015#1	1015#1	Low-speed integration function		→ 4.8.2
1714	2029	1029	Limit speed for disabling low-speed integration at acceleration		
1716	2030	1030	Limit speed for enabling low-speed integration at deceleration		
(1744#1)	(2204#1)	–	1: Increases the increment system for the switch velocity to 10 times.		
1951#6	2007#6	–	Fine acceleration/deceleration (FAD) function	☆	→ 4.8.3
1749#2	2209#2	–	0: FAD bell-shaped, 1: FAD linear type		
(1985)	(2092)	–	Position feed-forward coefficient (This parameter is also used for advanced preview control.)		
1742#0	2202#0	–	Cutting/rapid traverse-specific fine acceleration/deceleration function		→ 3.4.2 → 4.8.3
1800#3	1800#3	–	Enables feed-forward in rapid traverse.		
1702	2109	–	Fine acceleration/deceleration time constant		
1766	2143	–	Fine acceleration/deceleration time constant 2		
(1767)	(2144)	–	Position feed-forward coefficient for cutting		
(1768)	(2145)	–	Velocity feed-forward coefficient for cutting		
(1985)	(2092)	–	Position feed-forward coefficient for rapid traverse	☆	
(1962)	(2069)	–	Velocity feed forward coefficient for rapid traverse	☆	
[Dummy serial feedback functions]					
1953#0	2009#0	1009#0	Dummy serial feedback function	☆	→ 4.9
1800#1	1800#1	–	1: Ignores the V-READY ON alarm.		
1745#2	2205#2	–	Separate detector-based dummy feedback function		
[Brake control functions]					
1883#6	2005#6	–	Brake control function	☆	→ 4.10
1976	2083	–	Brake control timer	☆	
[Stop distance reduction functions]					
1959#0	2017#0	–	Emergency stop distance reduction function type 1 (VCMD0)		→ 4.11.1
1744#7	2204#7	–	Emergency stop distance reduction function type 2 (return)		→ 4.11.2
1745#4 1745#5	2205#4 2205#5	– –	Separate detector hardware disconnection stop distance reduction function For axes under synchronization control, this bit is also set.		→ 4.11.3
2600#7	2212#7	–	OVL and OVC alarm stop distance reduction function		→ 4.11.4

☆ : Parameters set up automatically or cleared at initialization

Parenthesized parameters : Common parameters that are also used for other functions

Parameter number			Meaning		
Series 15	Series 16, 18, 20, 21, Power Mate	Power Mate-E			
[Abnormal-load detection functions] @ (Optional functions)					
1958#0	2016#0	1016#0	Abnormal-load detection function		→ 4.12
1740#5	2200#5	–	Improvement in the accuracy of an estimated disturbance load (Series 9080, 9081, 9090, 90A0)		
–	2009#1	1009#1	Improvement in the accuracy of an estimated disturbance load (Series 9065, 9066)	☆	
1980	2087	1087	Torque offset	☆	
1727	2116	1116	Dynamic friction compensation value		
1997	2104	1104	Abnormal-load detection alarm level	☆	
1996	2103	1103	Retrace distance	☆	
1740#3	2200#3	–	Unexpected disturbance detection performed separately for cutting and rapid traverse		
(1997)	(2104)	–	Unexpected disturbance detection alarm level for cutting	☆	
1765	2142	–	Unexpected disturbance detection alarm level for rapid traverse		
[Linear motor functions]					
1705	2112	–	AMR conversion coefficient 1	☆	→ 4.14
1761	2138	–	AMR conversion coefficient 2		
1762	2139	–	AMR offset		
2628	2185	–	Position pulse conversion coefficient		
1740#6	2200#6	–	The velocity loop proportional gain format is changed.		
1750#2	2210#2	–	Quadruple current loop gain function	☆	
1753 1754 1755	2130 2131 2132	–	Correction of two thrust ripples per magnetic pole pair Correction of four thrust ripples per magnetic pole pair Correction of six thrust ripples per magnetic pole pair	☆	
1743#6	2203#6	–	Four-times correction of linear motor thrust ripples		
[Torque control functions]					
1951#7	2007#7	–	Torque control type 1	☆	→ 4.15
1743#4	2203#4	–	Torque control type 2		
1998	2105	–	Torque constant	☆	
[Super-precision machining functions] Series 9081 only					
1732	2121	–	Conversion coefficient for the number of feedback pulses		→ 4.16
1741#4	2201#4	–	1: The number of velocity pulses is set when the conversion coefficient is not used.		
1733	2122	–	Detection resistance conversion coefficient		
1884#1	2006#1	–	1: An amplifier input voltage change from 200 V to 60 V is made.	☆	
1884#3 1709#4	2006#3 2019#4	–	1: Uses a separate position detector of 1,000,000 pulses or more per revolution. (A special system must be configured with a separate velocity detector.) (Optional function)	☆	

☆ : Parameters set up automatically or cleared at initialization

Parenthesized parameters : Common parameters that are also used for other functions

Parameter number			Meaning		
Series 15	Series 16, 18, 20, 21, Power Mate	Power Mate-E			
[Tandem control functions] @(Optional functions)					
1817#6	1817#6	–	Tandem control function (main- and sub-axes)		→ 4.17
–	1010	–	Number of CNC controlled axes		
1021	–	–	Parallel-axis name (main axis: 77, sub-axis: 83)		
1980	2087	–	Preload value		→ 4.17.1
1952#7	2008#7	–	Damping compensation function	☆	→ 4.17.2
1721	2036	–	Damping compensation gain (main axis) and damping compensation phase (sub-axis)		
1952#2	2008#2	–	Velocity feedback averaging function	☆	→ 4.17.3
1951#1	2007#1	–	Servo alarm two-axis monitor function	☆	→ 4.17.4
1960#7	2018#7	–	Motor feedback sharing function (sub-axis)		→ 4.17.5
1940#1	2200#1	–	Full-closed loop feedback sharing function (sub-axis)		→ 4.17.6
1952#3	2008#3	–	Full preload function (main axis)	☆	→ 4.17.7
1952#4	2008#4	–	Selection of the motor output torque polarities (main axis)	☆	
1952#6	2008#6	–	1: Switches position feedback according to the direction of a torque command (main axis).	☆	→ 4.17.8
1737	2126	–	Position feedback switching time constant		
1952#5	2008#5	–	Velocity command tandem control	☆	→ 4.17.10
[Servo check board functions]					
1956#5 1956#4	2012#5 2012#4	1012#5 1012#4	VCMD output magnification 00: 1, 01: 16, 10: 16^2, 11: 16^3	☆	→ 4.19
1957#5	2015#5	1015#5	1: Outputs an estimated load to the check board. (The estimated load is output to the torque command channel.)		→ 4.6.5 and 4.12
1743#5	2203#5	–	1: Enables the four-times torque command output. (Small-torque command output can be measured.)		→ 4.14
1726	2115	1115	For internal data output: Must be kept at 0. The output of the SPEED signal (number of revolutions) is disabled.		→ 4.14 and 4.19
1746#7	2206#7	–	1: Performs high-speed data output to the check board (Series 90A0).		→ 3.4.1 and 4.5.6

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Revision Record

FANUC AC SERVO MOTOR α series PARAMETER MANUAL (B-65150E/04)

Edition	Date	Contents	Edition	Date	Contents
04	Dec., ‘99	1. Correction of errors 2. Addition of new functions 3. Total revision of Section for setting and adjusting the parameter			
03	Apr., ‘97	4. Correction of errors 5. Addition of new functions 6. Addition of parameter table for HRV control			
02	Mar., ‘95	1. Correction of errors 7. Addition of servo functions			
01	Apr.,’94	———————————————			

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