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

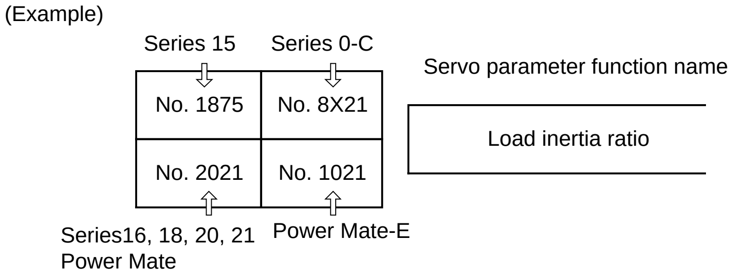
Document name	Document number	Major contents	Major usage	
FANUC AC SERVO MOTOR α series DESCRIPTIONS	B-65142E	• Specification • Characteristics • External dimensions • Connections	• Selection of motor • Connection of motor	
FANUC AC SERVO MOTOR β series DESCRIPTIONS	B-65232EN	• Specification • Characteristics • 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

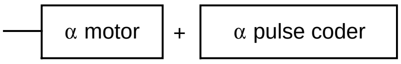
- * IBM is registered trademark of International Business Machines Corporation.
- * MS-DOS and Windows are registered trademarks of Microsoft Corporation.
- * 486SX and 486DX2 are registered trademarks of Intel corporation.

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

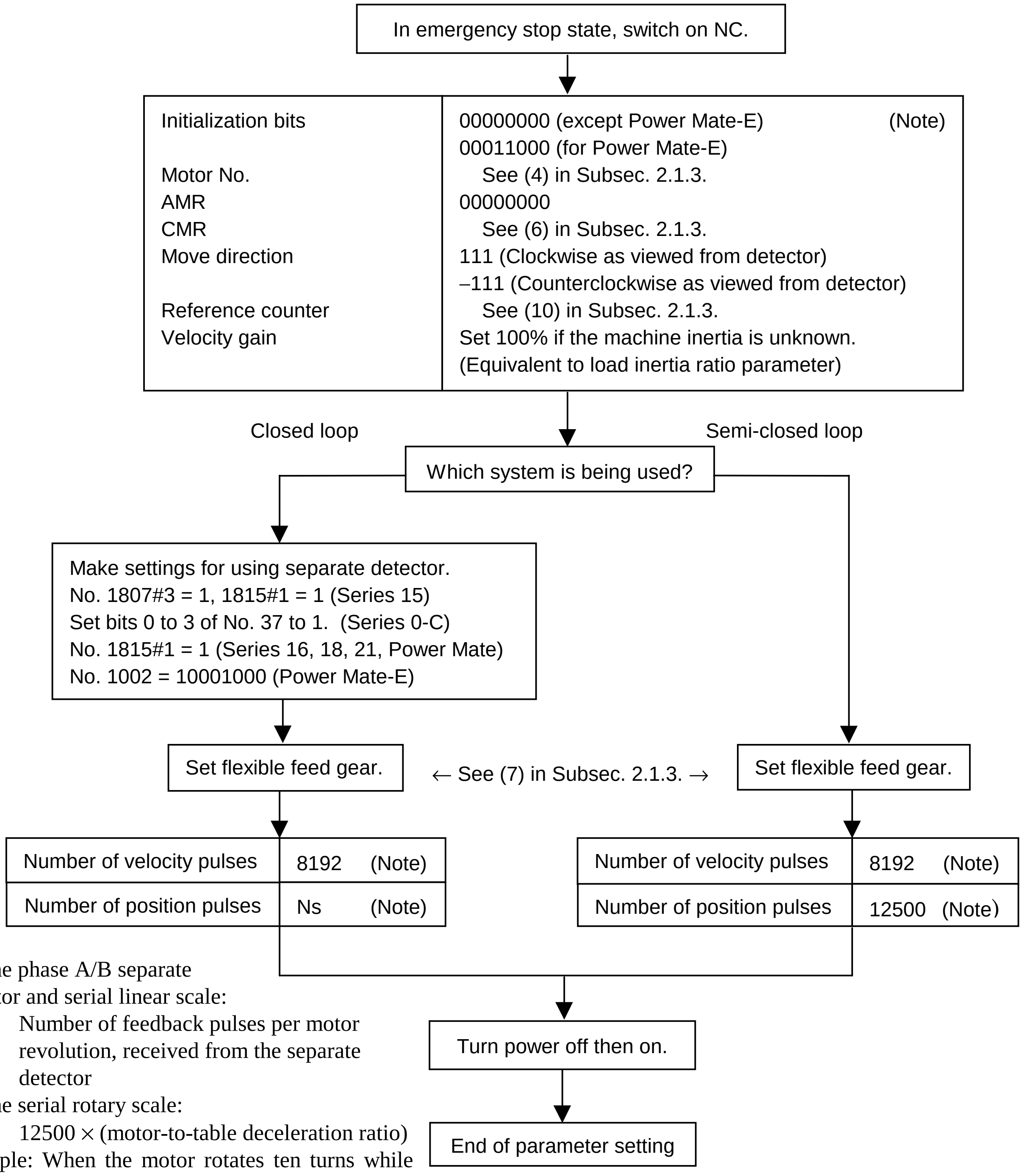
2.1.1 Before Servo Parameter Initialization

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.

← See (7) in Subsec. 2.1.3. →

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

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

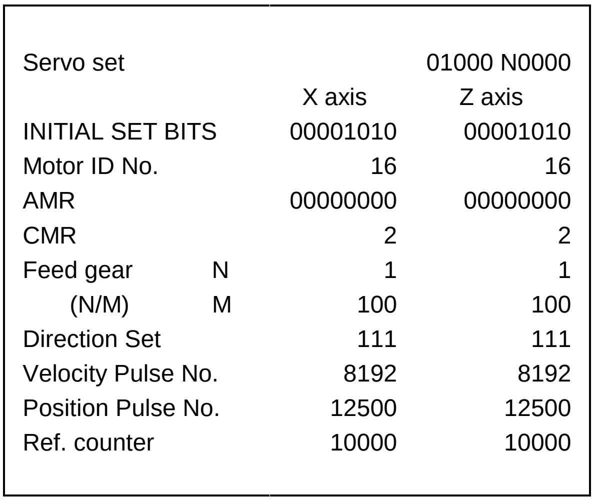
SYSTE → [SYSTEM] → [▷] → [SV-PRM]

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-<u>XXXX</u>-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

Servo software series / Motor model and motor type number		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

Servo software series / Motor model and motor type number		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

Servo software series / Motor model and motor type number		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

Servo software series Motor model and motor type number		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

Servo software series Motor model and motor type number		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

Servo software series Motor model and motor type number		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

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

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:

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

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

Setting for use of a separate detector (full-closed)

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

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.

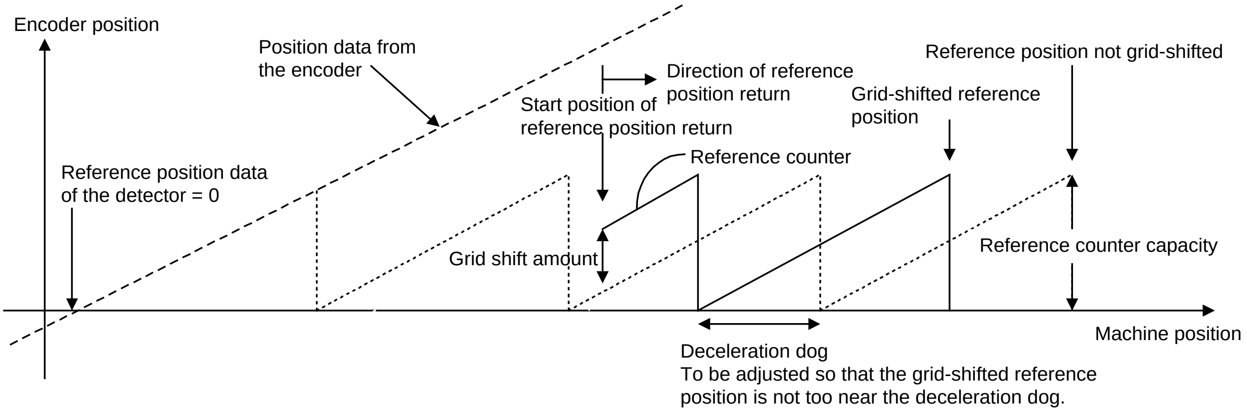
NOTE

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 $\tilde{A}$.

(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)

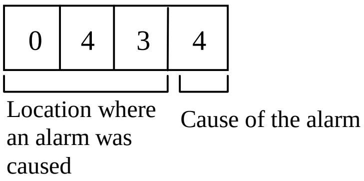
For example, when an invalid parameter setting alarm is caused for the first axis (set in parameter No. 1023), and 34 is set at address 1C0 and 04 is set at address 1C1 on the memory screen, alarm detail No. is 0434.

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:



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.)

1740	**–**
2200	**–**

#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
	P2EX						

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)

1804	**–**
2000	**1000**

#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
			PEX				

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.

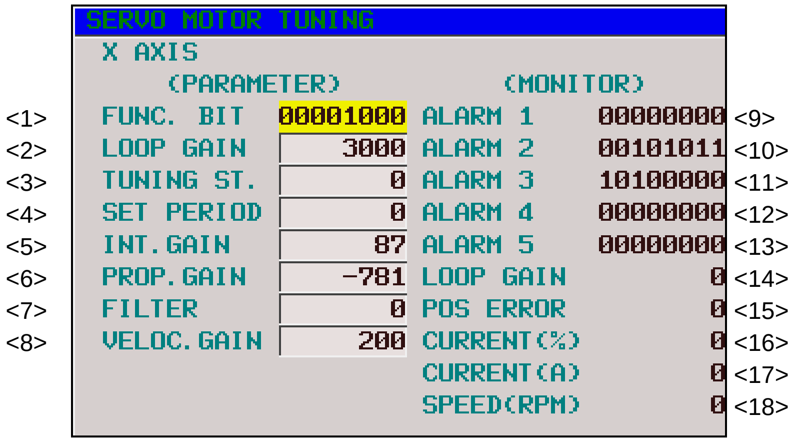
- **Series 16, 18, 20, and 21**

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.

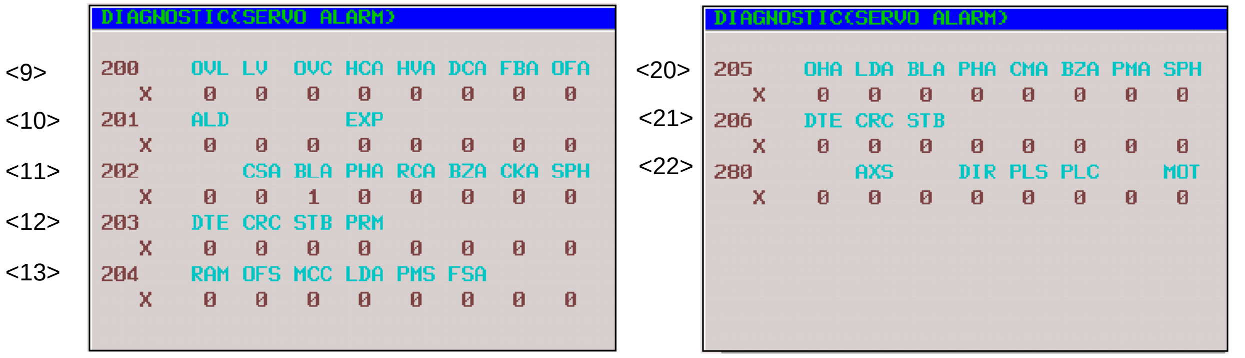
	#7	#6	#5	#4	#3	#2	#1	#0
3111								SVS

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



```
     SERVO MOTOR TUNING
       X AXIS
           (PARAMETER)                (MONITOR)
<1>    FUNC. BIT    00001000  ALARM 1      00000000 <9>
<2>    LOOP GAIN        3000  ALARM 2      00101011 <10>
<3>    TUNING ST.          0  ALARM 3      10100000 <11>
<4>    SET PERIOD          0  ALARM 4      00000000 <12>
<5>    INT.GAIN           87  ALARM 5      00000000 <13>
<6>    PROP.GAIN        -781  LOOP GAIN           0 <14>
<7>    FILTER              0  POS ERROR           0 <15>
<8>    VELOC.GAIN        200  CURRENT(%)          0 <16>
                              CURRENT(A)          0 <17>
                              SPEED(RPM)          0 <18>
```

Fig. 3.1 (a) Diagnosis screen



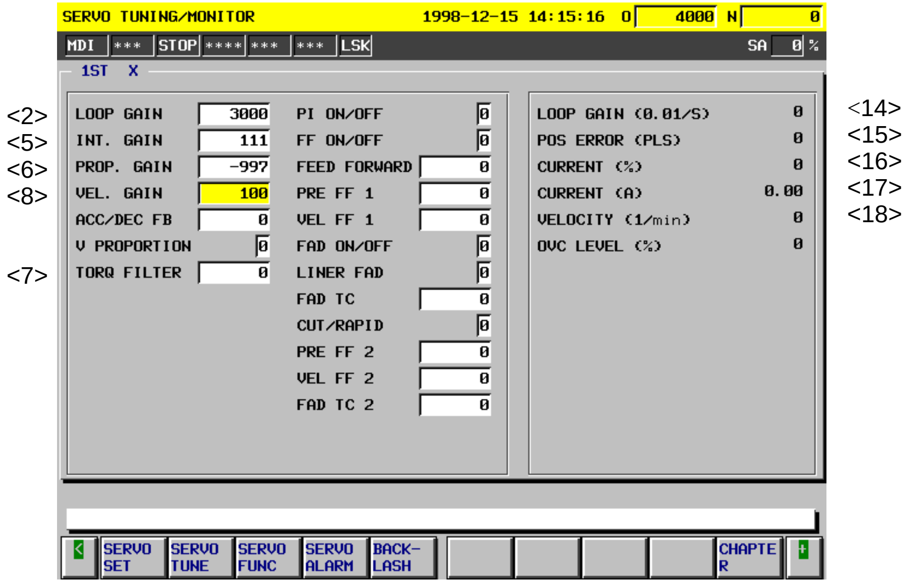
```
DIAGNOSTIC(SERVO ALARM)

200    OVL LV  OVC HCA HVA DCA FBA OFA
   X    0   0   0   0   0   0   0   0
201    ALD         EXP
   X    0   0   0   0   0   0   0   0
202        CSA BLA PHA RCA BZA CKA SPH
   X    0   0   1   0   0   0   0   0
203    DTE CRC STB PRM
   X    0   0   0   0   0   0   0   0
204    RAM OFS MCC LDA PMS FSA
   X    0   0   0   0   0   0   0   0
```

```
DIAGNOSTIC(SERVO ALARM)

205    OHA LDA BLA PHA CMA BZA PMA SPH
   X    0   0   0   0   0   0   0   0
206    DTE CRC STB
   X    0   0   0   0   0   0   0   0
280        AXS     DIR PLS PLC     MOT
   X    0   0   0   0   0   0   0   0
```

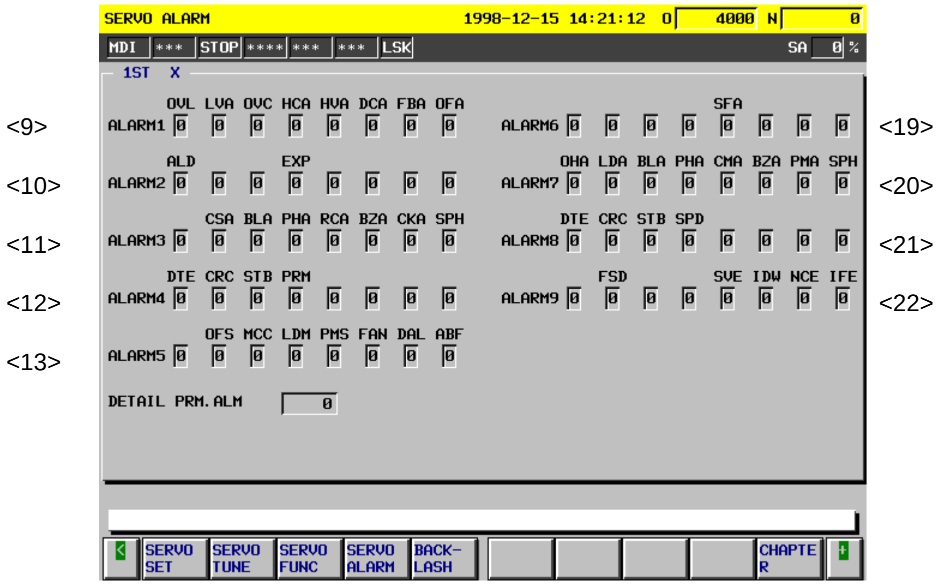
Fig. 3.1 (b) Diagnosis screen



```
SERVO TUNING/MONITOR          1998-12-15 14:15:16  O   4000 N     0
MDI *** STOP **** *** *** LSK                               SA   0 %
1ST  X

LOOP GAIN       3000   PI ON/OFF         0   LOOP GAIN (0.01/S)      0
INT. GAIN        111   FF ON/OFF         0   POS ERROR (PLS)         0
PROP. GAIN      -997   FEED FORWARD      0   CURRENT (%)             0
VEL. GAIN        100   PRE FF 1          0   CURRENT (A)          0.00
ACC/DEC FB         0   VEL FF 1          0   VELOCITY (1/min)        0
V PROPORTION       0   FAD ON/OFF        0   OVC LEVEL (%)           0
TORQ FILTER        0   LINER FAD         0
                       FAD TC            0
                       CUT/RAPID         0
                       PRE FF 2          0
                       VEL FF 2          0
                       FAD TC 2          0
```

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



```
SERVO ALARM                   1998-12-15 14:21:12  O   4000 N     0
MDI *** STOP **** *** *** LSK                               SA   0 %
1ST  X
          OVL LVA OVC HCA HVA DCA FBA OFA                          SFA
ALARM1  0   0   0   0   0   0   0   0      ALARM6  0   0   0   0   0   0   0   0
          ALD             EXP                        OHA LDA BLA PHA CMA BZA PMA SPH
ALARM2  0   0   0   0   0   0   0   0      ALARM7  0   0   0   0   0   0   0   0
              CSA BLA PHA RCA BZA CKA SPH                DTE CRC STB SPD
ALARM3  0   0   0   0   0   0   0   0      ALARM8  0   0   0   0   0   0   0   0
          DTE CRC STB PRM                                FSD         SVE IDW NCE IFE
ALARM4  0   0   0   0   0   0   0   0      ALARM9  0   0   0   0   0   0   0   0
              OFS MCC LDM PMS FAN DAL ABF
ALARM5  0   0   0   0   0   0   0   0

DETAIL PRM.ALM        0
```

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	No. 8X03	No. 1808	No. 2003	No. 1003
<2> Loop gain	No. 0517	No. 1825	No. 1825	No. 0209
<3> Tuning start bit	Not used at present			
<4> Setting period	Not used at present			
<5> Velocity loop integral gain	No. 8X43	No. 1855	No. 2043	No. 1043
<6> Velocity loop proportional gain	No. 8X44	No. 1856	No. 2044	No. 1044
<7> TCMD filter	No. 8X67	No. 1857	No. 2067	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	Nos. 720 to 723	Nos. 3014 + 20(X - 1)	No. 200	No. 2711
<10> Alarm 2	730 to 733	3015 + 20(X - 1)	201	2710
<11> Alarm 3	760 to 763	3016 + 20(X - 1)	202	2713
<12> Alarm 4	770 to 773	3017 + 20(X - 1)	203	2712
<13> Alarm 5	__________	__________	204	2714
<19> Alarm 6	__________	__________	__________	__________
<20> Alarm 7	__________	__________	__________	__________
<21> Alarm 8	__________	__________	__________	__________
<22> Alarm 9	__________	__________	__________	__________
<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 (%)	Indicates the percentage (%) of the current value to the continuous rated current.			Not supported
<17> Actual current (A)	Indicates the current value.			
<18> Actual speed (rpm)	Indicates the actual speed.			

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 $\overline{\text{A}}$ 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	–	

$$\text{Conversion coefficient} \; @\backslash \frac{\left(\begin{array}{l}\text{Number of feedback pulses per motor} \\ \text{revolution (detection unit)}\end{array}\right)}{1{,}000{,}000}$$

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.

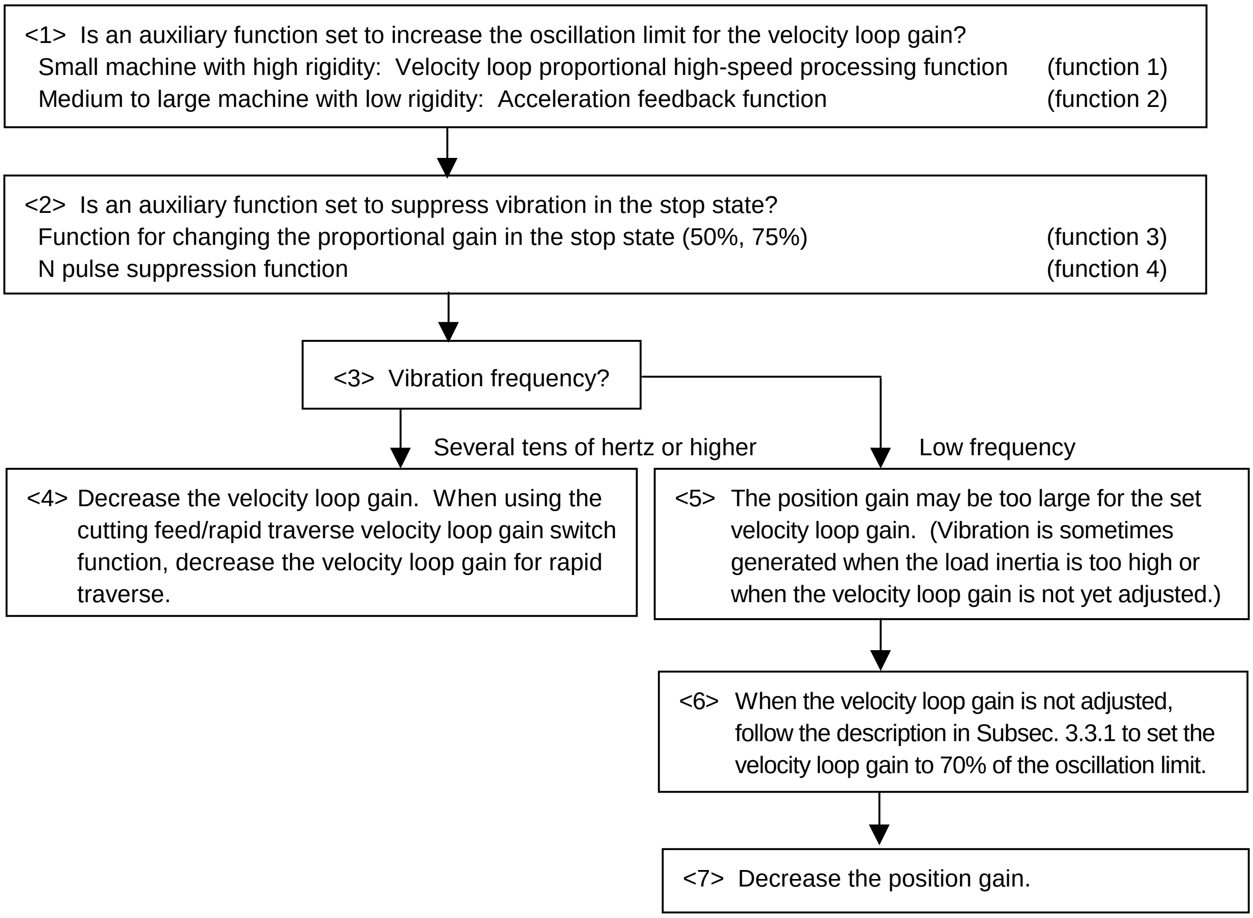
<7> Determining the position loop gain.

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.



<1> Is an auxiliary function set to increase the oscillation limit for the velocity loop gain?
Small machine with high rigidity: Velocity loop proportional high-speed processing function (function 1)
Medium to large machine with low rigidity: Acceleration feedback function (function 2)

<2> Is an auxiliary function set to suppress vibration in the stop state?
Function for changing the proportional gain in the stop state (50%, 75%) (function 3)
N pulse suppression function (function 4)

<3> Vibration frequency?

Several tens of hertz or higher

<4> Decrease the velocity loop gain. When using the cutting feed/rapid traverse velocity loop gain switch function, decrease the velocity loop gain for rapid traverse.

Low frequency

<5> The position gain may be too large for the set velocity loop gain. (Vibration is sometimes generated when the load inertia is too high or when the velocity loop gain is not yet adjusted.)

<6> When the velocity loop gain is not adjusted, follow the description in Subsec. 3.3.1 to set the velocity loop gain to 70% of the oscillation limit.

<7> Decrease the position gain.

(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

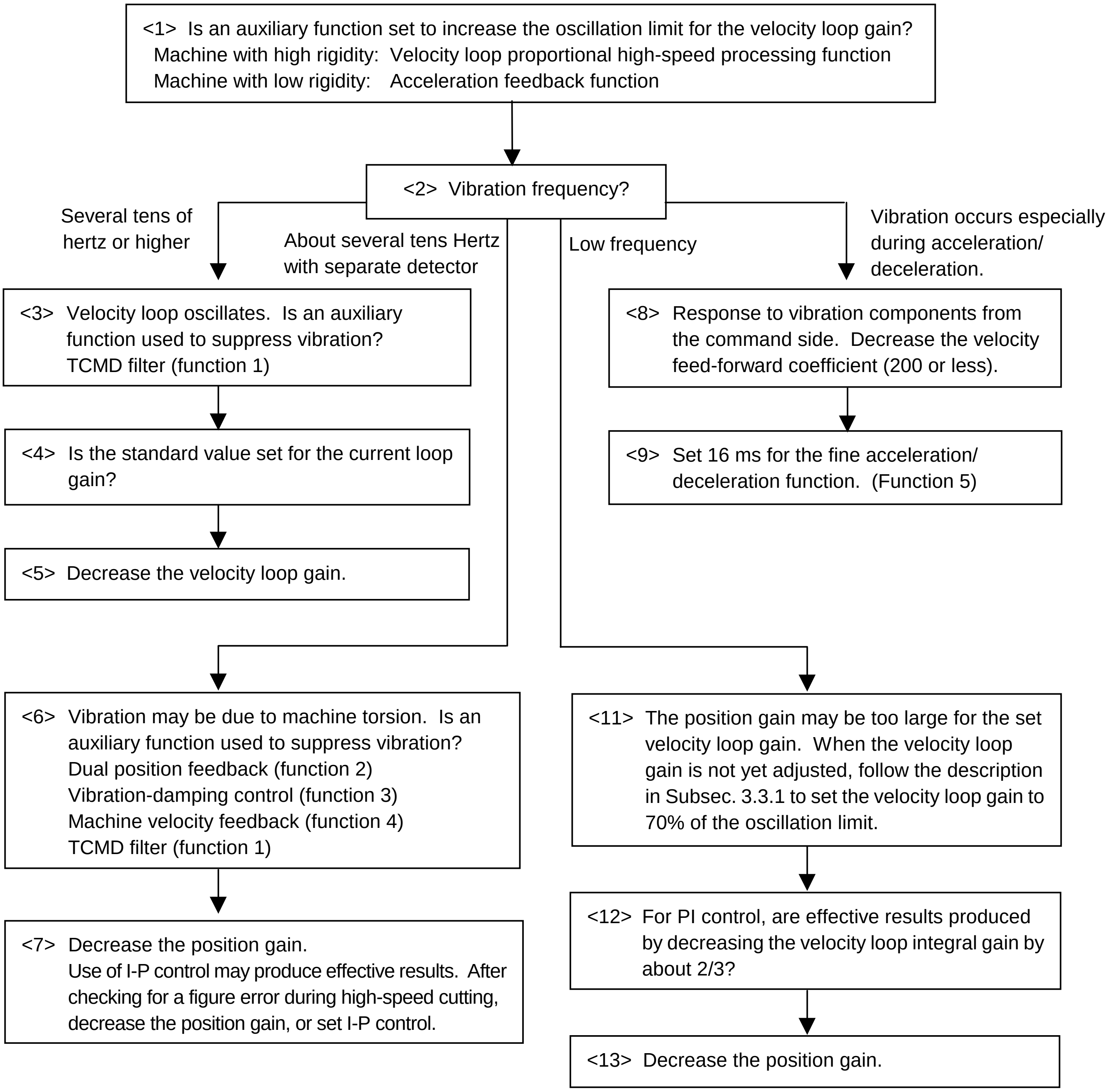
		#7	#6	#5	#4	#3	#2	#1	#0
No. 1953	**No. 8X09**					**K2VC**			
–	**–**								

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.



<1> Is an auxiliary function set to increase the oscillation limit for the velocity loop gain?
Machine with high rigidity: Velocity loop proportional high-speed processing function
Machine with low rigidity: Acceleration feedback function

<2> Vibration frequency?

<3> Velocity loop oscillates. Is an auxiliary function used to suppress vibration?
TCMD filter (function 1)

<4> Is the standard value set for the current loop gain?

<5> Decrease the velocity loop gain.

<6> Vibration may be due to machine torsion. Is an auxiliary function used to suppress vibration?
Dual position feedback (function 2)
Vibration-damping control (function 3)
Machine velocity feedback (function 4)
TCMD filter (function 1)

<7> Decrease the position gain.
Use of I-P control may produce effective results. After checking for a figure error during high-speed cutting, decrease the position gain, or set I-P control.

<8> Response to vibration components from the command side. Decrease the velocity feed-forward coefficient (200 or less).

<9> Set 16 ms for the fine acceleration/deceleration function. (Function 5)

<11> The position gain may be too large for the set velocity loop gain. When the velocity loop gain is not yet adjusted, follow the description in Subsec. 3.3.1 to set the velocity loop gain to 70% of the oscillation limit.

<12> For PI control, are effective results produced by decreasing the velocity loop integral gain by about 2/3?

<13> Decrease the position gain.

(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.

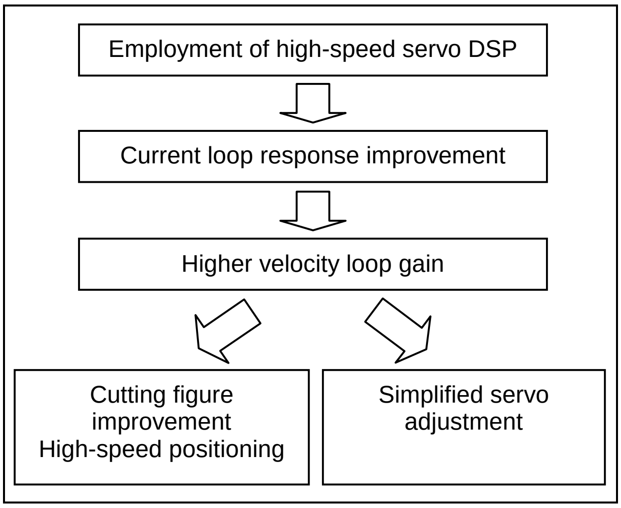
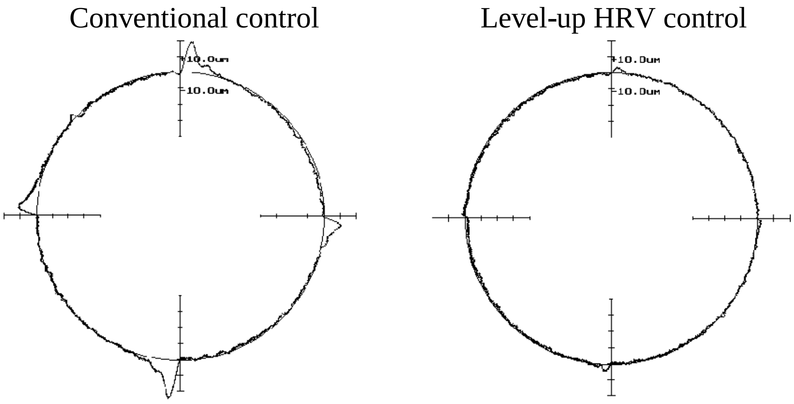


Fig. 3.4.1 (a) Achievements of level-up HRV control

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."


Conventional control

Level-up HRV control

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.

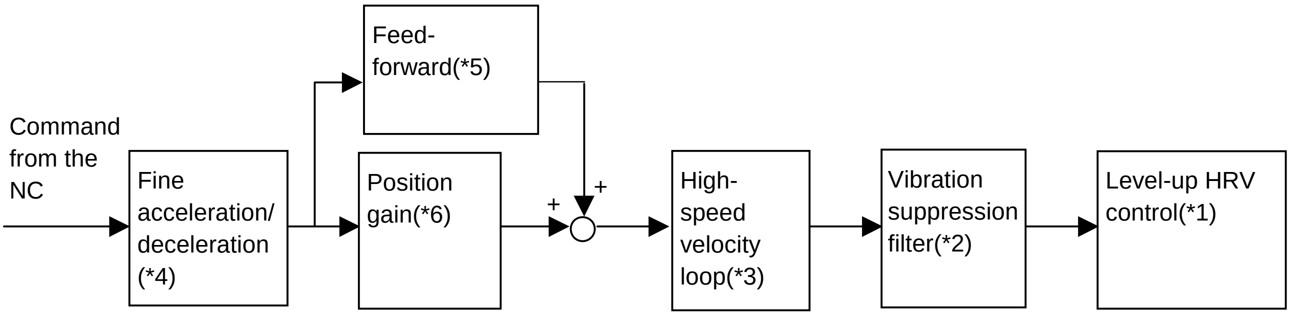


Fig. 3.4.1 (c) Level-up HRV control adjustment

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."

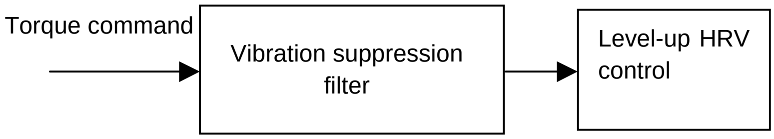


Fig. 3.4.1 (d) Vibration suppression filter

(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)

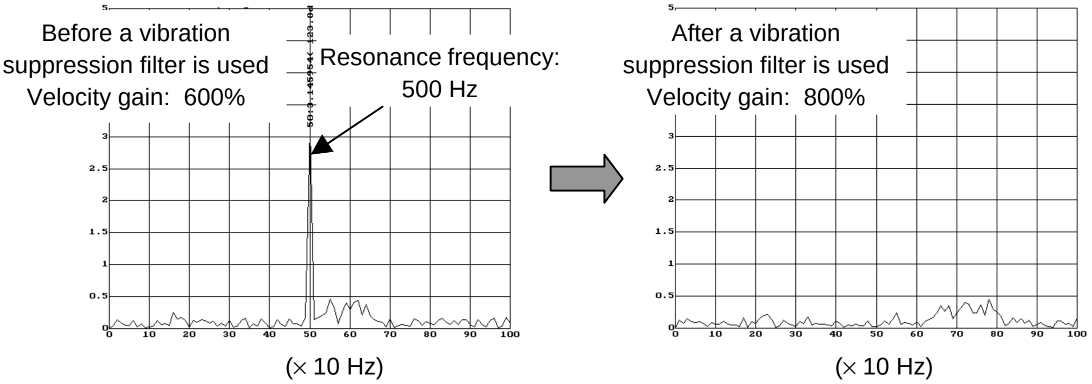


Fig. 3.4.1 (e) Effect of a vibration suppression filter (torque command waveform)

<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

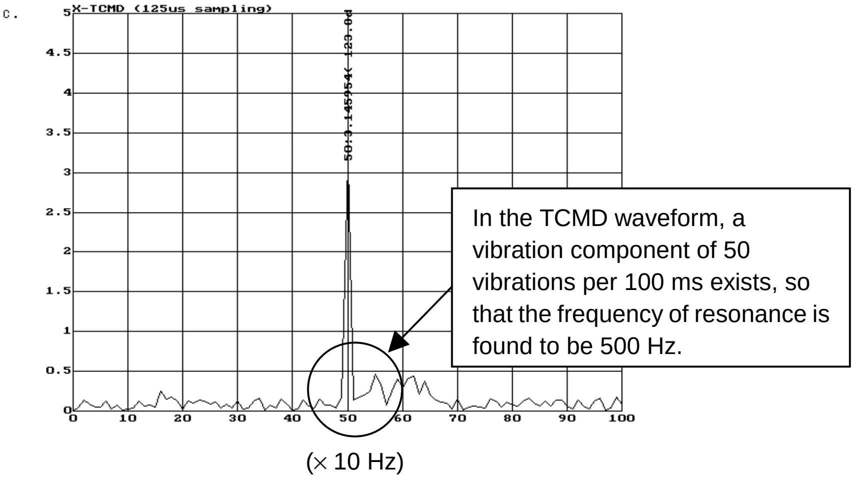
<7> While moving the motor, obtain data when an unusual sound is generated.

<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.



In the TCMD waveform, a vibration component of 50 vibrations per 100 ms exists, so that the frequency of resonance is found to be 500 Hz.

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.

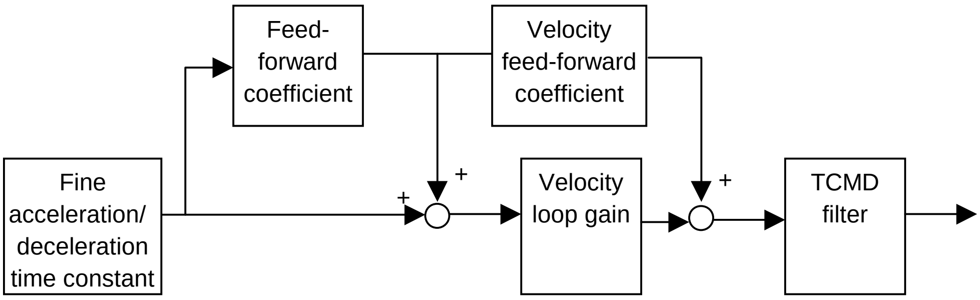


Fig. 3.4.2 Parameters switchable between cutting feed and rapid traverse

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

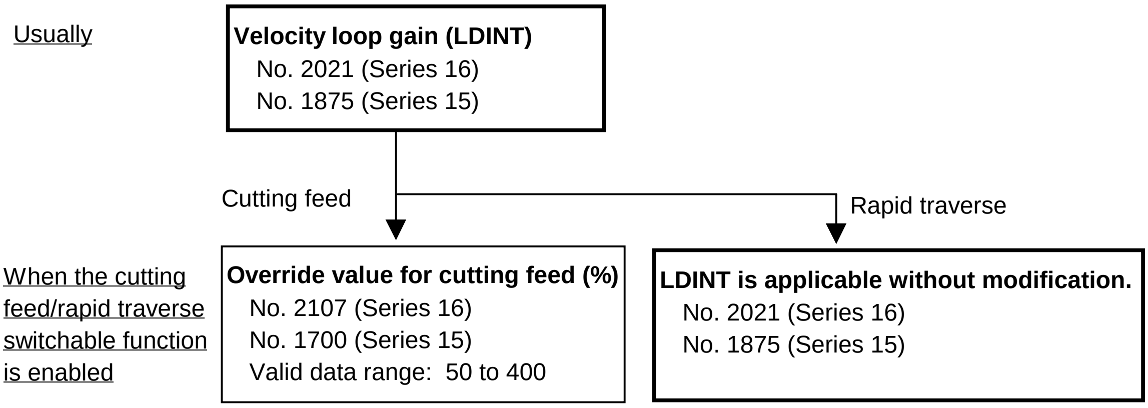
If acceleration in rapid traverse causes TCMD saturation, the velocity loop tends to oscillate at the end of acceleration in rapid traverse. Some machine systems tend to oscillate at a higher frequency when a higher feedrate is used. In such cases, gain switching between cutting feed and rapid traverse 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

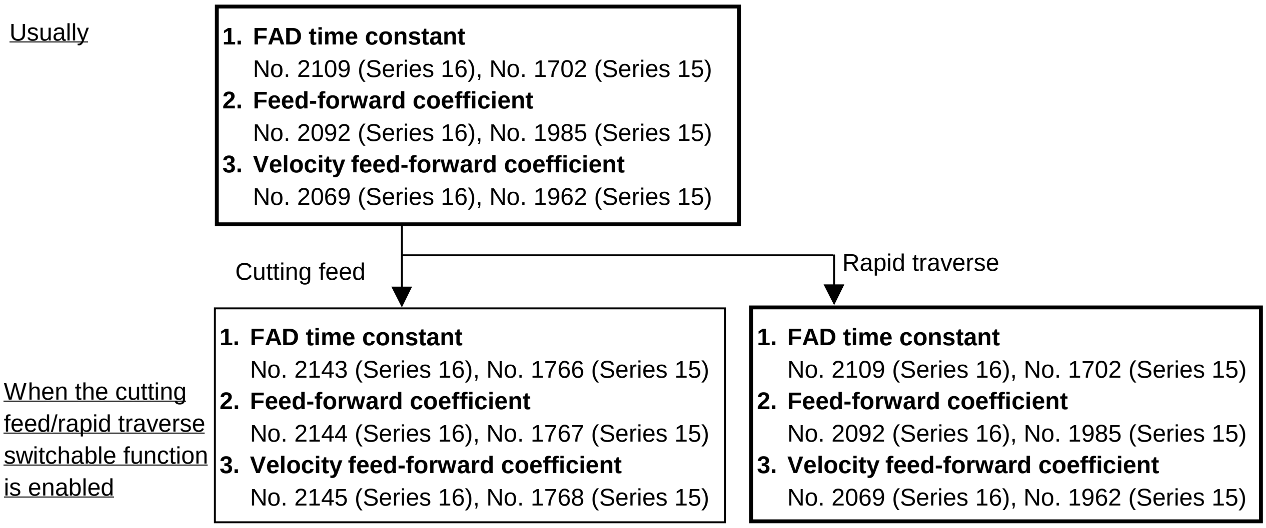
(Series 15*i*, 16*i*, 18*i*, 21*i*. The 320C543 servo card is required.)

[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

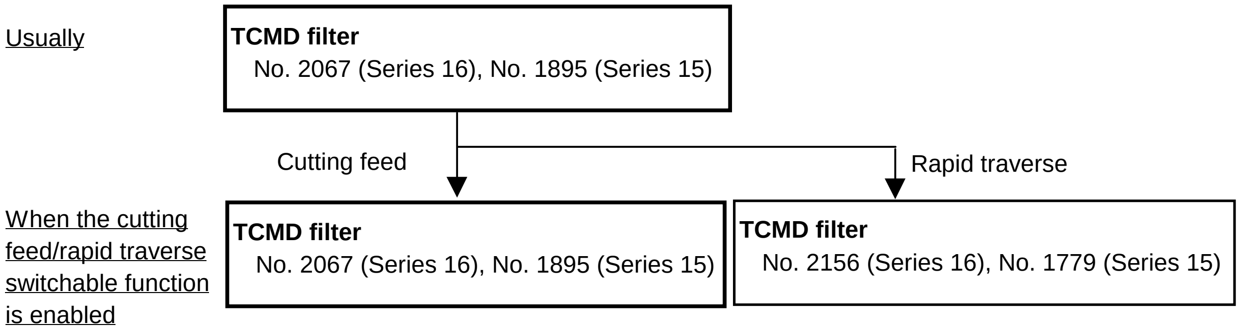
(Series 16-C, 18-C): The series/edition of the CNC software is the same as <1>.

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



<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]

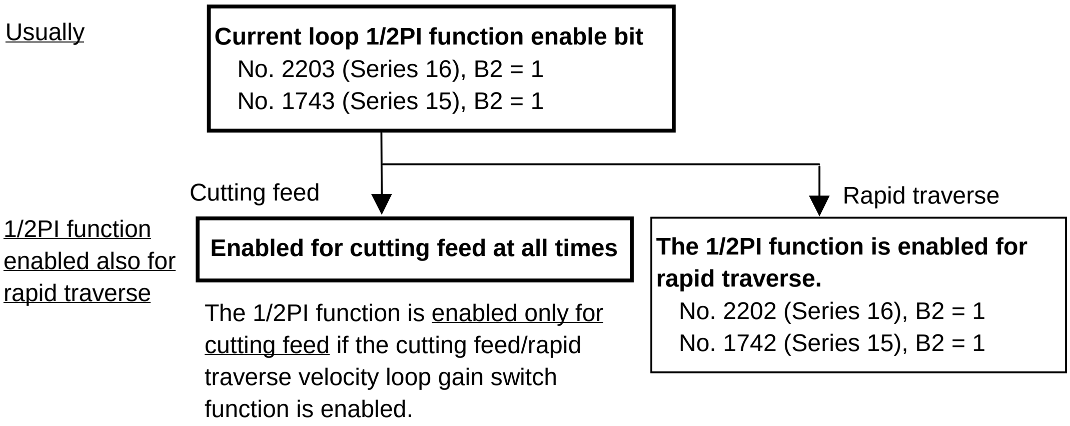
Series 9080/X(25) and subsequent editions
(Series 16-C, 18-C): The series/edition of the CNC software is the same as <1>.

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 **No. 2202**						**CPIAL**		

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.

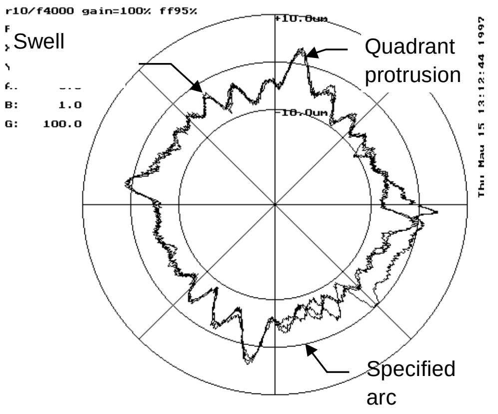


Fig. 3.4.3 (a) Feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 95%
FAD time constant: 24 ms (linear type)

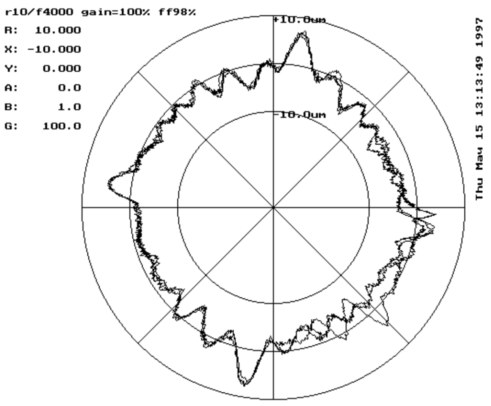


Fig. 3.4.3 (b) Feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 98%
FAD time constant: 24 ms (linear type)

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)).

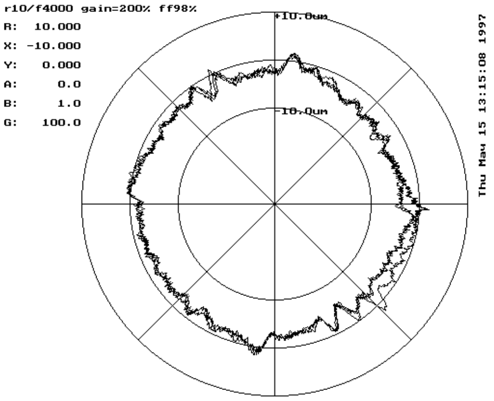


Fig. 3.4.3 (c) Effect of velocity loop gain
Velocity loop gain: 200%
Advanced preview feed-forward coefficient: 98%
FAD time constant: 24 ms (linear type)

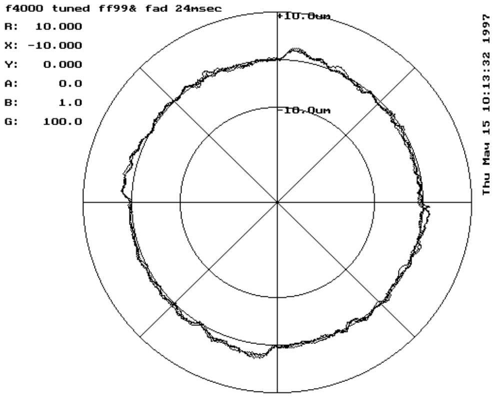


Fig. 3.4.3 (d) Effect of velocity loop gain
Velocity loop gain: 300%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)

(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.)

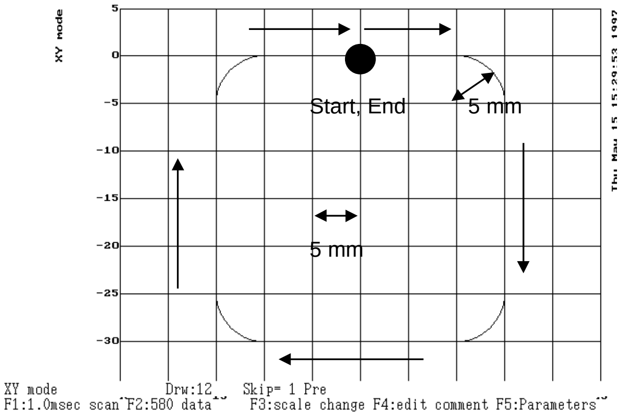


Fig. 3.4.3 (e) Programmed figure

```
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.

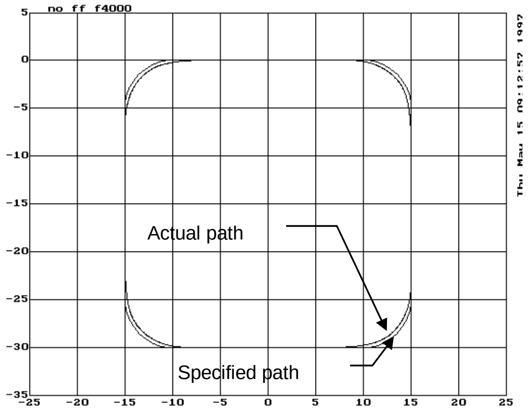


Fig. 3.4.3 (f) Specified path and actual path

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.

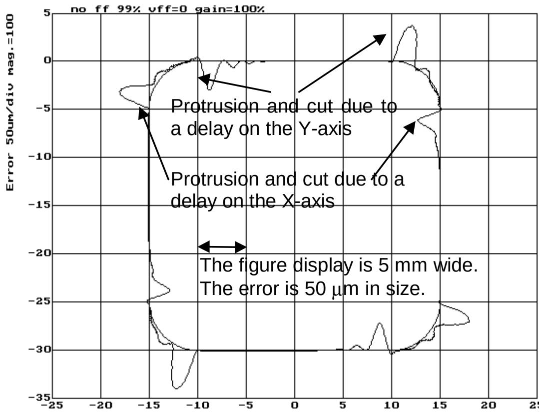


Fig. 3.4.3 (g) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: 0%

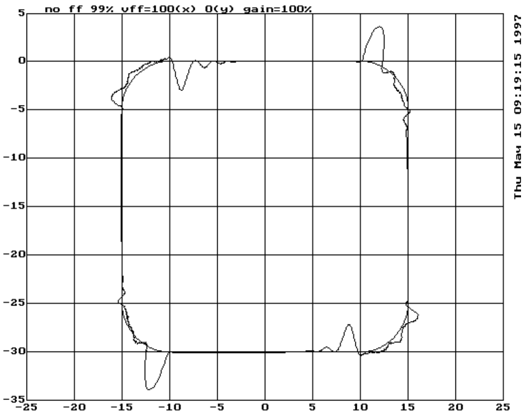


Fig. 3.4.3 (h) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X100%

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.

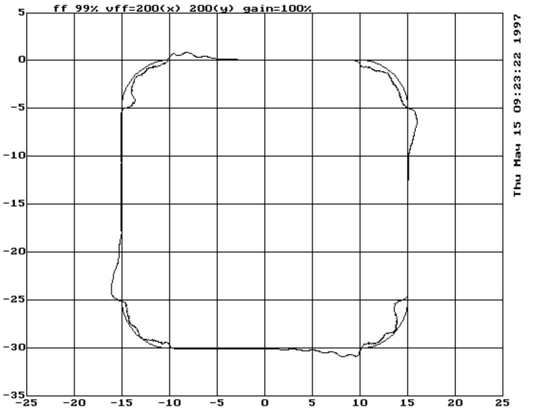


Fig. 3.4.3 (i) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X200%, Y200%

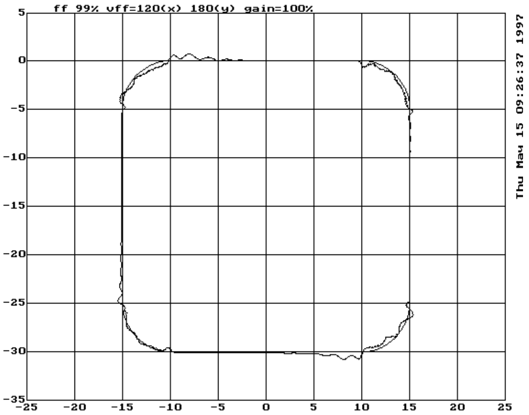
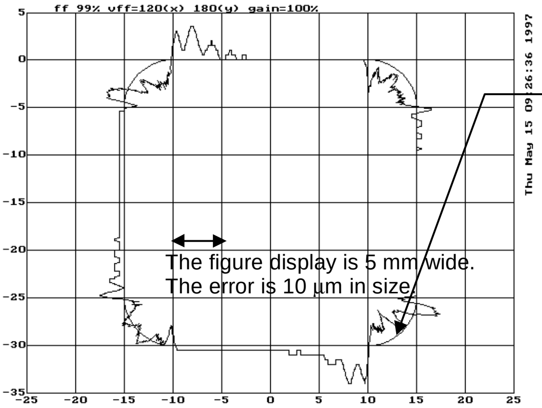


Fig. 3.4.3 (j) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X120%, Y180%

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).



The figure display is 5 mm wide.
The error is 10 µm in size.

Machine vibration caused by insufficient velocity control response is observed.

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).

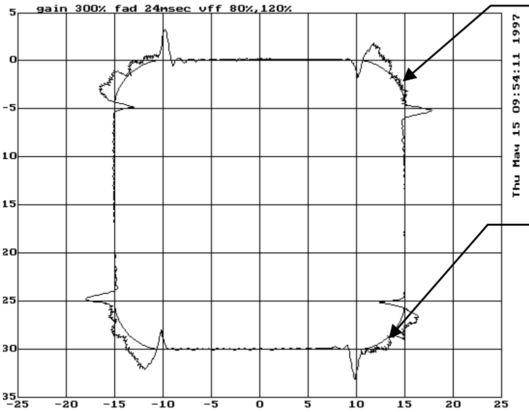


Figure errors in this area cannot be fully eliminated by increasing the velocity loop gain.

Swells can be reduced by increasing the velocity loop gain.

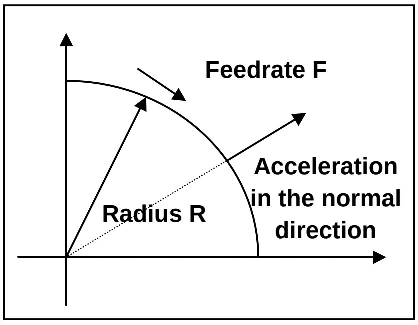
Fig. 3.4.3 (l) Velocity feed-forward adjustment
<u>Velocity loop gain: 300%</u>
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X120%, Y180%

(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:

$F^2/R = (4000/60)^2/5 = 889 \text{ mm/sec}^2$

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.

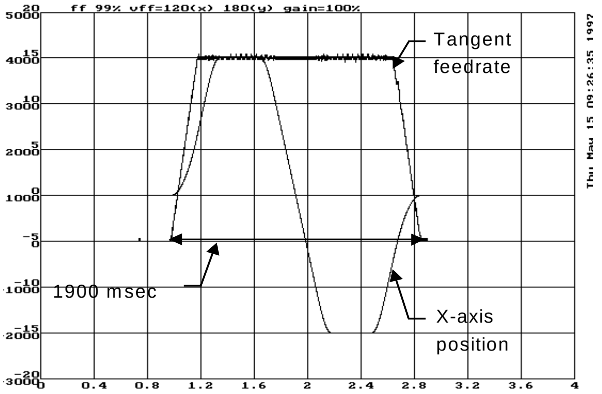


Fig. 3.4.3 (m) When the arc radius based feedrate clamp function is not used

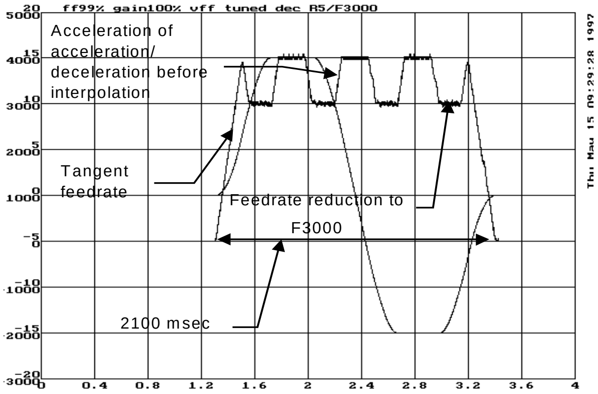


Fig. 3.4.3 (n) When the arc radius based feedrate clamp function is used

[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)

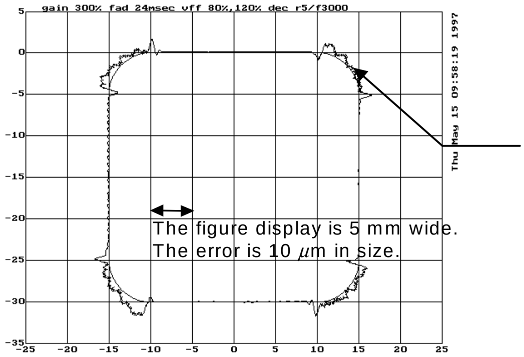
Medium-size or small machining centers with a relatively high rigidity: F3000 for R5 (500 mm/sec^2)

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.



The figure display is 5 mm wide.
The error is 10 μm in size.

The figure errors at the entries and exits of each arc area 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.

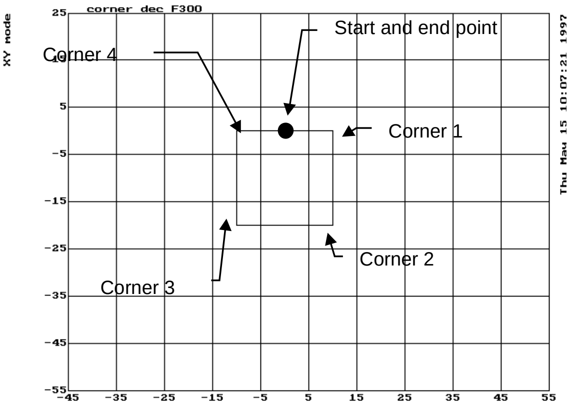
[Guideline for setting]

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.

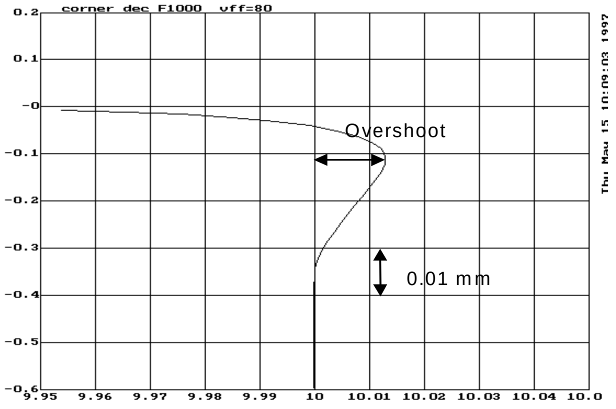


Fig. 3.4.3 (q) Reduced corner feedrate F1000

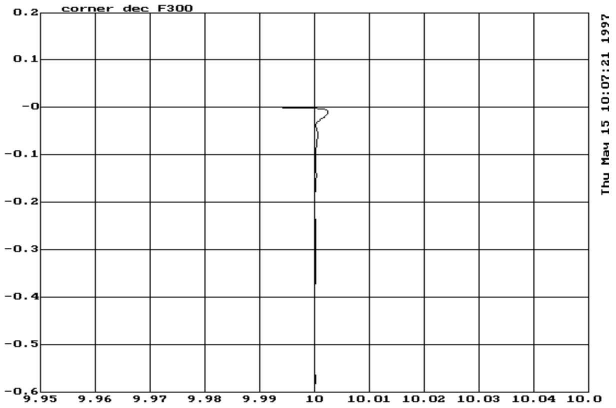


Fig. 3.4.3 (r) Reduced corner feedrate F300

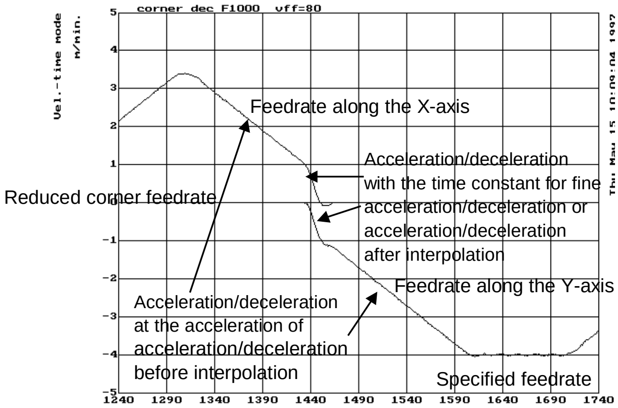


Fig. 3.4.3 (s) Time and feedrate relationship for reduced corner feedrate F1000

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.

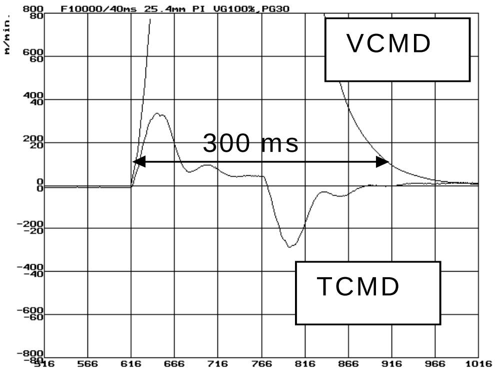


Fig. 3.4.4 (a) When PI control is used

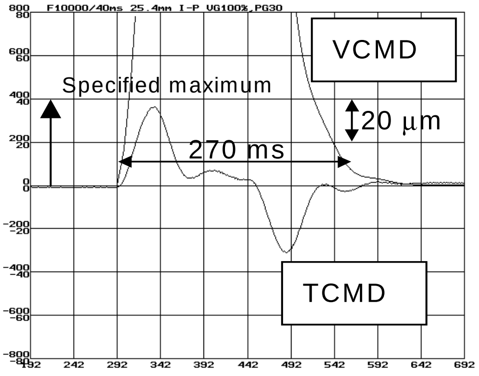
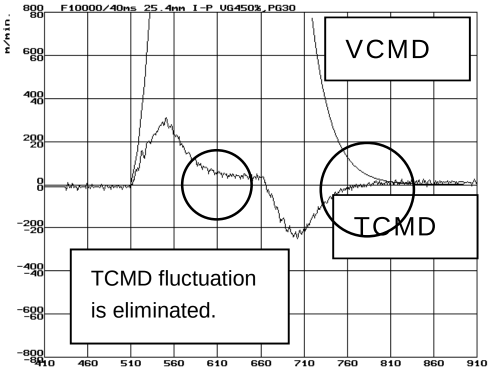


Fig. 3.4.4 (b) When I-P control is used

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



TCMD fluctuation is eliminated.

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).

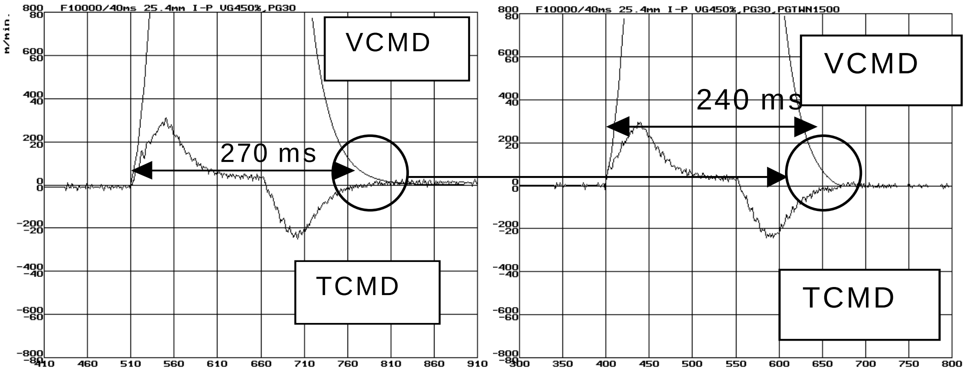
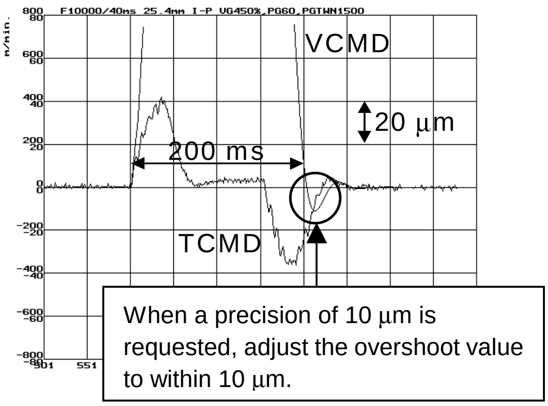
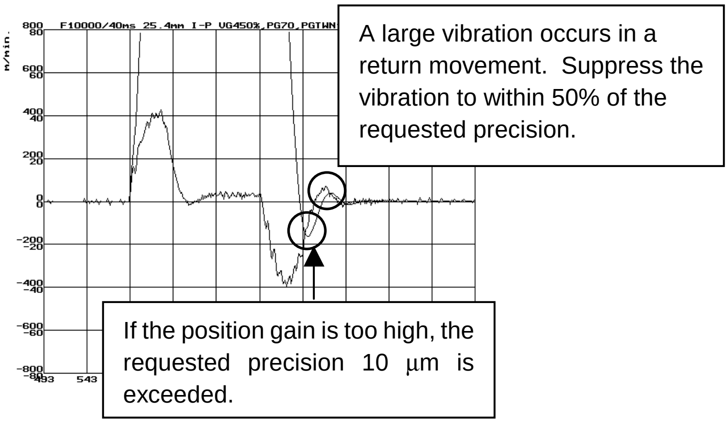


Fig. 3.4.4 (d) Position gain switch function

<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>.



When a precision of 10 µm is requested, adjust the overshoot value to within 10 µm.



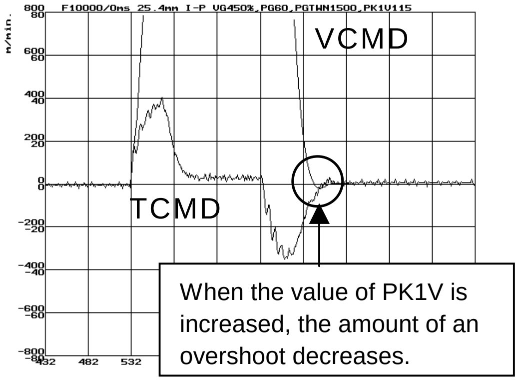
A large vibration occurs in a return movement. Suppress the vibration to within 50% of the requested precision.

If the position gain is too high, the requested precision 10 µm is exceeded.

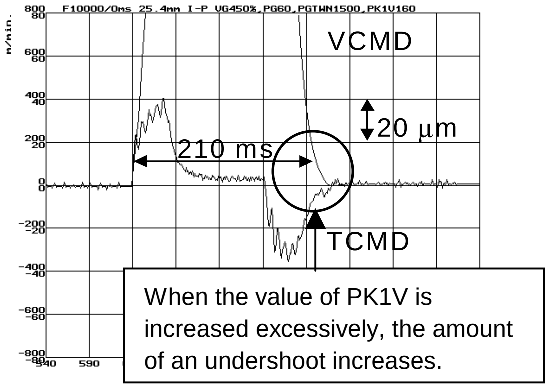
Fig. 3.4.4 (e) Adequate position gain

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.



When the value of PK1V is increased, the amount of an overshoot decreases.



When the value of PK1V is increased excessively, the amount of an undershoot increases.

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)).

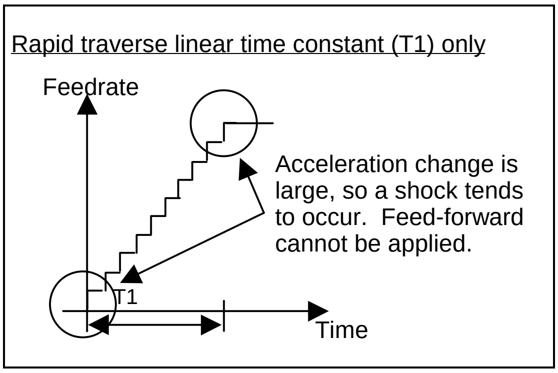


Fig. 3.4.5 (a) Rapid traverse linear acceleration/deceleration

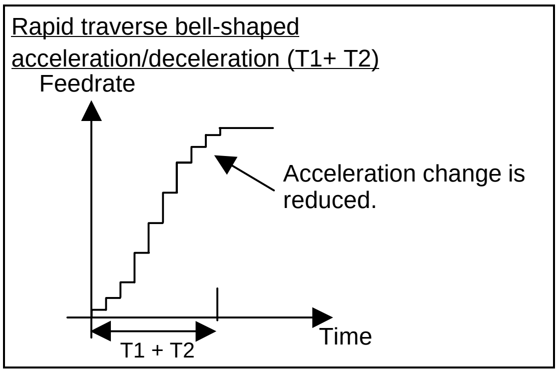
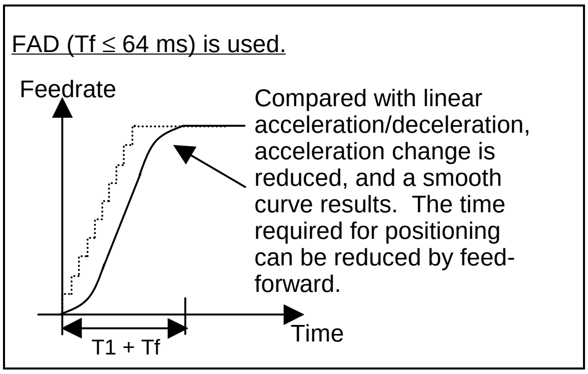


Fig. 3.4.5 (b) Rapid traverse bell-shaped acceleration/deceleration

(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.

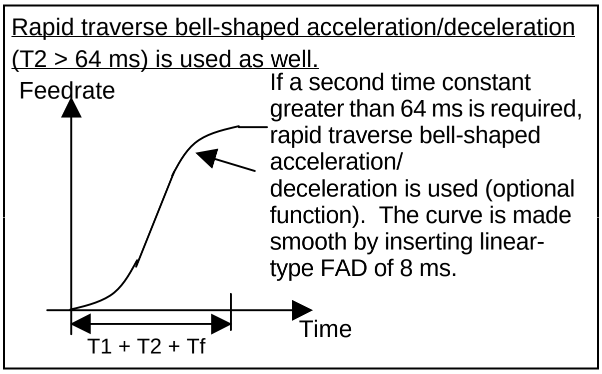
If feed-forward close to 100% is applied to normal acceleration/deceleration (Fig. 3.4.5 (a) and (b)), a mechanical shock due to acceleration change at the start and end of acceleration/deceleration, and a torque command vibration during acceleration/deceleration can pose a problem. To cope with this,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



FAD (Tf ≤ 64 ms) is used.

Compared with linear acceleration/deceleration, acceleration change is reduced, and a smooth curve results. The time required for positioning can be reduced by feed-forward.

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



Rapid traverse bell-shaped acceleration/deceleration (T2 > 64 ms) is used as well.

If a second time constant greater than 64 ms is required, rapid traverse bell-shaped acceleration/deceleration is used (optional function). The curve is made smooth by inserting linear-type FAD of 8 ms.

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.

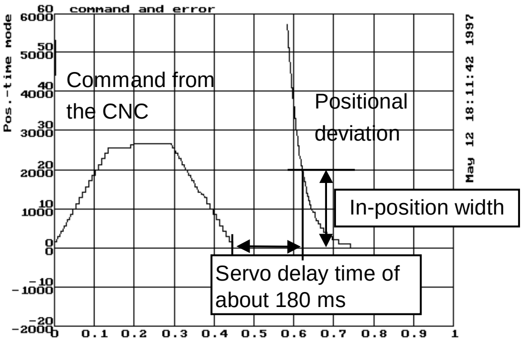


Fig. 3.4.5 (e) Measurement of time before adjustment

<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

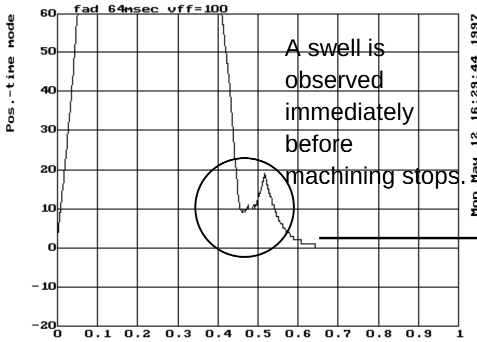
*1 When using different values for cutting and rapid traverse, use the cutting feed/rapid traverse switchable fine acceleration/deceleration function according to Subsec. 3.4.2, "Cutting Feed/Rapid Traverse Switchable Function."

*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)).



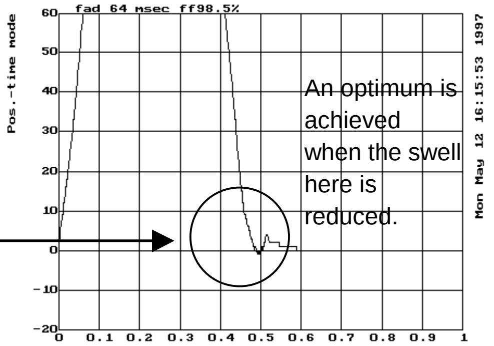
A swell is observed immediately before machining stops.

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

FAD: 64 ms

Feed-forward: 98.5%

Velocity feed-forward coefficient: <u>100%</u>



An optimum is achieved when the swell here is reduced.

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

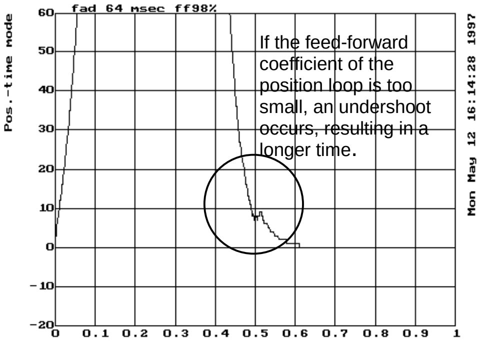
FAD: 64 ms

Feed-forward: 98.5%

Velocity feed-forward coefficient: <u>250%</u>

<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%.



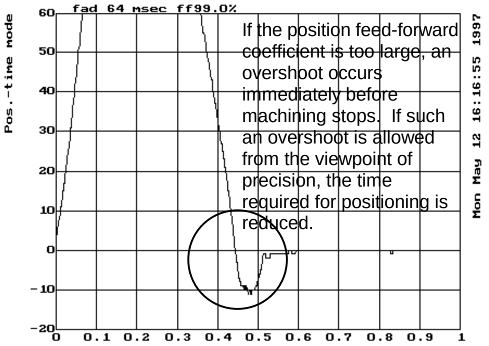
If the feed-forward coefficient of the position loop is too small, an undershoot occurs, resulting in a longer time.

Fig. 3.4.5 (h) When the feed-forward coefficient is too small

FAD: 64 ms

Feed-forward: <u>98%</u>

Velocity feed-forward coefficient: 250%



If the position feed-forward coefficient is too large, an overshoot occurs immediately before machining stops. If such an overshoot is allowed from the viewpoint of precision, the time required for positioning is reduced.

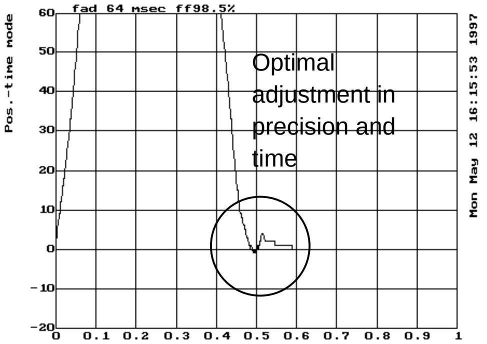
Fig. 3.4.5 (i) When the feed-forward coefficient is too high

FAD: 64 ms

Feed-forward: <u>99%</u>

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).



Optimal adjustment in precision and time

Fig. 3.4.5 (j) When an adequate feed-forward coefficient is set

FAD: 64 ms

Feed-forward: <u>98.5%</u>

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

Servo software series Function name	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

Servo software series **Function name**	**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**								

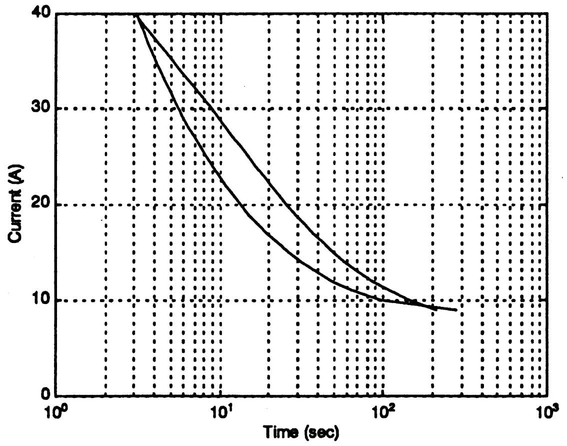
OVCR(#6) 1: To enable OVC alarm improvement

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

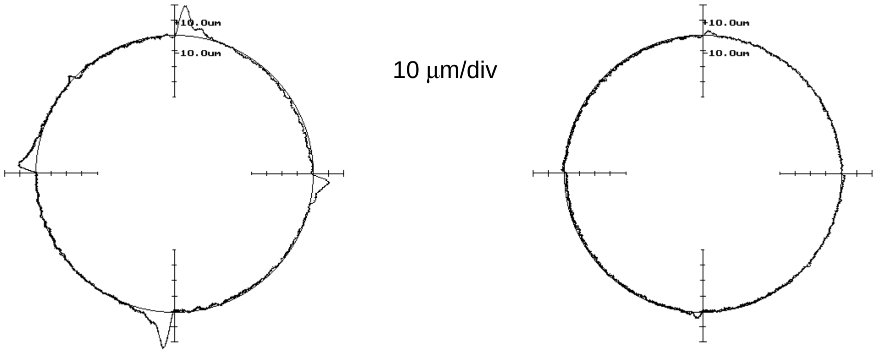
4.3 LEVEL-UP HRV CONTROL

(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:

1809	–
2004	–

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

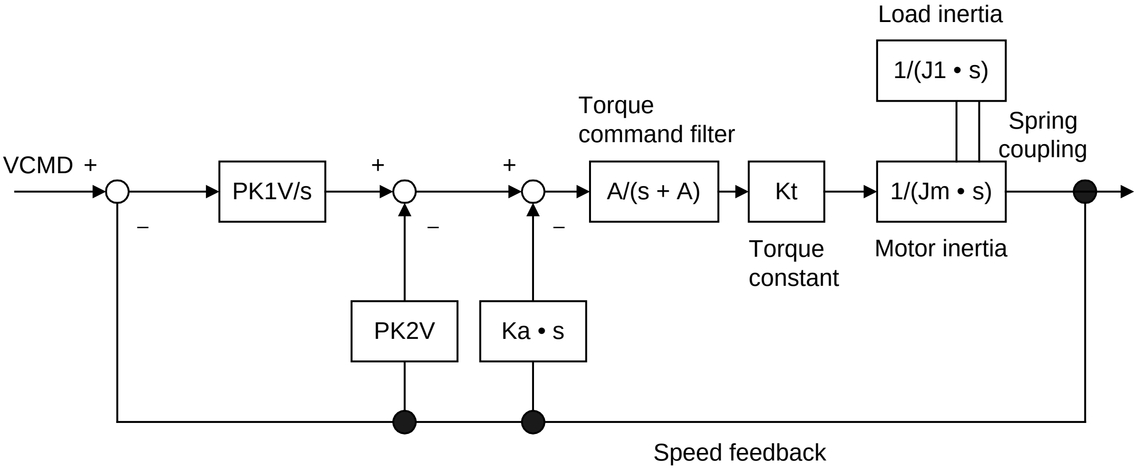
The acceleration feedback function is used to control velocity loop oscillation by using motor speed feedback signal multiplied by the acceleration feedback gain to compensate the torque command.

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*)

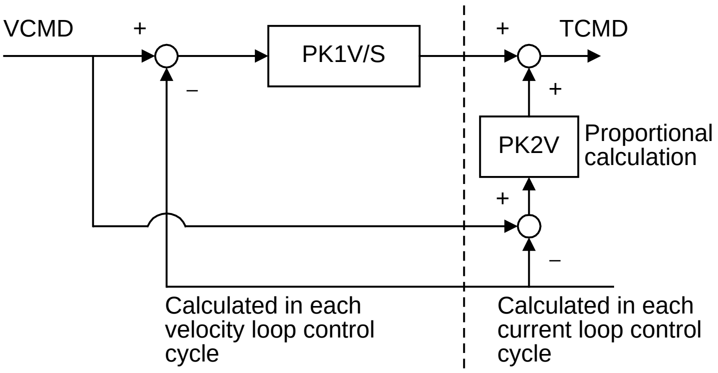
(3) Setting parameters

● 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.

Configuration of the control system (for PI control)



(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.

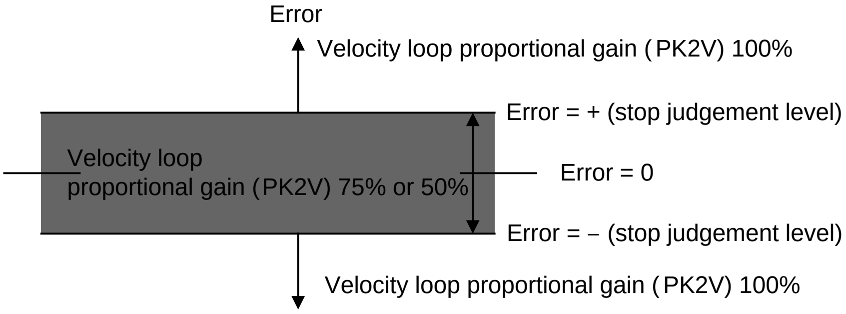


Fig. 4.4.3 Relationship between error and velocity loop proportional gain (PK2V)

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.

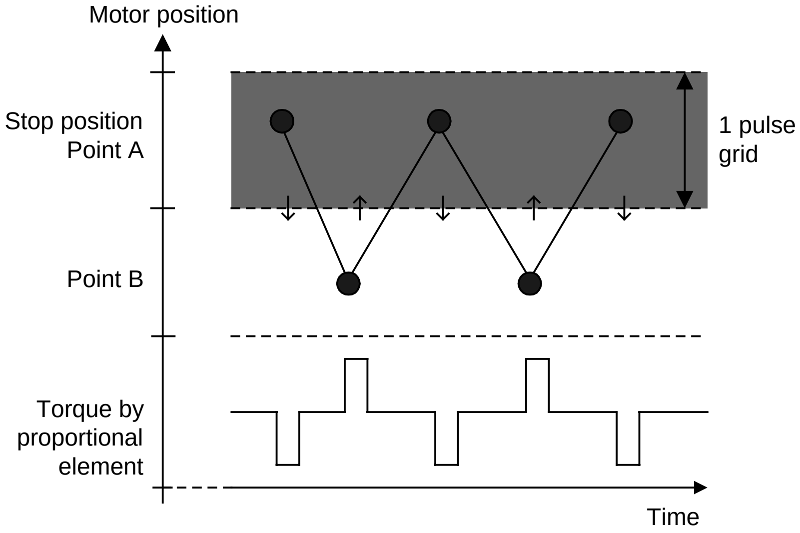


Fig. 4.4.4 (a) N pulse suppression function disabled (Torque due to the proportional term keeps up, leading to vibration.)

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.

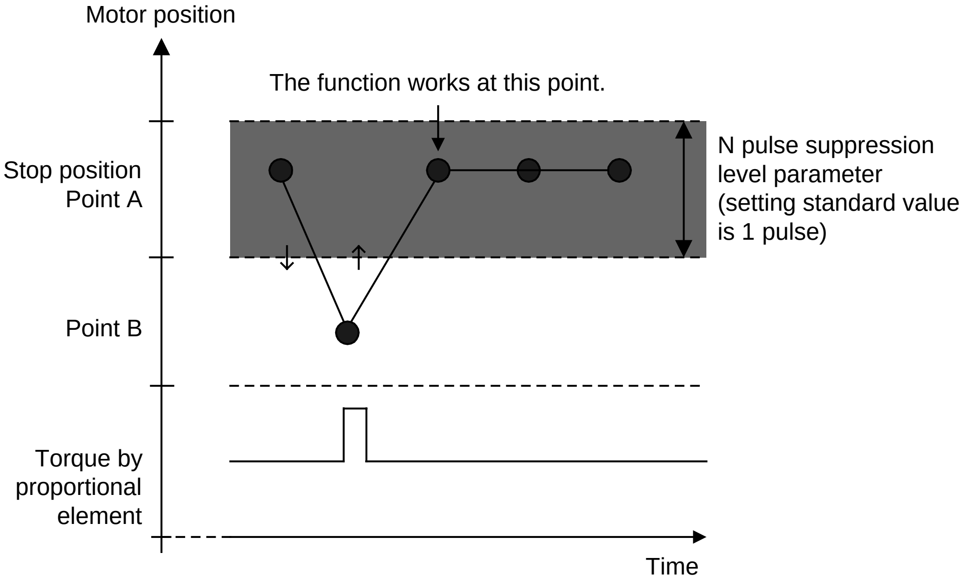


Fig. 4.4.4 (b) N pulse suppression function disabled
(The N pulse suppression function restricts the torques due to the proportional term, thus eliminating vibration.)

(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

1808	**8X03**
2003	**1003**

#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
			NPSP				

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

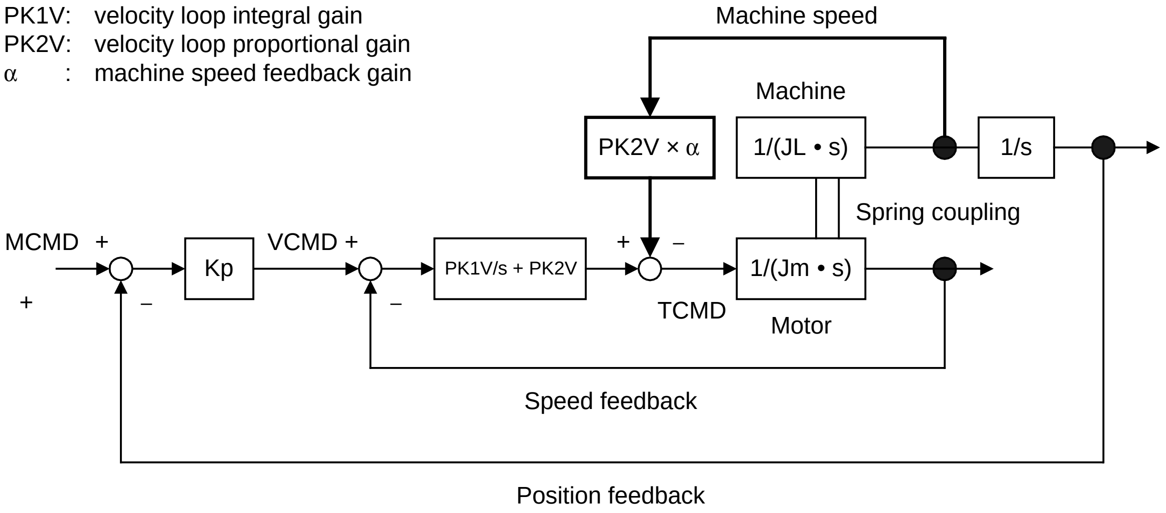


Fig. 4.5.1 Position loop block diagram that includes machine speed feedback function

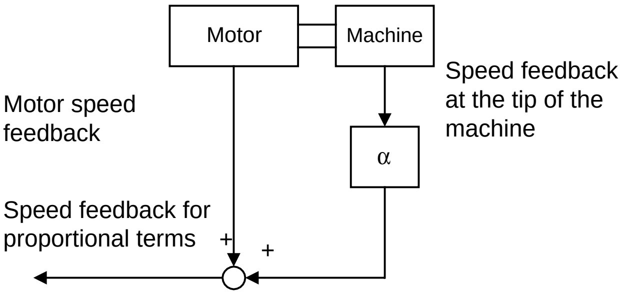
As shown in Fig. 4.5.1, this function corrects the torque command by multiplying the machine speed by machine velocity feedback gain, α, as shown by the bold line. When α = 1, the torque command is corrected equally by the motor speed and the machine speed.

(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)

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

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.
1: Enabled. ← Set this value.

● 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.

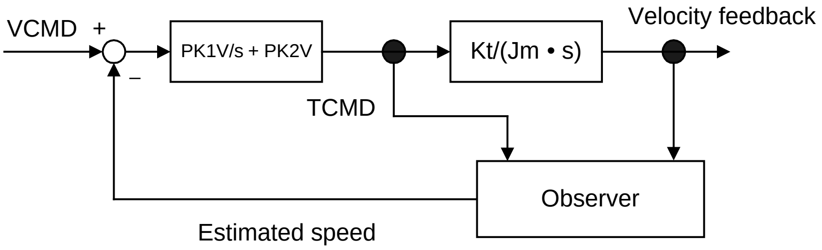


Fig. 4.5.2 (a) Configuration of velocity loop including observer

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

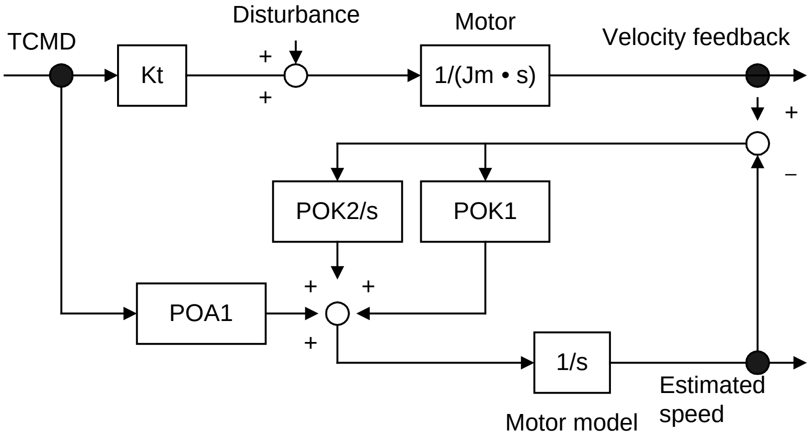


Fig. 4.5.2 (b) Block diagram of the observer

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

1808	**8X03**
2003	**1003**

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

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

1859	**8X47**
2047	**1047**

Observer coefficient (POA1)

Usually, use the standard setting.

1862	**8X50**
2050	**1050**

Observer coefficient (POK1)

Usually, use the standard setting.

1863	**8X51**
2051	**1051**

Observer coefficient (POK2)

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.

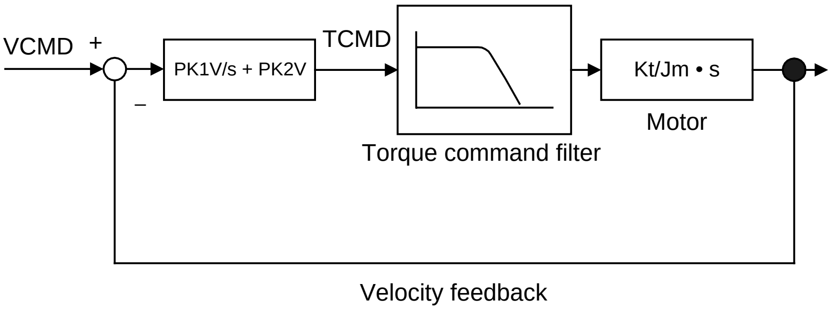


Fig. 4.5.3 Configuration of velocity loop including torque command filter

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.

Optional function

4.5.4 Dual Position Feedback 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:

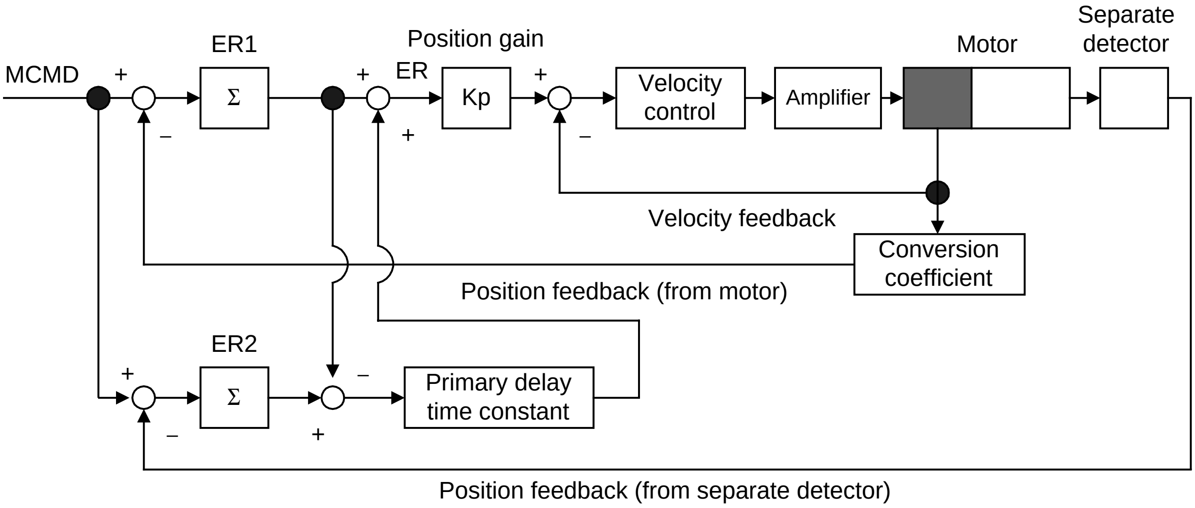


Fig. 4.5.4 Block diagram of dual position feedback control

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

1955 (Series 15-A) 1709 (Series 15*i*, 15-B)	**8X11**
2019	**1019**

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

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

1861	**8X49**
2049	**1049**

Dual position feedback maximum amplitude

[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**
2078	**1078**

Dual position feedback conversion coefficient (numerator)

1972	**8X79**
2079	**1079**

Dual position feedback conversion coefficient (denominator)

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

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

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**
2080	**1080**

Dual position feedback primary delay time constant

[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**
2081	**1081**

Dual position feedback zero-point amplitude

[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**
2118	**Not supported**

Dual position feedback: Level on which the difference in error between the semi-closed and full-closed modes becomes too large

[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.

1954	**8X10**
2010	**1010**

#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
		HBBL	**HBPE**				

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)

1746	**Not supported**
2206	**Not supported**

#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
			HBSF				

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.

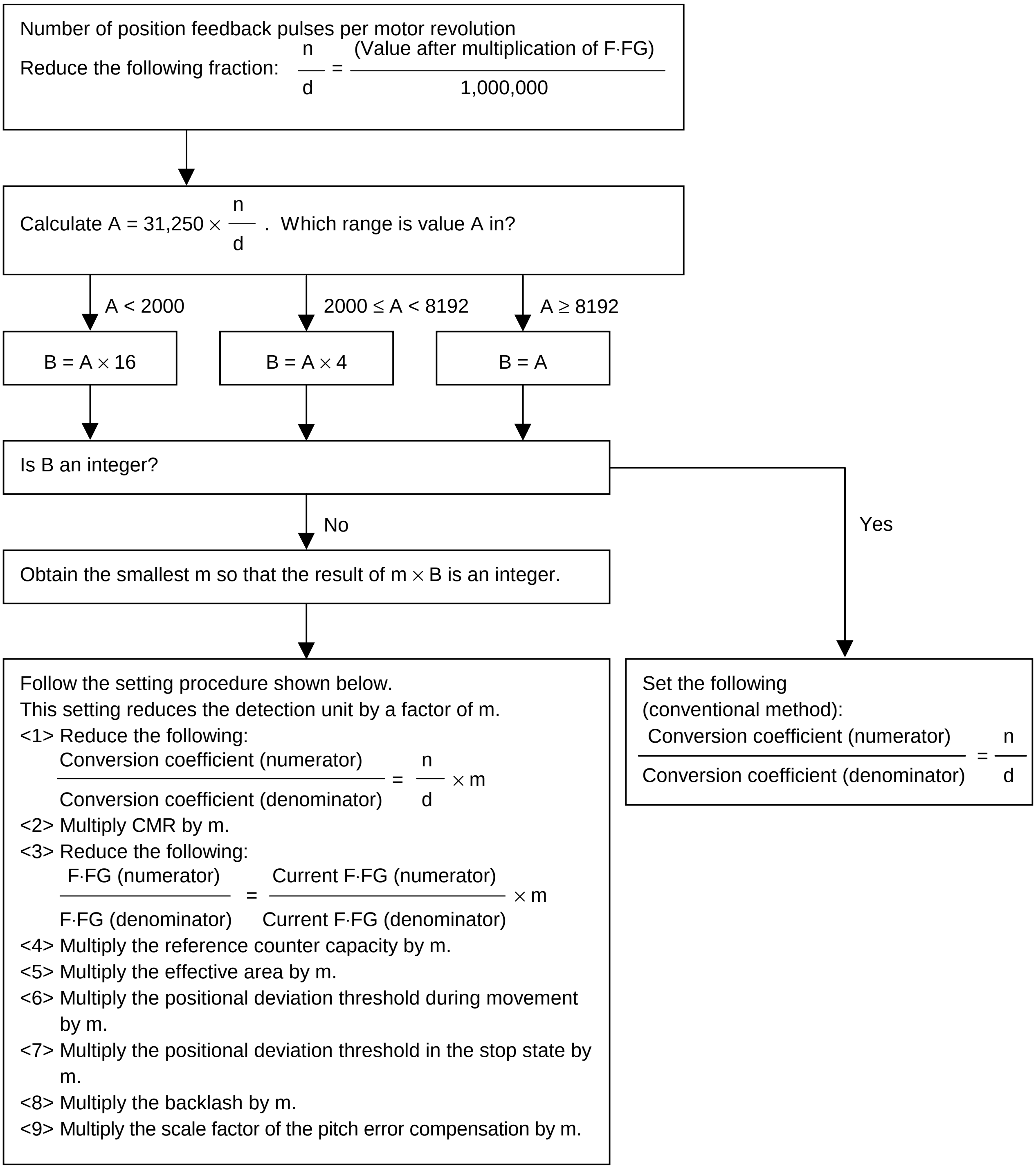
(7) Cautions on setting of the dual position feedback conversion coefficient

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



Number of position feedback pulses per motor revolution

Reduce the following fraction: $\frac{n}{d} = \frac{\text{(Value after multiplication of F·FG)}}{1{,}000{,}000}$

Calculate $A = 31{,}250 \times \frac{n}{d}$. Which range is value A in?

Is B an integer?

Obtain the smallest m so that the result of m × B is an integer.

Follow the setting procedure shown below.
This setting reduces the detection unit by a factor of m.

<1> Reduce the following:

$$\frac{\text{Conversion coefficient (numerator)}}{\text{Conversion coefficient (denominator)}} = \frac{n}{d} \times m$$

<2> Multiply CMR by m.

<3> Reduce the following:

$$\frac{\text{F·FG (numerator)}}{\text{F·FG (denominator)}} = \frac{\text{Current F·FG (numerator)}}{\text{Current F·FG (denominator)}} \times m$$

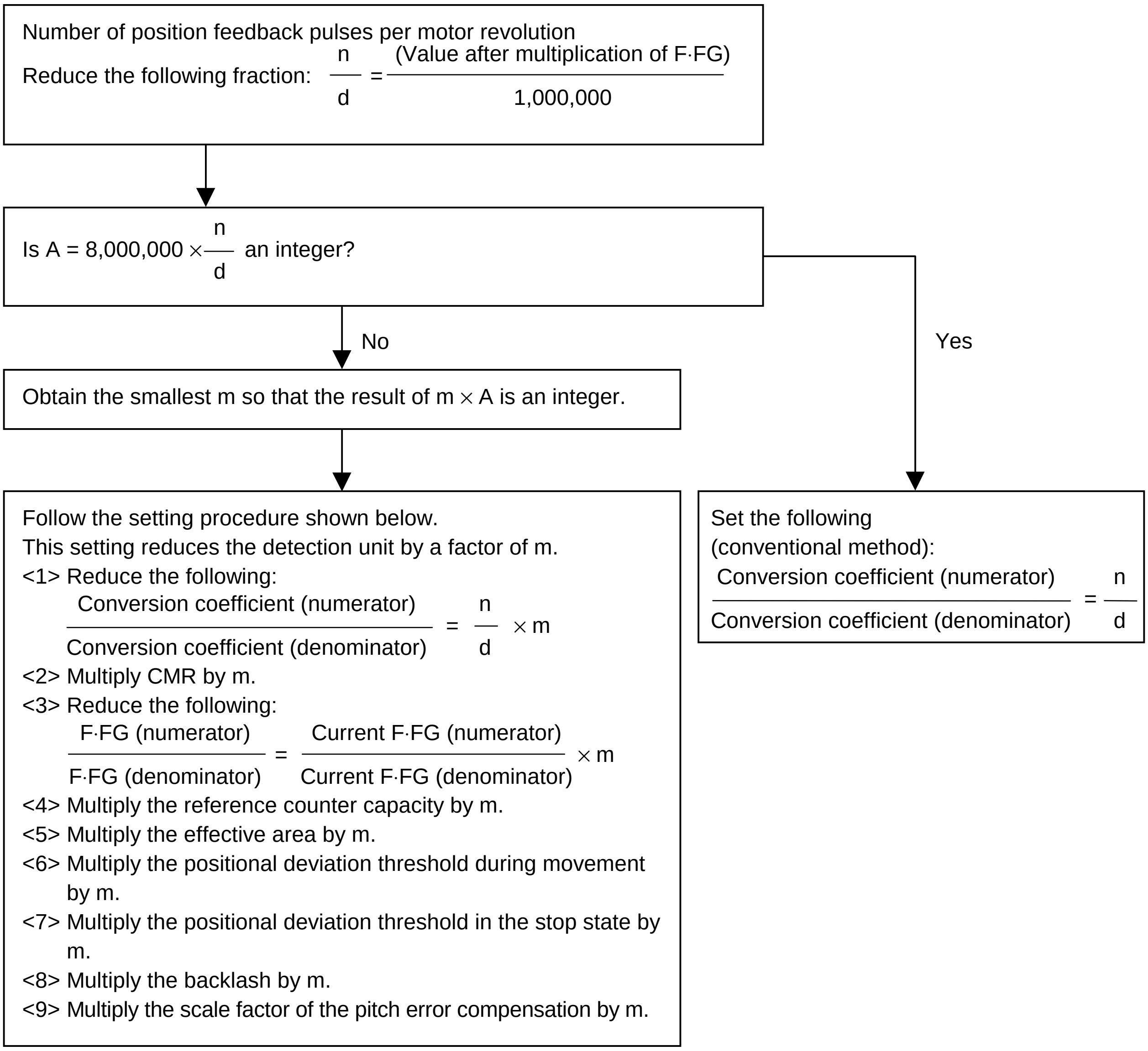
<4> Multiply the reference counter capacity by m.
<5> Multiply the effective area by m.
<6> Multiply the positional deviation threshold during movement by m.
<7> Multiply the positional deviation threshold in the stop state by m.
<8> Multiply the backlash by m.
<9> Multiply the scale factor of the pitch error compensation by m.

Set the following (conventional method):

$$\frac{\text{Conversion coefficient (numerator)}}{\text{Conversion coefficient (denominator)}} = \frac{n}{d}$$

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:

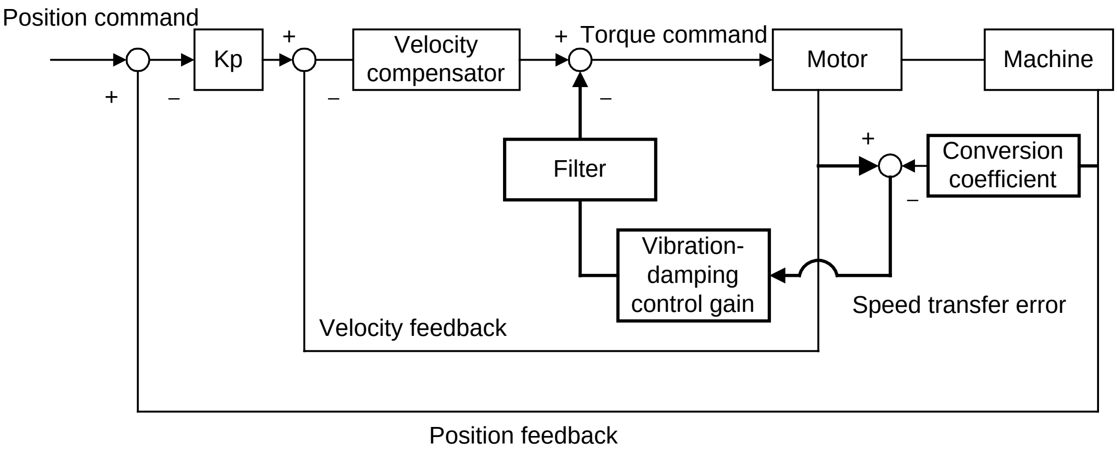


Fig. 4.5.5 Block diagram for vibration-damping control

(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

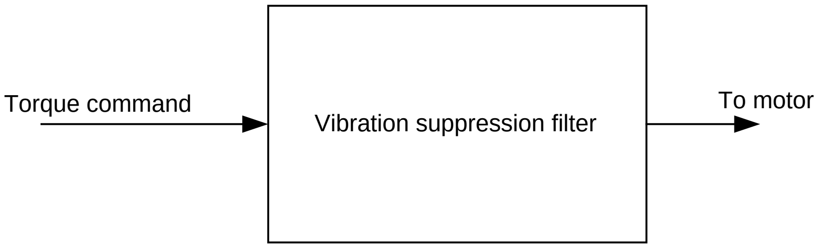


Fig. 4.5.6

(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.

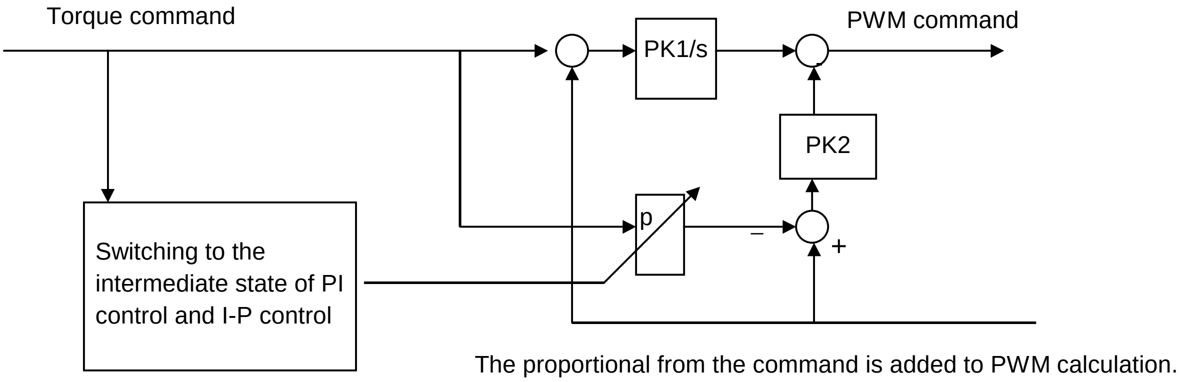


Fig. 4.5.7 Block diagram of current loop 1/2PI control

(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

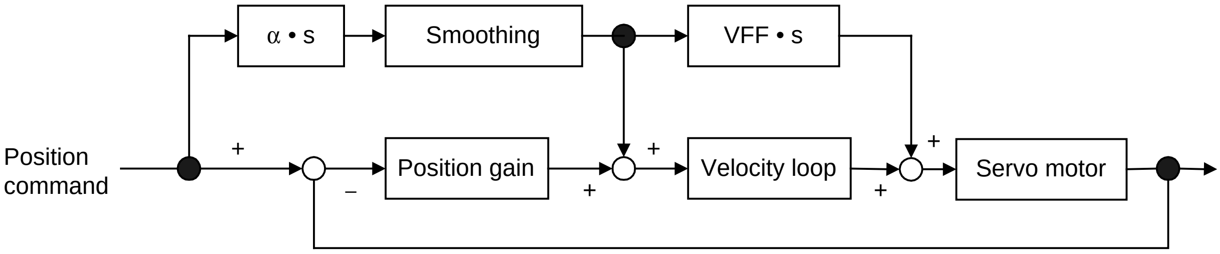
CAUTION

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



α: Feed-forward coefficient (0 to 1)
VFF: Velocity loop feed-forward coefficient

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.

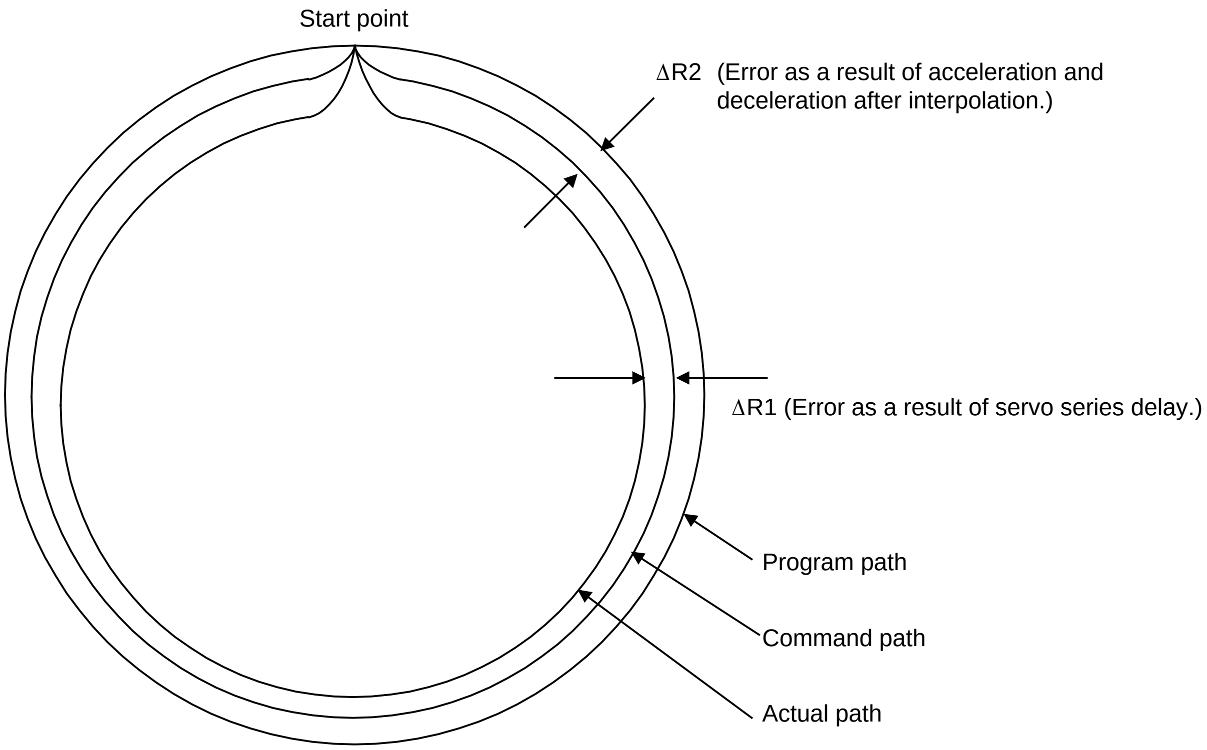


Fig. 4.6.1 (b) Path error during circular cutting

(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.

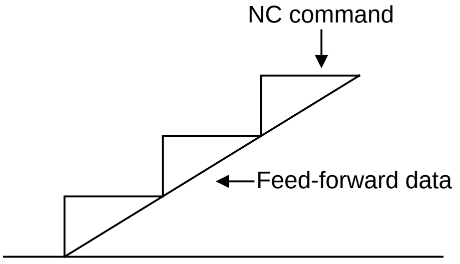


Fig. 4.6.2 (a) Conventional feed-forward control

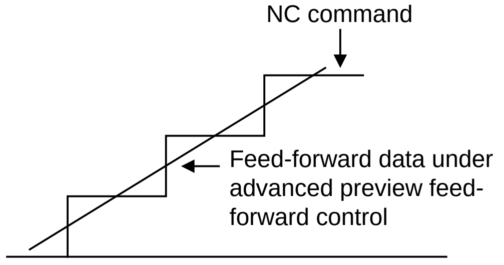


Fig. 4.6.2 (b) Advanced preview feed-forward control

(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)

= $\alpha \times 10000$ ($0 \le \alpha \le 1$)

[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

$\left.\begin{array}{l}\text{c}\\\text{c}\\\text{c}\end{array}\right\}$ Advanced preview feed-forward enabled

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.

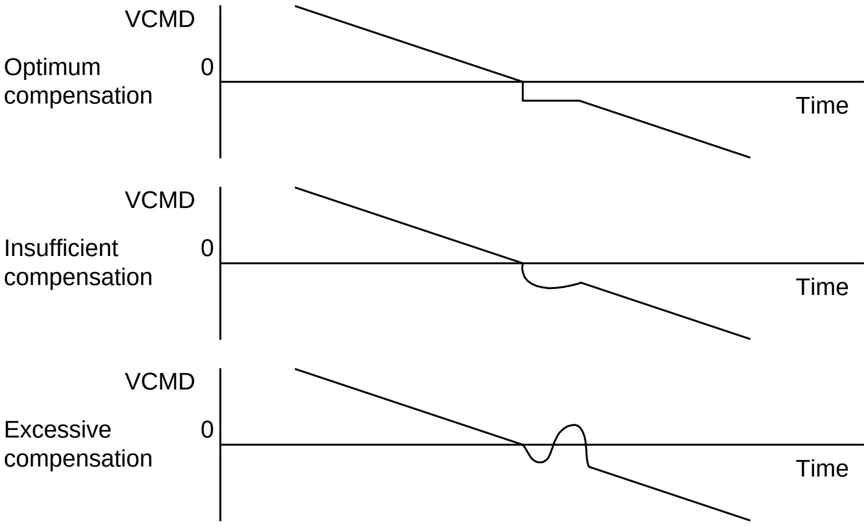


Fig. 4.6.4 (a) Two-stage backlash adjustment using the VCMD waveform

4.6.5 Two-stage Backlash Acceleration Function

(1) Overview

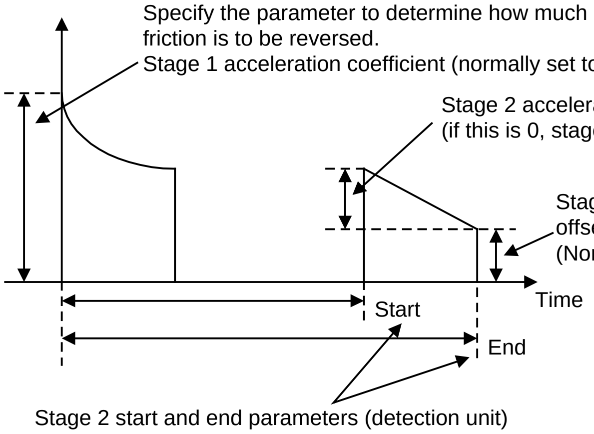
When the machine reverses the direction of feed, two types of delay are likely to occur; one type due to friction in the motor and the other due to friction in the machine.

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:



The stage 1 compensation value is determined automatically. Specify the parameter to determine how much of the estimated friction is to be reversed.
Stage 1 acceleration coefficient (normally set to 100%)

Stage 2 acceleration amount
(if this is 0, stage 2 does not occur.)

Stage 2 acceleration offset
(Normally, 0 is set.)

Stage 2 start and end parameters (detection unit)
The start point of stage 2 is specified as a distance relative to the start of stage 1.
The end point is determined automatically. Normally, if the setting is positive, the end point is set at a distance two times greater than the start point distance. If the setting is negative, the end point is set at a distance three times greater than the start point distance. An arbitrary end point can also be set by setting the end scale factor parameter.

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%.)

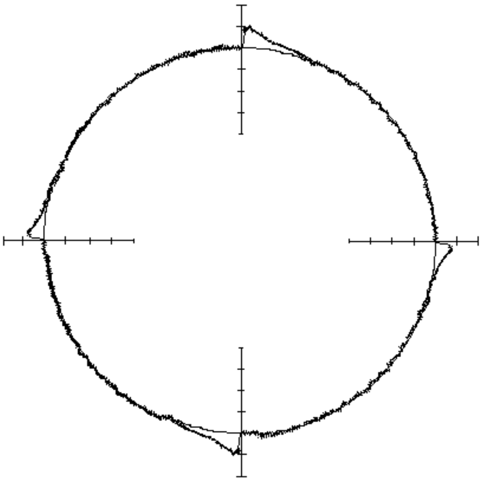
[Typical setting] 50 (Normally, optimum values range from 20% to 70%.)

1987	**–**	**Stage 1 acceleration amount from negative direction to positive direction (%)**
2094	**–**	

[Unit of data] %

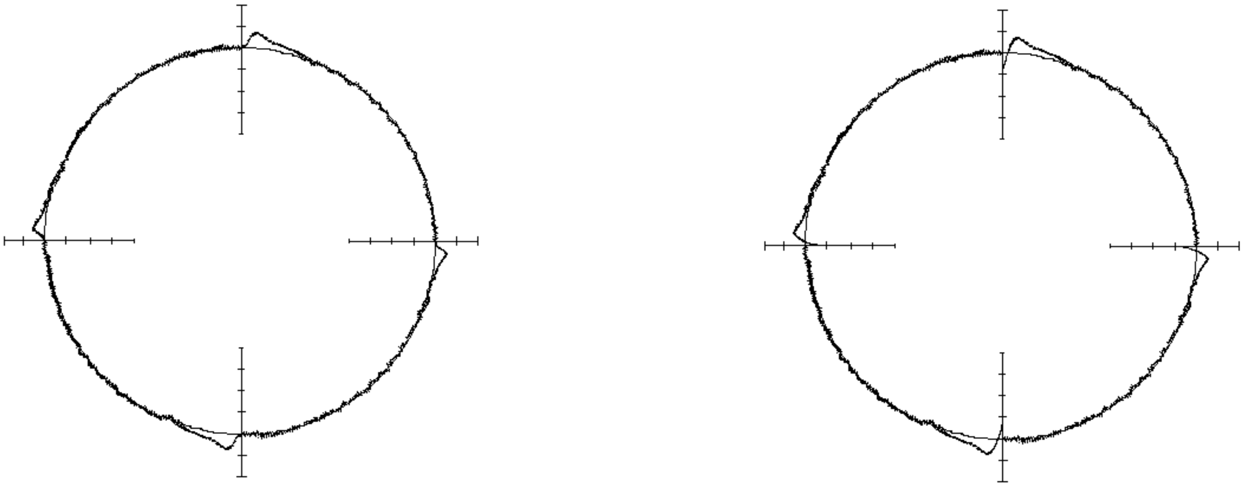
Normally, this parameter is set to 0. If the quadrant protrusion varies with the reverse direction of the position command in the machine conditions, set an appropriate value in this parameter.

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:

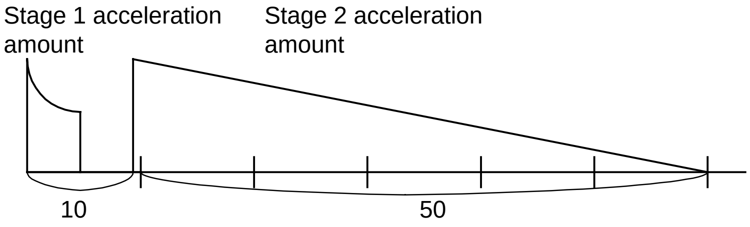
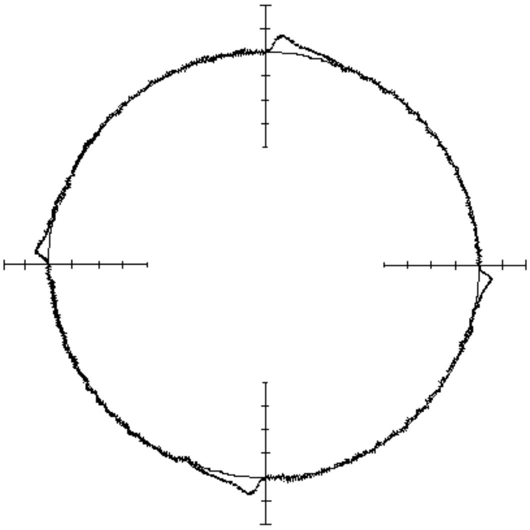
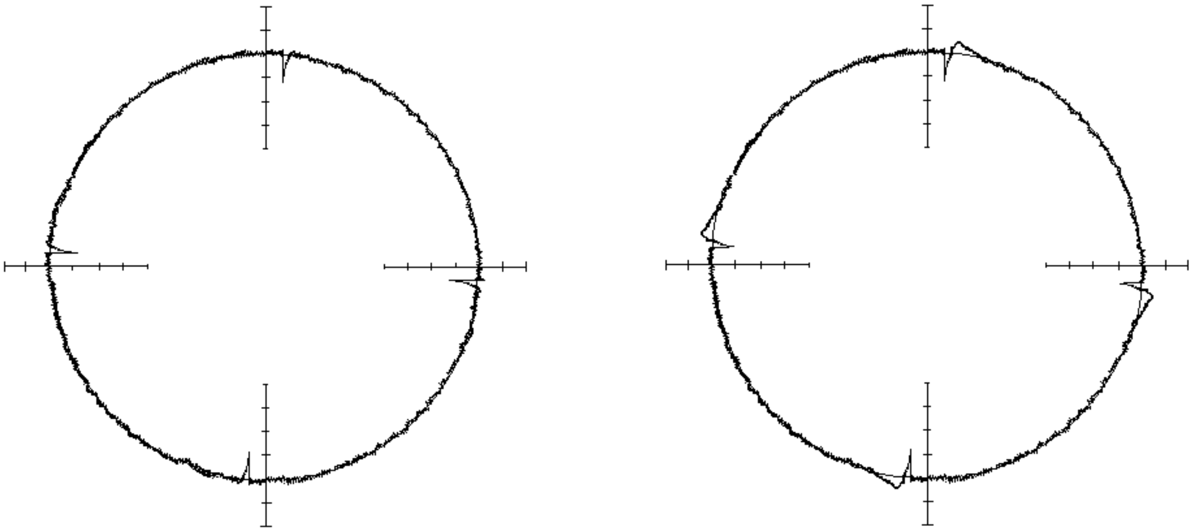


Fig. 4.6.5 (d) Stage 2 end scale factor



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.

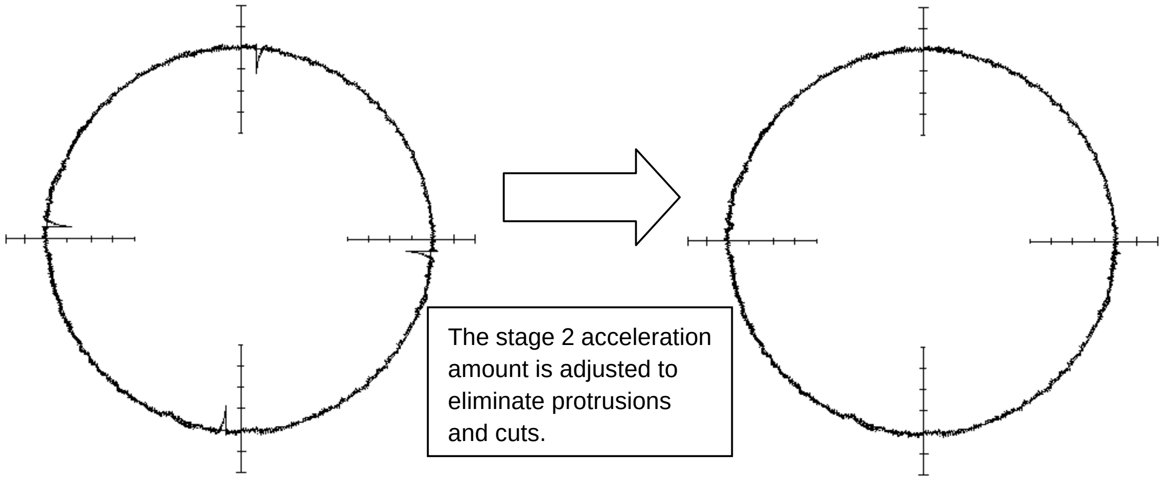
Adjust the stage 2 acceleration so that it falls in a range where no cut occurs.

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.



The stage 2 acceleration amount is adjusted to eliminate protrusions and cuts.

Before stage 2 acceleration amount adjustment (too large)

Stage 2 acceleration amount (adequate)

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, α → 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:

(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

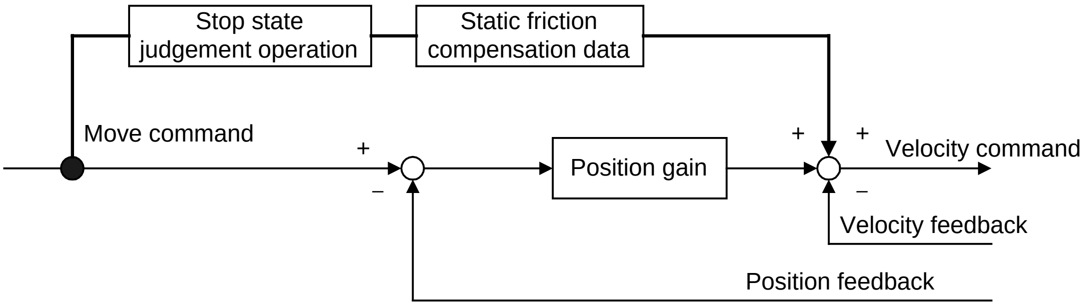
(1) Overview

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.

1883	8X05
2005	1005

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

SFCM (#7) 1: The static friction compensation function is enabled.

<2> Set adjustment parameters.

1964	8X71
2071	1071

Compensation count

[Valid data range] 0 to 32767
[Standard setting] 10

1965	8X72
2072	1072

Static friction compensation

[Valid data range] 0 to 32767
[Standard setting] 100

1996	8X73
2073	1073

Stop state judgement parameter

[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.

1953	8X09
2009	1009

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

BLST (#7) 1: The function used to release static friction compensation is enabled.

1990	8X97
2097	1097

Parameter for stopping static friction compensation

[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.

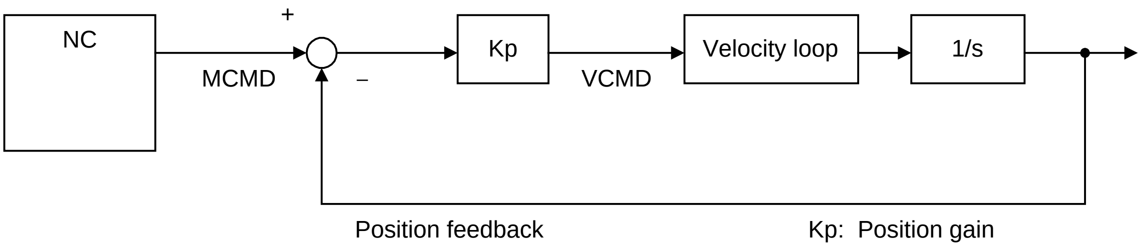


Fig. 4.7 (a) Digital servo system configuration

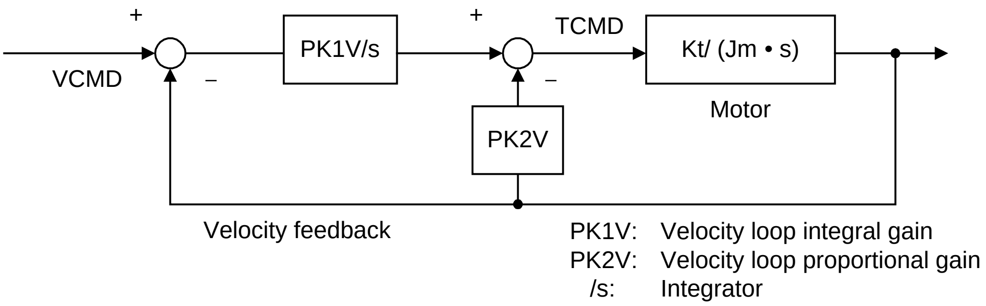


Fig. 4.7 (b) Velocity loop configuration

(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).

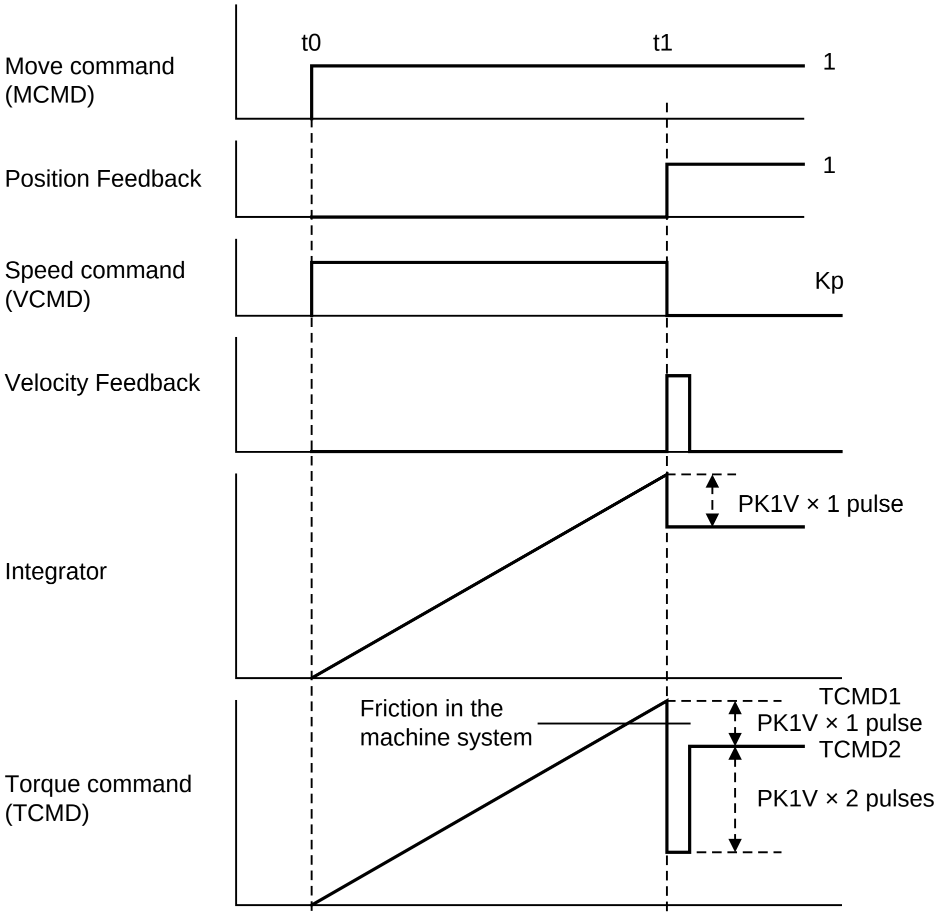


Fig. 4.7 (c) Response to 1 pulse movement commands

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)

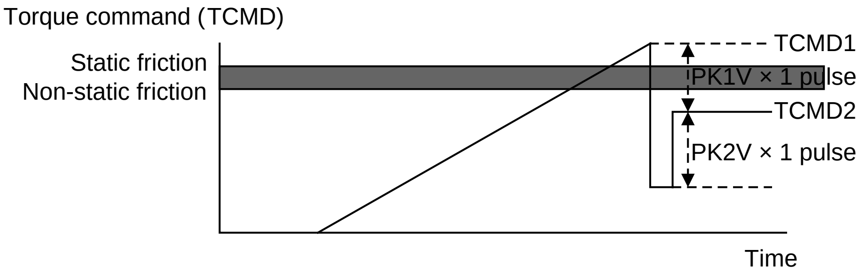


Fig. 4.7 (d) Torque commands (when there is no overshoot)

(ii) Torque commands for standard settings (during overshoot)

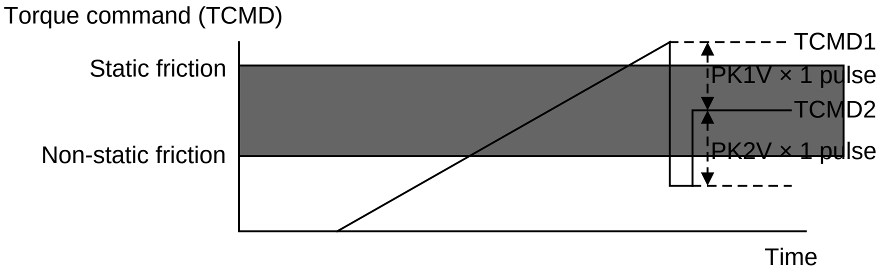


Fig. 4.7 (e) Torque commands (during overshoot)

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

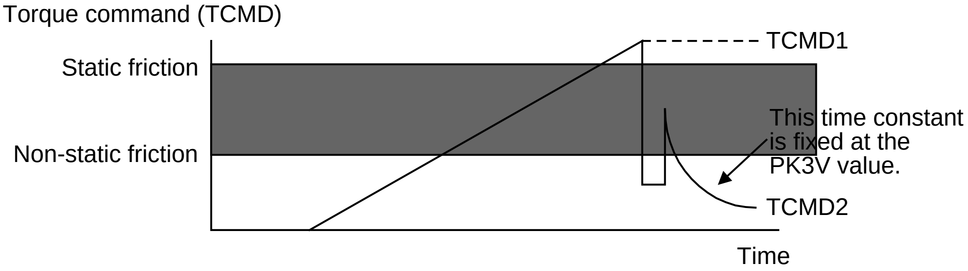


Fig. 4.7 (f) Torque command (when overshoot is used)

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.

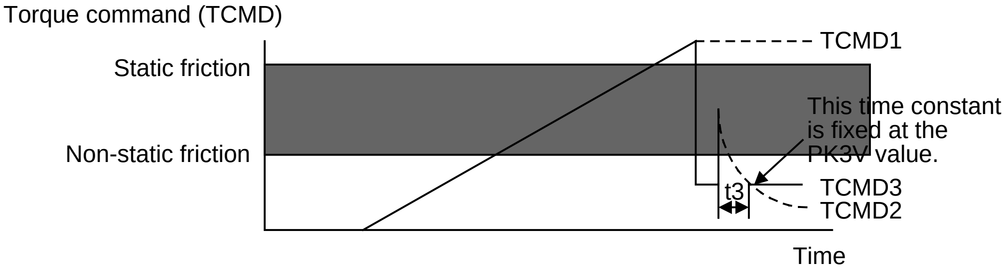


Fig. 4.7 (g) Torque command (using improved type overshoot compensation)

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.

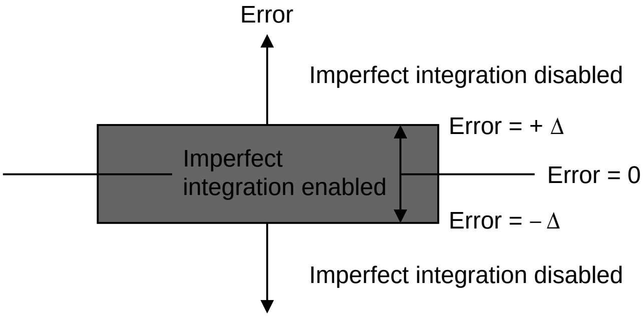


Fig. 4.7 (h) Relationship between error and overshoot compensation

(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*)

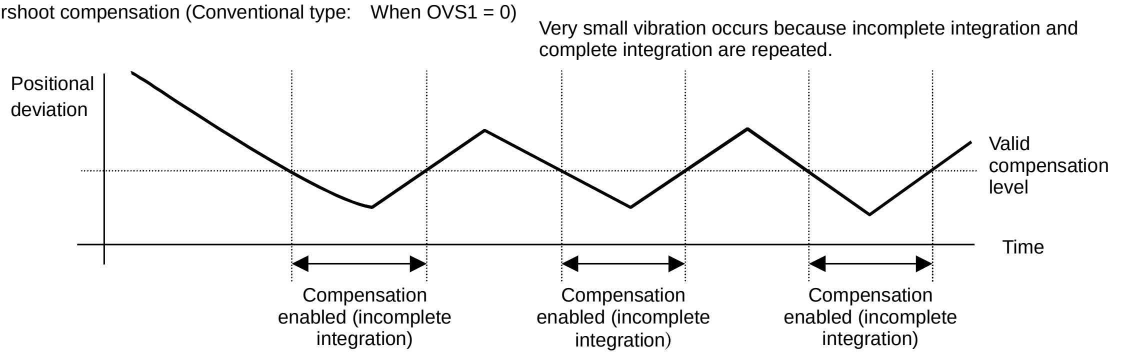
Series 90A0/A(01 and subsequent editions (Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)

(c) Setting parameters

		#7	#6	#5	#4	#3	#2	#1	#0
1742	–					**OVS1**			
2202	–								

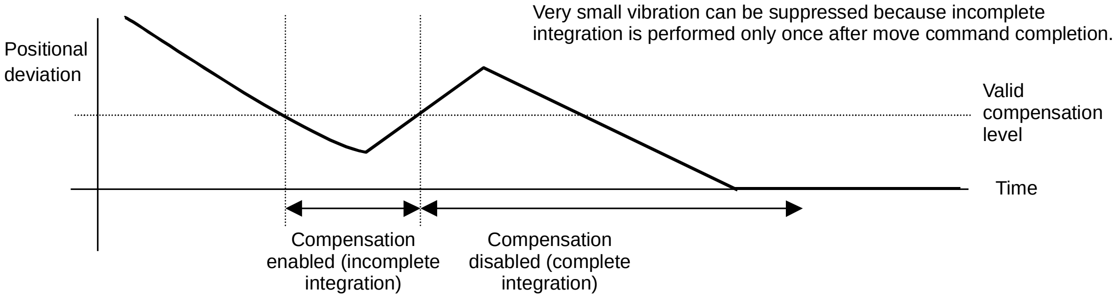
OVS1 (#3) 1: Overshoot compensation is enabled only once after the termination of a move command.

Overshoot compensation (Conventional type: When OVS1 = 0)



Very small vibration occurs because incomplete integration and complete integration are repeated.

Overshoot compensation (Type 2: When OVS1 = 1)



Very small vibration can be suppressed because incomplete integration is performed only once after move command completion.

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.)

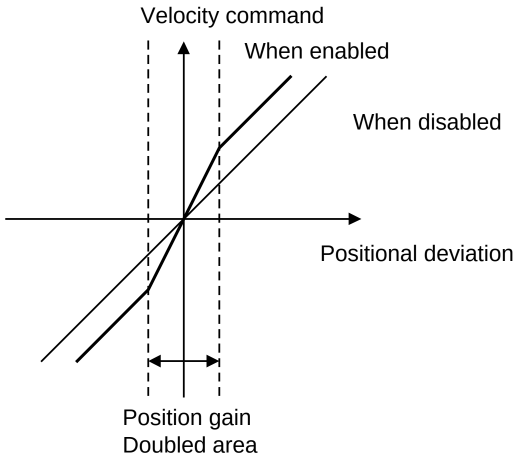


Fig. 4.8.1 (a) Position gain switching

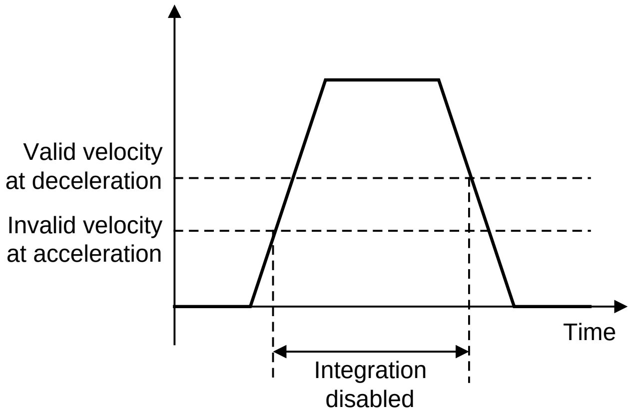


Fig. 4.8.1 (b) Integration invalid range at low-speed integration

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*)	–
2092	–

Position feed-forward coefficient for rapid traverse (in units of 0.01%)

1962 (Series 15*i*)	–
2069	–

Velocity feed forward coefficient for rapid traverse (%)

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:

$$\left(\begin{array}{l}\text{Newly set}\\ \text{position gain}\\ \text{value}\end{array}\right) = \frac{100000}{100000 - \left(\begin{array}{l}\text{Usually set position}\\ \text{gain value}\end{array}\right)} \times \left(\begin{array}{l}\text{Usually set}\\ \text{position gain}\\ \text{value}\end{array}\right)$$

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: To perform ← To be set

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:

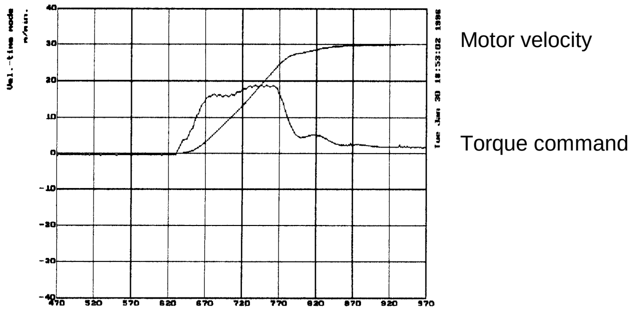
$$\text{Deviation increase (pulses)} = \frac{1800}{60 \times 1000 \times 0.001} \times \left(\frac{64}{2} + 1 \right) = 990 \text{ (pulses)}$$

When FAD is used, the entire deviation is then obtained as follows:

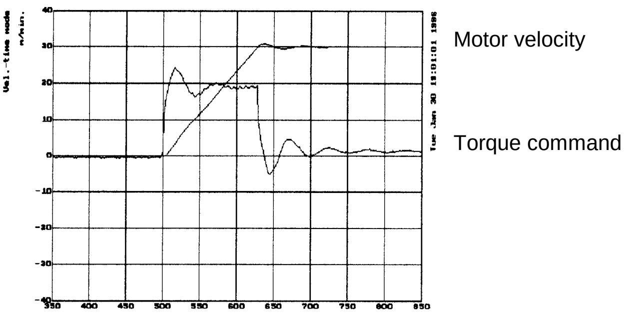
Deviation when FAD is used (pulses) = 1000 + 990
= 1990 (pulses)

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.

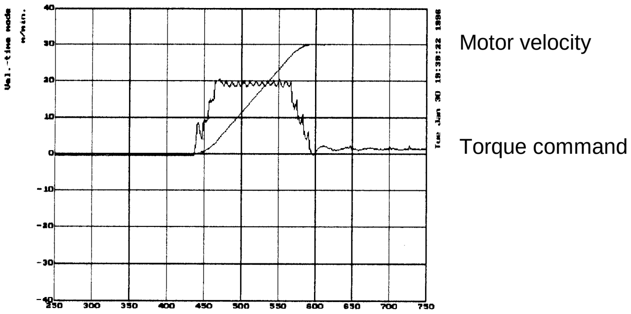
(8) Examples of applying the fine acceleration/deceleration function



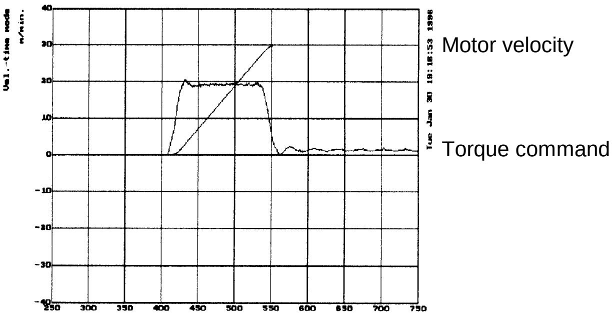
Conventional control in which the feed-forward function is not used



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:

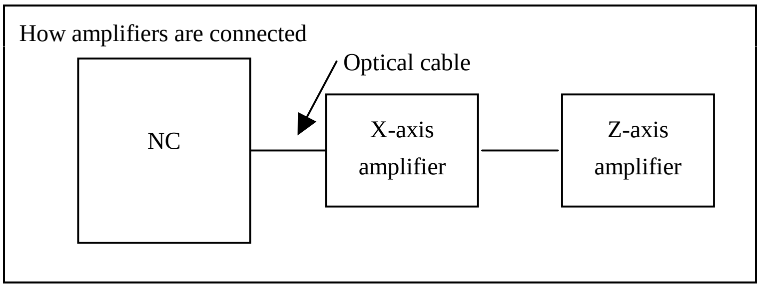
1: To enable

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

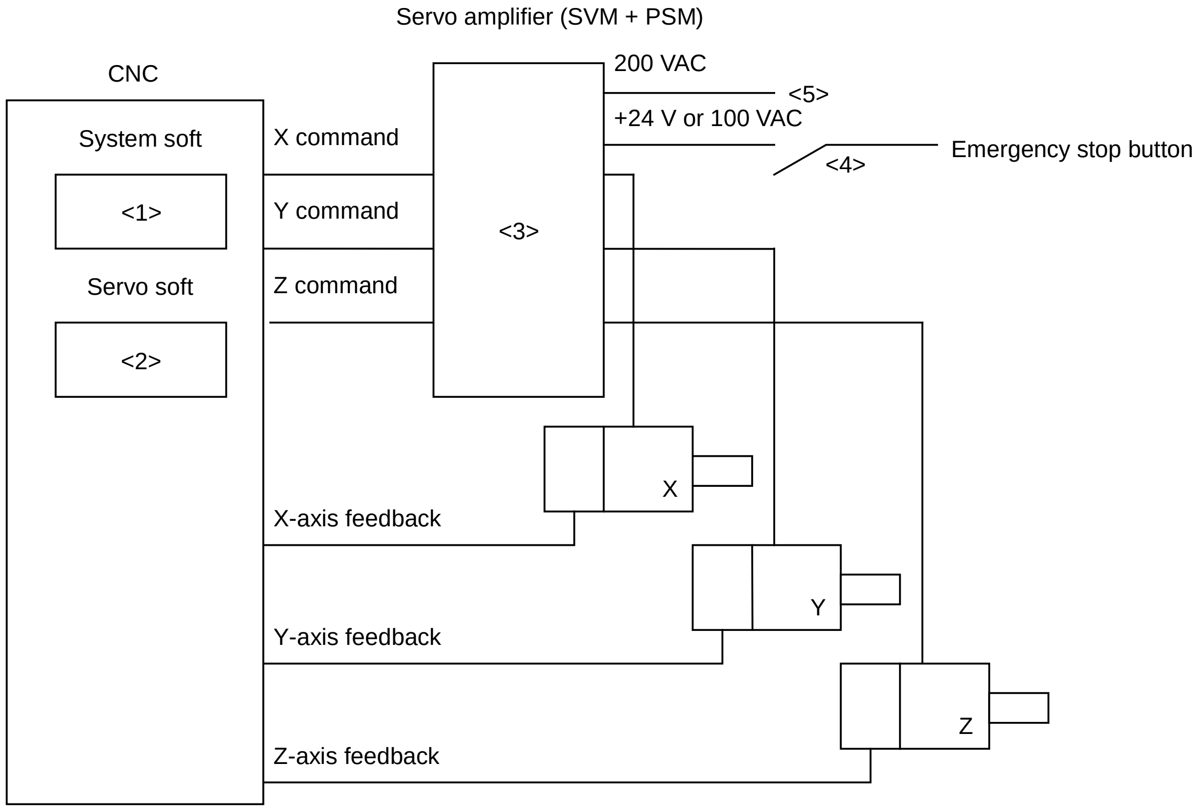


Fig. 4.10 (a) Example of configuration

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.

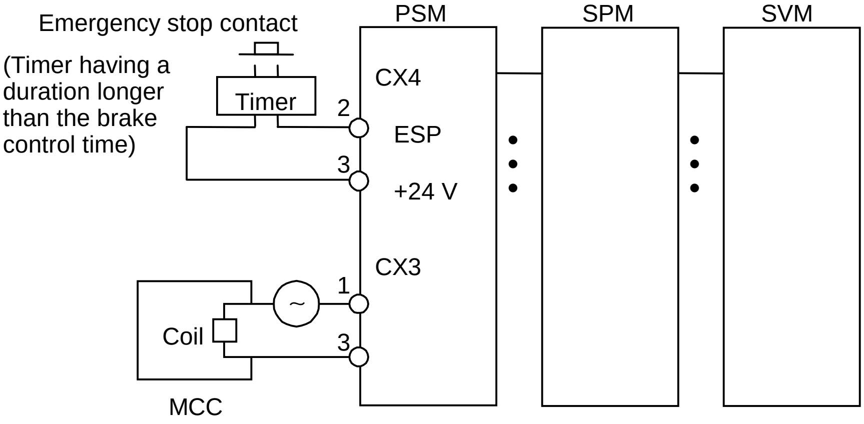


Fig. 4.10 (b) α series amplifier

(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.

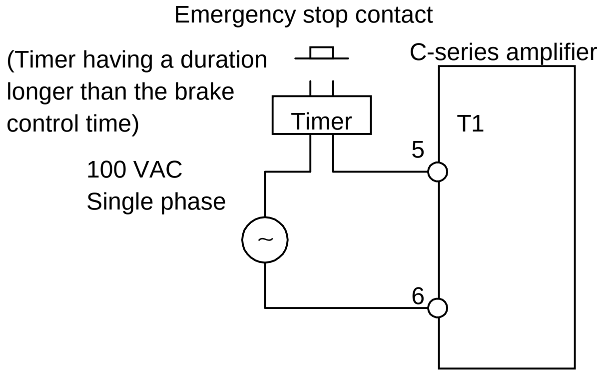


Fig. 4.10 (c) C-series amplifier

<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

1883	**8X05**
2005	**–**

#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
	BRKC						

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.