FANUC AC SERVO MOTOR αi series
FANUC AC SERVO MOTOR βi series
FANUC LINEAR MOTOR L*i*S series
FANUC SYNCHRONOUS BUILT-IN SERVO MOTOR D*i*S series

PARAMETER MANUAL

B-65270EN/06

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Should you wish to export or re-export these products, please contact FANUC for advice.

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

The parameters described in this manual must be set correctly according to the relevant descriptions. If the parameters are not set correctly, vibrations and unpredictable motions can occur. When setting and updating the parameters, place top priority on safety in operation by taking actions, such as lowering the torque limit value, excessive error level, and operation speed, and performing an operation so that an emergency stop can be initiated immediately, until the settings are confirmed to be appropriate.

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.

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APPENDIX

1 OVERVIEW

This manual describes the servo parameters of the CNC models using FANUC AC SERVO MOTOR α*i*S, α*i*F, and β*i*S series. The descriptions include the servo parameter start-up and adjustment procedures. The meaning of each parameter is also explained.

1.1 SERVO SOFTWARE AND SERVO CARDS SUPPORTED BY EACH NC MODEL

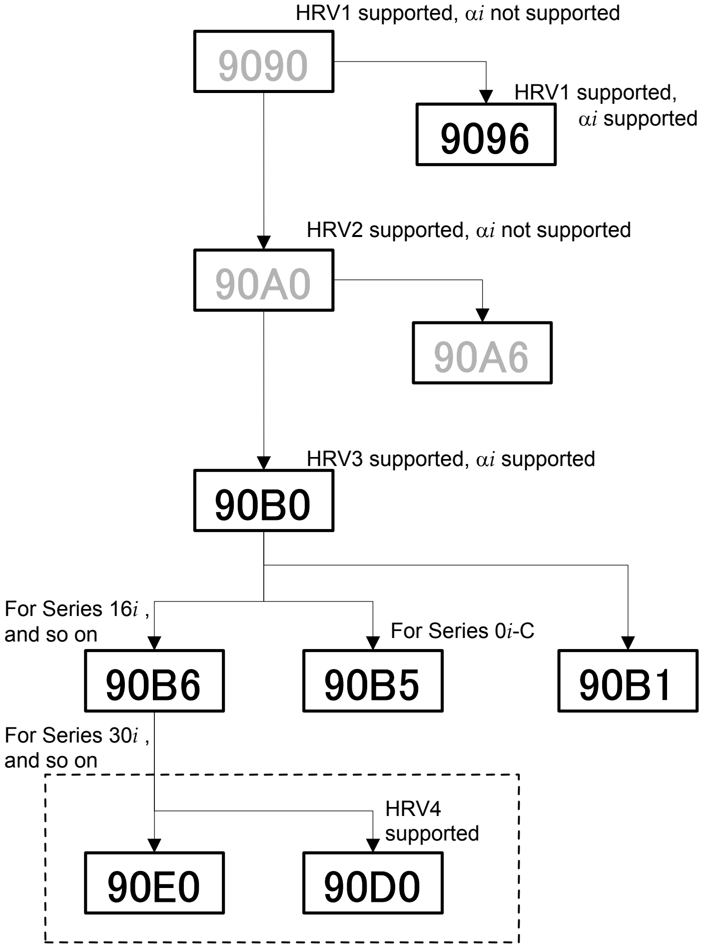
<table>
<tr><th>NC product name</th><th>Series and edition of applicable servo software</th><th>Servo card</th></tr>
<tr><td rowspan="2">Series 21i-MODEL B (Note1)
Series 0i-MODEL B (Note1)
Series 0i Mate-MODEL B (Note1)
Power Mate i-MODEL D (Note1)
Power Mate i-MODEL H (Note1)</td><td>Series 9096/A(01) and subsequent editions
(Supporting i series CNC and SERVO HRV1 control) (Note2)</td><td>320C52 servo card</td></tr>
<tr><td rowspan="2">Series 90B0/H(08) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Supporting i series CNC and SERVO HRV1, 2, and 3 control) (Note3)
Series 90B1/A(01) and subsequent editions (Note3)</td><td rowspan="2">320C5410 servo card</td></tr>
<tr><td>Series 15i-MODEL B
Series 16i-MODEL B
Series 18i-MODEL B</td></tr>
<tr><td>Series 0i-MODEL C
Series 0i Mate-MODEL C
Series 20i-MODEL B</td><td>Series 90B5/A(01) and subsequent editions
(Supporting i series CNC and SERVO HRV1, 2, and 3 control) (Note4)</td><td>320C5410 servo card</td></tr>
<tr><td rowspan="2">Series 30i-MODEL A
Series 31i-MODEL A</td><td>Series 90D0/A(01) and subsequent editions
(Supporting i series CNC and SERVO HRV4 control) (Note5, Note6)</td><td>Servo card for FS30i servo HRV4 control</td></tr>
<tr><td rowspan="2">Series 90E0/A(01) and subsequent editions
(Supporting i series CNC and SERVO HRV2 and 3 control) (Note6)</td><td rowspan="2">Servo card for FS30i servo HRV2 and 3 control</td></tr>
<tr><td>Series 32i-MODEL A</td></tr>
</table>

NOTE

1 The servo software series of the Series 21*i*-MODEL B, 0*i*-MODEL B, 0*i* Mate MODEL B, or Power Mate *i*-MODEL D/H depends on the incorporated servo card, as shown below:

Servo software	Servo card
Series 9096	320C52 servo card
Series 90B0 or Series 90B6	320C5410 servo card

Servo software series map



NOTE

1 The servo software Series 9096 is compatible with the conventional servo software Series 9090 except for the following function:
- Electric gear box (EGB) function can not be used.

2 The servo software Series 90B0 is upwardly compatible with the conventional servo software Series 90A0. Series 90B6 is a successor of Series 90B0. Series 90B1 is a special series compatible with Series 90B0 and is required when a PWM distribution module or pulse input DSA is used.

3 Servo software Series 90B5, which is a successor of Series 90B0 and supports the same functions as Series 90B6, is used in the Series 0*i*-MODEL C, 0*i* Mate-MODEL C, and 20*i*-MODEL B.

4 When using servo HRV4 control with Series 30*i*-MODEL A and 31*i*-MODEL A, use Series 90D0.

5 Servo software Series 90D0 and 90E0 is upwardly compatible with conventional servo software Series 90B0 except the following functions:
- Fine Acc./Dec. (FAD) function can not be used.
- HRV1 control can not be used.

1.2 ABBREVIATIONS OF THE NC MODELS COVERED BY THIS MANUAL

In this manual, the NC product names are abbreviated as follows.

<table>
<tr><th>NC product name</th><th colspan="3">Abbreviations</th></tr>
<tr><td>FANUC Series 30i-MODEL A</td><td>Series 30i-A</td><td>Series 30i</td><td rowspan="3">Series 30i
FS30i</td></tr>
<tr><td>FANUC Series 31i-MODEL A</td><td>Series 31i-A</td><td>Series 31i</td></tr>
<tr><td>FANUC Series 32i-MODEL A</td><td>Series 32i-A</td><td>Series 32i</td></tr>
<tr><td>FANUC Series 15i-MODEL B</td><td>Series 15i-B</td><td>Series 15i</td><td>Series 15i
FS15i</td></tr>
<tr><td>FANUC Series 16i-MODEL B</td><td>Series 16i-B</td><td>Series 16i</td><td rowspan="10">Series 16i and so on
Series 16i etc.
FS16i and so on
FS16i etc.</td></tr>
<tr><td>FANUC Series 18i-MODEL B</td><td>Series 18i-B</td><td>Series 18i</td></tr>
<tr><td>FANUC Series 20i-MODEL B</td><td>Series 20i-B</td><td>Series 20i
FS20i</td></tr>
<tr><td>FANUC Series 21i-MODEL B</td><td>Series 21i-B</td><td>Series 21i</td></tr>
<tr><td>FANUC Series 0i-MODEL C</td><td>Series 0i-C</td><td rowspan="4">Series 0i
FS0i</td></tr>
<tr><td>FANUC Series 0i Mate-MODEL C</td><td>Series 0i Mate-C</td></tr>
<tr><td>FANUC Series 0i-MODEL B</td><td>Series 0i-B</td></tr>
<tr><td>FANUC Series 0i Mate-MODEL B</td><td>Series 0i Mate-B</td></tr>
<tr><td>FANUC Power Mate i-MODEL D</td><td>Power Mate i-D
PMi-D</td><td rowspan="2">Power Mate i
Power Mate i-D/H
(Note 1)</td></tr>
<tr><td>FANUC Power Mate i-MODEL H</td><td>Power Mate i-H
PMi-H</td></tr>
</table>

NOTE

In this manual, Power Mate *i* refers to the Power Mate *i*-D, and Power Mate *i*-H.

1.3 RELATED MANUALS

The following seven kinds of manuals are available for FANUC AC SERVO MOTOR α*i*S, α*i*F or β*i*S series.
In the table, this manual is marked with an asterisk (*).

Table 1.3 Related manuals of SERVO MOTOR α*i*S/α*i*F/β*i*S series

Document name	Document number	Major contents	Major usage	
FANUC AC SERVO MOTOR α*i* series DESCRIPTIONS	B-65262EN	• Specification • Characteristics • External dimensions • Connections	• Selection of motor • Connection of motor	
FANUC AC SERVO MOTOR β*i* series DESCRIPTIONS	B-65302EN			
FANUC LINEAR MOTOR L*i*S series DESCRIPTIONS	B-65222EN			
FANUC SYNCHRONOUS BUILT-IN SERVO MOTOR D*i*S series DESCRIPTIONS	B-65332EN			
FANUC SERVO AMPLIFIER α*i*SV series DESCRIPTIONS	B-65282EN	• Specifications and functions • Installation • External dimensions and maintenance area • Connections	• Selection of amplifier • Connection of amplifier	
FANUC SERVO AMPLIFIER β*i*SV series DESCRIPTIONS	B-65322EN			
FANUC AC SERVO MOTOR α*i* series FANUC AC SPINDLE MOTOR α*i* series FANUC SERVO AMPLIFIER α*i* series MAINTENANCE MANUAL	B-65285EN	• Start up procedure • Troubleshooting • Maintenance of motor	• Start up the system (Hardware) • Troubleshooting • Maintenance of motor	
FANUC AC SERVO MOTOR β*i* series FANUC AC SPINDLE MOTOR β*i* series FANUC SERVO AMPLIFIER β*i* series MAINTENANCE MANUAL	B-65325EN			
FANUC AC SERVO MOTOR α*i* series FANUC AC SERVO MOTOR β*i* series FANUC LINEAR MOTOR L*i*S series FANUC SYNCHRONOUS BUILT-IN SERVO MOTOR D*i*S series PARAMETER MANUAL	B-65270EN	• Initial setting • Setting parameters • Description of parameters	• Start up the system (Software) • Turning the system (Parameters)	*
FANUC AC SPINDLE MOTOR α*i* series FANUC AC SPINDLE MOTOR β*i* series FANUC BUILT-IN SPINDLE MOTOR B*i* series PARAMETER MANUAL	B-65280EN			

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.

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:

(Example)

Series 15*i*	Servo parameter function name
No.1875(FS15*i*)	Load inertia ratio
No.2021(FS30*i*, 16*i*)	

Series 30*i*, 31*i*, 32*i*, 16*i*, 18*i*, 21*i*, 0*i*, Power Mate *i*

The following α*i*/β*i* Pulsecoders are available.

Pulsecoder name	Resolution	Type
α*i*A1000	1,000,000 pulse/rev	Absolute
α*i*I1000	1,000,000 pulse/rev	Incremental
α*i*A16000	16,000,000 pulse/rev	Absolute
β*i*A128	131,072 pulse/rev	Absolute
β*i*A64	65,536 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 effect of α*i*A16000 can be increased when used together with AI nano contour control.

2 SETTING α*i*S/α*i*F/β*i*S 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 16*i*-B)

<2> Servo motor model (ex.: α*i*F8/3000)

<3> Pulsecoder built in a motor (ex.: α*i*A1000)

<4> Is the separate position detector used? (ex.: Not used)

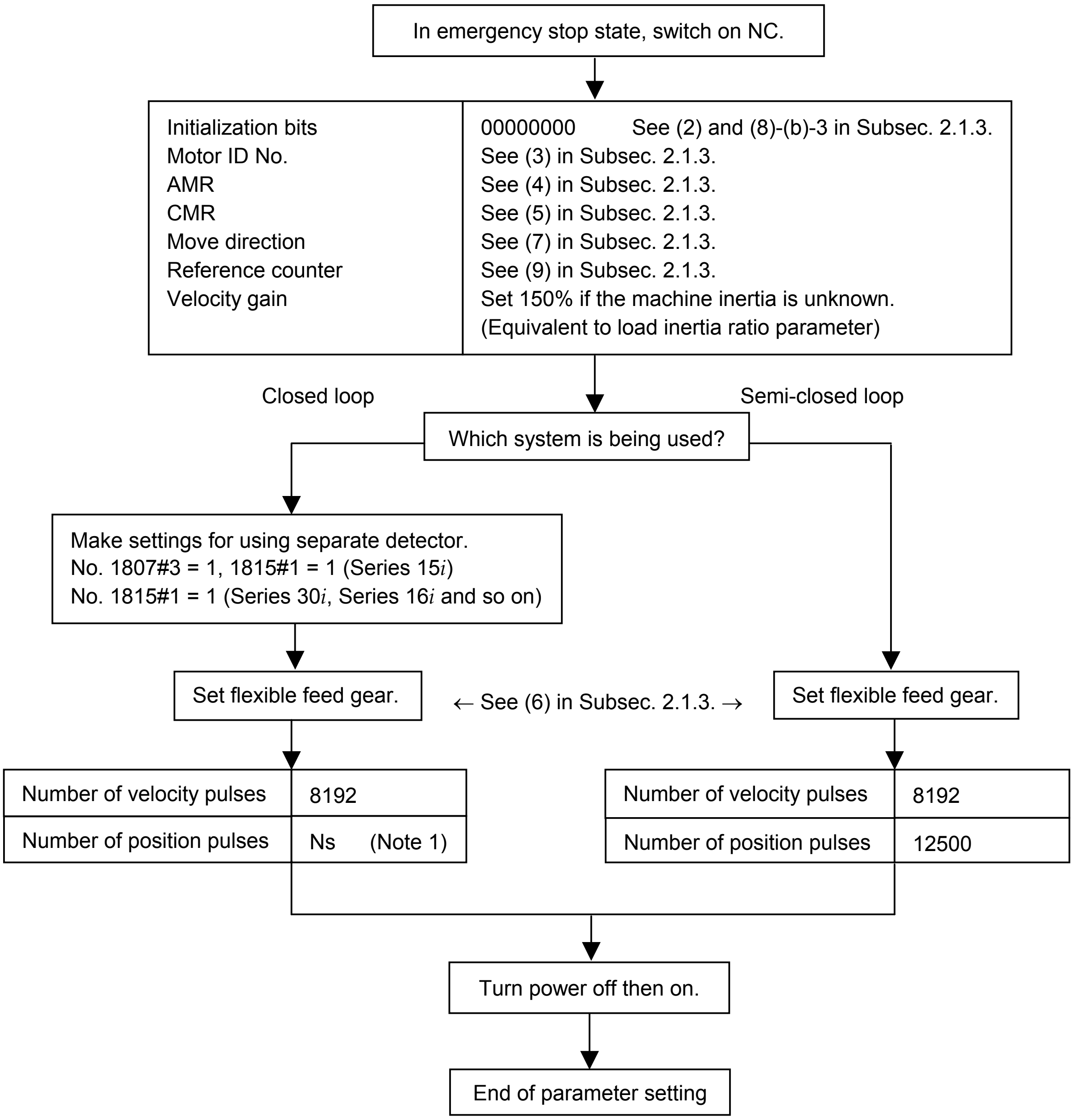
<5> Distance the machine tool moves per revolution of the motor (ex.:10 mm per one revolution)

<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:



NOTE

1 When a separate detector of A/B phase parallel type and a serial linear scale are used, Ns indicates the number of feedback pulses per motor revolution, sent from the separate detector.
When a serial rotary scale is used, the number of pulses is calculated using following expression: 12500 × (gear reduction ratio between the motor and table)
See (8)-(b)-2 in Subsec. 2.1.3.

2.1.3 Servo Parameter Initialization Procedure

(1) Preparation

Switch on the NC in an emergency stop state.
Enable parameter writing (PWE = 1).
Initialize servo parameters on the servo setting screen.
For a Power Mate *i* 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 15*i*

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

- Series30*i*,31*i*,32*i*,16*i*,18*i*,21*i*,20*i*,0*i*

SYSTEM → [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		Power Mate
		X axis	Z axis	
INITIAL SET BITS		00001010	00001010	No.2000
Motor ID No.		16	16	No.2020
AMR		00000000	00000000	No.2001
CMR		2	2	No.1820
Feed gear	N	1	1	No.2084
(N/M)	M	100	100	No.2085
Direction Set		111	111	No.2022
Velocity Pulse No.		8192	8192	No.2023
Position Pulse No.		12500	12500	No.2024
Ref. counter		10000	10000	No.1821

Fig. 2.1.3 Servo setting screen **Correspondence of Power Mate *i***

(2) Initialization

Start initialization.
Do not power off the NC until step (11).

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

(⇧ Note)

Reset initialization bit 1 to 0.
DGPR(#1)=0
After initialization is completed, DGPR (#1) is set to 1.

> **NOTE**
> Once initialization has been completed, bit 3 (PRMC) for initialization is automatically set to 1. (Except Series 30*i*, 31*i* and 32*i*)

(3) Motor ID No. setting

Specify the motor ID number.
Select the motor ID number of a motor to be used according to the motor model and motor specification (the middle four digits in A06B-****-B***) listed in the following tables.
When using servo HRV3 or HRV4 control, please use the motor ID number for servo HRV2 control. It is available with the series and editions listed in the table and later editions.
The mark "x" indicates a value that varies depending on the used options.
The mark "-" indicates that automatic loading of standard parameters is not supported as of December, 2005.

> **NOTE**
> - Series 30*i*, 31*i* and 32*i*
>   Specify the motor ID number for servo HRV2 control.
> - Other than the Series 30*i*, 31*i* and 32*i*
>   When a pair of the values set in parameter No. 1023 (servo axis number) are consecutive odd and even numbers, set motor ID numbers for servo HRV control of the same type.
>   (Correct examples)
>   Servo axes when parameter No.1023= 1,2: Motor ID number for servo HRV2 control
>   Servo axes when parameter No.1023= 3,4: Motor ID number for servo HRV1 control
>   (Wrong examples)
>   Servo axes when parameter No.1023= 1: Motor ID number for servo HRV2 control
>   Servo axes when parameter No.1023= 2,3: Motor ID number for servo HRV1 control

αiS series servo motor

Motor model	Motor specification	Motor ID No.		90D0 90E0	90B0	90B5 90B6	90B1	9096
		HRV1	HRV2					
αiS2/5000	0212	162	262	A	H	A	A	A
αiS2/6000	0218	-	284	G	-	B	B	-
αiS4/5000	0215	165	265	A	H	A	A	A
αiS8/4000	0235	185	285	A	H	A	A	A
αiS8/6000	0232	-	290	G	-	B	B	-
αiS12/4000	0238	188	288	A	H	A	A	A
αiS22/4000	0265	215	315	A	H	A	A	A
αiS30/4000	0268	218	318	A	H	A	A	A
αiS40/4000	0272	222	322	A	H	A	A	A
αiS50/3000	0275-Bx0x	224	324	B	V	A	A	F
αiS50/3000 FAN	0275-Bx1x	225	325	A	N	A	A	D
αiS100/2500	0285	235	335	A	T	A	A	F
αiS200/2500	0288	238	338	A	T	A	A	F
αiS300/2000	0292	115	342	B	V	A	A	-
αiS500/2000	0295	245	345	A	T	A	A	F

αiF series servo motor

Motor model	Motor specification	Motor ID No.		90D0 90E0	90B0	90B5 90B6	90B1	9096
		HRV1	HRV2					
αiF1/5000	0202	152	252	A	H	A	A	A
αiF2/5000	0205	155	255	A	H	A	A	A
αiF4/4000	0223	173	273	A	H	A	A	A
αiF8/3000	0227	177	277	A	H	A	A	A
αiF12/3000	0243	193	293	A	H	A	A	A
αiF22/3000	0247	197	297	A	H	A	A	A
αiF30/3000	0253	203	303	A	H	A	A	A
αiF40/3000	0257-Bx0x	207	307	A	H	A	A	A
αiF40/3000 FAN	0257-Bx1x	208	308	A	I	A	A	C

α*i*S series servo motor (for 400-V driving)

Motor model	Motor specification	Motor ID No.		90D0 90E0	90B0	90B5 90B6	90B1	9096
		HRV1	HRV2					
α*i*S2/5000HV	0213	163	263	A	Q	A	A	D
α*i*S2/6000HV	0219	-	287	G	-	B	B	-
α*i*S4/5000HV	0216	166	266	A	Q	A	A	D
α*i*S8/4000HV	0236	186	286	A	N	A	A	D
α*i*S8/6000HV	0233	-	292	G	-	B	B	-
α*i*S12/4000HV	0239	189	289	A	N	A	A	D
α*i*S22/4000HV	0266	216	316	A	N	A	A	D
α*i*S30/4000HV	0269	219	319	A	N	A	A	D
α*i*S40/4000HV	0273	223	323	A	N	A	A	D
α*i*S50/3000HV FAN	0276-Bx1x	226	326	A	N	A	A	D
α*i*S50/3000HV	0276-Bx0x	227	327	B	V	A	A	F
α*i*S100/2500HV	0286	236	336	B	V	A	A	F
α*i*S200/2500HV	0289	239	339	B	V	A	A	F
α*i*S300/2000HV	0293	243	343	B	V	A	A	F
α*i*S500/2000HV	0296	246	346	B	V	A	A	F
α*i*S1000/2000HV	0298	248	348	B	V	A	A	F
α*i*S2000/2000HV (Note 1)	0091	-	340	J	-	B	B	-

NOTE

1 The model needs manual setting. (See Subsection 2.1.7, "Setting Parameters when the PWM Distribution Module is used".)
When using the torque control function, contact FANUC.

α*i*F series servo motor (for 400-V driving)

Motor model	Motor specification	Motor ID No.		90D0 90E0	90B0	90B5 90B6	90B1	9096
		HRV1	HRV2					
α*i*F4/4000HV	0225	175	275	A	Q	A	A	E
α*i*F8/3000HV	0229	179	279	A	Q	A	A	E
α*i*F12/3000HV	0245	195	295	A	Q	A	A	E
α*i*F22/3000HV	0249	199	299	A	Q	A	A	E

αC*i* series servo motor

Motor model	Motor specification	Motor ID No.		90D0 90E0	90B0	90B5 90B6	90B1	9096
		HRV1	HRV2					
αC4/3000*i*	0221	171	271	A	H	A	A	A
αC8/2000*i*	0226	176	276	A	H	A	A	A
αC12/2000*i*	0241	191	291	A	H	A	A	A
αC22/2000*i*	0246	196	296	A	H	A	A	A
αC30/1500*i*	0251	201	301	A	H	A	A	A

βiS series servo motor

Motor model	Motor specification	Amplifier driving	Motor ID No. HRV1	Motor ID No. HRV2	90D0 90E0	90B0	90B5 90B6	90B1	9096
βiS0.2/5000	0111 (Note 1)	4A	-	260	A	N	A	A	*
βiS0.3/5000	0112 (Note 1)	4A	-	261	A	N	A	A	*
βiS0.4/5000	0114 (Note 1)	20A	-	280	A	N	A	A	*
βiS0.5/6000	0115	20A	181	281	G	-	B	B	-
βiS1/6000	0116	20A	182	282	G	-	B	B	-
βiS2/4000	0061 (Note 2)	20A	153	253	B	V	A	A	F
		40A	154	254	B	V	A	A	F
βiS4/4000	0063 (Note 2)	20A	156	256	B	V	A	A	F
		40A	157	257	B	V	A	A	F
βiS8/3000	0075 (Note 2)	20A	158	258	B	V	A	A	F
		40A	159	259	B	V	A	A	F
βiS12/2000	0077 (Note 2)	20A	169	269	-	-	D	-	-
βiS12/3000	0078	40A	172	272	B	V	A	A	F
βiS22/2000	0085	40A	174	274	B	V	A	A	F

NOTE

1. HRV1 control cannot be used with these motors. So, these motors cannot be used with Series 9096.
2. For a motor specification suffixed with "-Bxx6", be sure to use parameters dedicated to FS0*i*.

βiS series servo motor (for 400-V driving)

Motor model	Motor specification	Amplifier driving	Motor ID No. HRV1	Motor ID No. HRV2	90D0 90E0	90B0	90B5 90B6	90B1	9096
βiS2/4000HV	0062	10A	151	251	J	-	B	C	-
βiS4/4000HV	0064	10A	164	264	J	-	B	C	-
βiS8/3000HV	0076	10A	167	267	J	-	B	C	-
βiS12/3000HV	0079	20A	170	270	J	-	B	C	-
βiS22/2000HV	0086	20A	178	278	J	-	B	C	-

The mark "-" indicates that automatic loading of standard parameters is not supported as of December, 2005.

β*i*S series servo motor (dedicated to FS0*i*)

Motor model	Motor specification	Amplifier driving	Motor ID No.		90B5
			HRV1	HRV2	
β*i*S2/4000	0061-Bxx6	20A	206	306	D
		40A	210	310	D
β*i*S4/4000	0063-Bxx6	20A	211	311	D
		40A	212	312	D
β*i*S8/3000	0075-Bxx6	20A	183	283	D
		40A	194	294	D
β*i*S12/2000	0077-Bxx6	20A	198	298	D
β*i*S22/1500	0084-Bxx6	20A	202	302	D
		40A	205	305	D

The motor models above can be driven only with Series 90B5.

Linear motor

Linear motor parameters for servo HRV2 control

Note: The following linear motors are driven by 200V.

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1	9096
LiS300A1/4	0441-B200	351	G	-	B	B	-
LiS600A1/4	0442-B200	353	G	-	B	B	-
LiS900A1/4	0443-B200	355	G	-	B	B	-
LiS1500B1/4	0444-B210	357	G	-	B	B	-
LiS3000B2/2	0445-B110	360	G	-	B	B	-
LiS3000B2/4	0445-B210	362	G	-	B	B	-
LiS4500B2/2	0446-B110	364	G	-	B	B	-
LiS6000B2/2	0447-B110	368	G	-	B	B	-
LiS6000B2/4	0447-B210	370	G	-	B	B	-
LiS7500B2/2	0448-B110	372	G	-	B	B	-
LiS7500B2/4	0448-B210	374	G		B	B	-
LiS9000B2/2	0449-B110	376	G	-	B	B	-
LiS9000B2/4	0449-B210	378	G	-	B	B	
LiS3300C1/2	0451-B110	380	G	-	B	B	-
LiS9000C2/2	0454-B110	384	G	-	B	B	-
LiS11000C2/2	0455-B110	388	G	-	B	B	-
LiS15000C2/2	0456-B110	392	G	-	B	B	-
LiS15000C2/3	0456-B210	394	G	-	B	B	-
LiS10000C3/2	0457-B110	396	G	-	B	B	-
LiS17000C3/2	0459-B110	400	G	-	B	B	-

Note: The following linear motors are driven by 400V.

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1	9096
LiS1500B1/4	0444-B210	358	G	-	B	B	-
LiS3000B2/2	0445-B110	361	G	-	B	B	-
LiS4500B2/2HV	0446-B010	363	G	-	B	B	-
LiS4500B2/2	0446-B110	365	G	-	B	B	-
LiS6000B2/2HV	0447-B010	367	G	-	B	B	-
LiS6000B2/2	0447-B110	369	G	-	B	B	-
LiS7500B2/2HV	0448-B010	371	G	-	B	B	-
LiS7500B2/2	0448-B110	373	G	-	B	B	-
LiS9000B2/2	0449-B110	377	G	-	B	B	-
LiS3300C1/2	0451-B110	381	G	-	B	B	-
LiS9000C2/2	0454-B110	385	G		B	B	
LiS11000C2/2HV	0455-B010	387	G	-	B	B	-
LiS11000C2/2	0455-B110	389	G	-	B	B	-
LiS15000C2/3HV	0456-B010	391	G	-	B	B	-
LiS10000C3/2	0457-B110	397	G	-	B	B	-
LiS17000C3/2	0459-B110	401	G	-	B	B	-

Linear motor parameters for servo HRV1 control

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1	9096
L*i*S1500B1/4	0444-B210	90	A	A	A	A	A
L*i*S3000B2/2	0445-B110	91	A	A	A	A	A
L*i*S6000B2/2	0447-B110	92	A	A	A	A	A
L*i*S9000B2/2	0449-B110	93	A	A	A	A	A
L*i*S1500C2/2	0456-B110	94	A	A	A	A	A
L*i*S3000B2/4	0445-B210	120	A	A	A	A	A
L*i*S6000B2/4	0447-B210	121	A	A	A	A	A
L*i*S9000B2/4	0449-B210	122	A	A	A	A	A
L*i*S15000C2/3	0456-B210	123	A	A	A	A	A
L*i*S300A1/4	0441-B200	124	A	A	A	A	A
L*i*S600A1/4	0442-B200	125	A	A	A	A	A
L*i*S900A1/4	0443-B200	126	A	A	A	A	A
L*i*S6000B2/4	0412-B811	127 (160-A driving)	A	R	A	A	D
L*i*S9000B2/2	0413	128 (160-A driving)	A	N	A	A	D
L*i*S9000B2/4	0413-B811	129 (360-A driving)	A	Q	A	A	D
L*i*S15000C2/2	0414	130 (360-A driving)	A	Q	A	A	D

(Reference)
The parameter table presented in Chapter 6 has two motor ID Nos. for the same linear motor. One of the two is for driving the α series servo amplifiers (130A and 240A). Be careful not to use the wrong ID No.

Motor model	α servo amplifier driving		α*i* servo amplifier driving	
	Amplifier maximum current [A]	Motor ID No.	Amplifier maximum current [A]	Motor ID No.
L*i*S6000B2/4	240	121	160	127
L*i*S9000B2/2	130	93	160	128
L*i*S9000B2/4	240	122	360	129
L*i*S15000C2/2	240	94	360	130

Synchronous built-in servo motor
Synchronous built-in servo motor for servo HRV2 control
NOTE: The following synchronous built-in servo motors are driven by 200V.

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1	9096
D*i*S85/400	0483-B20x	423	K	-	-	-	-
D*i*S110/300	0484-B10x	425	K	-	-	-	-
D*i*S260/600	0484-B31x	429	K	-	-	-	-
D*i*S370/300	0484-B40x	431	K	-	-	-	-

NOTE: The following synchronous built-in servo motors are driven by 400V.

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1	9096
D*i*S85/400	0483-B20x	424	K	-	-	-	-
D*i*S110/300	0484-B10x	426	K	-	-	-	-
D*i*S260/600	0484-B31x	430	K	-	-	-	-
D*i*S370/300	0484-B40x	432	K	-	-	-	-

(4) AMR setting

For AMR, set 00000000. When using a linear motor, set AMR according to the description in Section 4.14, "LINEAR MOTOR PARAMETER SETTING". When using a synchronous built-in servo motor, set AMR according to the description in Section 4.15, "SYNCHRONOUS BUILT-IN SERVO MOTOR PARAMETER SETTING".

α*i*S/α*i*F/β*i*S motor	00000000

(5) CMR setting

Set, as CMR, a specified magnification for the amount of movement from the NC to the servo system.
CMR = Command unit / Detection unit

CMR 1/2 to 48	Setting value = CMR × 2

Usually, set CMR with 2, because command unit = detection unit (CMR = 1).

(6) Flexible feed gear setting

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 Pulsecoder or separate detector. It converts the incoming number of pulses from the position detector so that it matches the commanded number of pulses. When using a linear motor, set F·FG according to the description in Section 4.14, "LINEAR MOTOR PARAMETER SETTING". When using a synchronous built-in servo motor, set F·FG according to the description in Section 4.15, "SYNCHRONOUS BUILT-IN SERVO MOTOR PARAMETER SETTING".

(a) Semi-closed feedback loop

Setting for the αi Pulsecoder

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

NOTE

1 For both F·FG numerator and denominator, the maximum setting value (after reduced) is 32767.
2 αi Pulsecoders 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.

Example of setting

If the ball screw used in direct coupling has a lead of 5 mm/rev and the detection unit is 1 μm
The number of pulses generated per motor turn (5 mm) is:
5/0.001 = 5000 (pulses)
Because the αi Pulsecoder feeds back 1000000 pulses per motor turn:
FFG = 5000 / 1000000 = 1 / 200

Other FFG (numerator/denominator) setting examples, where the gear reduction ratio is assumed to be 1:1

Detection unit	Ball screw lead					
	6mm	8mm	10mm	12mm	16mm	20mm
1μm	6 / 1000	8 / 1000	10 / 1000	12 / 1000	16 / 1000	20 / 1000
0.5μm	12 / 1000	16 / 1000	20 / 1000	24 / 1000	32 / 1000	40 / 1000
0.1μm	60 / 1000	80 / 1000	100 / 1000	120 / 1000	160 / 1000	200 / 1000

Example of setting

If the gear reduction ratio between the rotary axis motor and table is 10:1 and the detection unit is 1/1000 degrees

The table rotates through 360/10 degrees when the motor makes one turn.

The number of position pulses necessary for the motor to make one turn is:

360/10 ÷ (1/1000) = 36,000 pulses

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

If the gear reduction ratio between the rotary axis motor and table is 300:1 and the detection unit is 1/10000 degrees

The table rotates through 360/300 degrees when the motor makes one turn.

The number of position pulses necessary for the motor to make one turn is:

360/300 ÷ (1/10000) = 12,000 pulses

$$\frac{\text{F·FG numerator}}{\text{F·FG denominator}} = \frac{12{,}000}{1{,}000{,}000} = \frac{12}{1{,}000}$$

(b) Full-closed feedback loop

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

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

Example of setting

To detect a distance of 1-µm using a 0.5-µm scale, set the following:
(L represents a constant distance.)

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

Other FFG (numerator/denominator) setting examples

Detection unit	Scale resolution			
	1 µm	0.5 µm	0.1 µm	0.05 µm
1µm	1 / 1	1 / 2	1 / 10	1 / 20
0.5µm	-	1 / 1	1 / 5	1 / 10
0.1µm	-	-	1 / 1	1 / 2

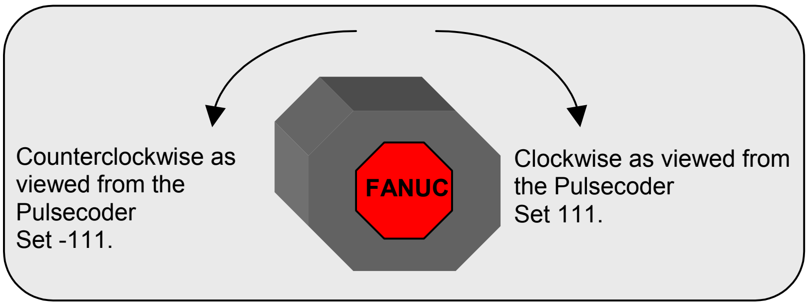
NOTE

The maximum rotation speed allowable with servo software depends on the detection unit. (See Appendix E, "VELOCITY LIMIT VALUES IN SERVO SOFTWARE".) Select a detection unit that enables a requested maximum rotation speed to be realized. When a speed of up to 6000 revolutions is used as a live tool in the direct motor connection mode, in particular, use a detection unit of 2/1000 deg (IS-B setting, CMR=1/2, flexible feed gear=18/100).

(7) Motor rotation direction setting

Set the direction in which the motor is to turn when a positive value is specified as a move command. For linear motors, set the parameter according to the description in Section 4.14, "LINEAR MOTOR PARAMETER SETTING". For synchronous built-in servo motors, set the parameter according to the description in Section 4.15, "SYNCHRONOUS BUILT-IN SERVO MOTOR PARAMETER SETTING".

111	Clockwise as viewed from the Pulsecoder
−111	Counterclockwise as viewed from the Pulsecoder



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

Set the number of velocity pulses and the number of position pulses according to the connected detector. For linear motors, set these parameters according to the description in Section 4.14, "LINEAR MOTOR PARAMETER SETTING". For synchronous built-in servo motors, set these parameters according to the description in Section 4.15, "SYNCHRONOUS BUILT-IN SERVO MOTOR PARAMETER SETTING".

(a) Number of velocity pulses

Set the number of velocity pulses to 8192.

αiS/αiF/βiS motor	8192

(b) Number of position pulses

(b)-1 Number of position pulses for semi-closed feedback loop

Set the number of position pulses to 12500.

Number of position pulses (αiS/αiF/βiS motor, semi-closed feedback loop)	12500

(b)-2 Number of position pulses for full-closed feedback loop (See Subsections 2.1.4 and 2.1.5)

Set the number of position pulses to the number of pulses fed back from the separate detector when the motor makes one turn. (The flexible feed gear has nothing to do with the calculation of the number of position pulses).

Number of position pulses (full-closed feedback loop)	Number of pulses fed back from the separate detector when the motor makes one turn

When using a serial rotary scale with a resolution of 1,000,000 pulses per revolution, set a value assuming that 12500 is equivalent to 1,000,000 pulses.

Number of position pulses (full-closed feedback loop) (*) 1,000,000 pulses / rev	12,500 ×(motor-table gear reduction ratio)

Example 1:

Parallel type, serial linear scale

If the ball screw used in direct coupling has a lead of 10 mm and the separate detector used has a resolution of 0.5 μm per pulse

Number of position pulses = 10 / 0.0005 = 20,000

Example 2:

Serial rotary scale

If the motor-table gear reduction ratio is 10:1,

Number of position pulses = 12,500 × (1/10) = 1250

(b)-3 If the setting for the number of position pulses is larger than 32767

Conventionally, initialization bit 0 (high resolution bit) must be changed according to the command unit. For the current *i* series CNC, however, there is no mutual dependence between the command unit and initialization bit 0.
Of course, the conventional setting method is applicable, but using the conversion coefficient for the number of position feedback pulses makes the setting easier.

2628 (FS15*i*)	**Conversion coefficient for the number of position feedback pulses**
2185 (FS30*i*,16*i*)	

Series 90E0, Series 90D0, Series 90B0, Series 90B5, Series 90B6, Series 90B1 :

Set the number of position pulses with a product of two parameters, using the conversion coefficient for the number of position feedback pulses.
Number of feedback pulses per motor revolution, sent from the separate detector
= Number of position pulses × Conversion coefficient for the number of position feedback pulses

Series 9096 :

No conversion coefficient for the number of position feedback pulses can be used. As usual, set the initialization bit 0 to 1, and set the number of velocity pulses and the number of position pulses to 1/10 the respective values stated earlier.
Number of feedback pulses per motor revolution, sent from the separate detector
= Number of position pulses × 10

→ See Supplementary 3 of Subsection 2.1.8.

(9) Reference counter setting

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

(a) Semi-closed loop

(Linear axis)		
Count on the reference counter	=	Number of position pulses corresponding to a single motor revolution or the same number divided by an integer value
(Rotary axis)		
Count on the reference counter	=	Number of position pulses corresponding to a single motor revolution/M, or the same number divided by an integer value
* When the motor-table gear reduction ratio is M/N (M and N are integers, and M/N is a fraction that is reduced to lowest terms.)		

NOTE

1. If the calculation above results in a fraction, a setting can be made with a fraction.
   See (a)-1.
2. If the rotation ratio between the motor and table on the rotary axis is not an integer, the reference counter capacity needs to be set so that the point (grid point) where the reference counter equals 0 appears at the same position relative to the table. So, with the rotary axis, the number of position pulses per motor revolution needs to be multiplied by 1/M.

Example of setting

αi Pulsecoder 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.
In such a case, set the reference counter capacity with a fraction to change the detection unit and eliminate the error in the reference counter. (Except Series 9096)

Example of setting

System using a detection unit of 1 μm, a ball screw lead of 20 mm/revolution, and a gear reduction ratio of 1/17

(a)-1 Method of specifying the reference counter capacity with a fraction (except Series 9096)

The number of position pulses necessary for the motor to make one turn is: 20000/17
Set the following parameter as stated below.

1896 (FS15*i*)	**Reference counter capacity (numerator)**
1821 (FS30*i*, 16*i*)	

[Valid data range] 0 to 99999999

Set the numerator of a fraction for the reference counter capacity.

2622 (FS15*i*)	Reference counter capacity (denominator)
2179 (FS30*i*, 16*i*)	

[Valid data range] 0 to 32767

A value up to around 100 is assumed to be set as the denominator of the reference counter capacity. Note that if a larger value is set, the grid width becomes too small, which makes it difficult to perform reference position return by grid method.

The denominator parameter is not indicated in the servo setting screen, so it must be set in the parameter screen.

In this example, set the numerator and denominator, respectively, to 20000 and 17.

> **NOTE**
> Even if a setting is made with a fraction, set the number of position pulses per motor revolution/M for a semi-closed loop rotary axis when the reduction ratio is M/N.
> Reference counter =
> Number of position pulses per motor revolution/M, or
> The same number divided by an integer

(a)-2 Method of changing the detection unit

The number of position pulses necessary for the motor to make one turn is: 20000/17

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 30*i*,15*i*,16*i*,0*i*, Power Mate *i*, and so on
FFG	Servo screen
CMR	Servo screen
Reference counter	Servo screen
Effective area	Nos. 1826, 1827
Position error limit in traveling	No. 1828
Position error limit in the stop state	No. 1829
Backlash	Nos. 1851, 1852

Changing the detection unit from 1 μm to 1/17 μm requires multiplying each of the parameter settings made for the detection unit 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 B.

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

(b) Full-closed loop (See Subsections 2.1.4 and 2.1.5)

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

NOTE
If the separate detector-table rotation ratio for the rotary axis is not an integer, it is necessary to set the reference counter capacity in such a way that points where reference counter = 0 (grid points) appear always at the same position for the table.

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 rotary 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.

If the calculated value of the reference counter capacity is not an integer, the reference counter capacity can be set as a fraction as in the case of a semi-closed loop. For details of parameters, see (a)-1.

NOTE
The following value can be set as a reference counter capacity:
(For linear axis)
Number of position pulses corresponding to the Z-phase interval of a separate detector (or the same number divided by an integer)
(For rotary axis)
Number of position pulses per revolution of a separate detector/M (or the same number divided by an integer)
(*) When the rotation ratio between the table and separate detector is M/N (M and N are integers, and M/N is a fraction that is reduced to lowest terms.)

(10) Full-closed system setting (go to (11) if a semi-closed system is in use)

For a full-closed system, it is necessary to set the following function bit.

(a) Series15*i* only

	#7	#6	#5	#4	#3	#2	#1	#0
1807 (FS15*i*) 2002 (FS30*i*, 16*i*)					PFSE			

↑ To be specified only for the Series 15*i*

PFSE(#3) The separate position detector is:

0: Not to be used

1: To be used

> ⚠ **CAUTION**
> Specify this parameter only for the Series 15*i*.

(b) Series30*i*,15*i*,16*i*, 0*i*,Power Mate *i*, and so on

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

↑To be specified for every NC.

OPTX(#1) The separate position detector is:

0: Not to be used

1: To be used

> **NOTE**
> For the Series 30*i*, 16*i*, 0*i*, Power Mate *i*, and so on, specifying this parameter automatically sets bit 3 of parameter No. 2002 to 1.

(11) NC restart

Switch the NC off and on again.
This completes servo parameter initialization.
If an invalid servo parameter setting alarm occurs, go to Subsec. 2.1.8.
If a servo alarm related to Pulsecoders occurs for an axis for which a servo motor or amplifier is not connected, specify the following parameter.

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*) 2009 (FS30*i*, 16*i*)								DMY

DMY (#0) The serial feedback dummy function is: (See Section 4.9, "SERIAL FEEDBACK DUMMY FUNCTIONS" for function detail)

0 : Not used

1 : Used

(12) Absolute position detector setting

When you are going to use an α*i*/β*i* Pulsecoder as an absolute Pulsecoder, use the following procedure.

Procedure

1. Specify the following parameter, then switch the NC off.

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

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

2. After making sure that the battery for the Pulsecoder is connected, turn off the CNC.
3. A request to return to the reference position is displayed.
4. Cause the servo motor to make one turn by jogging.
5. Turn off and on the CNC.
6. A request to return to the reference position is displayed.
7. Do the reference position return.

These steps were added for the αi/βi Pulsecoder.

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 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Classification of serial detectors and usable detector examples

Usable separate detectors for the serial interface are classified into four major types as shown below. Note that parameter settings vary with these types.

(a) Serial output type linear encoder

	Minimum resolution	Model	Backup
Mitutoyo Co., Ltd.	0.05μm	AT353, AT553	Not required
HEIDENHAIN	0.05μm/0.1μm 0.05μm/0.1μm	LC191F LC491F	Not required Not required

(b) Analog output type linear encoder + FANUC high-resolution serial output circuit

	Signal pitch	Model	Backup
Mitutoyo Co., Ltd.	20μm	AT402	Required
HEIDENHAIN	20μm	LS486, LS186	Required
Sony Precision Technology Inc.	20μm	SH12	Required

(c) Serial output type rotary encoder

	Minimum resolution (Note 1)	Model	Backup
FANUC	2^{20} pulse/rev	αA1000S	Required

(d) RCN220, RCN223, RCN723, and RCN727 manufactured by HEIDENHAIN

	Minimum resolution (Note 1)	Model	Backup
HEIDENHAIN	2^{20} pulse/rev 2^{23} pulse/rev 2^{27} pulse/rev	RCN220 RCN223, 723 RCN727	Not required Not required Not required

NOTE

1 The minimum resolution of a rotary encoder is the resolution of the encoder itself. For the FANUC systems, however:
One million pulses/rev for a minimum resolution of 2^{20} pulses/rev
Eight million pulses/rev for a minimum resolution of 2^{23} pulses/rev
Eight million pulses/rev for a minimum resolution of 2^{27} pulses/rev

(4) Setting parameters

Set the following parameters according to the type of the detector (described in the previous item).

(a) Parameter setting for a linear encoder of a serial output type

(Parameter setting method)

In addition to the conventional settings for a separate detector (bit 1 of parameter No. 1815 (Series30*i*,15*i*,16*i*,18*i*,21*i*,20*i*,0*i*, and Power Mate *i*), bit 3 of parameter No. 1807 (Series 15*i*), and if needed, FSSB), note the following parameters:

[Flexible feed gear]
Parameter Nos. 1977 and 1978 (Series 15*i*) or Nos. 2084 and 2085 (Series 30*i*, 16*i* and so on)
Flexible feed gear (N/M) =
Minimum resolution of detector [μm] / controller detection unit [μm]

[Number of position pulses]
Parameter No. 1891 (Series 15*i*) or No. 2024 (Series 30*i*, 16*i* and so on)
Number of position pulses =
Amount of movement per motor revolution [mm] / detection unit of the sensor [mm]

* If the result of the above calculation does not fall in the setting range (0 to 32767) for the number of position pulses, use “position feedback pulse conversion coefficient” to specify the number of position pulses according to the following procedure.
Number of position pulses to be set = A × B
Select B so that A is within 32767. Then, set the following:
A: Position pulses parameter (32767 or less)
No.1891 (Series15*i*), No.2024 (Series 30*i*, 16*i* and so on)
B: Position pulses conversion coefficient parameter
No.2628 (Series15*i*), No.2185 (Series 30*i*, 16*i* and so on)

(Example of parameter setting)

[System configuration]

- The Series 16*i* 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.

[Parameter setting]

- To enable a separate detector, set bit 1 of parameter No. 1815 to 1.
- Calculate the parameters for the flexible feed gear.
  Because flexible feed gear (N/M) = 0.1 μm/1 μm = 1/10:
  No. 2084 = 1 and No. 2085 = 10
- Calculate the number of position pulses.
  Number of position pulses = 16 mm/0.0001mm = 160000
  Because this result does not fall in the setting range (0 to 32767), set A and B, respectively, with the "number of position pulses" and "position pulses conversion coefficient" by assuming:
  160,000 = 10,000 × 16 → A = 10,000 and B = 16
  No.2024 = 10,000, No.2185 = 16

(b) Parameter setting for analog output type linear encoder + FANUC high-resolution serial output circuit

(Parameter setting method)

In addition to the conventional separate detector settings (bit 1 of parameter No. 1815 (Series15*i*,30*i*,16*i*,18*i*,21*i*,20*i*,0*i*, and Power Mate *i*), bit 3 of parameter No. 1807 (Series 15*i*), and, if necessary, FSSB setting), pay attention to the following parameter settings.

First check the type of the FANUC high-resolution output circuit to be coupled to the linear encoder, and then determine the settings of the following function bits.

[Function bit]

Circuit	Specification	Interpolation magnification
High-resolution serial output circuit	A860-0333-T501	512
High-resolution serial output circuit H	A860-0333-T701	2048
High-resolution serial output circuit C	A860-0333-T801	2048

	#7	#6	#5	#4	#3	#2	#1	#0
2687 (FS15*i*)								HP2048
2274 (FS30*i*, 16*i*)								

HP2048(#0) The 2048-magnification interpolation circuit (high-resolution serial output circuit H or C) is:
1: To be used
0: Not to be used

NOTE

1. When high-resolution serial output circuit H is used, set the setting pin SW3 inside the circuit to "Setting B" usually.
2. This function bit can be used with the following series and editions:
   (Series 30*i*, 31*i*, 32*i*)
   Series 90D0/A(01) and subsequent editions
   Series 90E0/A(01) and subsequent editions
   (Series 15*i*-B, 16*i*-B, 18*i*-B, 21*i*-B, 0*i*-B, 0*i* Mate-B, Power Mate *i*)
   Series 90B0/Q(17) and subsequent editions
   Series 90B1/A(01) and subsequent editions
   Series 90B6/A(01) and subsequent editions
   (Series 0*i*-C, 0*i* Mate-C, 20*i*-B)
   Series 90B5/A(01) and subsequent editions
   If this bit is specified, the minimum resolution setting of the detector is assumed to be:
   Encoder signal pitch/512 [μm]
   If the minimum resolution (signal pitch/2048 [μm]) is necessary as the detection unit, specify:
   Flexible feed gear = 4/1
3. When high-resolution serial output circuit H is used, and the input frequency 750 kHz needs to be supported, set the following:
   - Set the setting pin SW3 to "Setting A".
   - Set HP2048=1.
   - Set the minimum resolution of the detector as:
     Encoder signal pitch/128 [μm]
   (Related report: TMS03/16)

[Minimum resolution of the detector]
In the following calculation of a flexible feed gear and the number of position pulses, the minimum detector resolution to be used is:
(Linear encoder signal pitch/512 [μm])
(Specifying the above function bit appropriately makes it unnecessary to take the difference in the interpolation magnification among the high-resolution serial output circuits into account. So always use 512 for calculations.)

[Flexible feed gear]

Parameters Nos. 1977 and 1978 (Series 15*i*) or Nos. 2084 and 2085 (Series 30*i*, 16*i*, and so on)

Flexible feed gear (N/M)

= minimum resolution of the detector [μm] / detection unit of controller [μm]

[Number of position pulses]

Parameter No. 1891 (Series 15*i*) or No. 2024 (Series 30*i*, 16*i*, and so on)

Number of position pulses

= Amount of movement per motor revolution [mm] / minimum resolution of the detector [mm]

* If the result of the above calculation does not fall in the setting range (0 to 32767) for the number of position pulses, use "position feedback pulse conversion coefficient" to specify the number of position pulses according to the following procedure.
  Number of position pulses to be set = A × B
  Select B so that A is within 32767. Then, set the following:
  A: Position pulses parameter (32767 or less)
  No.1891 (Series15*i*), No.2024 (Series 30*i*, 16*i*, and so on)
  B: Position pulses conversion coefficient parameter
  No.2628 (Series15*i*), No.2185 (Series 30*i*, 16*i*, and so on)

(Example of parameter setting)

[System configuration]

- The Series 16*i* is used.
- A linear encoder with a signal pitch of 20 μm is used.
- The linear encoder is coupled with high-resolution serial output circuit H.
- The least input increment of the controller is 1 μm.
- The amount of movement per motor revolution is 16 mm.

[Parameter setting]

- To enable a separate detector, set bit 1 of parameter No. 1815 to 1.
- To use high-resolution serial output circuit H, set bit 0 of parameter No. 2274 to 1.
  Minimum resolution of the detector = 20 μm/512
  = 0.0390625 μm
- Calculate the parameters for the flexible feed gear.
  Because flexible feed gear (N/M)=(20/512μm)/1μm=5/128
  No.2084=5, No.2085=128
- Calculate the number of position pulses.
  Number of position pulses = 16 mm/(20/512μm) = 409,600
  Because this result does not fall in the setting range (0 to 32767), set A and B, respectively, with the "number of position pulses" and "position pulses conversion coefficient" by assuming:
  409,600 = 25,600 × 16 → A = 25,600, B = 16
  No.2024 = 25,600, No.2185 = 16

(c) Parameter setting for the serial output type rotary encoder

* For explanations about the rotary encoders RCN220, RCN223, RCN723, and RCN727 made by HEIDENHAIN, see "Parameter setting for the rotary encoders RCN220, RCN223, RCN723, and RCN727 made by HEIDENHAIN."

(Parameter setting method)

In addition to the conventional settings for a separate detector (bit 1 of parameter No. 1815 (Series15*i*, 30*i*, 16*i*, 18*i*, 21*i*, 20*i*, 0*i*, and Power Mate *i*), bit 3 of parameter No. 1807 (Series 15*i*), and if needed, FSSB), note the following parameters:

[Flexible feed gear]
Parameters Nos. 1977 and 1978 (Series 15*i*) or Nos. 2084 and 2085 (Series 30*i*, 16*i* and so on)
Flexible feed gear (N/M) =
(Amount of table movement [deg] per detector revolution) / (detection unit [deg]) / 1,000,000

[Number of position pulses]
Parameter No. 1891 (Series 15*i*) or No. 2024 (Series 30*i*, 16*i* and so on)
Number of position pulses = 12500×(motor-to-table deceleration ratio)

* If the result of the above calculation does not fall in the setting range (0 to 32767) for the number of position pulses, use "position feedback pulse conversion coefficient" to specify the number of position pulses according to the following procedure.
Number of position pulses to be set = A × B
Select B so that A is within 32767. Then, set the following:
A: Position pulses parameter (32767 or less)
No.1891 (Series15*i*), No.2024 (Series 30*i*, 16*i* and so on)
B: Position pulses conversion coefficient parameter
No.2628 (Series15*i*), No.2185 (Series 30*i*, 16*i* and so on)

(Example of parameter setting)

[System configuration]

- The Series 16*i* 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 reduction ratio = 1/1

[Parameter setting]

- To enable a separate detector, set bit 1 of parameter No. 1815 to 1.
- Calculate the parameters for the flexible feed gear.
  Because flexible feed gear (N/M)
  =360 degrees /0.001 degrees /1,000,000 =36/100
  No.2084=36, No.2085=100
- Calculate the number of position pulses.
  Because number of position pulses = 12500 × (1/2)=6250
  No.2024=6250

(d) Parameter setting for the rotary encoders RCN220, RCN223, RCN723, and RCN727 made by HEIDENHAIN

(Series and editions of applicable servo software)

To use the high-resolution rotary encoders RCN220, RCN223, RCN723, and RCN727 manufactured by HEIDENHAIN as separate detectors, the following servo software is required:

[RCN220,223,723]

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 90B0/T(19) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

[RCN727]

(Series 30*i*,31*i*,32*i*)
- Series 90D0/J(10) and subsequent editions
- Series 90E0/J(10) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 90B1/B(02) and subsequent editions

(Parameter setting method)

To specify parameters for the high-resolution rotary encoders RCN220, RCN223, RCN723, and RCN727 (supporting FANUC serial interface) made by HEIDENHAIN, use the following procedure.

In addition to the conventional separate detector settings (bit 1 of parameter No. 1815 (Series 30*i*, 15*i*, 16*i*, 18*i*, 21*i*, 0*i*, and Power Mate *i*), bit 3 of parameter No. 1807 (Series 15*i*), and, if necessary, FSSB setting), pay attention to the following parameter settings.

[Function bit]

To use the RCN220, RCN223, RCN723, or RCN727, set the following function bit to 1.

	#7	#6	#5	#4	#3	#2	#1	#0
2688 (FS15*i*) / 2275 (FS30*i*, 16*i*)							RCNCLR	800PLS

800PLS (#0) A rotary encoder with eight million pulses per revolution is:

1: To be used. (To use the RCN223, RCN723, or RCN727, set the bit to 1.)

0: Not to be used. (To use the RCN220, leave this bit set to 0.)

RCNCLR (#1) The number of revolution is:

1: To be cleared. (To use the RCN220, RCN223, RCN723, or RCN727, set the bit to 1.)

0: Not to be cleared.

This function bit is to be set in combination with the number of data mask digits, described below.

2807 (FS15*i*)	Number of data mask digits
2394 (FS30*i*, 16*i*)	

[Settings] 8. (To use the RCN223, RCN723, or RCN727)

5. (To use the RCN220)

The value to be set in this parameter depends on the detector. At present, only the above detectors require clearing the speed data.

This parameter is to be set in combination with RCNCLR, described above.

NOTE

The speed data of the RCN220, RCN223, RCN723, or RCN727 is maintained while the power to the separate detector interface unit is on. The data, however, is cleared when the unit is turned off. Since the speed data becomes undetermined depending on where the power is turned off, it is necessary to make a setting to clear the speed data. In addition, for this reason, the RCN220, RCN223, RCN723, and RCN727 cannot be used with a linear axis.

When using the RCN220, set the parameters for the flexible feed gear and the number of position pulses according to the setting method described in the previous item, "Parameter setting for the serial output type rotary encoder".

The following explains how to calculate the parameter values when the RCN223, RCN723, or RCN727 is used.

[Flexible feed gear]

Parameters Nos. 1977 and 1978 (Series 15*i*) or Nos. 2084 and 2085 (Series 30*i*, 16*i*, and so on)

Flexible feed gear (N/M) =

(Amount of table movement [deg] per detector revolution) / (detection unit [deg]) / 8,000,000

For the RCN223, RCN723, and RCN727, the number of pulses per detector turn is assumed to be eight million for calculation.

For the RCN727, when the detection unit is set to 1/8,000,000 revolution or less, the flexible feed gear may be set to up to 8/1. (If the flexible feed gear is set to 8/1, the detection unit is 64,000,000 pulses per revolution.)

[Number of position pulses]

Parameter No. 1891 (Series 15*i*) or No. 2024 (Series 30*i*, 16*i*, and so on)

Number of position pulses = 100,000×(motor-to-table reduction ratio)

* If the result of the above calculation does not fall in the setting range (0 to 32767) for the number of position pulses, use “position feedback pulse conversion coefficient” to specify the number of position pulses according to the following procedure.
Number of position pulses to be set = A × B
Select B so that A is within 32767. Then, set the following:
A: Position pulses parameter (32767 or less)
No.1891 (Series15*i*), No.2024 (Series 30*i*, 16*i*, and so on)
B: Position pulses conversion coefficient parameter
No.2628 (Series15*i*), No.2185 (Series 30*i*, 16*i*, and so on)

[Reference counter capacity]

Parameter No. 1896 (Series 15*i*) or No. 1821 (Series 30*i*, 16*i*, and so on)

Specify the number of feedback pulses per table turn (detection unit).

* If bit 0 of parameter No. 2688 (Series 15*i*) or parameter No. 2275 (Series 30*i*, 16*i*, and so on) is 0, specify the number of pulses per table turn divided by 8 as the reference counter capacity. In this case, eight grid points occur per table turn.

(Example of parameter setting)

[System configuration]

- The Series 16*i* is used.
- The rotary encoder RCN223 made by HEIDENHAIN is used.
- The least input increment of the controller is 1/10,000 degree.
- The amount of movement per motor revolution is 180 degrees (reduction ratio: 1/2)
- Table-to-separate-encoder reduction ratio = 1/1

[Parameter setting]

- To enable a separate detector, set bit 1 of parameter No. 1815 to 1.
- To use the detector RCN223, set bit 0 of parameter No. 2275 to 1, bit 1 of this parameter to 1, and parameter No. 2394 to 8.
- Calculate the parameters for the flexible feed gear.
  Because flexible feed gear (N/M) =
  (360 degrees /0.0001 degrees)/8,000,000=9/20
  No.2084=9, No.2085=20
- Calculate the number of position pulses.
  Number of position pulses = 100,000 × (1/2) = 50,000
  Because this result does not fall in the setting range (0 to 32767), set A and B, respectively, with the "number of position pulses" and "position pulses conversion coefficient" by assuming:
  50,000 = 12,500 × 4 → A = 12,500, B = 4
  No.2024 = 12,500, No.2185 = 4

- Calculate the reference counter capacity.
  Reference counter capacity = 360 degrees/0.0001 degrees = 3,600,000

(About speed limit)

When the RCN223, RCN723, or RCN727 is used as a separate detector, the maximum permissible speed that can be controlled is 937 min^{-1}. (*) (See Appendix E.)

(*) The above maximum speed does not include hardware limitations. For the maximum permissible speed of the detector itself, refer to the specifications of the detector.

Setting the signal direction of the separate detector

When a serial type separate detector is used with its signals connected in reverse directions, the following parameter must be used:

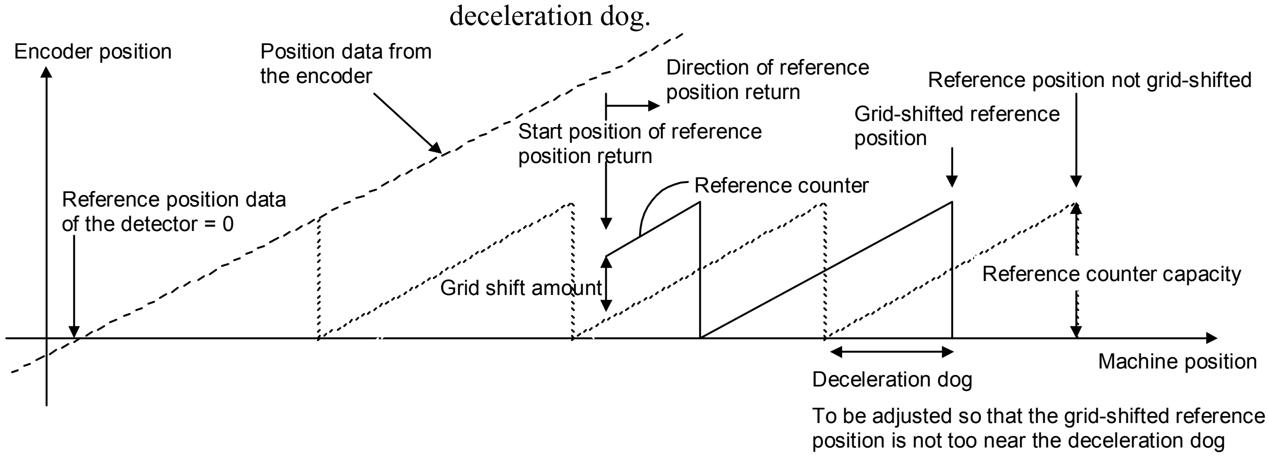
	#7	#6	#5	#4	#3	#2	#1	#0
1960 (FS15*i*) / 2018 (FS30*i*, 16*i*)								RVRSE

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

(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.
(This description does not apply if a detector that does not require battery backup is in use.)

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

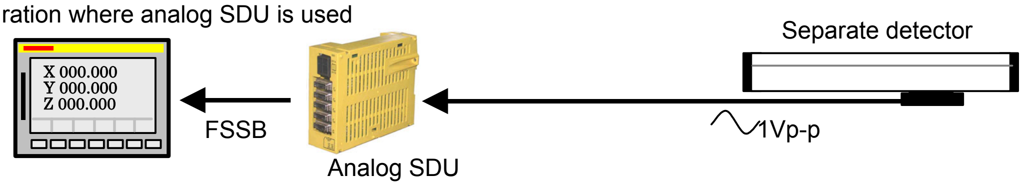


2.1.5 Setting Servo Parameters when an Analog Input Separate Interface Unit is Used

(1) Overview

An analog input separate interface unit (analog SDU) can be connected directly to an encoder having an analog output signal of 1 Vp-p. This subsection explains parameter settings to be made when this unit is connected to a separate detector. After performing the initialization procedure (full-closed loop) described in Subsection 2.1.3, change the setting described below according to the signal pitch of the detector.

Configuration where analog SDU is used



(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/J(10) and subsequent editions
Series 90E0/J(10) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B1/C(03) and subsequent editions

(3) Setting parameters

After performing the initialization (full-closed loop) described in Subsection 2.1.3, change the following setting according to the signal pitch of the detector:

[Setting the flexible feed gear]

Parameter	Description
1977 (FS15*i*) 2084 (FS30*i*,16*i*)	**Numerator of flexible feed gear**
1978 (FS15*i*) 2085 (FS30*i*,16*i*)	**Denominator of flexible feed gear**

Set the flexible feed gear according to the following equation.
(Equation for parameter calculation)

$$\text{Flexible feed gear (N/M)} = \frac{\text{Detector signal pitch [}\mu\text{m]/512}}{\text{Detection unit of controller [}\mu\text{m]}}$$

[Setting the number of position pulses]

1891 (FS15*i*)	Number of position pulses (PPLS)
2024 (FS30*i*,16*i*)	

Set the number of position pulses according to the following equation:
(Equation for parameter calculation)

$$\text{Number of position pulses} = \frac{\text{Amount of movement per motor revolution [mm]}}{\text{Detector signal pitch [mm]/512}}$$

If the calculation result is greater than 32767, use the following position pulse conversion coefficient (PSMPYL) to obtain the parameter setting (PPLS).

2628 (FS15*i*)	Position pulse conversion coefficient (PSMPYL)
2185 (FS30*i*,16i*i*)	

This parameter is used when the calculation result of the number of position pulses is greater than 32767.
(Equation for parameter calculation)
Set this parameter so that the following equation is satisfied:
Number of position pulses = PPLS × PSMPYL
(→ See Supplementary 3 in Subsection 2.1.8.)

(Example of parameter setting)

[System configuration]

- The Series 30*i* is used.
- A linear scale with a signal pitch of 20 μm is used.
- The least input increment of the controller is 1 μm.
- The amount of movement per motor revolution is 16 mm.

[Parameter setting]

- To enable a separate detector, set bit 1 of parameter No. 1815 to 1.
- Calculate the parameters for the flexible feed gear.
  Because flexible feed gear (N/M)=(20/512μm)/1μm=5/128
  No.2084=5, No.2085=128
- Calculate the number of position pulses.
  Number of position pulses = 16 mm/(0.02 mm/512= 409,600
  Because this result does not fall in the setting range (0 to 32767), set A and B, respectively, with the "number of position pulses" and "position pulses conversion coefficient" by assuming:
  409,600 = 25,600 × 16 → A = 25,600, B = 16
  No.2024 = 25,600, No.2185 = 16

2.1.6 Setting Parameters when an αiCZ Sensor is Used

(1) Overview

αiCZ sensors may be used in the following two ways:
<1> Used as a detector for a synchronous built-in servo motor
<2> Used as a separate detector
This subsection explains parameter settings to be made when the sensor is used in each of these two ways.

The following three types of αiCZ sensor are available:

	Signal interval	Number of pulses at setting
αiCZ 512S	512λ/rev	500,000pulse/rev
αiCZ 1024S	768λ/rev	750,000pulse/rev
αiCZ 1024S	1024λ/rev	1,000,000pulse/rev

NOTE
1 When turning on and off the CNC, be sure to turn on and off the αiCZ 768S if it is used.
2 The absolute αiCZ 768S can be used only when the number of revolutions is finite (the integral number of revolutions is 10 or less).

(2) Series and editions of applicable servo software

- αiCZ 512S, αiCZ 1024S
  (Series 30*i*,31*i*,32*i*)
  Series 90D0/A(01) and subsequent editions
  Series 90E0/A(01) and subsequent editions
  (Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
  Series 90B0/A(01) and subsequent editions (*)
  Series 90B1/A(01) and subsequent editions
  Series 90B6/A(01) and subsequent editions (*)
  (Series 0*i*-C,0*i* Mate-C,20*i*-B)
  Series 90B5/A(01) and subsequent editions (*)
- αiCZ 768S
  (Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
  Series 90B1/C(03) and subsequent editions
  (Series 30*i*,31*i*,32*i*)
  Series 90D0/J(10) and subsequent editions
  Series 90E0/J(10) and subsequent editions

(*) With Series 90B0, 90B5, and 90B6, a αiCZ sensor cannot be used as the detector for a synchronous built-in servo motor. (The αiCZ sensor can be used as a separate detector.)

(3) Setting parameters

(a) Used as the detector for a synchronous built-in servo motor)

[Setting AMR]

	#7	#6	#5	#4	#3	#2	#1	#0
1806 (FS15*i*) 2001 (FS30*i*,16*i*)	0	AMR6	AMR5	AMR4	AMR3	AMR2	AMR1	AMR0

Set the value listed below according to the detector.

Detector	AMR
α*i*CZ 512S	Set the number of poles of the synchronous built-in servo motor in binary.
α*i*CZ 768S	Set 0.
α*i*CZ 1024S	Set a value obtained by dividing the number of poles of the synchronous built-in servo motor by 2 in binary.

Setting example:

When an 88-pole synchronous built-in servo motor and the α*i*CZ 1024S are used:
Number of poles/2 = 88/2 = 44
→ The binary representation of the above value is 00101100. This value is set in AMR.

	#7	#6	#5	#4	#3	#2	#1	#0
2608 (FS15*i*) 2220 (FS30*i*,16*i*)								DECAMR

Set one of the following values according to the detector.

Detector	DECAMR
α*i*CZ 512S	Set 0.
α*i*CZ 768S	Set 1.
α*i*CZ 1024S	Set 0.

1705 (FS15*i*) 2112 (FS30*i*,16*i*)	AMR conversion coefficient 1

1761 (FS15*i*) 2138 (FS30*i*,16*i*)	AMR conversion coefficient 2

Set one of the following values according to the detector.

Detector	AMR conversion coefficient 1	AMR conversion coefficient 2
α*i*CZ 512S	Set 0.	Set 0.
α*i*CZ 768S	Set 768.	Set half the number of poles.
α*i*CZ 1024S	Set 0.	Set 0.

[Setting flexible feed gear]

1977 (FS15*i*) 2084 (FS30*i*,16*i*)	**Flexible feed gear (numerator)**

1978 (FS15*i*) 2085 (FS30*i*,16*i*)	**Flexible feed gear (denominator)**

Set the flexible feed gear according to the equation below.
The number of pulses per detector rotation is as follows:

Detector	Number of pulses per detector rotation
αiCZ 512S	$\dfrac{\text{Amount of movement per motor revolution [deg]/ detection unit [deg]}}{500{,}000}$
αiCZ 768S	$\dfrac{\text{Amount of movement per motor revolution [deg]/ detection unit [deg]}}{750{,}000}$
αiCZ 1024S	$\dfrac{\text{Amount of movement per motor revolution [deg]/ detection unit [deg]}}{1{,}000{,}000}$

(Equation for parameter calculation)

$$\text{Flexible feed gear (N/M)} = \frac{\text{Amount of movement per motor revolution [deg]/ detection unit [deg]}}{\text{Number of pulses per detector rotation}}$$

[Setting number of velocity pulses]

1876 (FS15*i*) 2023 (FS30*i*,16*i*)	**Number of velocity pulses (PULCO)**

Set a value listed in the following table according to the detector used.

Detector	Number of velocity pulses
αiCZ 512S	4096
αiCZ 768S	6144
αiCZ 1024S	8192

[Setting number of position pulses]

1891 (FS15*i*) 2024 (FS30*i*,16*i*)	**Number of position pulses (PPLS)**

Set a value listed in the following table according to the detector used.

Detector	Number of position pulses
αiCZ 512S	6250
αiCZ 768S	9375
αiCZ 1024S	12500

[Setting reference counter capacity]

1896 (FS15*i*)	Reference counter capacity
1821 (FS30*i*,16*i*)	

Set one of the following values according to the detector.

Detector	Reference counter capacity
αiCZ 512S	Set the number of pulses per motor revolution (detection unit) or a value obtained by dividing that number by an integer.
αiCZ 768S	Set the number of pulses per 120-degree motor revolution (one-third revolution) (detection unit) or a value obtained by dividing that number by an integer.
αiCZ 1024S	Set the number of pulses per motor revolution (detection unit) or a value obtained by dividing that number by an integer.

(Example of parameter setting)

[System configuration]

- The Series 30*i* is used.
- An 88-pole/rev, synchronous built-in servo motor is used.
- The detector used is the αiCZ512S.
- The least input increment of the controller is 1/1000 deg.
- Gear ratio 1:1

[Parameter setting]

AMR=01011000 (88 in decimal representation)
Flexible feed gear (N/M) = 360,000/500,000 = 18/25, so parameter No. 2084 = 18, and parameter No. 2085 = 25
Number of velocity pulses = 4096
Number of position pulses = 6250
Reference counter capacity = 360,000

(b) Used as a separate detector

After performing the initialization procedure (full-closed loop) described in Subsection 2.1.3, change the settings described below according to the signal pitch of the detector.

[Setting flexible feed gear]

1977 (FS15*i*)	Flexible feed gear (numerator) (N)
2084 (FS30*i*,16*i*)	

1978 (FS15*i*)	Flexible feed gear (denominator) (M)
2085 (FS30*i*,16*i*)	

Set a value listed in the following table according to the detector used.

Detector	Number of pulses per detector rotation
α*i*CZ 512S	Amount of movement per motor revolution [deg]/ detection unit [deg] / 500,000
α*i*CZ 768S	Amount of movement per motor revolution [deg]/ detection unit [deg] / 750,000
α*i*CZ 1024S	Amount of movement per motor revolution [deg]/ detection unit [deg] / 1,000,000

[Setting number of velocity pulses]

1876 (FS15*i*)	Number of velocity pulses (PULCO)
2023 (FS30*i*,16*i*)	

Set the number of velocity pulses to 8192.

[Setting number of position pulses]

1891 (FS15*i*)	Number of position pulses (PPLS)
2024 (FS30*i*,16*i*)	

Set a value listed in the following table according to the detector used.

Detector	Number of position pulses
α*i*CZ 512S	6250 × (gear reduction ratio from the motor to table)
α*i*CZ 768S	9375 × (gear reduction ratio from the motor to table)
α*i*CZ 1024S	12500 × (gear reduction ratio from the motor to table)

If the calculation result is greater than 32767, use the following position pulse conversion coefficient (PSMPYL) to obtain the parameter value (PPLS).

2628 (FS15*i*)	Conversion coefficient for the number of position feedback pulses (PSMPYL)
2185 (FS30*i*,16*i*)	

This parameter is used when the calculated number of position pulses is greater than 32767.
(Equation for parameter calculation)
Set this parameter so that the following equation is satisfied:
Number of position pulses = PPLS × PSMPYL
(→ See Supplementary 3 in Subsection 2.1.8.)

[Setting reference counter capacity]

1896 (FS15*i*)	Reference counter capacity
1821 (FS30*i*,16*i*)	

Set one of the following values according to the detector.

Detector	Reference counter capacity
α*i*CZ 512S	Set the number of pulses per revolution of the detector installed separately (detection unit) or a value obtained by dividing that number by an integer.
α*i*CZ 768S	Set the number of pulses per 120-degree revolution (one-third revolution) of the detector installed separately (detection unit) or a value obtained by dividing that number by an integer.
α*i*CZ 1024S	Set the number of pulses per revolution of the detector installed separately (detection unit) or a value obtained by dividing that number by an integer.

(Example of parameter setting)

[System configuration]

- The Series 30*i* is used.
- The detector used is the α*i*CZ1024S
- The least input increment of the controller is 1/1000 deg.
- Gear ratio 1:1

[Parameter setting]

Flexible feed gear (N/M) = 360,000/1,000,000＝9/25,
so parameter No. 2084 = 9, and parameter No. 2085 = 25
Number of position pulses = 12500
Reference counter capacity = 360,000

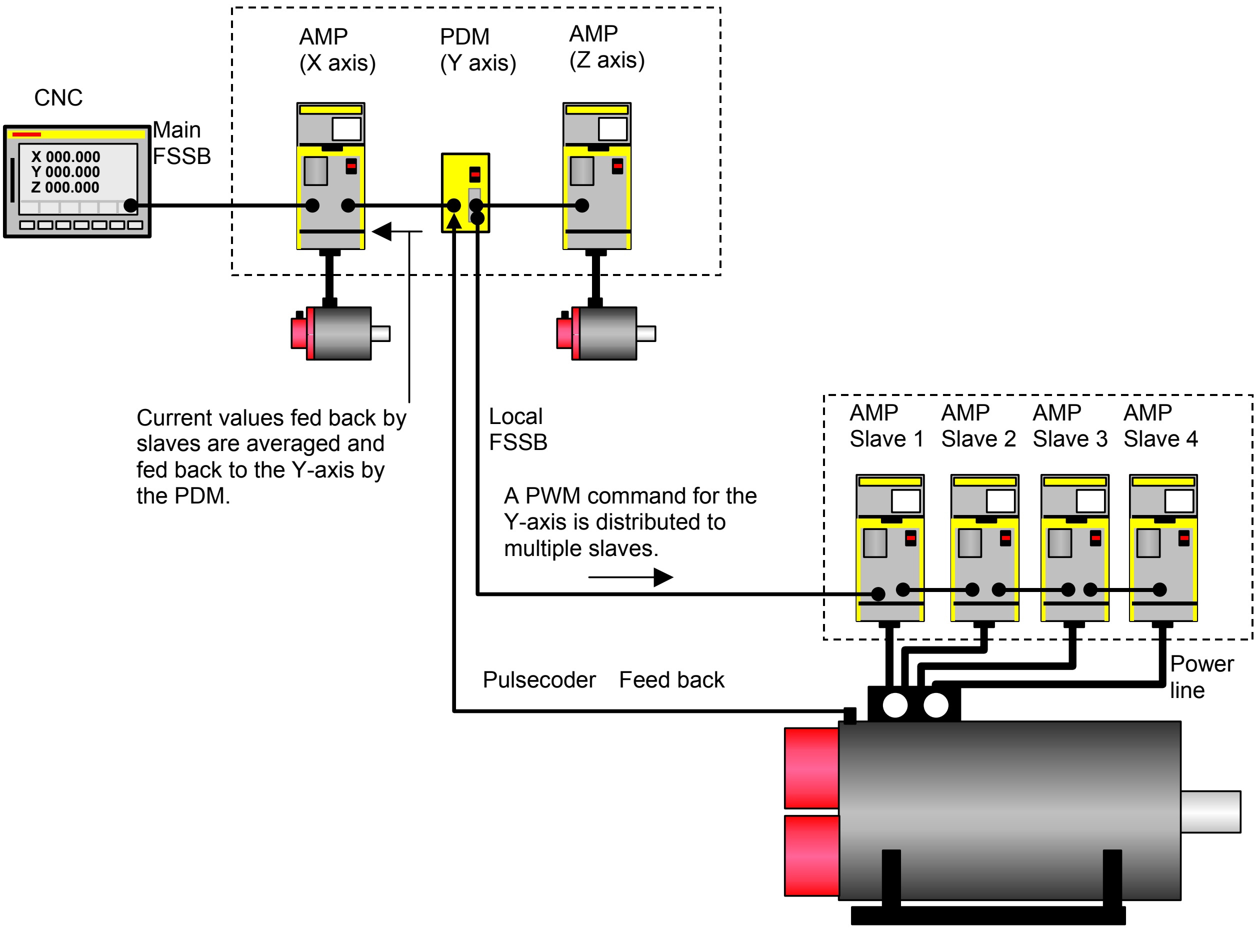
2.1.7 Setting Parameters when the PWM Distribution Module is Used

(1) Overview

The PWM distribution module (PDM) distributes a copy of a PWM command for one axis received from the CNC to more than one servo amplifier. When receiving current feedback signals from the servo amplifiers, the PDM obtains an average current value per servo amplifier and transfers it to the CNC. Since the CNC regards servo amplifiers connected to the PDM as one axis, use of the PDM allows large output by parallel driving without increasing the number of axes controlled by the CNC.

The PDM is used mainly for driving a servo motor having four or more windings (such as the αiS2000/2000HV and αiS3000/2000HV).

Connection example:



Servo motor (αiS2000/2000HV and so on)

(2) Series and editions of applicable servo software

(Series 16*i*-B,18*i*-B,21*i*-B, Power Mate *i*)
Series 90B1/A(01) and subsequent editions

(*) When the PDM is used, it must be supported by the CNC system software. (With the system software series listed below, the PDM can be used.)

CNC model	Series and edition
Series 16*i*-MB	B0HA-17 and subsequent editions
Series 18*i*-MB	BDHA-17 and subsequent editions
Series 18*i*-MB5	BDHE-07 and subsequent editions
Series 21*i*-MB	DDHA-17 and subsequent editions
Power Mate *i*-D	88E1-01 and subsequent editions
Power Mate *i*-H	88F2-01 and subsequent editions

(3) Setting parameters

(a) Setting for the PDM

When the PDM is used for an axis, servo HRV3 control must be set for the axis. Set the parameter shown below.

After setting parameters with servo HRV2 control specified, set servo HRV3 control by parameter setting as follows (**HR3 = 1**). (For each axis)

	#7	#6	#5	#4	#3	#2	#1	#0
2013 (FS16*i*)								**HR3**

HR3(#0) 1: Uses servo HRV3 control.
0: Does not use servo HRV3 control.
(*) To use the PDM, set **HR3 to 1**. In actual control, operation equivalent to HRV2 takes place. (It is also impossible to perform switching between high-speed current control modes by G5.4.)

For the axis for which the PDM is used, set the following parameter in addition to the above HR3 setting.

2165 (FS16*i*)	**Set 0.**

If this setting is omitted, the invalid motor-amplifier combination state may occur.
When the PDM is used, this parameter needs to be set to 0. So, note that actual current display (in amperes) on the servo adjustment screen is disabled. (Indication by % is provided.)

(b) Setting for 16-pole servo motors

For an axis for which one of the following servo motor is used, set the following parameter for 16-pole servo motors:

Servo motor name	Motor specification
αiS2000/2000HV	0091
αiS3000/2000HV	0092

	#7	#6	#5	#4	#3	#2	#1	#0
2220 (FS16*i*)			**P16**					

P16(#5) 1: Uses a 16-pole servo motor.
0: Does not use a 16-pole servo motor.

	#7	#6	#5	#4	#3	#2	#1	#0
2001 (FS16*i*)	**0**	**AMR6**	**AMR5**	**AMR4**	**AMR3**	**AMR2**	**AMR1**	**AMR0**

AMR0 to 6 (#0 to 6) Set the AMR value according to the number of motor poles.

AMR							**Number of motor poles**
6	5	4	3	2	1	0	
0	0	0	1	0	0	0	16-pole servo motor αiS2000/2000HV, αiS3000/2000HV
0	0	0	0	0	0	0	Other than 16-pole servo motor (8-pole servo motor)

2.1.8 Actions for Illegal 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 30*i*,31*i*,32*i*)
Series90D0/A(01) and subsequent editions
Series90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series9096/A(01) and subsequent editions
Series90B0/A(01) and subsequent editions
Series90B1/A(01) and subsequent editions
Series90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series90B5/A(01) and subsequent editions

(3) Illegal 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 the servo software detects an alarm, 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 (See the descriptions of detailed display provided later.)
0: Alarm detected by the system software (With Series including 16*i*, identification is possible using DGN280.)

	#7	#6	#5	#4	#3	#2	#1	#0
DGN280		AXS		DIR	PLS	PLC		MOT

MOT(#0) 1: As the motor number in parameter No. 2020, a value not within the specifiable range is set.

The table given below lists the valid motor ID numbers for each series.
If a number beyond the indicated range is set, an illegal parameter setting alarm is issued.
(In this case, keep PRM = 0.)

Servo software series/edition	Motor ID No.
Series 9096/A(01) and subsequent editions	1 to 250
Series 90B0/H(08) and subsequent editions	1 to 350
Series 90B1/B(02) and subsequent editions	1 to 550
Series 90B5,90B6/B(02) and subsequent editions	1 to 550
Series 90D0,90E0/B(02) and subsequent editions	1 to 550

PLC(#2) 1: As the number of velocity feedback pulses per motor revolution in parameter No. 2023, an invalid value such as a number equal to or less than 0 is set.

PLS(#3) 1: As the number of position feedback pulses per motor revolution in parameter No. 2024, an invalid value such as a number equal to or less than 0 is set.

DIR(#4) 1: As the motor rotation direction in parameter No. 2022, a correct value (111 or -111) is not set.

AXS(#6) 1: Parameter No. 1023 (servo axis number) is set incorrectly.

(4) Method

When an illegal 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 illegal 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 30*i*, 16*i* and so on)

On the diagnosis screen, search for No. 352. Check the number written in No. 352.

Analyzing illegal parameter setting alarms in detail

The detail alarm data basically consists of three to five digits as shown:

0	0	4	3	4

Location where an alarm was caused　　Cause of the alarm

Upper four digits:

Indicate the location where an alarm was caused.

Table 2.1.8 lists the displayed numbers and corresponding parameter numbers.

*1 Basically, the low-order three digits of the 4-digit parameter number of the Series 16*i* indicate the location where an alarm was caused. (When an alarm is due to more than one parameter, these digits and parameter numbers do not sometimes match.)

*2 When the digits are displayed on the servo alarm screen (Series 15*i*) or diagnosis screen (Series 30*i*, 16*i*, and so on), 0s in high-order digits are not displayed.

Lowest digit:

Indicates the cause of an alarm.

The displayed numbers and their meanings are explained below:

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.

Table 2.1.8 Detail analysis of illegal parameter setting alarms

Alarm detail No.	Parameter No. Series 15*i*	Parameter No. Series 30*i*, 16*i*, and so on	Cause	Action
83	-	2008	Parameter settings related to learning control are illegal → See Supplementary 1.	Change the parameter settings so that they fall in the applicable range.
233	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.
243	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 3.
434 435	1855	2043	The internal value of the velocity loop integral gain overflowed.	Decrease the value of the velocity loop integral gain parameter.
443 444 445	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. Alternatively, decrease the parameter setting. → See Supplementary 4.
474 475	1859	2047	The internal value of the observer parameter (POA1) overflowed.	Correct the setting to (−1) × (desired value)/10.
534 535	1865	2053	The internal value of a parameter related to dead zone compensation overflowed.	Decrease the setting to the extent that the illegal parameter setting alarm is not caused.
544 545	1866	2054	The internal value of a parameter related to dead zone compensation overflowed.	Decrease the setting to the extent that the illegal parameter setting alarm is not caused.
686 687 688	1961	2068	The internal value of the feed-forward coefficient overflowed.	Use the position gain expansion function. → See Supplementary 5.
694 695 696 699	1962	2069	The internal value of the velocity feed-forward coefficient overflowed.	Decrease the velocity feed-forward coefficient.
754 755	1968	2075	The setting for this parameter has overflowed.	This parameter is not used at present. Set 0.
764 765	1969	2076	The setting for this parameter has overflowed.	This parameter is not used at present. Set 0.
843	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)
853	1978	2085	A positive value is not set as the flexible feed gear denominator.	Set a positive value as the flexible feed gear denominator.
883	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.

Alarm detail No.	Parameter No. Series 15*i*	Parameter No. Series 30*i*, 16*i*, and so on	Cause	Action
884 885 886	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.
926 927 928	1985	2092	The internal value of the look-ahead feed-forward coefficient overflowed.	Use the "position gain precision optimization function" or the "position gain increment function". → See Supplementary 5.
953	1988 1763 2808	2095 2140 2395	The internally set value of the feed-forward timing adjustment coefficient is ±12800 or over.	This error can be avoided by setting bit 4 of parameter No. 2612 (for the Series 15*i*) or bit 5 of parameter No. 2224 (for the Series 16*i* and so on) to 1 if not nano-interpolation is used.
994 995 996	1992	2099	The internal value for N pulse suppression overflowed.	Disable the N pulse suppression function. (Series 15*i* : No.1808#4=0, Series 30*i*, 16*i*, and so on : No.2003#4=0) Alternatively, decrease the parameter setting so that no overflow will occur.
1033	1996	2103	There is a difference in retract distance under unexpected disturbance torque between position tandem synchronous axes (if the same-axis retract function is in use).	Set the same value for position tandem synchronous axes.
1123	1705	2112	Although a linear motor is used, the AMR conversion coefficient parameter is not input.	Set the AMR conversion coefficient.
1182	1729 1971 1972	2118 2078 2079	The dual position feedback conversion coefficient has not been specified.	Specify the dual position feedback conversion coefficient.
1284 1285	1736	2128	When a small value is set as the number of velocity pulses, the internal value of a parameter related to current control overflows.	Decrease the value in this parameter to the extent that the alarm is 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 this parameter 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.	Keep the setting of this parameter within ±45. Alternatively, set bit 0 of parameter No. 2683 (for the Series 15*i*) or bit 0 of parameter No. 2270 (for the Series 30*i*, 16*i*, and so on) to 1 to increase the setting range of the AMR offset, and then specify the parameter anywhere within ±60.

Alarm detail No.	Parameter No. Series 15*i*	Parameter No. Series 30*i*, 16*i*, and so on	Cause	Action
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 5.
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.
1493	1772	2149	A value greater than 6 is specified in this parameter.	Only 6 or less can be specified in this parameter. Change the setting to 6 or below 6.
1503	1773	2150	A value equal to or greater than 10 is set.	Set a value less than 10.
1793	2622	2179	A negative value or a value greater than the setting of parameter No. 1821 (Series 16*i* and so on) or parameter No. 1896 (Series 15*i*) is set.	Set a positive value less than the setting of parameter No. 1821 (Series 30*i*, 16*i*, and so on) or parameter No. 1896 (Series 15*i*).
1853	2628	2185	A negative value or a value greater than the setting of parameter No. 2023 (Series 16*i* and so on) or parameter No. 1876 (Series 15*i*) is set.	Set a positive value less than the setting of parameter No. 2023 (Series 30*i*, 16*i*, and so on) or parameter No. 1876 (Series 15*i*).
2243	2612#5	2224#5	Series 15*i* : No.2612#5=1 and Series 16*i* and so on : No.2224#5=1 (feed-forward timing adjustment function overflow alarm ignored) were specified and a nano interpolation command was issued.	Use either one.
2713	1707#0	2013#0	The PDM is used, but the HRV3 function bit is off.	Set the HRV3 function bit to 1.
3423	2755	2342	A negative value or a value equal to or greater than 101 is set.	Set a positive value less than 100.
3433	2756	2343	A value not within -180 to 180 is set.	Set a value within -180 to 180.
8213	1896	1821	A positive value is not set in the reference counter capacity parameter.	Set a positive value in this parameter.
8254 8255 8256	1825	1825	The internal value of the position gain overflowed.	Use the "position gain precision optimization function" or the "position gain increment function". → See Supplementary 5.
10016 10019	1740#0	2200#0	The internal value of a parameter related to runaway detection overflowed.	Do not use the runaway detection function. (Set bit 0 to 1.)
10024 10025			An overflow occurred in internal calculation on the separate detector serial feedback extrapolation level.	When servo software Series 90B0 is used, change the software edition to edition D or a later edition. (For series other than 90B0, the software edition need not be changed.)

Alarm detail No.	Parameter No. Series 15*i*	Parameter No. Series 30*i*, 16*i*, and so on	Cause	Action
10033	1809	2004	Illegal control cycle setting This error occurs if automatic modification is carried out for the control cycle.	Correct this parameter related to interrupt cycle setting.
10053	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	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.
10072	1951#6	2007#6	The customer's board function and FAD were specified at the same time.	The customer's board function and the FAD function cannot be used together. Turn off one of them.
10082	2601#6	2213#6	The NC does not support the improved version of the cutting/rapid position gain switching function.	Disable this function.
10092 10093	1809 1707#0 1708#0	2004 2013#0 2014#0	This alarm is issued when an invalid control cycle is set.	Change the control cycle setting to HRV1, HRV2, HRV3 or HRV4. → See Supplementary 2.
			Different control cycles are set within one servo CPU.	Set the same control cycle for axes controlled by one servo CPU. → See Supplementary 2.
			When HRV4 is enabled, a detector that does not support HRV4 is used. (FS30*i* only)	Replace the detector with a detector supporting HRV4. Alternatively, disable HRV4. → See Supplementary 2.
			When HRV4 is enabled, a servo amplifier that does not support HRV4 is connected. (FS30*i* only)	Replace the servo amplifier with a servo amplifier supporting HRV4. Alternatively, disable HRV4. → See Supplementary 2.
			HRV1 is set. (FS30*i* only)	The Series 30*i* does not allow HRV1 setting. Set HRV2, HRV3 or HRV4. → See Supplementary 2.
10103	1809 1707#0	2004 2013#0	If a current control cycle of 250 μs is set, this error occurs when HRV3 is specified.	Set the control cycle correctly. → See Supplementary 2.
10113	1707#0	2013#0	This error occurs if the specified current cycle does not match the actual setting.	An axis for which HRV3 is specified exists on the same optical cable. Review the placement of the amplifier, or disable HRV3. → See Supplementary 2.

Alarm detail No.	Parameter No. Series 15*i*	Parameter No. Series 30*i*, 16*i*, and so on	Cause	Action
10123	1707#0	2013#0	This alarm is issued when the axis supports HRV3 but the other axis of the pair does not support HRV3.	Eliminate the cause of the disability in setting the other axis. Alternatively, cancel the HRV3 setting. → See Supplementary 2.
	1707#0 1708#0	2013#0 2014#0	When HRV4 is set, this alarm is issued if any of the following conditions is met. (FS30*i* only) - Servo software not supporting HRV4 is used. - The same FSSB system includes axes with HRV4 setting and axes with HRV2 or HRV3 setting. - The limitation in the number of axes is not observed. (In HRV4 control, one axis/DSP is set.)	Eliminate the causes listed on the left. Alternatively, cancel the HRV4 setting. → See Supplementary 2.
10133 (*4)	1707#0 1708#0	2013#0 2014#0	This alarm is issued when HRV3 or HRV4 is set, but the amplifier does not support these control types.	HRV3 or HRV4 is unusable for the axis on which the error occurred. → See Supplementary 2.

* The alarms indicated by "(FS30*i* only)" may be issued only when servo software Series 90D0 or 90E0 is used. When other servo software series are used, these alarms are not issued.

Supplementary 1: Details of illegal settings of learning control parameters

For the Series 16*i* and so on, reset parameter No. 2115 to 0, and set parameter No. 2151 to 1913, and then change the value of diagnosis information (DGN) No. 353 to binary form. If a resulting binary bit is 1, its bit position indicates the detail cause. (For the Series 15*i*, no learning control is available.)

Bit position	Cause
B3	The band stop filter setting (No. 2244) is out of the valid range.
B4	The profile number setting (No. 2233) is out of the valid range.
B5	The command data cycle setting (Nos. 2243, 2236, 2238, 2240, and 2266) is out of the valid range.
B6	The total of the profiles (No. 2264) is out of the valid range.
B7	G05 was started during memory clear processing.
B8	The profile number (No. 2233) was 0 when the total of profiles (No. 2264) is nonzero.
B9	An automatically set value for thinning-out shift was out of the valid range because of a long command data cycle.

Supplementary 2: Control cycle setting

There are four different types of control cycle setting (HRV1, HRV2, HRV3 and HRV4). Their settings are explained below.

For Series 15*i*
HRV1: No1809=0X000110
HRV2: No1809=0X000011, No1707#0=0
HRV3: No1809=0X000011, No1707#0=1

For Series 16*i* and so on
HRV1: No2004=0X000110
HRV2: No2004=0X000011, No2013#0=0
HRV3: No2004=0X000011, No2013#0=1

For Series 30*i*
HRV2: No2004=0X000011, No2013#0=0, No2014#0=0
HRV3: No2004=0X000011, No2013#0=1, No2014#0=0
HRV4: No2004=0X000011, No2013#0=0, No2014#0=1

When an invalid value is set in control cycle related parameters, the following alarm messages are indicated on the CNC:

Alarm detail No.	Alarm number	Message
10092 10093	456	Invalid current control cycle setting
10103	457	Invalid High-speed HRV setting
10113	458	Invalid current control cycle setting
10123	459	High-speed HRV setting not allowed
10133	468	High-speed HRV setting not allowed (amplifier)

Supplementary 3: Setting the number of position pulses

If the resolution of the separate detector is high and the number of position feedback pulses becomes greater than 32767, take the following measure.

(a) For other than servo software Series 9096

Use "position feedback pulse conversion coefficient" to make settings.
Number of position feedback pulses = A × B
Select B so that A is within 32767.

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

1891 (FS15*i*) / 2024 (FS30*i*, 16*i*)	Number of position feedback pulses

2628 (FS15*i*) / 2185 (FS30*i*, 16*i*)	Conversion coefficient for the number of position feedback pulses

(Example of setting)
If the linear scale used has a minimum resolution of 0.1 μm and the distance to move per motor turn is 16 mm
Set A and B, respectively, to 10000 and 16, because:
Ns = distance to move per motor turn (mm)/detector minimum resolution (mm) = 16 mm/0.0001 mm = 160000(>32767) = 10000×16

> **NOTE**
> If the detector on the motor is an αi Pulsecoder (number of velocity pulses = 8192), select a value raised to the second power (2, 4, 8, ...) as the conversion coefficient as much as possible (so the position gain used within the software becomes more accurate).

If the setting of the number of position pulses becomes very large, a subtle difference in response may occur between two axes submitted to interpolation, because of position gain canceling. To avoid this problem, make the following setting.

	#7	#6	#5	#4	#3	#2	#1	#0
1749 (FS15*i*) 2209 (FS30*i*, 16*i*)		PGAT						

PGAT(#6) The position gain precision optimization function is:
1: Enabled
0: Disabled (conventional method)

> **NOTE**
> 1 Specify this function for all the simultaneous contouring axes.
> 2 In servo software Series 90D0 and 90E0, automatic format change for position gain is enabled by default regardless of the PGAT setting. So, PGAT need not be set.

(b) For servo software Series 9096

Because the "position feedback pulse conversion coefficient" is unusable, change the parameters as stated below.

(i) If the number of position pulses is in a range from 32,768 to 131,000
Change the parameters according to the following table.

Parameter number		Method for changing parameters
Series 15*i*	Series 30*i*, 16*i*, and so on	
1804#0	2000#0	1
1876	2023	(Setting target)/10
1891	2024	(Setting target)/10

(ii) If the number of position pulses is larger than 131,000
Change the parameters according to the following table.
In this table, letter E satisfies:
Number of position feedback pulses/10/E < 13100

Parameter number		Method for changing parameters
Series 15*i*	Series 30*i*, 16*i*, and so on	
1804#0	2000#0	1
1876	2023	(Setting target)/10/E
1891	2024	(Setting target)/10/E
1855	2043	(Setting target)/E
1856	2044	(Setting target)/E
1859	2047	(Setting target)×E
1865	2053	(Setting target)×E
1866	2054	(Setting target)/E
1871	2059	(Setting target)×E
1969	2076	(Setting target)/E
1736	2128	(Setting target)/E
1752	2129	(Quotient of setting target/256) ×E×256 +(remainder of setting target/256)

Supplementary 4: 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.

	#7	#6	#5	#4	#3	#2	#1	#0
1740 (FS15*i*) / 2200 (FS30*i*, 16*i*)		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 5: Preventing an overflow in the position gain or the feed-forward coefficient

If the position gain or feed-forward coefficient overflows, take one of the following measures depending on the servo software series in use.
In servo software Series 90D0 and 90E0 for the Series 30*i*/31*i*/32*i*, automatic format change for position gain is enabled regardless of the following setting. (Setting is unnecessary.)

(a) For other than servo software Series 9096

	#7	#6	#5	#4	#3	#2	#1	#0
1749 (FS15*i*) / 2209 (FS16*i*)		PGAT						

PGAT(#6) The position gain precision optimization function is:
1: To be enabled
0: To be disabled (conventional method)

> **NOTE**
> Specify this function for all the simultaneous contouring axes.

(b) For servo software Series 9096

	#7	#6	#5	#4	#3	#2	#1	#0
1804 (FS15*i*) / 2000 (FS16*i*)				PGEX				

PGEX (#4) 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.

If an overflow in the position gain cannot be prevented by this function, change the CMR.
If the CMR is multiplied by N (integer), multiply also the flexible feed gear by N. This means that the detection unit is refined to 1/N. So, the settings of all parameters that need to be set in the detection unit need to be increased by N.
See Appendix B for a list of the parameters set in the detection unit.

3 α*i*S/α*i*F/β*i*S SERIES PARAMETER ADJUSTMENT

This chapter describes parameter tuning for the FANUC AC SERVO MOTOR α*i*S, α*i*F, and β*i*S series. A servo tuning tool, SERVO GUIDE, is available which lets you perform parameter tuning smoothly. See Section 4.20 for the summary of SERVO GUIDE.

3.1 SERVO TUNING SCREEN

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

- Series 15*i*

Press the [SYSTEM] key several times to display the servo setting screen.

Then press the [⬇] key to display the servo tuning screen.

- Series 30*i*, 31*i*, 32*i*, 16*i*, 18*i*, 21*i*, 20*i*, 0*i*, and Power Mate *i*

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

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

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

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

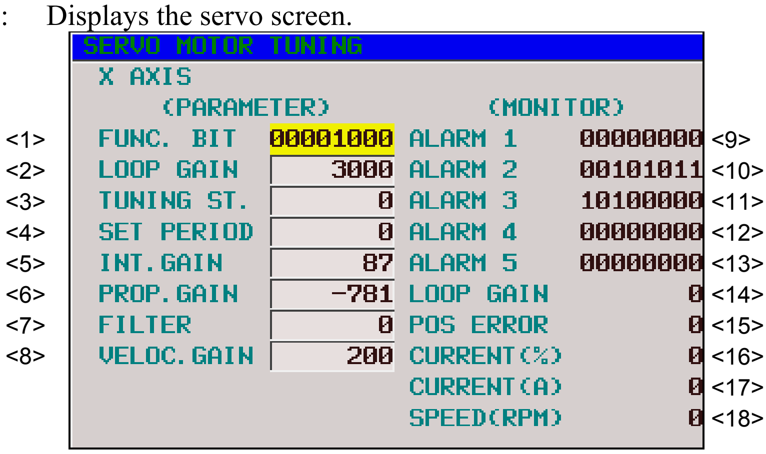


Fig. 3.1(a) Tuning screen

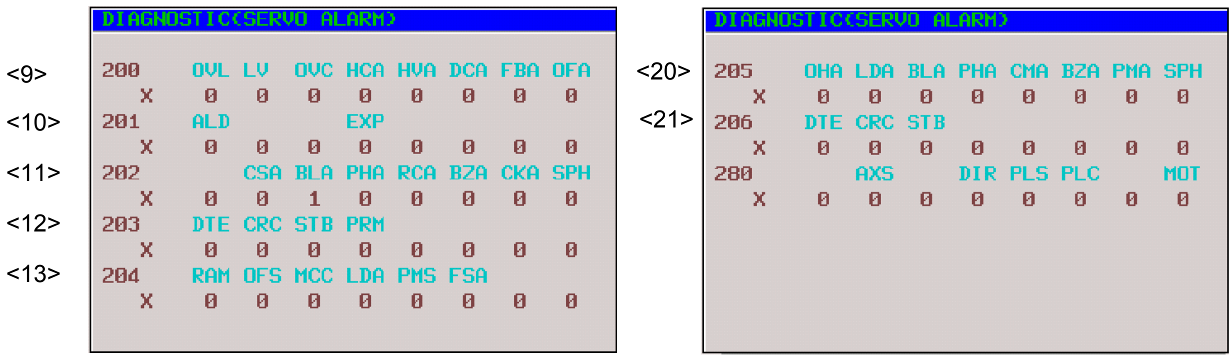


Fig. 3.1(b) Diagnosis screen

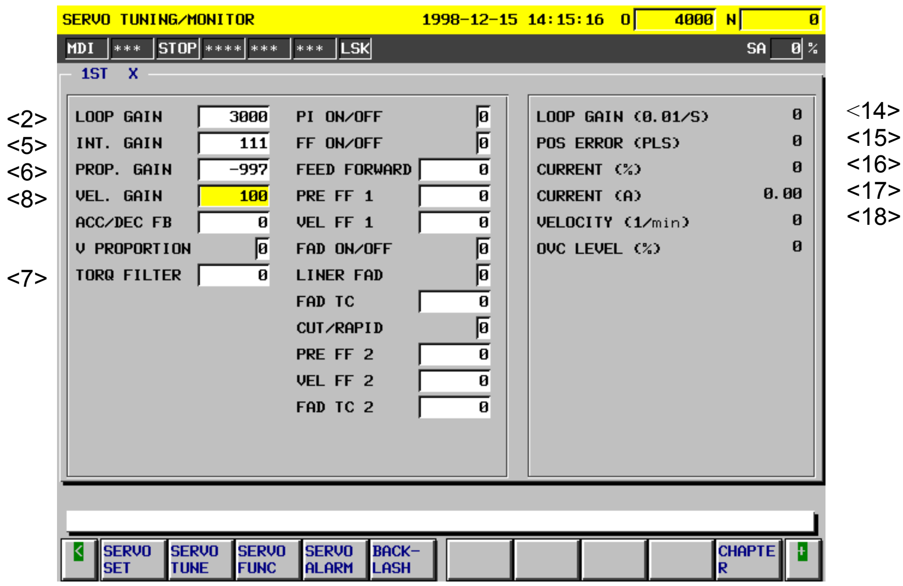


Fig. 3.1(c) Series 15*i* servo tuning screen

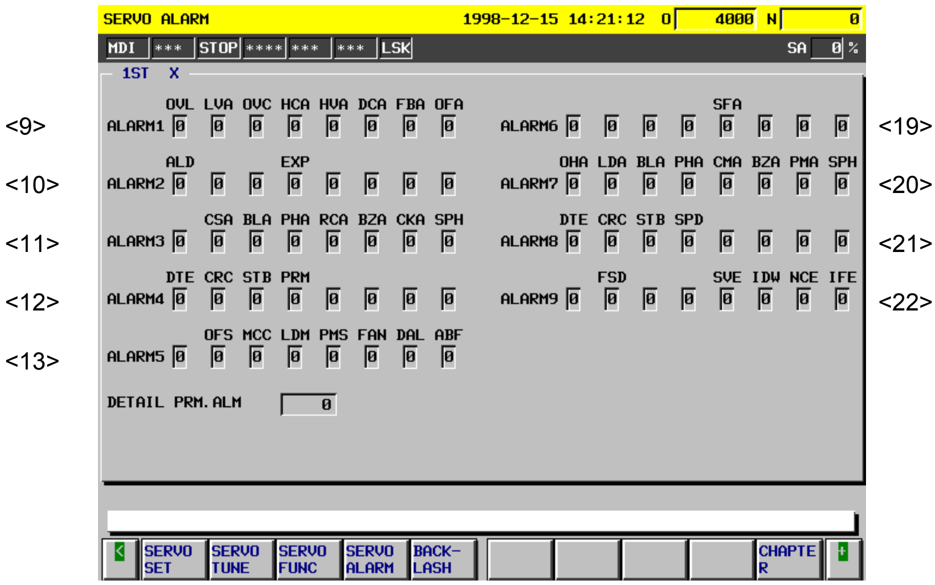


Fig. 3.1 (d) Series 15*i* servo diagnosis screen

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

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

<table>
<tr><th></th><th>Series 15i</th><th>Series 30i, 16i, and so on</th></tr>
<tr><td><1> Function bit
<2> Loop gain</td><td>No. 1808
No. 1825</td><td>No. 2003
No. 1825</td></tr>
<tr><td><3> Tuning start bit
<4> Setting period</td><td colspan="2">Not used at present
Not used at present</td></tr>
<tr><td><5> Velocity loop integral gain
<6> Velocity loop proportional gain
<7> TCMD filter</td><td>No. 1855
No. 1856
No. 1857</td><td>No. 2043
No. 2044
No. 2067</td></tr>
<tr><td rowspan="2"><8> Velocity loop gain</td><td>Related to No. 1875</td><td>Related to No. 2021</td></tr>
<tr><td colspan="2">The relationship with the load inertia ratio (LDINT=No.1875,No.2021) is as follows:
Velocity gain = (1 + LDINT/256) × 100 [%]</td></tr>
<tr><td><9> Alarm 1 diagnostic
<10> Alarm 2
<11> Alarm 3
<12> Alarm 4
<13> Alarm 5
<19> Alarm 6
<20> Alarm 7
<21> Alarm 8
<22> Alarm 9</td><td>Diagnostic Nos. 3014 + 20(X - 1)
Diagnostic Nos. 3015 + 20(X - 1)
Diagnostic Nos. 3016 + 20(X - 1)
Diagnostic Nos. 3017 + 20(X - 1)
——
——
——
——
——</td><td>Diagnostic No. 200
Diagnostic No. 201
Diagnostic No. 202
Diagnostic No. 203
Diagnostic No. 204
——
Diagnostic No. 205
Diagnostic No. 206
——</td></tr>
<tr><td><14> Loop gain or actual loop gain</td><td colspan="2">The actual servo loop gain is displayed.</td></tr>
<tr><td rowspan="2"><15> Position error diagnostic</td><td>Diagnostic No. 3000</td><td>Diagnostic No. 300</td></tr>
<tr><td colspan="2">Position error =
(feedrate) [mm/min] / (least input increment × 60 × loop gain × 0.01) [mm]</td></tr>
<tr><td><16> Actual current [%]

<17> Actual current [Ap]
<18> Actual speed [min^{-1}] or [mm/min]</td><td colspan="2">Indicates the percentage [%] of the current value to the continuous rated current.
Indicates the current value (peak value).
Indicates the actual speed or feedrate.</td></tr>
</table>

3.2 ACTIONS FOR ALARMS

If a servo alarm occurs, 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

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	Alarm indicating 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									1	1	Motor overheat (Note)	2
							1				MCC fusing, precharge	
								1	0	0	Fan stopped (PSM)	
								1	0	1	Fan stopped (SVM)	
		1									OVC alarm	3

> **NOTE**
> 1 For alarms with no action number indicated, refer to the Maintenance Manual.
> 2 OVL = 1, ALD = 1, and EXP = 1 indicate an overheat alarm using DI signals in a linear motor or a synchronous built-in servo motor and are set when bit 7 of parameter No. 2713 (Series 15*i*) or bit 7 of parameter No. 2300 (Series 30*i*, 16*i*, and so on) is set to 1. When these alarms are issued, take the same action as for ordinary motor overheat alarms. (See the Subsection 4.14.2, "Detection of an Overheat Alarm by Servo Software when a Linear Motor and a Synchronous Built-in Servo Motor are Used".)

Action 1: Overcurrent alarms

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

When an overcurrent alarm always occurs after emergency stop is released or at the time of moderate acc./dec., 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 referring to the maintenance manual on the servo amplifier.

No. 1809	No. 1852	No. 1853
No. 2004	No. 2040	No. 2041

(Parameters for the Series 15*i* are indicated on the upper side, and parameters for the Series 30*i*, 16*i*, and so on are indicated on the lower side.)

If an overcurrent alarm occurs only when an strong acc./dec. is performed, the operating conditions may be too abrupt. Increase the acc./dec. time constant, and see whether the alarm occurs.

> ⚠ **CAUTION**
> 1 If an overcurrent alarm is detected, and the LED indication in the amplifier remains set to "–", the overcurrent alarm may have been detected by the servo software. The cause may be one of the following:
> - The contact of the power line is poor, or the power line is disconnected or broken.
> - The AMR conversion coefficient or AMR offset is not set correctly.
>
> 2 If the emergency stop state is released without connecting the power line in a test such as a test for machine start-up, the servo software may detect an overcurrent alarm. In such a case, the alarm can be avoided temporarily by setting the bit parameter indicated below to 1. However, be sure to return the bit parameter to 0 before starting up in the normal operation state after completion of a test.
> To ignore the overcurrent alarm (software), set the following:
> - No2207#0 (Series 30*i*, 16*i*, and so on)
> - No1747#0 (Series15*i*)

Action 2: Overheat alarms

If an overheat alarm occurs 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. If the alarm still occurs after the power is kept off for about 10 minutes, the hardware may be defective.

If the alarm occurs intermittently, increase the time constant, or increase the programmed stop time period to suppress temperature rise.

Motor and Pulsecoder temperature information is displayed on the diagnosis screen.

	Series 30*i*, 16*i*, and so on	**Series15*i***
Motor temperature (°C)	Diagnosis No.308	Diagnosis No.3520
Pulsecoder temperature (°C)	Diagnosis No.309	Diagnosis No.3521

Action 3: OVC alarms

When an OVC alarm occurs, 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. 1878	No. 1893
No. 2062	No. 2063	No. 2065

No. 1784	No. 1785	No. 1786	No. 1787
No. 2161	No. 2162	No. 2163	No. 2164

(Parameters for the Series 15*i* are indicated on the upper side, and parameters for the Series 30*i*, 16*i*, and so on are indicated on the lower side.)

For the Series 30*i* and 15*i*, OVC data is displayed on the diagnosis screen. (An OVC alarm occurs when OVC data is set to 100%.)
For the Series 16*i*, the OVC status can be checked if thermal simulation data is obtained by using the waveform display function.

	Series 30*i* and so on	**Series 15*i***
OVC data (%)	Diagnosis No.750	Diagnosis No.3540

(2) Alarms related to the Pulsecoder and separate serial Pulsecoder

(2-1) αi Pulsecoder

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								Zero volts in battery	1
			1						1	1	0	Count error alarm	2
		1										EEPROM abnormal alarm	
	1											Voltage drop in battery (Warning)	1
								1				Pulse error alarm	
							1					LED abnormality alarm	

> ⚠ **CAUTION**
> For alarms with no action number indicated, the Pulsecoder may be defective. Replace the Pulsecoder.

(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	
					1			Zero volts in battery	1
				1				Count error alarm	2
			1					Phase alarm	2
		1						Voltage drop in battery (Warning)	1
	1							LED abnormality alarm	
1								Separate detector 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 occurs. In this case, turn the power off then on again. If the alarm occurs again, check the battery voltage. If the battery voltage drop alarm occurs, check the voltage, then replace the battery.

Action 2: Alarms that may occur due to noise

When an alarm occurs intermittently or occurs 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 still occurs 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 Pulsecoder
	1							
		1						
				1				Communication alarm in separate serial Pulsecoder
					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 STB occurs, the alarm may be caused by noise. Take noise-preventive measures. If the alarm always occurs after power is turned on, the Pulsecoder, the control board of the amplifier (*i* series), or the separate detector interface unit (*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 Pulsecoder)	3

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

Action 2: This alarm occurs 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 does not occur. 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
1808 (FS15*i*) / 2003 (FS30*i*, 16*i*)							TGAL	

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

1892 (FS15*i*) / 2064 (FS30*i*, 16*i*)	Software disconnection alarm level

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

Action 3: This alarm occurs when the absolute position data sent from the built-in Pulsecoder cannot be synchronized with the phase data. Remove the Pulsecoder cable with the NC power switched off and wait for about 10 minutes, then connect the cable again. If this alarm occurs again, replace the Pulsecoder.
When an absolute type linear encoder is used with a linear motor or when a synchronous built-in servo motor is used, this alarm must be ignored because the detector does not have phase data. Set the following bit.

	#7	#6	#5	#4	#3	#2	#1	#0
1707(FS15*i*) / 2013(FS30*i* ,16*i*)	APTG							

APTG(#7) 1: Ignores α Pulsecoder software disconnection.

(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 Illegal 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 occurs 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: Switch the A and $\overline{A}$ connections.
Serial detector: Switch the signal direction setting for the separate detector.

The following servo software allows the signal directions to be reversed by setting the parameter shown below even when a detector of A/B phase parallel type is used.

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
- Series 90B0/G(07) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

	#7	#6	#5	#4	#3	#2	#1	#0
1960 (FS15*i*) / 2018 (FS30*i*, 16*i*)								RVRSE

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 occur when an abrupt acc./dec. is performed. In such a case, change the detection level.

	#7	#6	#5	#4	#3	#2	#1	#0
1741 (FS15*i*) / 2201 (FS30*i*, 16*i*)							RNLV	

RNLV (#1) Change of the feedback mismatch alarm detection level
1: To be detected at 1000 min^{-1} or more
0: To be detected at 600 min^{-1} or more

Action 2: This alarm occurs when the difference between the motor position and the position of the separate detector becomes larger than the 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 still occurs after the level is changed, check the scale connection direction.

1971 (FS15*i*)	Dual position feedback conversion coefficient (numerator)
2078 (FS30*i*, 16*i*)	

1972 (FS15*i*)	Dual position feedback conversion coefficient (denominator)
2079 (FS30*i*, 16*i*)	

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

1729 (FS15*i*)	Dual position feedback semi-closed loop error level
2118 (FS30*i*, 16*i*)	

[Setting unit] 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 occurs again after the power is turned on and off, the current detector may be abnormal. Replace the amplifier.

3.3 ADJUSTING PARAMETERS FOR HIGH-SPEED AND HIGH-PRECISION MACHINING

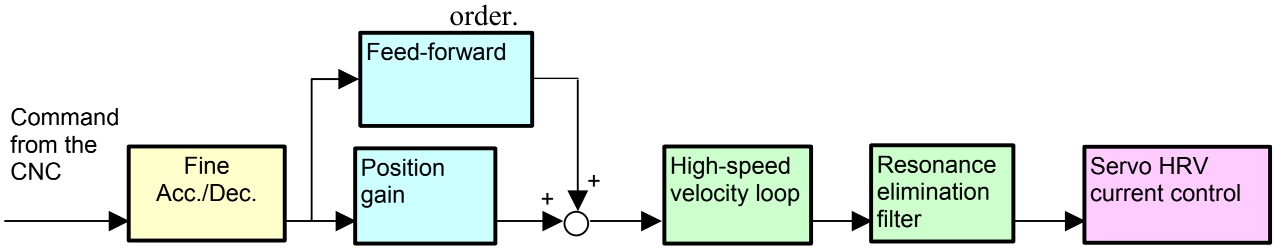
3.3.1 Servo HRV Control Adjustment Procedure

(1) Overview

For higher positioning precision, higher precision in machined surface and machining profile, shorter machining time, and other improvements in machine tools, servo adjustment is required. This subsection explains the servo adjustment procedure using servo HRV control. In the *i* series CNCs (such as the Series 30*i* and 16*i*), servo adjustments can be made easily by using SERVO GUIDE, which supports adjustments.

(2) Outline of the adjustment procedure

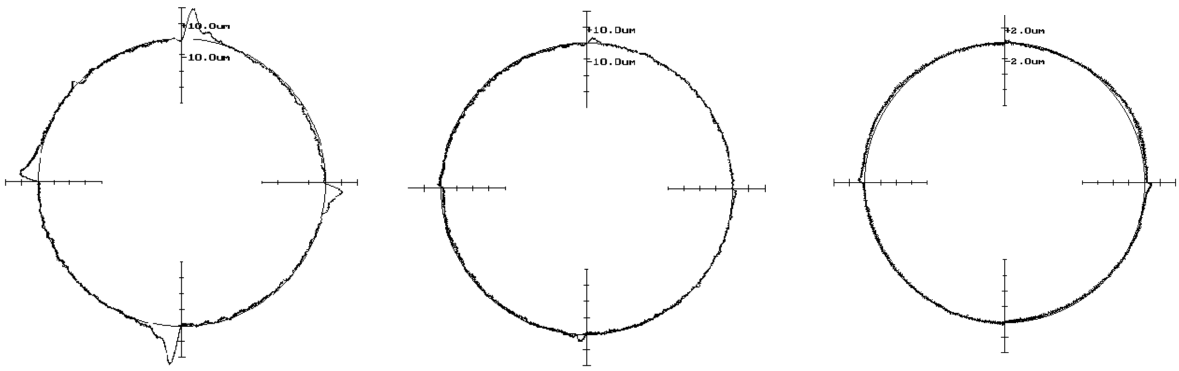
Before servo control performance can be improved by servo adjustment, it is necessary to understand these procedures and make adjustments step by step accordingly. Servo control is implemented by the structure shown in the block diagram below. Servo HRV current control, which is located just before the motor in the regulation loop, drives the motor according to the command output by high-speed velocity control. The performance of high-speed velocity control is supported by the performance of servo HRV current control. High-speed velocity control controls the motor speed according to the velocity command output by position control. To attain the final target, which is to improve the capability to follow up position commands, a higher position gain must be set. This requires improvement of high-speed velocity control performance. Hence, this requires improvement in servo HRV current control performance.
Therefore, in servo adjustment for improving the performance of servo control, the highest priority is given to the improvement in servo HRV current control, the next highest priority is given to the improvement in high-speed velocity control, then the third priority is given to the improvement of position control. Be sure to follow this order.



Servo HRV control improves the response speed of the current loop, therefore, higher gains can be set for the velocity loop and position loop. Increased gains lead not only to improvement in command follow-up performance and disturbance suppression performance but also to simplification in servo function adjustments such as quadrant protrusion compensation. As a result, servo adjustments can be made more easily.

The figure below shows the results of a gain adjustment for each servo HRV control type. The figure indicates that improvement in response speed of the current loop by servo HRV control further improves the response speed of velocity control and position control, and therefore quadrant protrusions can be reduced without the backlash acceleration function.

Servo HRV1 control Servo HRV2 control Servo HRV3 control



R100mm 10000mm/min without backlash acceleration function

This manual explains the servo adjustment procedure in the following order:

- Initialization of parameters related to high-speed and high-precision machining
  Before starting the servo adjustment for high-speed and high-precision machining, set minimum required parameters.
- Servo HRV control setting
  Select the servo HRV control type. Select suitable servo HRV control from servo HRV2, HRV3, and HRV4.
- Adjustment of high-speed velocity control
  Adjust the velocity loop gain and filter by using SERVO GUIDE.
- Adjustment of acc./dec. in rapid traverse
  Adjust the time constant for rapid traverse. In position gain setting made in the next step, the limit is confirmed by checking stability during rapid traverse.
- Position gain adjustment
  Adjust the position gain while observing the TCMD and motor speed in rapid traverse and cutting feed.
- Adjustment by using an arc
  Adjust the feed-forward and backlash acceleration while measuring an arc figure.
- Adjustment by using a square figure
  Adjust the reduced feedrate and the acceleration for deceleration at a corner while measuring the corner figure.
- Adjustment by using a square figure with 1/4 arcs
  Adjust the velocity in the round corners while measuring the contour error in the round corners.

(3) Initialization of parameters related to high-speed and high-precision machining

The parameter values to be set first before servo adjustments are made are listed below. Sufficient performance can be obtained just by setting these values. Furthermore, by separately adjusting the settings indicated by gray shading, much higher speed and higher precision can be obtained.

[Fundamental Parameters]

Parameter No.		Standard setting value	Description
FS15*i*	FS30*i*, 16*i*, and so on		
1809	2004	0X000011 (Note 1)	Enables HRV2 control
1852	2040	Standard parameter (Note 1)	Current integral gain
1853	2041	Standard parameter (Note 1)	Current proportional gain
1808 #3	2003 #3	1 (Note 2)	Enables PI function
1959 #7	2017 #7	1 (Note 3)	Enables velocity loop high cycle management function
1884 #4	2006 #4	1	Enables 1-ms velocity feedback acquisition
1958 #3	2016 #3	1	Enables variable proportional gain in the stop state
1730	2119	2 (detection unit of 1 μm) 20 (detection unit of 0.1μm)	For variable proportional gain function in the stop state : judgment level for stop state (specified in detection units)
1825	1825	5000	Servo loop gain
1875	2021	128	Load Inertia ratio (Velocity Loop Gain) (Note 4)
1742 #1	2202 #1	1	Cutting/rapid traverse velocity loop gain variable
1700	2107	150	Velocity loop gain override at cutting traverse

NOTE

1. Optimum parameters can be loaded automatically by setting a motor ID number for servo HRV2 control.
   If there is no motor ID number for servo HRV2 control, load the standard parameters for servo HRV1, then calculate parameter values as follows:
   No. 2004 = 0X000011 (Keep X unchanged.)
   No. 2040 = Standard parameter for HRV1 × 0.8
   No. 2041 = Standard parameter for HRV1 × 1.6
2. To use I-P function, set 0.
   PI function and I-P function have the following features:
   PI function: Provides good follow-up to a target command. This function is required for high-speed and high-precision machining.
   I-P function: Requires a relatively short time to attain a target position. This function is suitable for positioning applications.
3. With some machines, a higher velocity loop gain can be set by using neither the acceleration feedback function nor auxiliary function rather than by using these functions. If it is impossible to set a high velocity loop gain (about 300%) when the velocity loop high cycle management function is used, try to use the acceleration feedback function (See Subsection 4.4.2), and use the function that allows a higher velocity loop gain to be set.
4. There is the following relationship between the load inertia ratio and velocity loop gain (%).
   Velocity loop gain (%) = (1 + load inertia ratio / 256) × 100

[Feed-forward and FAD(Fine acc./dec.)]

Parameter No.		Standard setting value	Description
FS15*i*	FS30*i*, 16*i*, and so on		
1951 #6	2007 #6	1	Enables FAD (Fine acc./dec.) (Note 1)
1749 #2	2209 #2	1	Enables FAD of linear type.
1702	2109	16	FAD time constant (Note 2)
1883 #1	2005 #1	1	Enables feed-forward
1800 #3	1800 #3	0	Feed-forward at rapid traverse (Note 2)
1959 #5	2017 #5	1	RISC feed-forward is improved
1740 #5	2200 #5	1	RISC feed-forward is improved
1985	2092	10000	Advanced preview feed-forward coefficient
1962	2069	50	Velocity feed-forward coefficient

NOTE

1 With the Series 30*i*, Series 31*i*, and Series 32*i*, which use nano interpolation as a standard function, the fine acc./dec. function is not required.
During AI nano contour control, AI contour control, and high precision contour control, the fine acc./dec. function is disabled. So, set the time constant of acc./dec. after interpolation on the CNC side.

2 As the time constant of fine acc./dec., be sure to set a multiple of 8.
When using fine Acc./Dec also in rapid traverse, enable rapid traverse feed-forward, or use the cutting/rapid FAD switching function (see Subsection 4.8.3).

3 RISC feed-forward is enabled during AI contour control and high precision contour control and allows smoother feed-forward operation.

[Backlash Acceleration]

Parameter No.		Standard setting value	Description
FS15*i*	FS30*i*, 16*i*, and so on		
1851	1851	1 or more	Backlash compensation
1808 #5	2003 #5	1	Enables backlash acceleration
1884 #0	2006 #0	0/1	0 : Semi-close system 1 : Full-close system
1953 #7	2009 #7	1	Backlash acceleration stop
1953 #6	2009 #6	1	Backlash acceleration only at cutting feed (FF)
2611 #7	2223 #7	1	Backlash acceleration only at cutting feed (G01)
1957 #6	2015 #6	0	Two-stage backlash acceleration (Note)
1769	2146	50	Stage-2 backlash acceleration end timer
1860	2048	100	Backlash acceleration amount
1975	2082	5 (detection unit of 1 μm) 50 (detection unit of 0.1 μm)	Backlash acceleration stop timing
1964	2071	20	Backlash acceleration time

NOTE

The above table lists the initial values set when the conventional backlash acceleration function is used. When much higher precision is required, use the 2-stage backlash acceleration function.

[Time Constant]

Set the initial value of the time constant of acc./dec. according to the high-speed and high-precision function of the CNC used. Adjust the time constant of acc./dec. to an optimum value while checking the rapid traverse and cutting feed operations.

- AI nano contour control, AI contour control, AI advanced preview control, and advanced preview control

Parameter No. FS16*i* and so on	Standard setting value	Description
1620	200	Time constant of acc./dec. in rapid traverse - linear part (ms)
1621	200	Time constant of acc./dec. in rapid traverse - bell-shaped part (ms)
1770	10000	Acc./dec. before interpolation: Maximum cutting feedrate
1771	240	Acc./dec. before interpolation: Time (ms) → 0.07G
1772	64	Acc./dec. before interpolation: Bell-shaped time constant (ms) (for other than advanced preview control)
1768	24	Time constant for acc./dec. after interpolation (ms)

- AI nano high-precision contour control, AI high-precision contour control, and high-precision contour control

Parameter No. FS16*i* and so on	Standard setting value	Description
1620	200	Time constant of acc./dec. in rapid traverse - linear part (ms)
1621	200	Time constant of acc./dec. in rapid traverse - bell-shaped part (ms)
8400	10000	Acc./dec. before interpolation: Maximum cutting feedrate
19510	240	Acc./dec. before interpolation: Time (ms) → 0.07G (No. 8401 for high precision contour control)
8416	64	Acc./dec. before interpolation: Bell-shaped time constant (ms)
1768	24	Time constant for acc./dec. after interpolation (ms)

- AI contour control I and AI contour control II (Series 30*i*, Series 31*i*, and Series 32*i*)

Parameter No. FS30*i*	Standard setting value	Description
1620	200	Time constant of acc./dec. in rapid traverse - linear part (ms)
1621	200	Time constant of acc./dec. in rapid traverse - bell-shaped part (ms)
1660	700	Acc./dec. before interpolation: Acceleration(mm/s^2) → 0.07G
1772	64	Acc./dec. before interpolation: Bell-shaped time constant (ms)
1769	24	Time constant for Acc./dec. after interpolation (ms)

- Series 15*i*

Parameter No. FS15*i*	Standard setting value	Description
1620	200	Time constant of Acc./dec. in rapid traverse - linear part (ms)
1636	200	Time constant of Acc./dec. in rapid traverse - bell-shaped part (ms)
1660	700	Acc./dec. before interpolation: Acceleration(mm/s^2) → 0.07G
1663	700	Acc./dec. before interpolation: Acceleration(mm/s^2) → 0.07G
1656	64	Acc./dec. before interpolation: Bell-shaped time constant (ms)
1635	24	Time constant for acc./dec. after interpolation (ms)

(4) Servo HRV control setting

Set the type of servo HRV control. The setting of servo HRV2 is always required. So, load the standard parameters for servo HRV2 by following the description given below. Then, set HRV3 or HRV4 as necessary.

(For Series 30*i*)

In standard setting, servo HRV2 control is set. However, to make high-speed and high-precision adjustments, servo HRV3 is recommended. If sufficient precision cannot be obtained with servo HRV3, consider using servo HRV4. (See Subsec. 4.2.2.)

(For other than Series 30*i*)

In standard setting, servo HRV2 control is set. However, if sufficient precision cannot be obtained with servo HRV2, consider using servo HRV3. (See Subsec. 4.2.1.)

(a) Servo HRV2 control

By setting a motor ID number for servo HRV2 control, load the standard parameters.

NOTE

If there is no motor ID number for servo HRV2 control, load the standard parameters for servo HRV1, then calculate parameter values as follows:

No. 2004 = 0X000011 (Keep X unchanged.)
No. 2040 = Standard parameter for HRV1 × 0.8
No. 2041 = Standard parameter for HRV1 × 1.6

(b) Servo HRV3 control

After setting servo HRV2 control, set the following parameters:

[HRV3 parameters] (for FS15*i*, FS16*i*, and so on)

Parameter No.		Recommended value	Description
FS15*i*	FS16*i*		
1707#0	2013#0	1	Enables HRV3 current control.
1742#1	2202#1	1	Enables the cutting/rapid velocity loop gain switching function.
-	2283#0	1	Enables high-speed HRV current control in cutting feed (Note 1).
2747	2334	150	Current gain magnification in HRV3 mode
2748	2335	200	Velocity gain magnification in HRV3 mode

NOTE

1 To use high-speed HRV current control, G codes need to be set. (High-speed HRV current control is enabled between G5.4Q1 and G5.4Q0.)

2 With Series 90B0, 90B1, 90B6, and 90B5, the torque command during high-speed HRV current control is limited to 70% of the maximum value.

[HRV3 parameters] (for FS30i)

Parameter No. FS30i	Recommended value	Description
2013#0	1	Enables HRV3 current control.
2202#1	1	Enables the cutting/rapid velocity loop gain switching function.
2334	150	Current gain magnification in HRV3 mode
2335	200	Velocity gain magnification in HRV3 mode

NOTE
1 When N2283#0=1, no G code is needed.
2 To use high-speed HRV current control when N2283#0=0, G codes need to be set. (High-speed HRV current control is enabled between G5.4Q1 and G5.4Q0.)
3 When servo HRV3 control is used with Series 90E0, such a restriction that the maximum allowable number of axes per servo card is reduced to 3 is imposed.

(c) Servo HRV4 control

After setting servo HRV2 control, set the parameters listed below. Servo HRV4 control and servo HRV3 control cannot be set at the same time.

[HRV4 parameters]

Parameter No. FS30i	Recommended value	Description
2014#0	1	Enables HRV4 current control.
2300#0	1	Enables the extended HRV function.
2202#1	1	Enables the cutting/rapid velocity loop gain switching function.
2334	150	Current gain magnification in high-speed HRV current control
2335	200	Velocity gain magnification in high-speed HRV current control

NOTE
1 Servo HRV4 can be used with Series 90D0.
2 Use of servo HRV4 decreases the maximum number of axes per servo card and limits the maximum torque of the servo motor to 70%. For details, see Subsection 4.2.2, "Servo HRVV4 Control".
3 To use high-speed HRV current control, G codes must be set. (High-speed HRV current control is enabled between G5.4Q1 and G5.4Q0.)

(5) Adjustment of high-speed velocity control

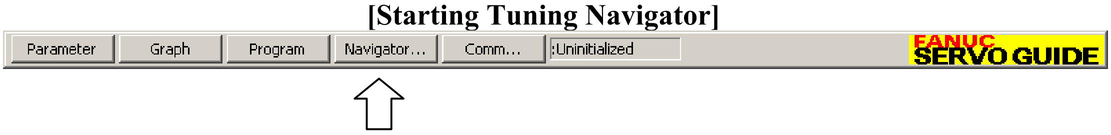
After setting servo HRV control, adjust the velocity loop gain and the resonance elimination filter.
To obtain high servo performance, a high velocity loop gain must be set. Some machines, however, vibrate easily at a particular frequency, and setting a high velocity loop gain can cause vibration at that frequency (machine resonance). As a result, it becomes impossible to set a high velocity loop gain.
In such a case, the resonance elimination filter must be adjusted. The resonance elimination filter can lower the gain only in an area around a particular frequency, therefore allowing a high velocity loop gain to be set without the occurrence of machine resonance.

The velocity loop gain and the resonance elimination filter can be adjusted more easily by using Tuning Navigator of SERVO GUIDE.

(a) Adjusting the velocity loop gain and the resonance elimination filter (when Tuning Navigator is used)

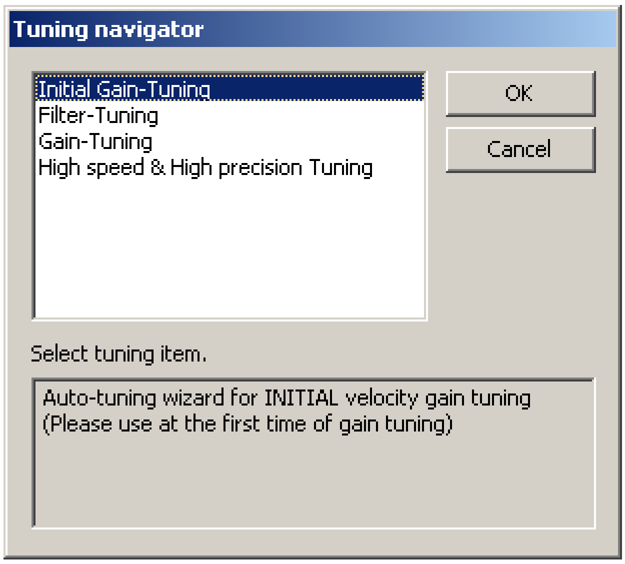
For adjustment of the resonance elimination filter, Tuning Navigator of SERVO GUIDE can be used. On the main bar of SERVO GUIDE, press the [Navigator] button.

[Starting Tuning Navigator]



Clicking this button displays the menu as shown below.

<1>
<2>
<3>

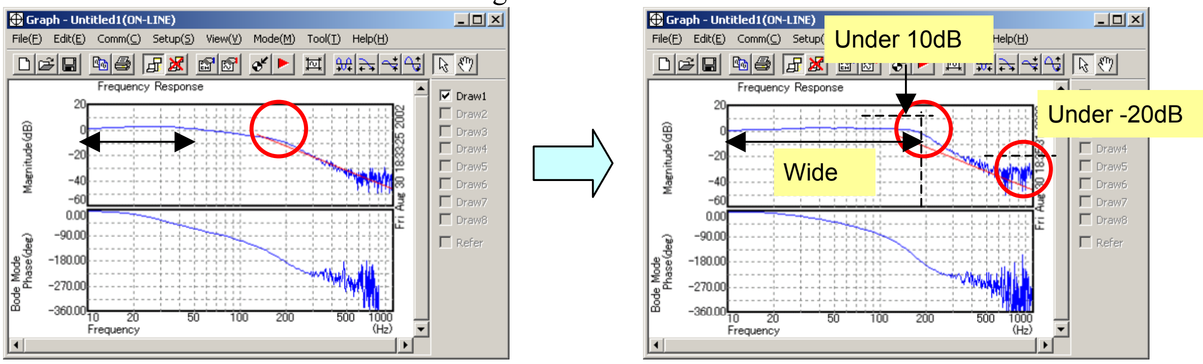


(Procedure for adjusting the velocity loop gain and the resonance elimination filter)
In the adjustment of the velocity loop gain and the resonance elimination filter, use <1> through <3> in the above figure. Make adjustments in order from <1>.

<1> Initial Gain Tuning

Initial Gain Tuning determines the velocity loop gain value with a margin for the oscillation limit. By making this adjustment, a higher velocity gain than the initial value is set, so the frequency of machine resonance can be determined clearly.

First, select Initial Gain Tuning from the dialog box of Tuning Navigator.



Tuning Navigator shows bode-plot of velocity loop and you can check the performance of velocity loop.

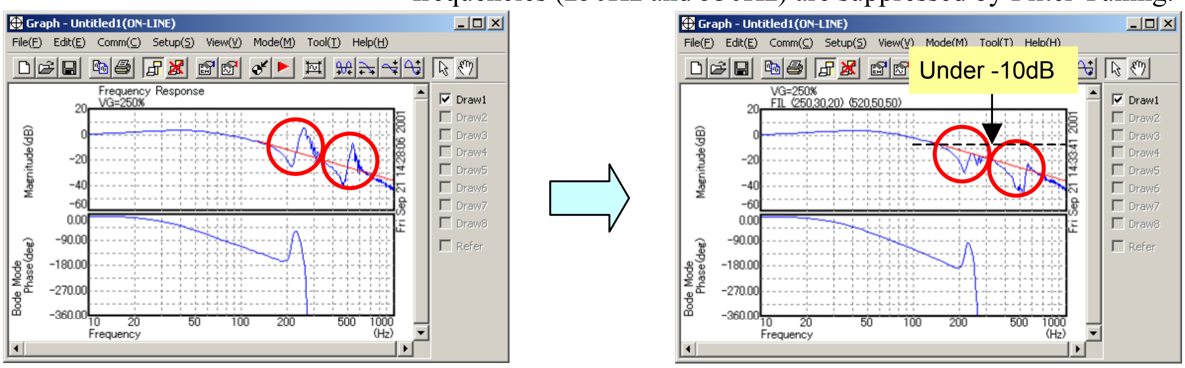
Upper line in bode-plot shows gain characteristic and lower line shows phase characteristic. Important points of this figure that you should note are as follows. (About the details of bode-plot, please refer to several books of basic control method)

- The width of 0dB level of gain line is important. By setting higher velocity loop gain, it becomes wide.
- Gain level of resonance frequency has to be suppressed at least under -10dB.
- Gain level around cut-off frequency is less than 10dB.
- Gain level near 1000Hz has to be lower than -20dB.

<2> Filter Tuning

Next, select Filter Tuning from Tuning Navigator to adjust the resonance elimination filter to suppress machine resonance.

Following example shows that gain line at two resonance frequencies (250Hz and 530Hz) are suppressed by Filter Tuning.



<3> Gain Tuning

Finally, select "Gain Tuning". Tuning Navigator decides the final result of gain tuning. By adjusting the resonance elimination filter, the influence of machine resonance can be eliminated, so a high velocity loop gain can be set.

(b) Adjusting the velocity loop gain and the resonance elimination filter (when Tuning Navigator is not used)

A) Adjustment by torque command waveform

1. Perform rapid traverse with a full stroke of the machine, and observe the torque command when the machine is stopped and when the machine moves at high speed. (The sampling cycle period should be 125 μs.)

> **NOTE**
> When using the cutting/rapid velocity loop gain switching function, perform cutting feed at the maximum cutting feedrate to also check the cutting-time oscillation limit.

2. As the velocity loop gain is increased gradually, the following oscillation phenomena occur:
   - Vibration occurs in the torque command waveform.
   - Vibration sound is generated from the machine.
   - A large variation in positional deviation is observed when the machine movement stops.
3. Perform frequency analysis (Ctrl-F) for the torque command issued when the above phenomena occur, and measure the vibration frequency.
4. Set the measured vibration frequency as the attenuation center frequency, and set the initial values of the attenuation bandwidth and damping by consulting the setting guideline.

[Setting guideline]

Resonance frequency	Attenuation bandwidth	Damping
Lower than 150 Hz	Decrease the velocity loop gain. (Note 1)	
150 to 200 Hz	Decrease the velocity loop gain. (Note 2)	
200 to 400 Hz	60 to 100Hz	0 to 50%
Higher than 400 Hz	100 to 200Hz	0 to 10%

[Parameter Nos.]

Series 30*i*, 16*i*	Attenuation center frequency [Hz]	Attenuation bandwidth [Hz]	Damping [%]
Resonance elimination filter 2	No.2360	No.2361	No.2362
Resonance elimination filter 3	No.2363	No.2364	No.2365
Resonance elimination filter 4	No.2366	No.2367	No.2368
Resonance elimination filter 1	No.2113	No.2177	No.2359

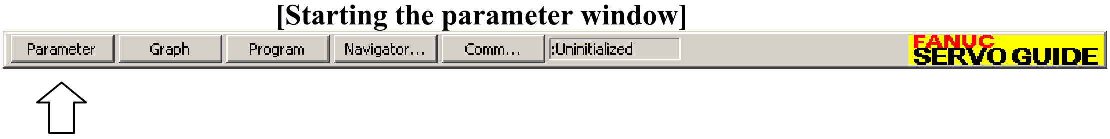
Series 15*i*	Attenuation center frequency [Hz]	Attenuation bandwidth [Hz]	Damping [%]
Resonance elimination filter 2	No.2773	No.2774	No.2775
Resonance elimination filter 3	No.2776	No.2777	No.2778
Resonance elimination filter 4	No.2779	No.2780	No.2781
Resonance elimination filter 1	No.1706	No.2620	No.2772

NOTE

1. The disturbance elimination filter (see Section 4.5) may be effective.
2. When the resonance elimination filter is used, set a narrow attenuation bandwidth (about 50 Hz or less) and a large damping attenuation factor (about 50% to 80%).
3. When the center frequency becomes 200 Hz or lower, almost the same effect as when the velocity loop gain is decreased is obtained. Since the resonance elimination filter also has the effect in the change of phase, decreasing the velocity loop gain is recommended.
4. The resonance elimination filter becomes more effective as damping becomes closer to 0%. Therefore, when adjusting damping, start with a large value and decrease it gradually.

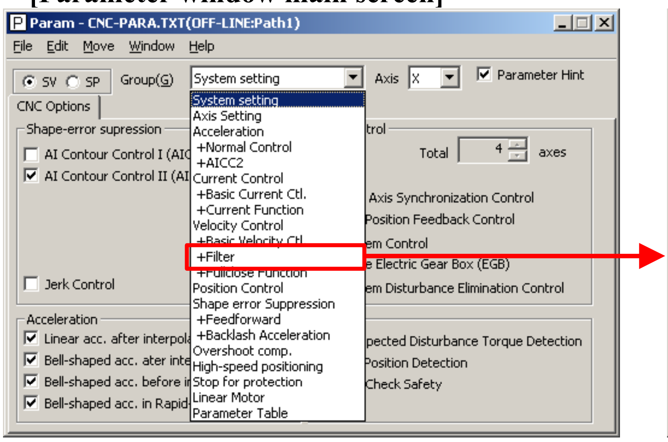
When SERVO GUIDE can be used, the resonance elimination filter can be set from the parameter window.

[Starting the parameter window]

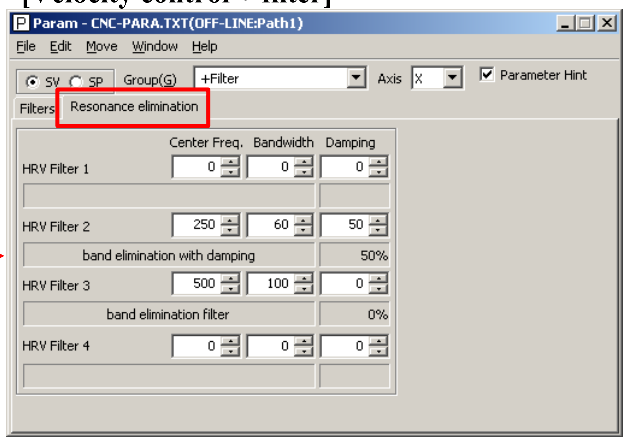


Clicking this button displays the parameter window.

[Parameter window main screen]



[Velocity control + filter]



5. After setting the resonance elimination filter in step 4, measure the torque command again. If there is still vibration left at the same frequency, decrease the damping setting. If vibration occurs at a frequency other than the set frequency, it may be adversely influenced by the setting of the resonance elimination filter. So, try to increase the setting of damping to about 80% to reduce the influence of the resonance elimination filter on velocity control. If vibration is still observed, stop setting the resonance elimination filter and decrease the velocity loop gain.

6. After determining the attenuation bandwidth and damping, increase the velocity loop gain again until vibration phenomena listed in step 2 occur. The final value of the velocity loop gain is 70% to 80% of the velocity loop gain set when the vibration phenomena occur.

B) Adjustment using the frequency characteristics

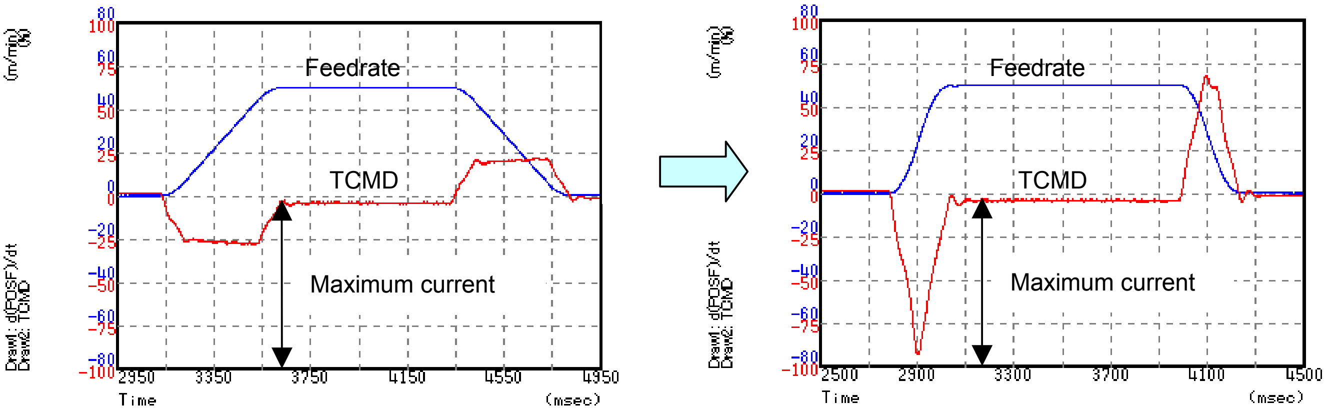
The velocity loop gain can be adjusted also by increasing the velocity loop gain while measuring the frequency characteristics.
As the velocity loop gain increases, the gain at a certain frequency swells in the frequency characteristics. The frequency corresponding to the swell is the resonance frequency. So, the velocity loop gain is increased while the swell in gain is suppressed with the resonance elimination filter.
The velocity loop gain to be set is 70% to 80% of the velocity loop gain observed when the swell can no longer be suppressed by the resonance elimination filter. It is regarded as the final setting if there is no problem during rapid traverse and cutting feed at the maximum feedrate. If vibration occurs, decrease the velocity loop gain until the vibration stops.
For measurement of the frequency characteristics, see "Details".

(6) Adjustment of acc./dec. in rapid traverse

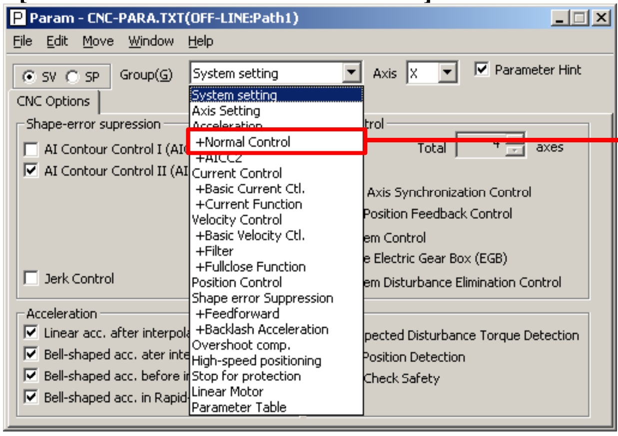
The time constant of acc./dec. in rapid traverse is adjusted. Adjusting the time constant in rapid traverse can reduce the total machining time. While observing the torque command (TCMD) at the time of acc./dec. in rapid traverse to check that the TCMD does not reach the maximum current value, decrease the time constant of acc./dec. in rapid traverse. When bell-shaped acc./dec. in rapid traverse is used, a small TCMD value can be obtained with mechanical impact suppressed.

> **NOTE**
> Make adjustments in rapid traverse with the maximum load applied to the machine.

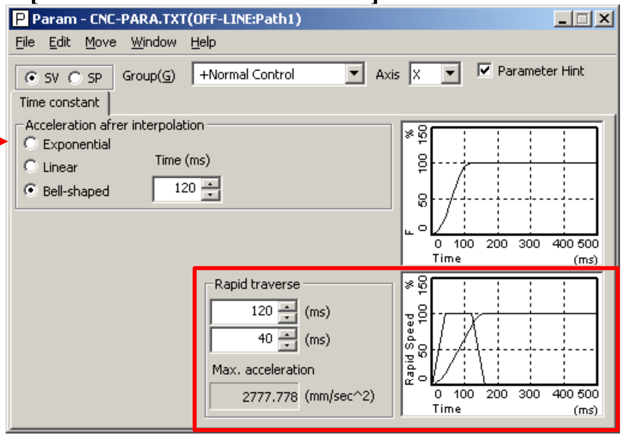
The following graphs show how the time constant in rapid traverse is adjusted.



[Parameter window main screen]



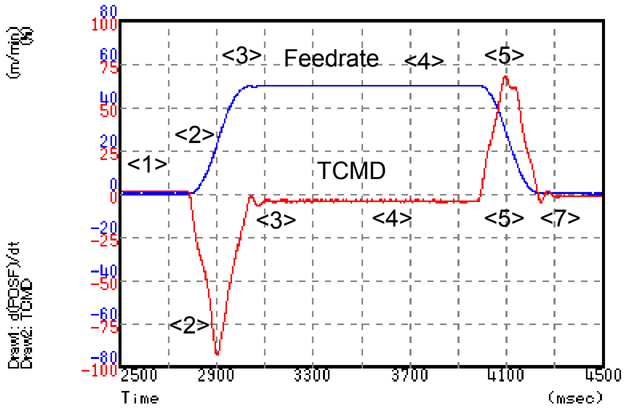
[Acc./dec. + normal control]



(7) Adjustment of the position gain

Observe the torque command waveform at the time of acc./dec. during rapid traverse and cutting feed at the maximum cutting feedrate. When a low frequency vibration (hunting) of about 10 to 30 Hz occurs in the torque command waveform, the corresponding position gain is regarded as the oscillation limit. The position gain to be set is about 80% of the position gain of the oscillation limit.

The standard setting is within 5000 to 10000.



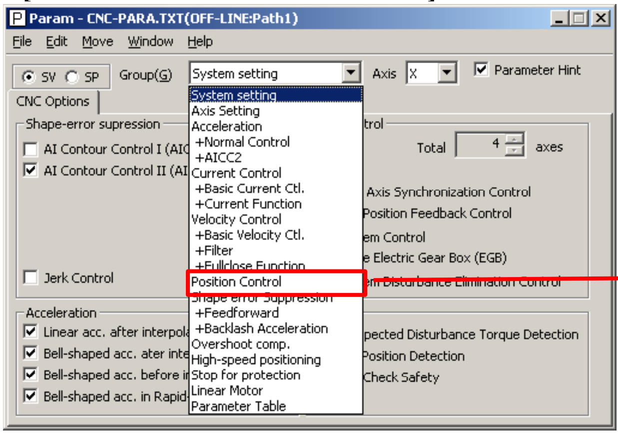
(Check points)

- No vibration is allowed in the stopped state. Also check the positional deviation on the CNC. (<1>)
- Neither vibration nor sound must be generated during acceleration and deceleration. If the TCMD level has reached the maximum value, increase T1. (<2>, <5>)
- Neither vibration nor excessive overshoot must be generated at the end of acceleration and deceleration. If the TCMD level has reached the maximum value, increase T2. (<3>, <7>)
- There must be no large variation in feedrate during movement at a constant feedrate. (<4>)

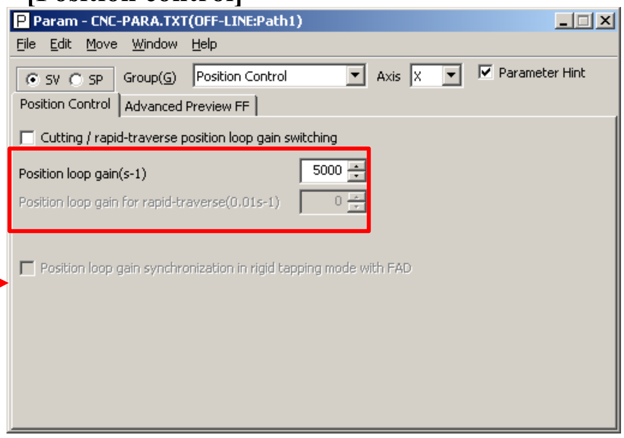
NOTE

For axes for which interpolation is performed, set the same position gain.

[Parameter window main screen]



[Position control]



(8) Adjustment by using an arc (adjustment of the feed-forward coefficient and adjustment of the servo function)

(a) Feed-forward function

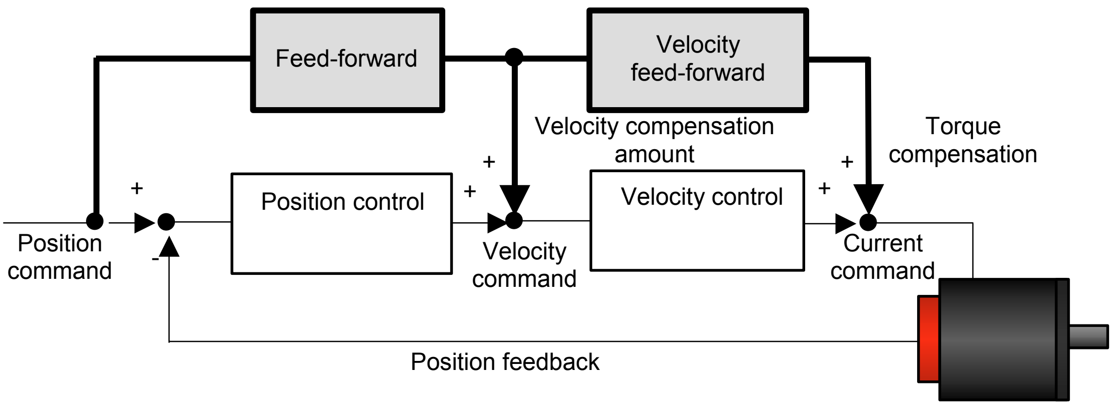
For higher precision (higher performance) with small servo follow-up delay, the feed-forward function is used. When the feed-forward coefficient is set to 100%, the positional deviation can be almost eliminated.

(Feed-forward)

By adding to a velocity command value the velocity compensation value equivalent to the position command issued from the CNC, the contour error due to position loop response delay can be reduced.

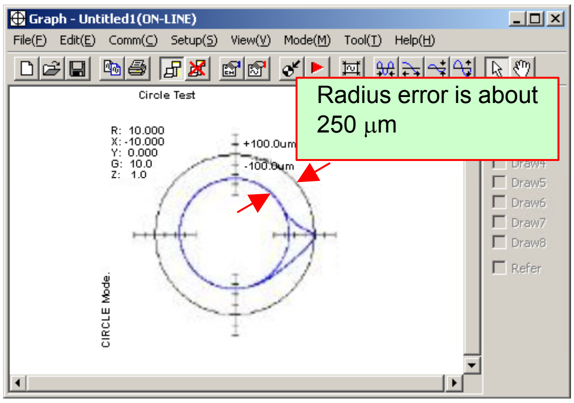
(Velocity feed-forward)

The torque compensation amount equivalent to the amount of change in velocity command (acceleration) is added to a specified torque value so that the contour error due to velocity loop response delay can be reduced.

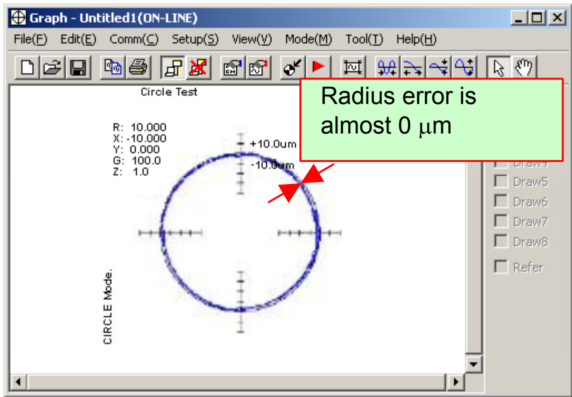


The following figure shows the effect of the feed-forward function. The figure indicates that an arc radius error of 250 μm, which was measured before the use of the feed-forward function, has been reduced to almost 0 after the use of the feed-forward function.

Feed-forward coefficient 0%



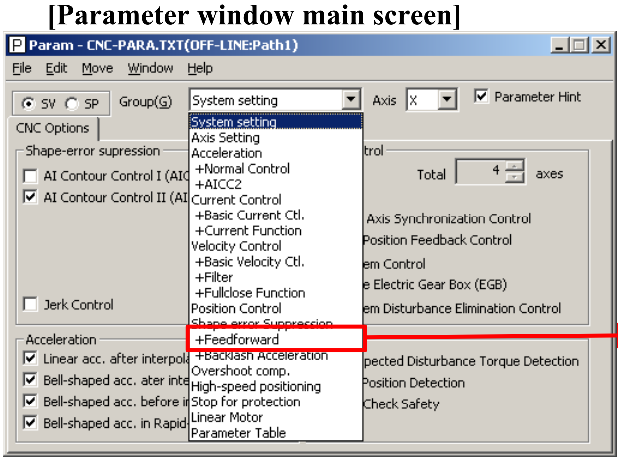
Feed-forward coefficient 100%



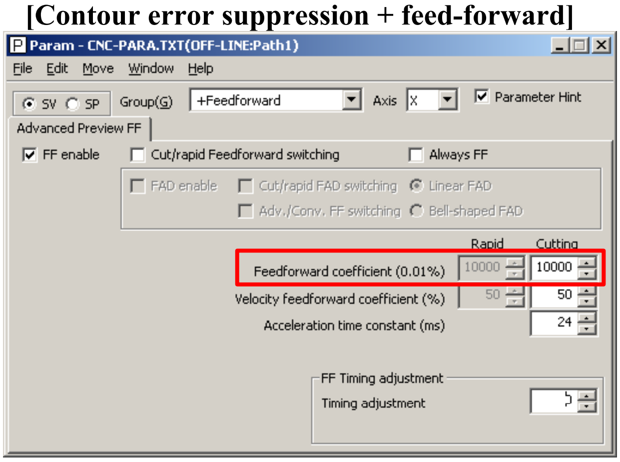
(b) Adjusting the feed-forward coefficient

The feed-forward coefficient can be adjusted on the screen shown below. Note that, however, setting the feed-forward coefficient to more than 10000 (100%) means that the actual machine position advances ahead of commands from the CNC. So, such setting is not permitted.

[Parameter window main screen]



[Contour error suppression + feed-forward]

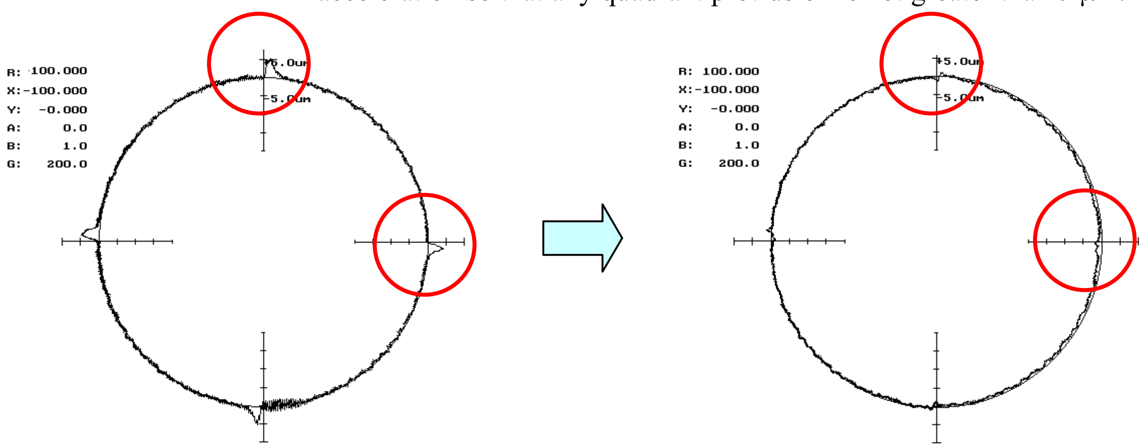


While checking fluctuation of radius by using an arc with about R10/F4000 or R100/F10000 set, make an adjustment so that the actual path matches the commanded path. At this time set the velocity feed-forward coefficient to about 100.

> **NOTE**
> To fine-tune the amount of arc radius, also adjust the feed-forward timing parameter after adjusting the feed-forward coefficient. (See Subsection 4.6.5.)

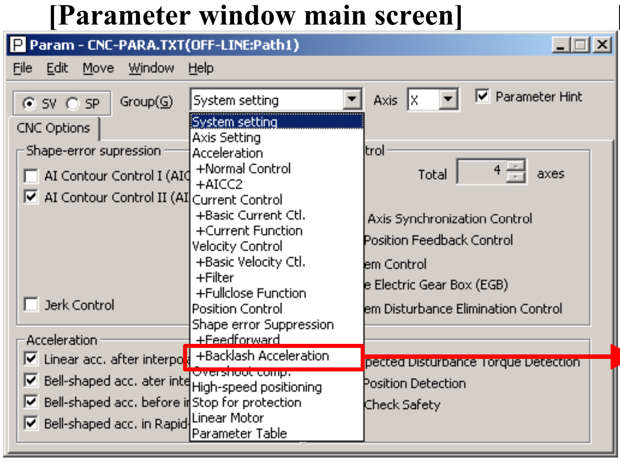
(c) Adjusting backlash acceleration

To reduce quadrant protrusions (errors generated where the axis move direction is reversed), the backlash acceleration function is used.
While observing the quadrant protrusion size, change the backlash acceleration value in steps of about 10 to 20, and ends the adjustment immediately before undercut occurs. A large quadrant protrusion or undercut may adversely affect cutting results. So, adjust the backlash acceleration so that any quadrant protrusion is not greater than 5 μm.

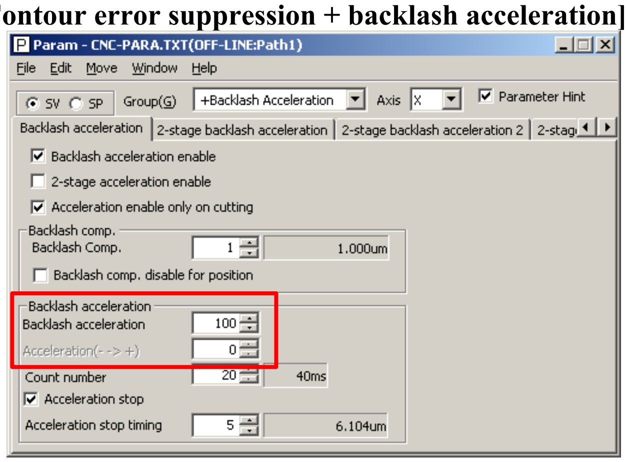


> **NOTE**
> 1 For the adjustment of the conventional backlash acceleration function, see Subsection 4.6.6.
> 2 When higher precision is required, use the 2-stage backlash acceleration function (see Subsection 4.6.7).

[Parameter window main screen]



[Contour error suppression + backlash acceleration]

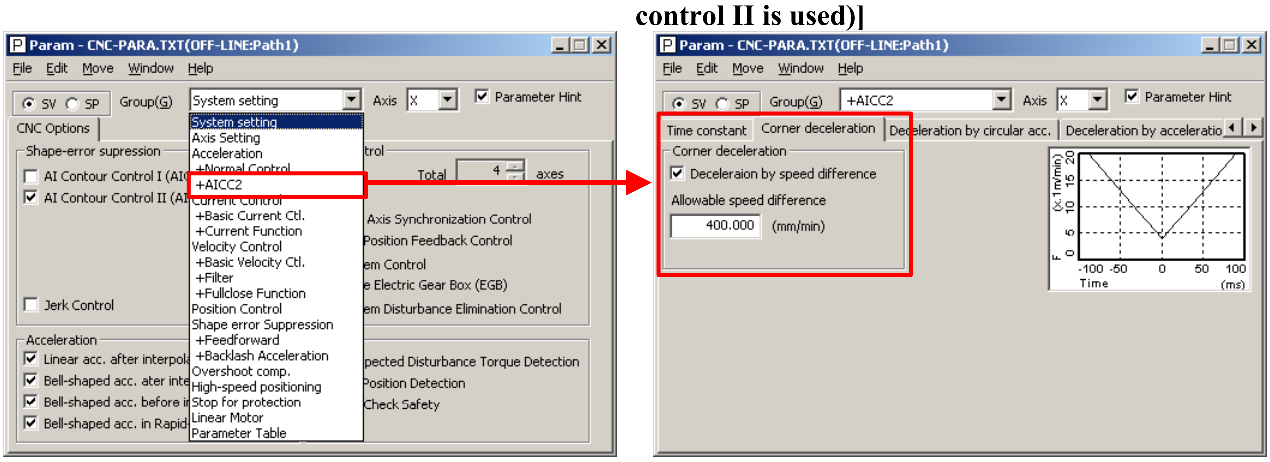


(9) Adjustment by using a square figure (adjustment of the high-speed and high-precision function and adjustment of the servo function)

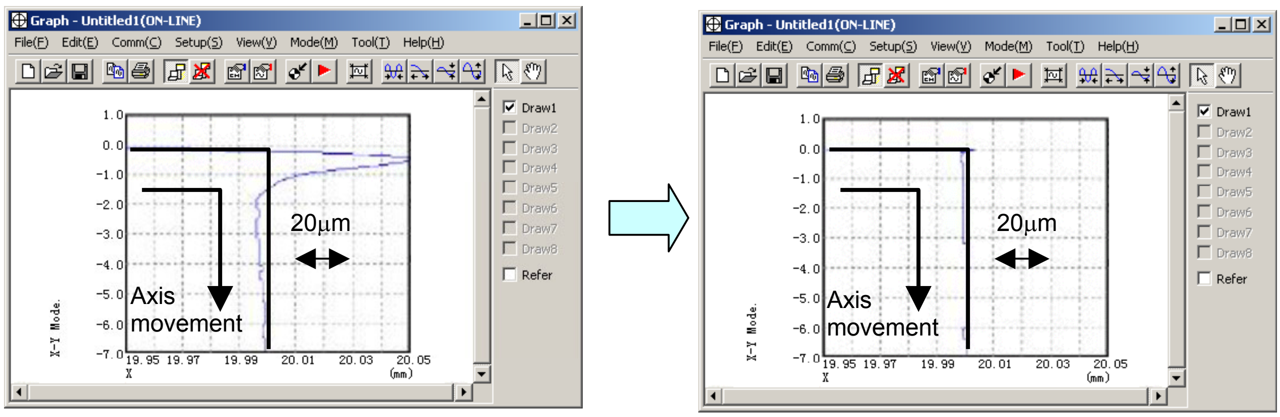
(a) Setting the corner deceleration function

When the automatic corner deceleration function is used, an error at the corner (overshoot) can be reduced. First, set the reduced corner feedrate to 400 mm/min.

[Parameter window main screen] **[Acc./dec. + AI contour control 2 (when AI contour control II is used)]**



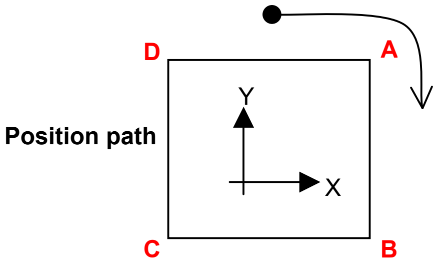
The figure below shows the effect of the corner deceleration function. Deceleration at a corner reduces the amount of the overshoot.

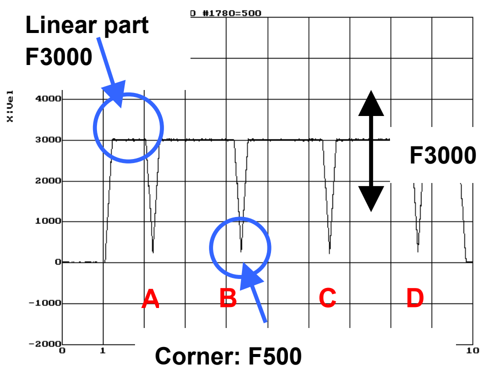


> **NOTE**
> For fine-adjustment of a corner overshoot, the following parameters are also related:
> - Acc./dec. before interpolation
> - Velocity feed-forward coefficient

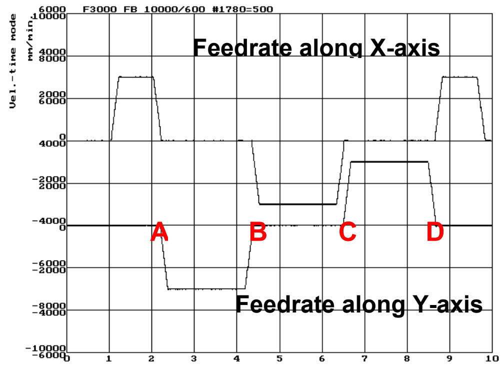
(b) Adjusting the time constant in cutting feed

In automatic corner deceleration, the feedrate at which the tool moves along a corner is reduced according to the permissible acceleration set for acc./dec. before interpolation. When the automatic corner deceleration function is used, the tangential feedrate at the corner changes in a V-shaped manner as shown below. As the permissible acceleration for acc./dec. before interpolation is decreased, deceleration at the corner becomes smoother, therefore, the contour error at the corner can be decreased.



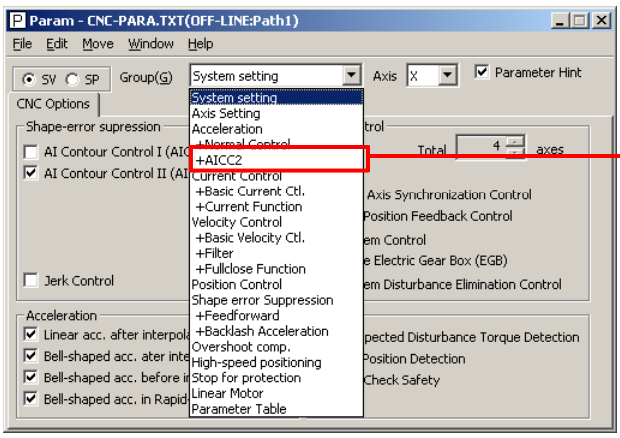


Tangential feedrate indication

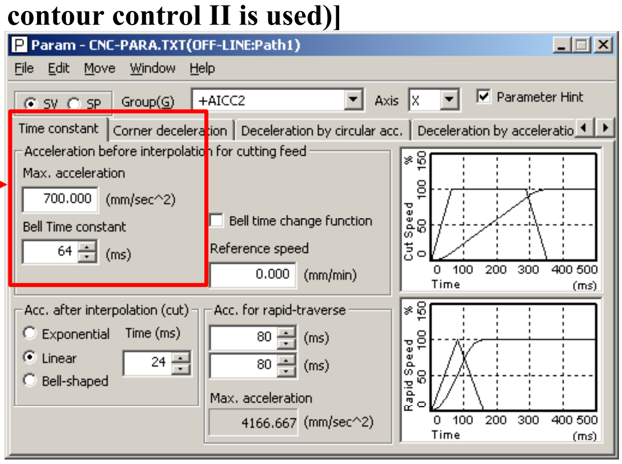


Indication of feedrate along each axis

[Parameter window main screen]



[Acc./dec. + AI contour control 2 (when AI contour control II is used)]



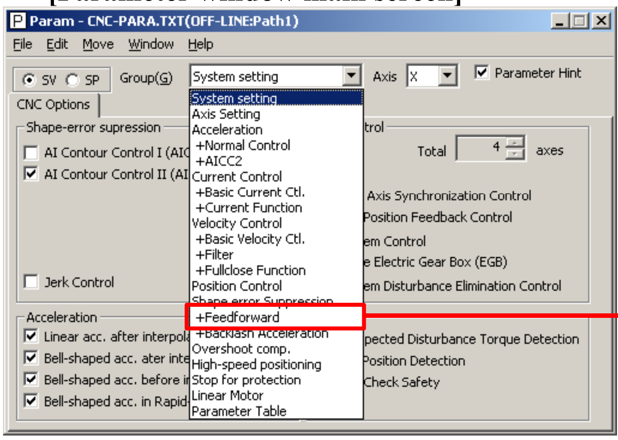
If the contour error at the corner cannot be reduced even by adjusting the permissible feedrate difference, increase the time constant of acc./dec. before interpolation.

When bell-shaped Acc/Dec. before interpolation is used, contour errors not only at corners but also rounded corners may be improved. Note that, however, a larger time constant extends the total machining time.

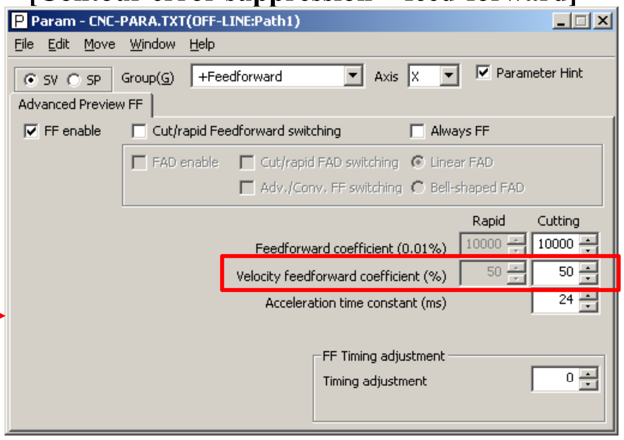
(c) Adjusting velocity feed-forward

The velocity feed-forward function has the effect of helping the torque command start earlier at the time of acc./dec. This effect is reflected in corner figures. So, adjust the velocity feed-forward coefficient so that corner figures can be improved. When nano interpolation is not used, set the coefficient value to 400 or smaller.

[Parameter window main screen]



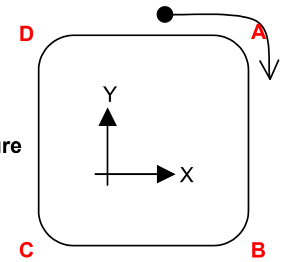
[Contour error suppression + feed-forward]

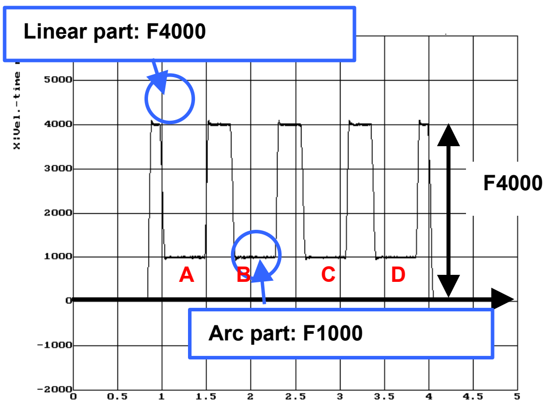


(10) Adjustment by using a square figure with 1/4 arcs (adjustment of the high-speed and high-precision function and adjustment of the servo function)

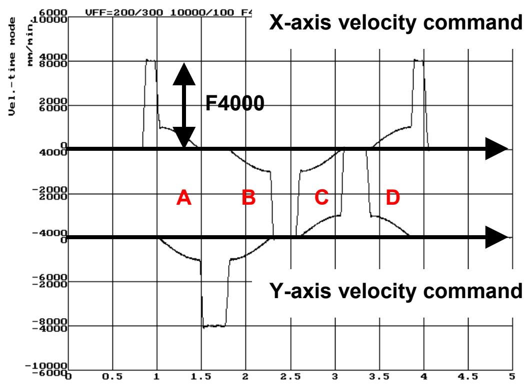
When acceleration changes suddenly at an arc part, positional deviation occurs. To reduce this positional deviation, set the permissible acceleration. Hence, the feedrate is changed depending on whether the tool moves along a linear part or an arc part in a square figure with 1/4 arcs as shown below. In this example, the feedrate decreases to F1000 in an arc part, and after the arc part is passed, the feedrate increases to restore F4000. The acc./dec. before and after an arc is determined by the time constant of acc./dec. before interpolation.

Figure



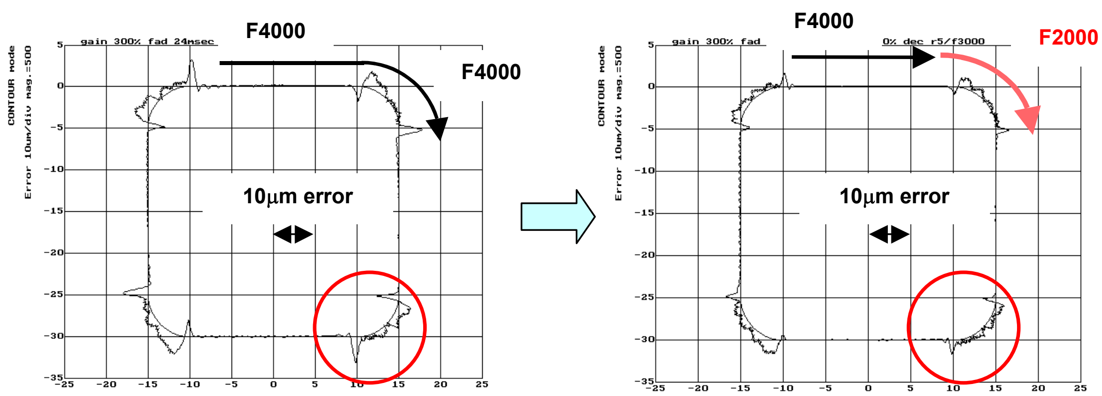


Target velocity command

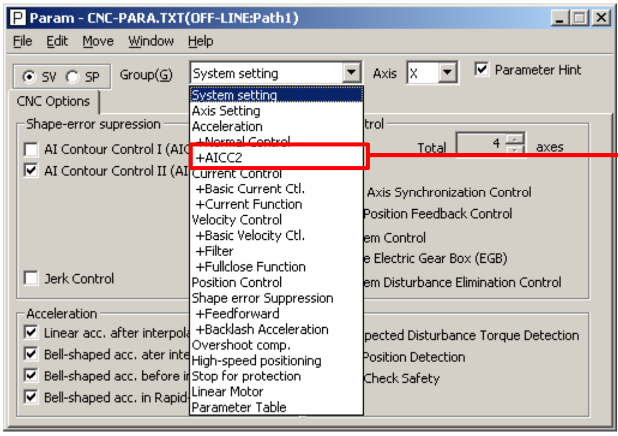


Velocity command (each axis)

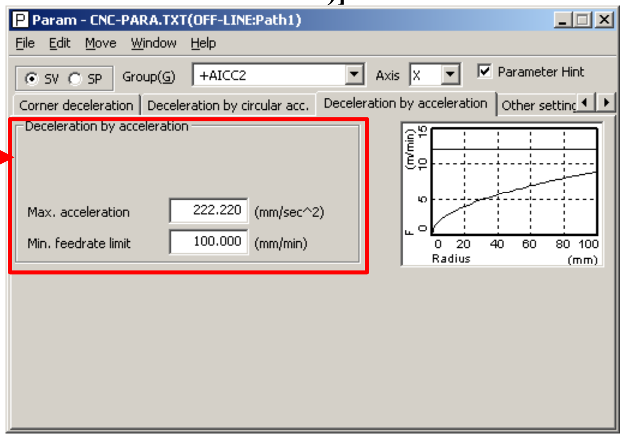
The following figure shows that this function reduces the positional deviation.



[Parameter window main screen]

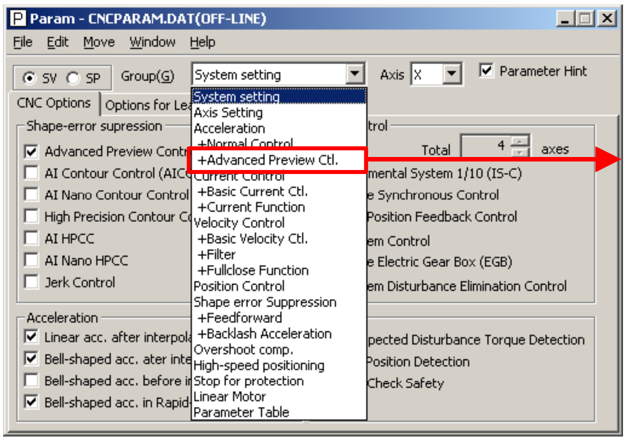


[Acc./dec. + AI contour control 2 (when AI contour control II is used)]

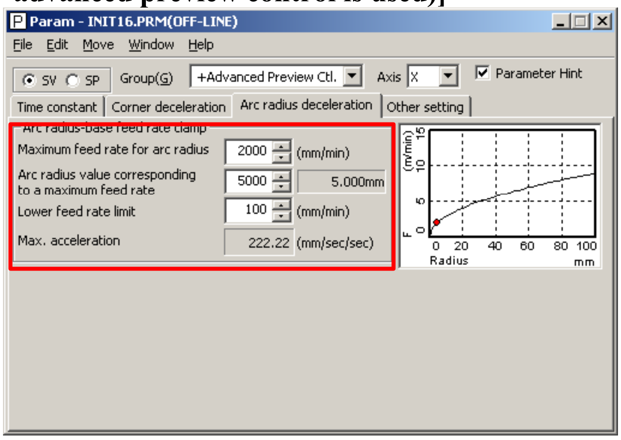


When advanced preview control is used, the feedrate at a rounded portion is suppressed by setting the arc radius and feedrate. For example, when the arc radius is 5 mm, and the feedrate is to be decreased to F2000, set R to 5 mm, and the feedrate to F2000 mm/min.

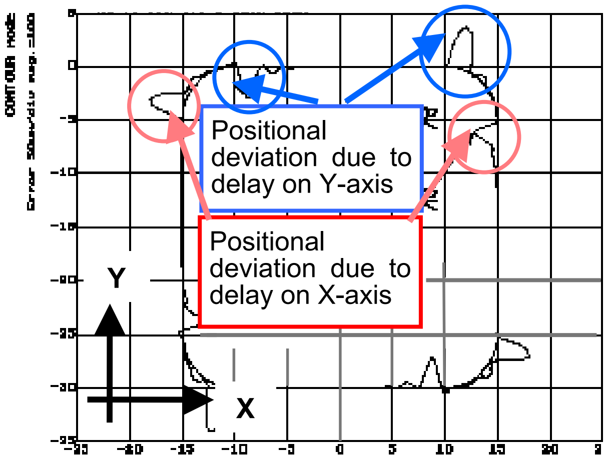
[Parameter window main screen]



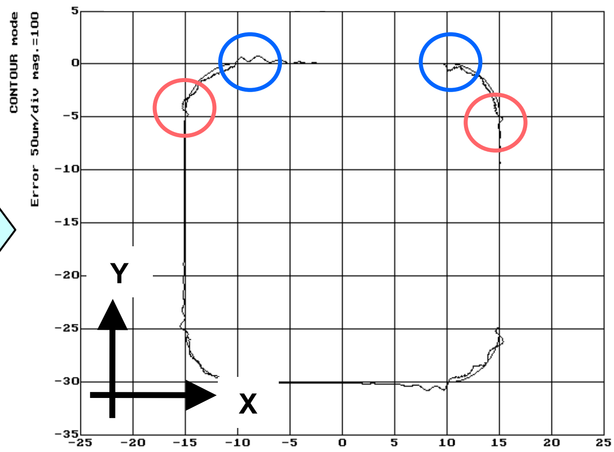
[Acc./dec. + advanced preview control (when advanced preview control is used)]



The positional deviation in an arc part can be suppressed also by adjusting the velocity feed-forward coefficient. Since the positional deviation in an arc part is caused by velocity loop delay at the start and end of the arc, velocity feed-forward, which compensates for delay, is effective in the suppression of the positional deviation in arc parts.



Velocity feed-forward disabled



Velocity feed-forward enabled

3.3.2 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 ERR (servo error amount) and TCMD. Set a measurement range as described below.

- ERR: Adjust the measurement range so that the precision required for positioning can be seen. When using the analog check board, measure VCMD instead of ERR. (Adjust the VCMD magnification and the measurement voltage level.) 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 function setting

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

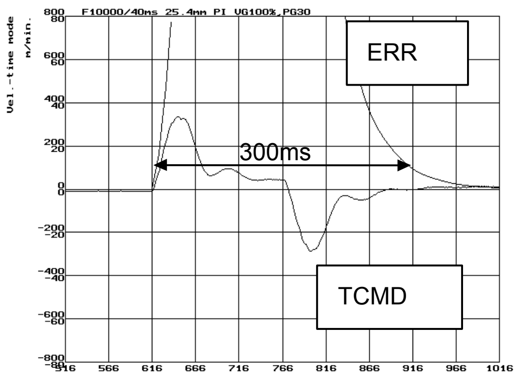


Fig. 3.3.2 (a) When PI function is used

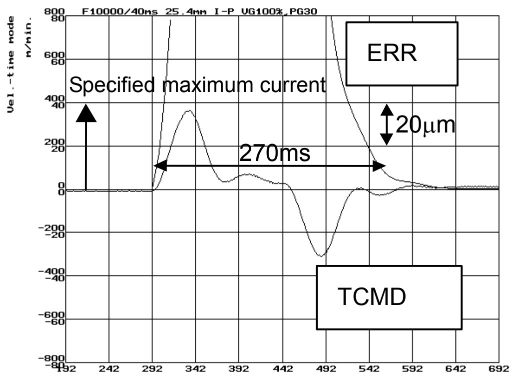


Fig. 3.3.2 (b) When I-P function is used

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

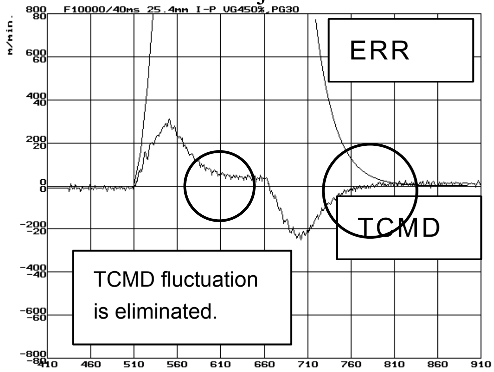


Fig. 3.3.2(c) After velocity loop gain adjustment

<3> Set a switch speed of 1500 (15 min^{-1}) with the position gain switch function (see Subsec. 4.8.1).

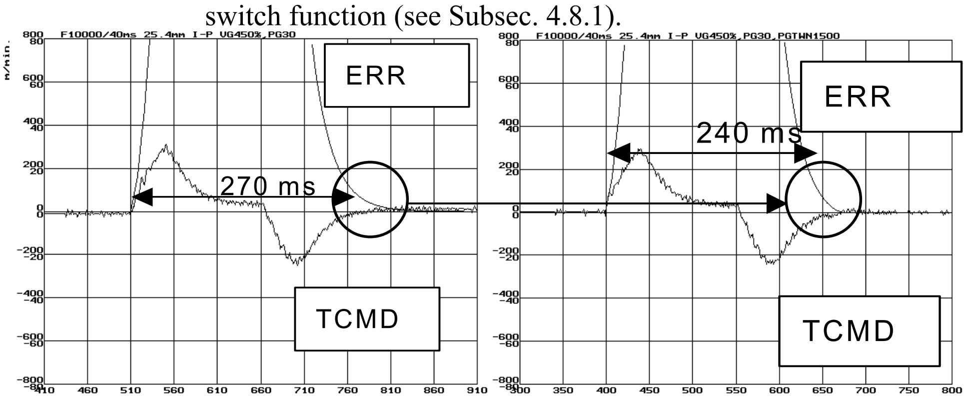


Fig. 3.3.2(d) Position gain switch function

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

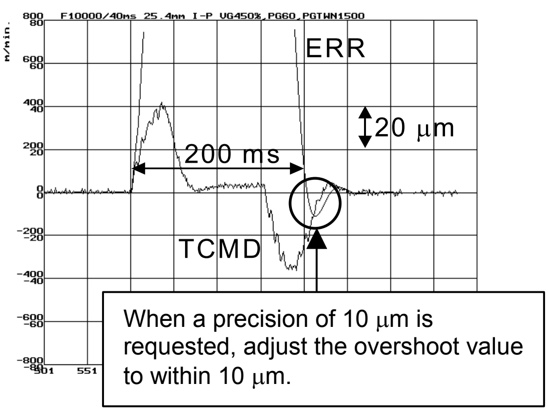


Fig. 3.3.2(e) Adequate position gain

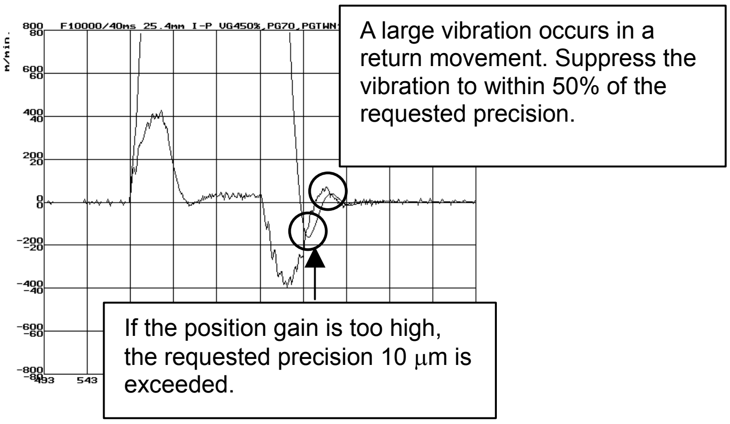


Fig. 3.3.2(f) Excessively high position gain

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

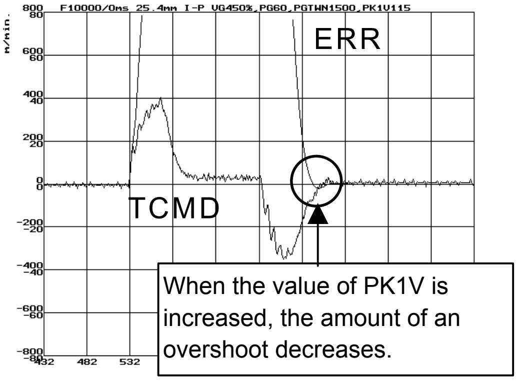


Fig. 3.3.2(g) After PK1V adjustment

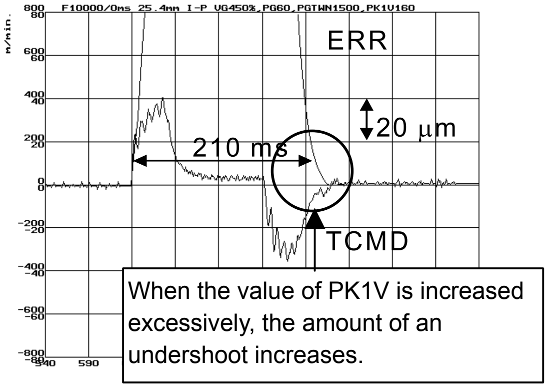


Fig. 3.3.2(h) When the value of PK1V is too large

3.3.3 Rapid Traverse Positioning Adjustment Procedure

(1) Overview

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

> **NOTE**
> In the Series 30*i*, 31*i*, and 32*i*, smooth acc./dec. is always performed by nano interpolation, so the fine acc./dec. function is unnecessary.
> Please use the bell-shaped acc./dec in rapid traverse in stead of the fine acc./dec. function.

(2) High-speed positioning by a combination of fine acc./dec. and feed-forward

(Rapid traverse positioning when fine acc./dec. 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 acc./dec. (Fig. 3.3.3 (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 acc./dec. 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 acc./dec. (optional function) (Fig. 3.3.3 (b)).

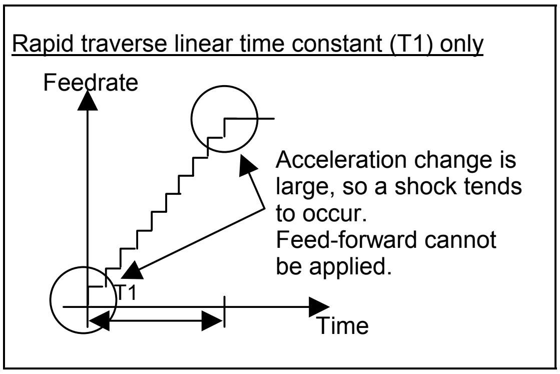


Fig. 3.3.3 (a) Rapid traverse linear acc./dec.

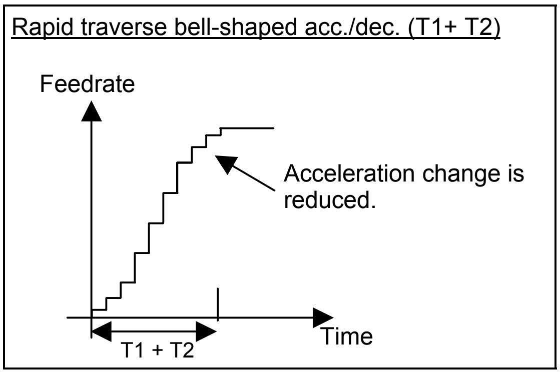


Fig. 3.3.3 (b) Rapid traverse bell-shaped acc./dec.

(Rapid traverse positioning when fine acc./dec. is used)

For further reduction in the time required for rapid traverse positioning, a delay due to 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 acc./dec. (Fig. 3.3.3 (a) and (b)), a mechanical shock due to acceleration change at the start and end of acc./dec., and a torque command vibration during acc./dec. can pose a problem. To cope with this, the fine acc./dec. function is available (Fig. 3.3.3 (c) and (d)).

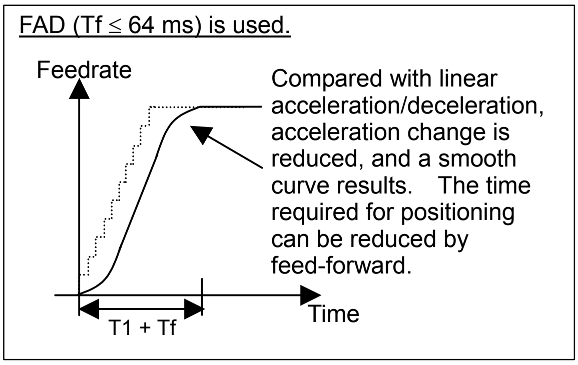


Fig. 3.3.3 (c) Fine acc./dec. (FAD)

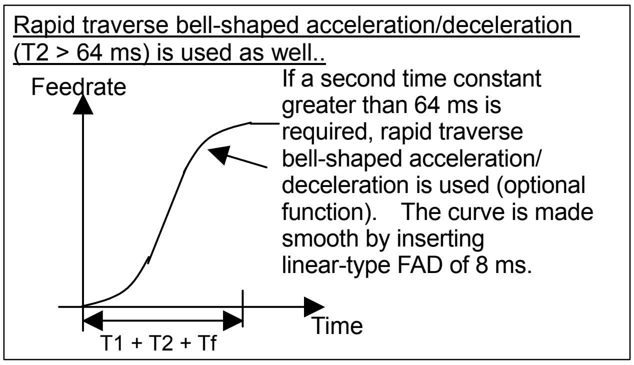


Fig. 3.3.3 (d) Rapid traverse bell-shaped acc./dec. + FAD

Fine acc./dec. 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 acc./dec. 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 acc./dec. If a time constant greater than 64 ms is required, use rapid traverse bell-shaped acc./dec., and set 8 ms for linear-type fine acc./dec. (Fig. 3.3.3 (d)).

(3) Adjustment procedure

Make a rapid traverse positioning adjustment while viewing the ERR (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 item (5), “Adjustment of high-speed velocity control” in the Subsec. 3.3.1, "Gain Adjustment Procedure."

The measurement data of Fig. 3.3.3 (e) has been obtained under the condition below. Fine acc./dec. 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.

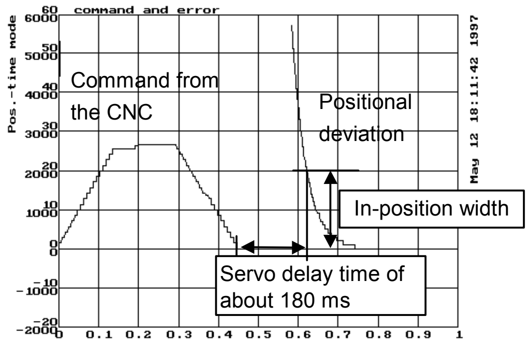


Fig. 3.3.3 (e) Measurement of time before adjustment

<1> Default parameter setting for fine acc./dec. and feed-forward

Set the parameters according to Table 3.3.3. By setting the default parameters, the time required for positioning can be much reduced.

Table 3.3.3 Default parameters for rapid traverse positioning adjustment

Item	Default parameter		
	Series 15*i*	Series 30*i*, 16*i*, and so on	Setting
Rapid traverse feed-forward enable	No. 1800 #3	No. 1800 #3	1
Fine acc./dec. function enable	No. 1951 #6	No. 2007 #6	1
Linear-type fine acc./dec.	No. 1749, #2	No. 2009 #2	1
Fine acc./dec. time constant	No. 1702	No. 2109 (*1)	40
Feed-forward enable	No. 1883 #1	No. 2005 #1	1
Feed-forward coefficient	No. 1985	No. 2092 (*1)	9700
Velocity feed-forward coefficient	No. 1962	No. 2069 (*1)	100

*1 When using different values for cutting and rapid traverse, use the cutting feed/rapid traverse switchable fine acc./dec. function according to Section 4.3, "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. 3.3.3 (f)). The swell can be reduced by increasing the velocity feed-forward coefficient (Fig. 3.3.3 (g)).

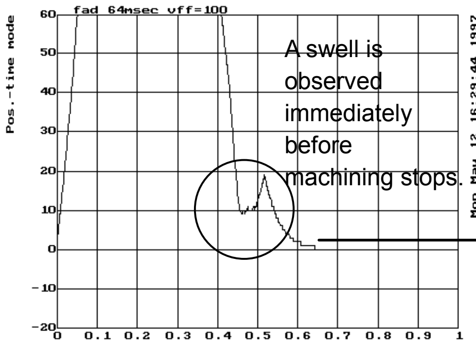


Fig. 3.3.3 (f) Before velocity feed-forward adjustment

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

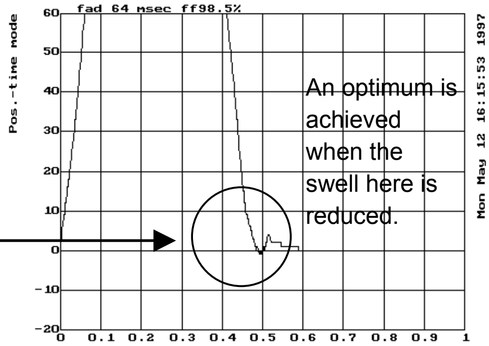


Fig. 3.3.3 (g) After velocity feed-forward adjustment

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

<3> Fine adjustment of feed-forward

Reduce the time required for positioning by making a fine adjustment of the feed-forward coefficient. If the feed-forward coefficient is not sufficiently large (Fig. 3.3.3 (h)), increase the feed-forward coefficient by about 0.5%. If the feed-forward coefficient is too large (Fig. 3.3.3 (i)), decrease the feed-forward coefficient by about 0.5%.

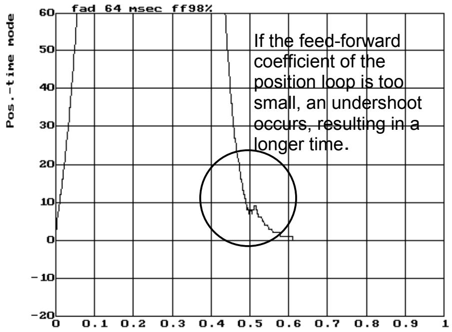


Fig. 3.3.3 (h) When the feed-forward coefficient is too small

FAD: 64 ms
Feed-forward: 98%
Velocity feed-forward coefficient: 250%

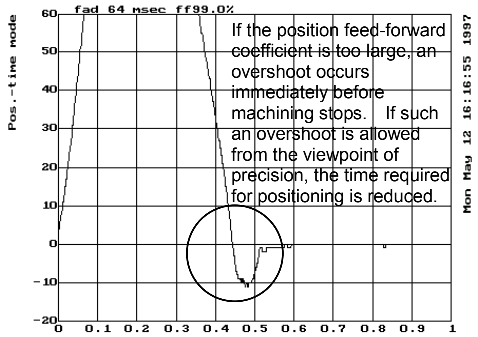


Fig. 3.3.3 (i) When the feed-forward coefficient is too high

FAD: 64 ms
Feed-forward: 99%
Velocity feed-forward coefficient: 250%

If an adequate feed-forward coefficient is set, the in-position width is satisfied nearly at the same as distribution command completion, and shortest-time positioning is achieved as shown in Fig. 3.3.3 (j).

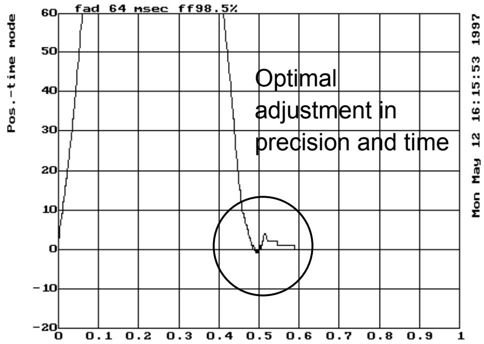


Fig. 3.3.3 (j) When an adequate feed-forward coefficient is set
FAD: 64 ms
Feed-forward: <u>98.5%</u>
Velocity feed-forward coefficient: 250%

3.3.4 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?
Machine with high rigidity: Velocity loop proportional high-speed processing function (function 1)
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%, arbitrary) (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 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

	#7	#6	#5	#4	#3	#2	#1	#0
1959 (FS15*i*) **2017 (FS30*i*, 16*i*)**	**PK2V25**							

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

Function 2: Acceleration feedback

1894 (FS15*i*) **2066 (FS30*i*, 16*i*)**	**Acceleration feedback gain**

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

	#7	#6	#5	#4	#3	#2	#1	#0
1958 (FS15*i*) 2016 (FS30*i*, 16*i*)					PK2VDN			

PK2VDN (#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
1747 (FS15*i*) 2207 (FS30*i*, 16*i*)					PK2D50			

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

1730 (FS15*i*) 2119 (FS30*i*, 16*i*)	Stop decision level

2737 (FS15*i*) 2324 (FS30*i*, 16*i*)	Function for changing the proportional gain in the stop state: Arbitrary magnification in the stop state (during cutting feed only)

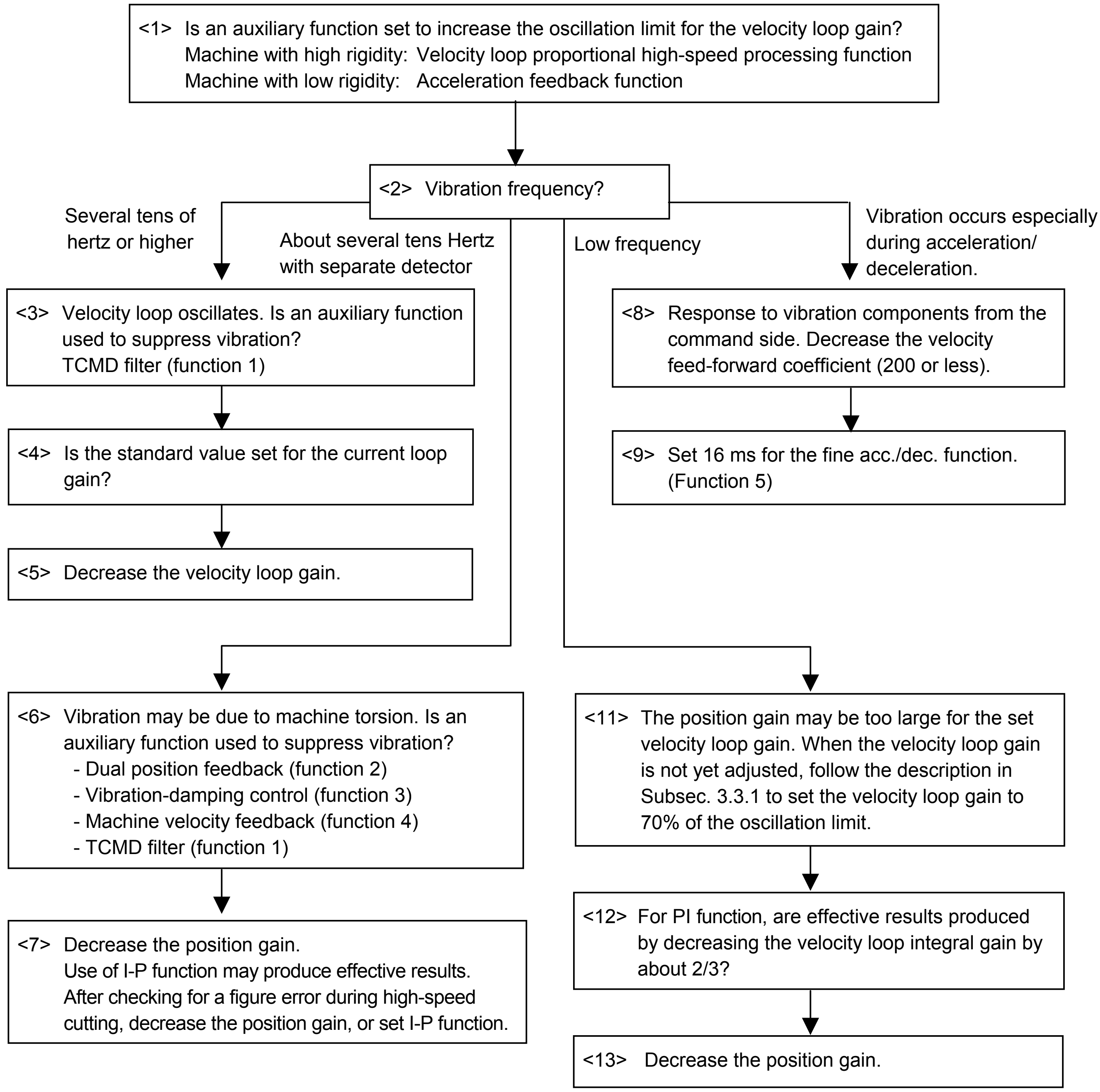
Function 4: N pulse suppress function

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) 2003 (FS30*i*, 16*i*)				NPSP				

NPSP (#4) 1: Uses the N pulse suppress function.

3.3.5 Vibration during Travel

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



(Reference: Parameter numbers)
For details, see Chapter 4, "SERVO FUNCTION DETAILS."

Function 1: TCMD filter

1895 (FS15*i*) / **2067 (FS30*i*, 16*i*)**	**TCMD filter coefficient**

Function 2: Dual position feedback function

	#7	#6	#5	#4	#3	#2	#1	#0
1709 (FS15*i*) / **2019 (FS30*i*, 16*i*)**	**DPFB**							

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

1971 (FS15*i*) / **2078 (FS30*i*, 16*i*)**	**Dual position feedback: conversion coefficient (numerator)**

1972 (FS15*i*) / **2079 (FS30*i*, 16*i*)**	**Dual position feedback: conversion coefficient (denominator)**

1973 (FS15*i*) / **2080 (FS30*i*, 16*i*)**	**Dual position feedback: primary delay time constant**

Function 3: Vibration-damping control

1718 (FS15*i*) / **2033 (FS30*i*, 16*i*)**	**Vibration-damping control function: number of position feedback pulses**

1719 (FS15*i*) / **2034 (FS30*i*, 16*i*)**	**Vibration-damping control function: gain**

Function 4: Machine velocity feedback

	#7	#6	#5	#4	#3	#2	#1	#0
1956 (FS15*i*) / **2012 (FS30*i*, 16*i*)**							**MSFE**	

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

1981 (FS15*i*) / **2088 (FS30*i*, 16*i*)**	**Machine velocity feedback gain**

Function 5: Fine acc./dec. function

	#7	#6	#5	#4	#3	#2	#1	#0
1951 (FS15*i*) / **2007 (FS30*i*, 16*i*)**		**FAD**						

FAD (#6) 1: Enables fine acc./dec.

1702 (FS15*i*)	Fine acc./dec. time constant
2109 (FS30*i*, 16*i*)	

> **NOTE**
> In the Series 30*i*, 31*i*, and 32*i*, smooth acc./dec. is always performed by nano interpolation, so the fine acc./dec. function is ignored.

3.3.6 Stick Slip

When the time from the detection of a position error until the compensation torque is output is too long, a stick slip 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 stick slip phenomenon may occur.

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

↓

<2> Set PI function.

↓

<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
1808 (FS15*i*) / 2003 (FS30*i*, 16*i*)	VOFS							

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

1857 (FS15*i*)	Incomplete integral gain
2045 (FS30*i*, 16*i*)	

3.3.7 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 the 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 function.

↓

<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
1808 (FS15*i*) / **2003 (FS30*i*, 16*i*)**		**OVSC**						

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

1970 (FS15*i*) / **2077 (FS30*i*, 16*i*)**	**Overshoot prevention counter**

1857 (FS15*i*) / **2045 (FS30*i*, 16*i*)**	**Incomplete integral coefficient**

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) / **2202 (FS30*i*, 16*i*)**					**OVS1**			

OVS1 (#3) 1: Enables overshoot compensation TYPE-2.

4 SERVO FUNCTION DETAILS

4.1 SERVO HRV CONTROL

(1) Overview

Servo HRV control is a digital servo control system based on high-speed, high-response current control and includes servo HRV1 control, servo HRV2 control, servo HRV3 control, and servo HRV4 control. Use of these control systems allows higher acceleration, higher speed, and higher precision.

Servo HRV control system

- Servo HRV control
  - Servo HRV1 control
  - Servo HRV2 control
  - Servo HRV3 control
  - Servo HRV4 control

(2) Servo HRV control and Series and editions of applicable servo software

	Series30*i*		**Other than the Series 30*i***	
	Series 90D0/A(01) and subsequent editions (Note 1, 2)	**Series 90E0/A(01) and subsequent editions (Note 2)**	**Series 90B0/H(08) and subsequent editions (Note 3)**	**Series 9096/A(01) and subsequent editions**
ServoHRV1 control	×	×	○	○
ServoHRV2 control	○	○	●	×
ServoHRV3 control	●	●	○	×
ServoHRV4 control	○	×	×	×

○: Supported (● is recommended)
×: Not supported

NOTE
1 When using servo HRV4 control, use Series 90D0/J(10) and subsequent editions.
2 For Series 90D0 and 90E0, apply the same servo HRV control to all axes.
3 Series 90B1/A(01) and subsequent editions, Series 90B6/A(01) and subsequent editions, and Series 90B5/A(01) and subsequent editions are also supported.

(3) Features of servo HRV control

(a) Servo HRV2 control

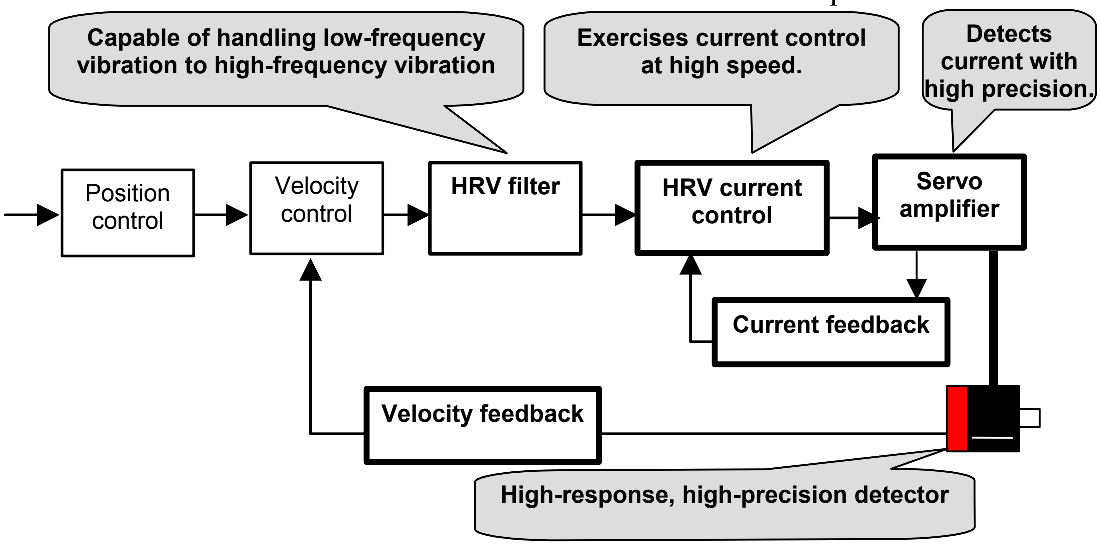
Servo HRV control is a total control technology implemented by a servo motor, servo amplifier, and control systems as shown in the figure below. Servo HRV2 control has the following features:

(1) HRV filters for eliminating vibration components of the machine system can be used.
The HRV filters include the following filters to cover a wide range of vibration from low frequency vibration to high frequency vibration:
TCMD filter (a filter for eliminating middle frequency vibration)
Resonance elimination filter (a filter for eliminating high frequency vibration)
Disturbance elimination filter (a filter for eliminating low frequency vibration)

(2) Use of a α*i*S/α*i*F/β*i*S series motor and a α*i*/β*i* servo amplifier enables high-speed, high-precision, and smooth feed.

(3) Use of a precise pulse coder improves control performance.

With Series 90B0, 90B1, 90B6, and 90B5, it is recommended that servo HRV2 control be used for the current loop.



(b) Servo HRV3 control

In addition to the features of HRV2 control, servo HRV3 control has the following features:

(1) Use of high-speed DSP enables high-speed HRV current control, therefore improving the response performance of the current loop.

(2) When a linear motor or an α*i*S series servo motor are used, both high acceleration, high speed and high precision can be provided at the same time.

With Series 90D0 and 90E0, use of servo HRV3 control is recommended.

(c) Servo HRV4 control

In addition to the features of servo HRV2 and servo HRV3, servo HRV4 control has the following features:

(1) An improved servo HRV control system is employed. (Extended HRV function)

(2) Improved thermal resistance in the high-speed DSP and servo amplifier provides the current loop with higher response performance than the response performance provided by servo HRV3 current control.

4.1.1 Servo HRV2 Control

(1) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(2) Setting parameters

By using a motor ID number for servo HRV2 control, load the standard parameters.
Set the motor ID number supporting servo HRV2 control, listed in the table below, and perform servo initialization.

NOTE
1 For the motor ID number, see the table below.
2 With servo software editions earlier than the editions listed in the table, automatic parameter loading cannot be performed. In such cases, enter the standard parameters listed in the parameter list in Section 6.2 in this manual.

α*i*S series servo motor

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
α*i*S2/5000	0212	262	A	H	A	A
α*i*S2/6000	0218	284	G	-	B	B
α*i*S4/5000	0215	265	A	H	A	A
α*i*S8/4000	0235	285	A	H	A	A
α*i*S8/6000	0232	290	G	-	B	B
α*i*S12/4000	0238	288	A	H	A	A
α*i*S22/4000	0265	315	A	H	A	A
α*i*S30/4000	0268	318	A	H	A	A
α*i*S40/4000	0272	322	A	H	A	A
α*i*S50/3000	0275-Bx0x	324	B	V	A	A
α*i*S50/3000 FAN	0275-Bx1x	325	A	N	A	A
α*i*S100/2500	0285	335	A	T	A	A
α*i*S200/2500	0288	338	A	T	A	A
α*i*S300/2000	0292	342	B	V	A	A
α*i*S500/2000	0295	345	A	T	A	A

αiF series servo motor

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
αiF1/5000	0202	252	A	H	A	A
αiF2/5000	0205	255	A	H	A	A
αiF4/4000	0223	273	A	H	A	A
αiF8/3000	0227	277	A	H	A	A
αiF12/3000	0243	293	A	H	A	A
αiF22/3000	0247	297	A	H	A	A
αiF30/3000	0253	303	A	H	A	A
αiF40/3000	0257-Bx0x	307	A	H	A	A
αiF40/3000 FAN	0257-Bx1x	308	A	I	A	A

αiS series servo motor (for 400-V driving)

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
αiS2/5000HV	0213	263	A	Q	A	A
αiS2/6000HV	0219	287	G	-	B	B
αiS4/5000HV	0216	266	A	Q	A	A
αiS8/4000HV	0236	286	A	N	A	A
αiS8/6000HV	0233	292	G	-	B	B
αiS12/4000HV	0239	289	A	N	A	A
αiS22/4000HV	0266	316	A	N	A	A
αiS30/4000HV	0269	319	A	N	A	A
αiS40/4000HV	0273	323	A	N	A	A
αiS50/3000HV FAN	0276-Bx1x	326	A	N	A	A
αiS50/3000HV	0276-Bx0x	327	B	V	A	A
αiS100/2500HV	0286	336	B	V	A	A
αiS200/2500HV	0289	339	B	V	A	A
αiS300/2000HV	0293	343	B	V	A	A
αiS500/2000HV	0296	346	B	V	A	A
αiS1000/2000HV	0298	348	B	V	A	A
αiS 2000/2000HV(Note 1)	0091	340	-	-	-	B

The mark "-" indicates that automatic loading of standard parameters is not supported as of December, 2005.

NOTE

1 The model needs manual setting. (See Subsection 2.1.7, "Setting Parameters when the PWM Distribution Module is used".)
When using the torque control function, contact FANUC.

α*i*F(HV) series servo motor (for 400-V driving)

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
α*i*F4/4000HV	0225	275	A	Q	A	A
α*i*F8/3000HV	0229	279	A	Q	A	A
α*i*F12/3000HV	0245	295	A	Q	A	A
α*i*F22/3000HV	0249	299	A	Q	A	A

αC*i* series servo motor

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
αC4/3000*i*	0221	271	A	H	A	A
αC8/2000*i*	0226	276	A	H	A	A
αC12/2000*i*	0241	291	A	H	A	A
αC22/2000*i*	0246	296	A	H	A	A
αC30/1500*i*	0251	301	A	H	A	A

β*i*S series servo motor

Motor model	Motor specification	Amplifier driving	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
β*i*S0.2/5000	0111	4A	260	A	N	A	A
β*i*S0.3/5000	0112	4A	261	A	N	A	A
β*i*S0.4/5000	0114	20A	280	A	N	A	A
β*i*S0.5/6000	0115	20A	281	G	-	B	B
β*i*S1/6000	0116	20A	282	G	-	B	B
β*i*S2/4000	0061	20A	253	B	V	A	A
		40A	254	B	V	A	A
β*i*S4/4000	0063	20A	256	B	V	A	A
		40A	257	B	V	A	A
β*i*S8/3000	0075	20A	258	B	V	A	A
		40A	259	B	V	A	A
β*i*S12/2000	0077 (Note 1)	20A	269	-	-	D	-
β*i*S12/3000	0078	40A	272	B	V	A	A
β*i*S22/2000	0085	40A	274	B	V	A	A

NOTE

1 For a motor specification suffixed with “-Bxx6”, be sure to use parameters dedicated to FS0*i*.

β*i*S series servo motor (for 400-V driving)

Motor model	Motor specification	Amplifier driving	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
β*i*S2/4000HV	0062	10A	251	-	-	B	-
β*i*S4/4000HV	0064	10A	264	-	-	B	-
β*i*S8/3000HV	0076	10A	267	-	-	B	-
β*i*S12/3000HV	0079	20A	270	-	-	B	-
β*i*S22/2000HV	0086	20A	278	-	-	B	-

The mark "-" indicates that automatic loading of standard parameters is not supported as of December, 2005.

β*i*S series servo motor (dedicated to FS0*i*)

Motor model	Motor specification	Amplifier driving	Motor ID No.	90B5
β*i*S2/4000	0061-Bxx6	20A	306	D
		40A	310	D
β*i*S4/4000	0063-Bxx6	20A	311	D
		40A	312	D
β*i*S8/3000	0075-Bxx6	20A	283	D
		40A	294	D
β*i*S12/2000	0077-Bxx6	20A	298	D
β*i*S22/1500	0084-Bxx6	20A	302	D
		40A	305	D

The motor models above can be driven only with Series 90B5.

Linear motor (for 200-V driving)

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
L*i*S300A1/4	0441-B200	351	G	-	B	B
L*i*S600A1/4	0442-B200	353	G	-	B	B
L*i*S900A1/4	0443-B200	355	G	-	B	B
L*i*S1500B1/4	0444-B210	357	G	-	B	B
L*i*S3000B2/2	0445-B110	360	G	-	B	B
L*i*S3000B2/4	0445-B210	362	G	-	B	B
L*i*S4500B2/2	0446-B110	364	G	-	B	B
L*i*S6000B2/2	0447-B110	368	G	-	B	B
L*i*S6000B2/4	0447-B210	370	G	-	B	B
L*i*S7500B2/2	0448-B110	372	G	-	B	B
L*i*S7500B2/4	0448-B210	374	G		B	B
L*i*S9000B2/2	0449-B110	376	G	-	B	B
L*i*S9000B2/4	0449-B210	378	G	-	B	B
L*i*S3300C1/2	0451-B110	380	G	-	B	B
L*i*S9000C2/2	0454-B110	384	G	-	B	B
L*i*S11000C2/2	0455-B110	388	G	-	B	B
L*i*S15000C2/2	0456-B110	392	G	-	B	B
L*i*S15000C2/3	0456-B210	394	G	-	B	B

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
L*i*S10000C3/2	0457-B110	396	G	-	B	B
L*i*S17000C3/2	0459-B110	400	G	-	B	B

Linear motor (for 400-V driving)

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1
L*i*S1500B1/4	0444-B210	358	G	-	B	B
L*i*S3000B2/2	0445-B110	361	G	-	B	B
L*i*S4500B2/2HV	0446-B010	363	G	-	B	B
L*i*S4500B2/2	0446-B110	365	G	-	B	B
L*i*S6000B2/2HV	0447-B010	367	G	-	B	B
L*i*S6000B2/2	0447-B110	369	G	-	B	B
L*i*S7500B2/2HV	0448-B010	371	G	-	B	B
L*i*S7500B2/2	0448-B110	373	G	-	B	B
L*i*S9000B2/2	0449-B110	377	G	-	B	B
L*i*S3300C1/2	0451-B110	381	G	-	B	B
L*i*S9000C2/2	0454-B110	385	G		B	B
L*i*S11000C2/2HV	0455-B010	387	G	-	B	B
L*i*S11000C2/2	0455-B110	389	G	-	B	B
L*i*S15000C2/3HV	0456-B010	391	G	-	B	B
L*i*S10000C3/2	0457-B110	397	G	-	B	B
L*i*S17000C3/2	0459-B110	401	G	-	B	B

The mark “-” indicates that automatic loading of standard parameters is not supported as of December, 2005.

Synchronous built-in servo motor (for 200-V driving)

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1	9096
D*i*S85/400	0483-B20x	423	K	-	-	-	-
D*i*S110/300	0484-B10x	425	K	-	-	-	-
D*i*S260/600	0484-B31x	429	K	-	-	-	-
D*i*S370/300	0484-B40x	431	K	-	-	-	-

Synchronous built-in servo motor (for 400-V driving)

Motor model	Motor specification	Motor ID No.	90D0 90E0	90B0	90B5 90B6	90B1	9096
D*i*S85/400	0483-B20x	424	K	-	-	-	-
D*i*S110/300	0484-B10x	426	K	-	-	-	-
D*i*S260/600	0484-B31x	430	K	-	-	-	-
D*i*S370/300	0484-B40x	432	K	-	-	-	-

4.2 HIGH-SPEED HRV CURRENT CONTROL

4.2.1 Servo HRV3 Control

(1) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B)
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(2) Setting parameters for servo HRV3 control

<1> See Subsection 4.1.1, and make settings for servo HRV2 control.

<2> Set servo HRV3 current control. (For each axis)

	#7	#6	#5	#4	#3	#2	#1	#0
1707(FS15*i*) / 2013(FS30*i*,16*i*)								HR3

HR3(#0) 1: Uses servo HRV3 control.
0: Does not use servo HRV3 control.

NOTE
1 When servo HRV3 control is used with Series 90E0, a multiple of 4 cannot be set in parameter No. 1023. Skip multiples of 4 when setting the parameter.
Example: when using eight axes with Series 90E0, set parameter No. 1023 as follows: 1,2,3,5,6,7,9,10

<3> Set the cutting/rapid velocity loop gain switching function.

	#7	#6	#5	#4	#3	#2	#1	#0
1742(FS15*i*) / 2202(FS30*i*,16*i*)							VGCCR	

VGCCR (#1) 1: Uses the cutting/rapid velocity loop gain switching function.
0: Does not use the cutting/rapid velocity loop gain switching function.

<4> Set the current loop gain magnification.

2747(FS15*i*) / 2334(FS30*i*,16*i*)	**Current loop gain magnification in high-speed HRV current control mode**

[Unit of data] %
[Valid data range] 100 to 270
[Recommended value] 150

This parameter is valid only for cutting feed in the high-speed HRV current control mode.

<5> Set the velocity loop gain magnification.

2748(FS15*i*) / 2335(FS30*i*,16*i*)	**Velocity loop gain magnification in high-speed HRV current control mode**

[Unit of data] %
[Valid data range] 100 to 400

This parameter is valid only for cutting feed in the high-speed HRV current control mode.

1700(FS15*i*) / 2107(FS30*i*,16*i*)	**Velocity loop gain magnification (cutting/rapid velocity loop gain switching)**

[Unit of data] %
[Valid data range] 100 to 400

This parameter is valid only for cutting feed when the high-speed HRV current control mode is not set.

<6> Set the high-speed HRV current control mode.
To use servo HRV3 control with servo software Series 90D0 and 90E0 for the Series 30*i*, 31*i*, and 32*i*, set the following bit, which automatically sets the high-speed HRV current control mode during cutting feed:

	#7	#6	#5	#4	#3	#2	#1	#0
- / 2283(FS30*i*,31*i*,32*i*)								NOG54

NOG54(#0) The high-speed HRV current control mode (servo HRV3 control) is:
0: Set only when both G5.4Q1 and G01 are specified.
1: Set when G01 is specified (G5.4Q1 is not monitored).

> **NOTE**
> This function cannot be used during servo HRV4 control.

<7> This completes parameter setting. To actually enter the high-speed HRV current control mode, G codes must be programmed. (This is not required if NOG54 is set to 1. See Subsection 4.2.3.)

> **NOTE**
> The velocity loop gain is changed as listed below according to whether the high-speed HRV current control mode is set or not.

[Series30*i*,16*i*, and so on]

High-speed HRV current control mode	Feed	Velocity loop gain [%]
Set (G5.4Q1 - G5.4Q0)	Rapid traverse	(1 + No. 2021 / 256) × 100
	Cutting feed	(1 + No. 2021 / 256) × **No. 2335** (High-speed HRV current control: Velocity loop gain magnification)
Not set	Rapid traverse	(1 + No. 2021 / 256) × 100
	Cutting feed	(1 + No. 2021 / 256) × No. 2107 (Cutting/rapid switching: Velocity loop gain magnification)

[Series15*i*]

High-speed HRV current control mode	Feed	Velocity loop gain [%]
Set (G5.4Q1 - G5.4Q0)	Rapid traverse	(1 + No. 1875 / 256) × 100
	Cutting feed	(1 + No. 1875 / 256) × **No. 2748** (High-speed HRV current control: Velocity loop gain magnification)
Not set	Rapid traverse	(1 + No. 1875 / 256) × 100
	Cutting feed	(1+No1875 / 256) × No. 1700 (Cutting/rapid switching: Velocity loop gain magnification)

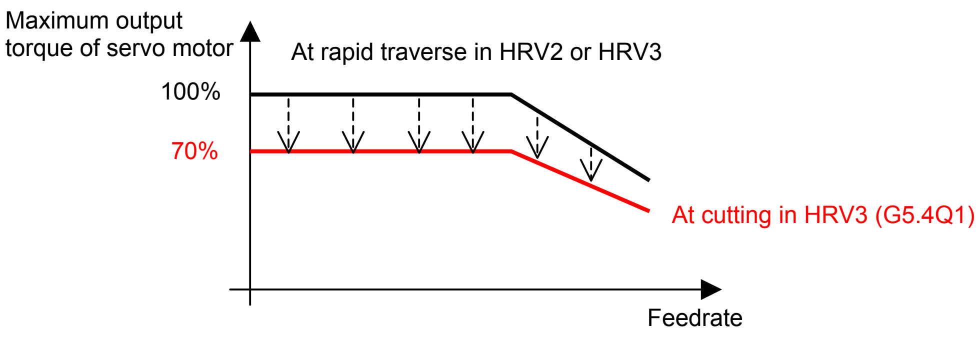
(3) Limitation on servo HRV3 control

(a) Servo motor output torque

(Series 90B0, 90B1, 90B6, 90B5)

During cutting operation in high-speed HRV current control, the torque command is automatically limited to 70% of the maximum current value of the servo amplifier. As a result, the torque command is easily saturated. Therefore, when determining the time constant in cutting feed, consider the cutting load and the above limitation. Normally, the high-speed HRV current control mode is used for light cutting for finish machining, so the limitation of the torque command to 70% of the maximum current value of the servo amplifier is not regarded as critical.

Torque curve during G5.4Q1 command



(Series 90D0, 90E0)

The servo amplifiers supporting the Series 30*i* and so on have advanced thermal resistance. So, unlike Series 90B0, 90B1, 90B6, and 90B5, there is no torque command limitation.

(4) Servo HRV3 control hardware

(a) Separate detector

(Series 90B0, 90B1, 90B6, 90B5)

When a separate detector is used for servo HRV3 control, the following separate detector interface unit supporting servo HRV3 control must be specified:

Separate detector interface unit for servo HRV3 control	Specification drawing number
Basic 4 axes	A02B-0236-C205

(Series 90D0, 90E0)

When a separate detector is used with the Series 30*i* and so on, the following separate detector interface unit supporting the Series 30*i* and so on must be specified:

Separate detector interface unit for Series 30*i* and other CNC	Specification drawing number
Basic 4 axes	A02B-0303-C205

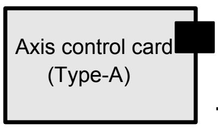
(b) Servo axis control cards

(Series 90B0, 90B1, 90B6, 90B5)

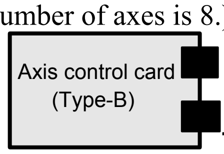
Servo axis control cards are divided into two groups: type A and type B.

Type A card: One optical connector is provided. (The maximum number of axes is 8.)

Type B card: Two optical connectors are provided. (The maximum number of axes is 8.)



Type A has one optical connector.



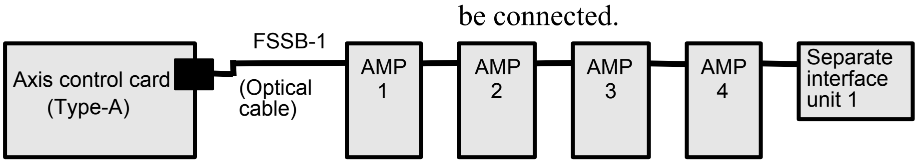
Type B has two optical connectors.

When servo HRV3 control is used, up to four servo amplifier axes can be connected to one optical connector, and only one separate detector interface unit can be connected to one optical connector. When five or more servo amplifier axes or two separate detector interface units are to be connected, a type B card is required.

> **NOTE**
> When four servo amplifier axes and one separate interface unit are connected to one optical connector, the separate interface unit must be connected in the fifth position.

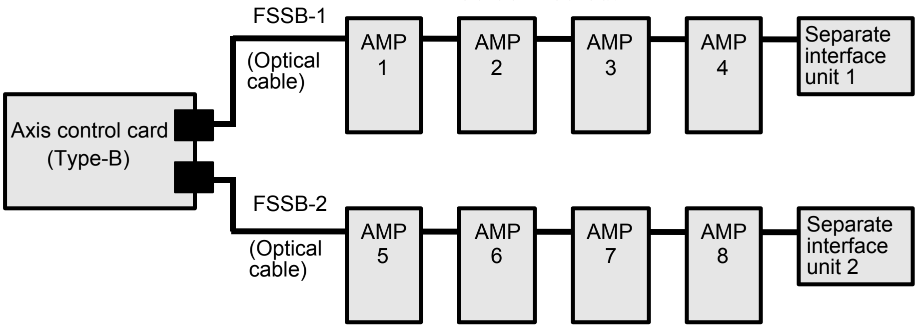
[Number of controlled axes]
When a type A card is used: Up to four servo HRV3 control axes
When a type B card is used: Up to eight servo HRV3 control axes

- When a type A card is used: Up to four axes plus one unit can be connected.



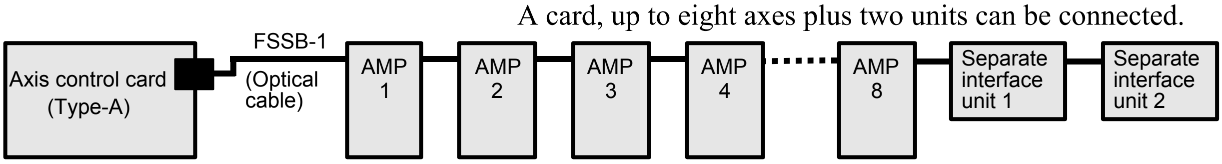
(Up to four axes)

- When a type B card is used: Up to eight axes plus two units can be connected.

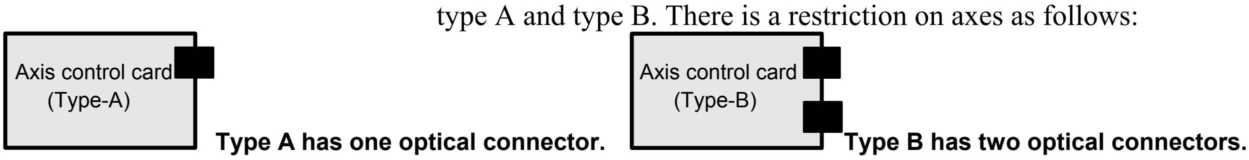


(Up to eight axes)

- (Reference) When servo HRV3 control is not used: With a type A card, up to eight axes plus two units can be connected.



(Series 90D0, 90E0)
There are two types of servo axis cards for Series 90D0 and 90E0: type A and type B. There is a restriction on axes as follows:



- Number of units that can be connected to one FSSB optical connector

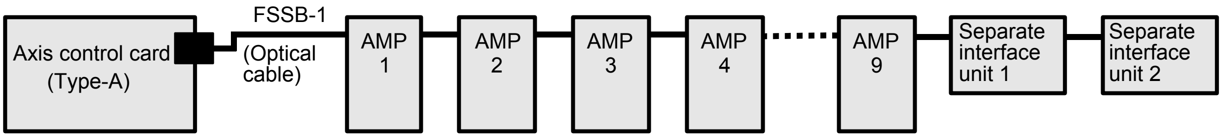
Servo HRV3 control is:	Amplifier	Separate detector interface unit
Used. (Note)	10 axes	2 units
Note used.	16 axes	2 units

- Numbers of units that can be connected to the servo cards

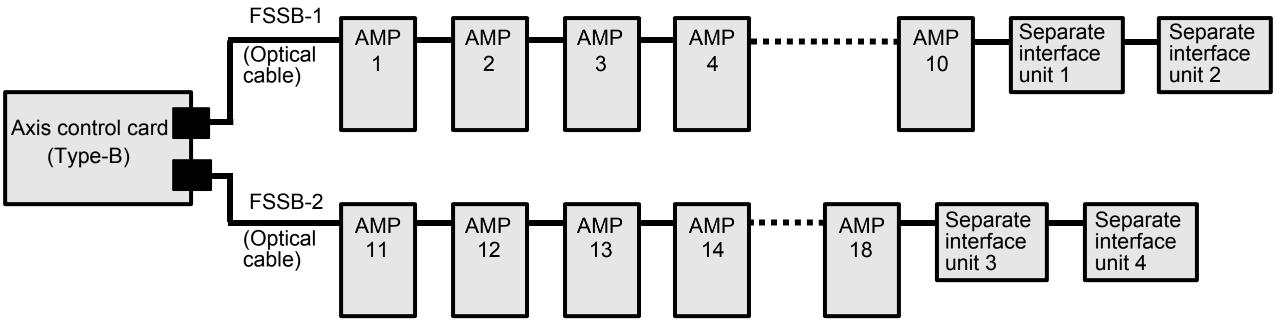
Servo card	Series 90E0 servo HRV2 control	Series 90E0 servo HRV3 control	Series 90D0 servo HRV2, 3 control	Separate detector interface unit
Servo card B13 A02B-0303-H084 (Type-A card)	Amplifier 12 axes	Amplifier 9 axes	Amplifier 6 axes	2 units
Servo card B26 A02B-0303-H085 (Type-B card)	Amplifier 24 axes	Amplifier 18 axes	Amplifier 12 axes	4 units

> **NOTE**
> When 10 or more servo amplifier axes or three separate detector units are used with servo HRV3 control, the Type-B card is required.
> When 13 or more servo amplifier axes or five separate detector interface units are used without servo HRV3 control, the Type-B card is required.

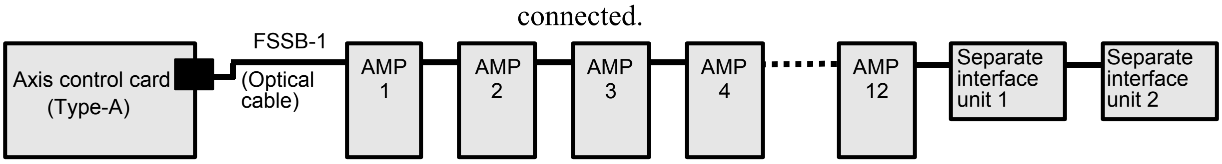
- When the Type-A card is used: Up to nine axes plus two units can be connected.

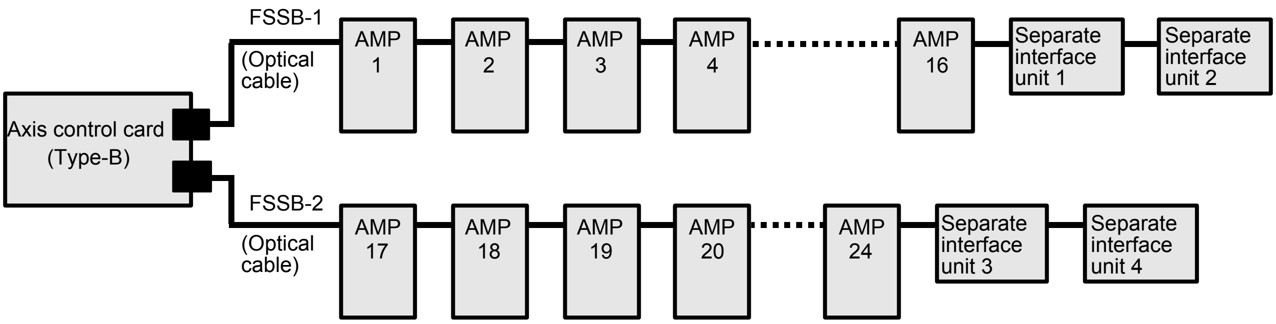


- When the Type-B card is used: Up to 18 axes plus four units can be connected.



- (Reference) When servo HRV3 control is not used:
  With the Type-A card, up to 12 axes plus two units can be connected.
  With the Type-B card, up to 24 axes plus four units can be connected.





4.2.2 Servo HRV4 Control

(1) Series and editions of applicable servo software

(Series 30*i*, 31*i*)

Series 90D0/J(10) and subsequent editions

(2) Setting parameters for servo HRV4 control

<1> See Subsection 4.1.1, and make settings for servo HRV2 control.

<2> Set servo HRV4 control. (For each axis)

	#7	#6	#5	#4	#3	#2	#1	#0
-								HR4
2014(FS30*i*, 31*i*)								

HR4(#0) 1: Uses servo HRV4 control.
0: Does not use servo HRV4 control.

NOTE

1 When the high-speed HRV current control mode is set by the G5.4Q1 command, servo HRV3 control or servo HRV4 control, whichever set in a parameter, is enabled. Therefore, both the servo HRV3 control enable bit and the servo HRV4 control enable bit cannot be set to 1 at the same time. (If these bits are both set to 1, an alarm indicating invalid current control setting is issued.)

2 When servo HRV4 control is used with Series 90D0, multiples of 2 cannot be set in parameter No. 1023. Set values with multiples of 2 skipped.
Example: When five axes are used with 90D0, values 1,3,5,7,9 are set in parameter No. 1023.

3 If servo HRV4 control is set, servo HRV3 control is performed during rapid traverse or when high-speed HRV current control is disabled.

4 In servo HRV4 control using Series 90D0, one axis is controlled with one CPU. So, functions (such as tandem vibration-damping control during synchronization control, and torque tandem control) involving two or more axes in servo software processing cannot be used.

<3> Enable the extended HRV function. (For each axis)

	#7	#6	#5	#4	#3	#2	#1	#0
-								HRVEN
2300(FS30*i*, 31*i*)								

HRVEN(#0)

1: Uses the extended HRV function.
0: Does not use the extended HRV function.

<4> Set the cutting/rapid velocity loop gain switching function.

	#7	#6	#5	#4	#3	#2	#1	#0
-							VGCCR	
2202(FS30*i*, 31*i*)								

VGCCR (#1) 1: Uses the cutting/rapid velocity loop gain switching function.
0: Does not use the cutting/rapid velocity loop gain switching function.

<5> Set the current loop gain magnification.

-	Current loop gain magnification in high-speed HRV current control mode
2334(FS30*i*, 31*i*)	

[Unit of data] %
[Valid data range] 100 to 270
[Recommended value] 150
This parameter is valid only for cutting feed in the high-speed HRV current control mode.

<6> Set the velocity loop gain magnification.

-	Velocity loop gain magnification in high-speed HRV current control mode
2335(FS30*i*, 31*i*)	

[Unit of data] %
[Valid data range] 100 to 400
This parameter is valid only for cutting feed when the high-speed HRV current control mode is set.

-	Velocity loop gain magnification (cutting/rapid velocity loop gain switching)
2107(FS30*i*, 31*i*)	

[Unit of data] %
[Valid data range] 100 to 400
This parameter is valid only for cutting feed when the high-speed HRV current control mode is not set.

<7> This completes parameter setting. To actually enter the high-speed HRV current control mode, G codes must be programmed. (See Subsection 4.2.3.)

NOTE
The velocity loop gain is changed as listed below according to whether the high-speed HRV current control mode is set or not.

[Series 30*i* and so on]

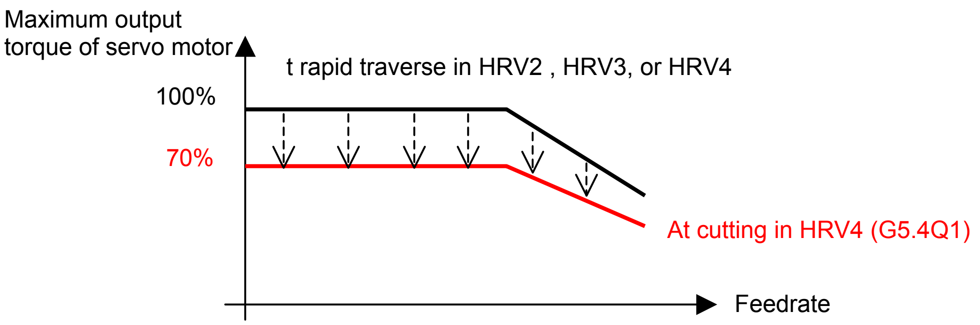
High-speed HRV current control mode	Feed	Velocity loop gain [%]
Set (G5.4Q1 - G5.4Q0)	Rapid traverse	(1 + No. 2021 / 256) × 100
	Cutting feed	(1 + No. 2021 / 256) × **No. 2335** (High-speed HRV current control: Velocity loop gain magnification)
Not set	Rapid traverse	(1 + No. 2021 / 256) × 100
	Cutting feed	(1 + No. 2021 / 256) × No. 2107 (Cutting/rapid switching: Velocity loop gain magnification)

(3) Limitation on servo HRV4 control

(a) Servo motor output torque

During cutting operation in high-speed HRV current control, the torque command is automatically limited to 70% of the maximum current value of the servo amplifier. As a result, the torque command is easily saturated. Therefore, when determining the time constant in cutting feed, consider the cutting load and the above limitation. Normally, the high-speed HRV current control mode is used for light cutting for finish machining, so the limitation of the torque command to 70% of the maximum current value of the servo amplifier is not regarded as critical.

Torque curve during G5.4Q1 command



(4) Servo HRV4 control hardware

(a) Separate detector

When a separate detector is used with the Series 30*i* and so on, the following separate detector interface unit supporting the Series 30*i* and so on must be specified:

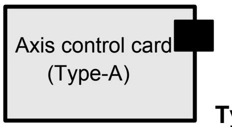
Separate detector interface unit for Series 30*i* and other CNC	Specification drawing number
Basic 4 axes	A02B-0303-C205

(b) Servo amplifiers

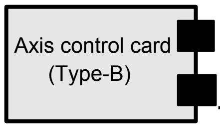
A servo amplifier supporting servo HRV4 control must be specified.

(c) Servo axis control cards

There are two types of servo axis cards for Series 90D0 and 90E0: Type-A and Type-B. There is a restriction on axes as follows:



Type A has one optical connector.



Type B has two optical connectors.

- Number of units that can be connected to one FSSB optical connector

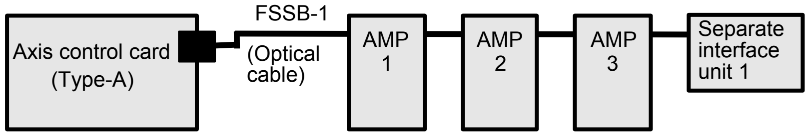
Servo HRV4 control is:	Amplifier	Separate detector interface unit
Used. (Note 1)	4	1
Not used.	(Note 2)	

- Numbers of units that can be connected to the servo cards

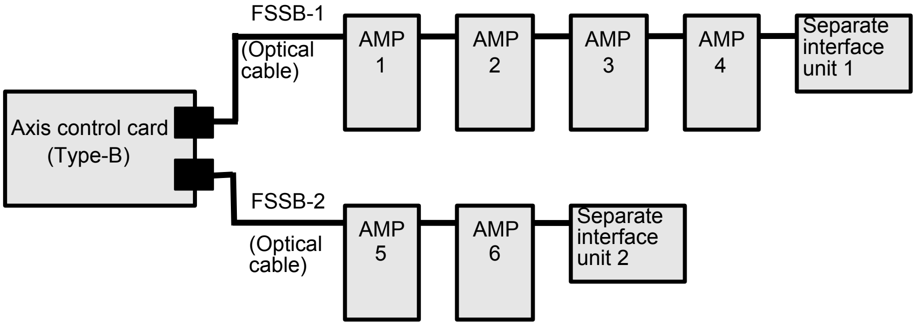
Servo card	Series 90D0 servo HRV4 control	Separate detector interface unit
Servo card B13 A02B-0303-H084 (Type-A card)	Amplifier 3 axes	1 unit
Servo card B26 A02B-0303-H085 (Type-B card)	Amplifier 6 axes	2 units

> **NOTE**
> 1 When four or more servo amplifier axes or two separate detector units are used with servo HRV4 control, the Type-B card is required.
> 2 See the description of the servo axis control cards for servo HRV3 control.

- When the Type-A card is used: Up to three axes plus one unit can be connected.



- When the Type-B card is used: Up to six axes plus two units can be connected.



(d) Detector

To use servo HRV4 control, a detector supporting high-speed communication needs to be used for motor feedback (as a detector on the semi-closed loop side).
The table below indicates examples of detectors that support high-speed communication.

If a setting is made to enable HRV4 when a detector not supporting high-speed communication is connected, "SV0456 INVALID CURRENT CONTROL PERIOD SETTING ALARM" is issued.

Table 4.2.2 (a) Sample configuration of a detector usable with HRV4

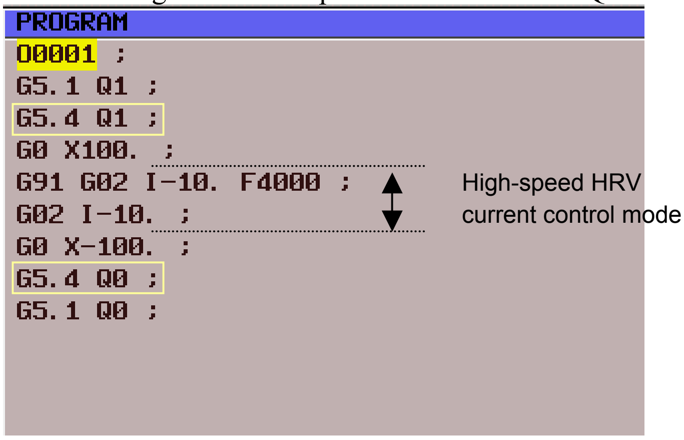
Manufacture	Configuration or model
FANUC	αi Pulse coder
FANUC	αiCZ sensor (512S, 768S, 1024S)
FANUC	Combination of high-resolution serial output circuit H with an incremental scale supplied by a vendor other than FANUC
FANUC	Combination of high-resolution serial output circuit C with an incremental scale supplied by a vendor other than FANUC
HEIDENHAIN	RCN727
MITSUTOYO Co., Ltd.	AT553

* The table above indicates the configurations and models whose support for high-speed communication is confirmed as of December, 2005. For details, contact the detector manufacturers.

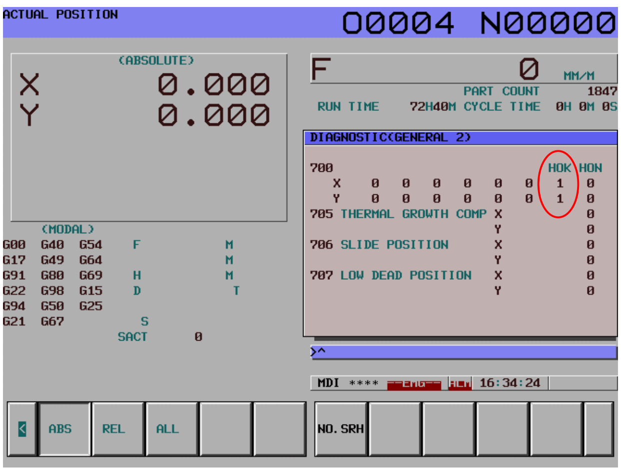
4.2.3 High-speed HRV Current Control

(1) Starting the high-speed HRV current control mode

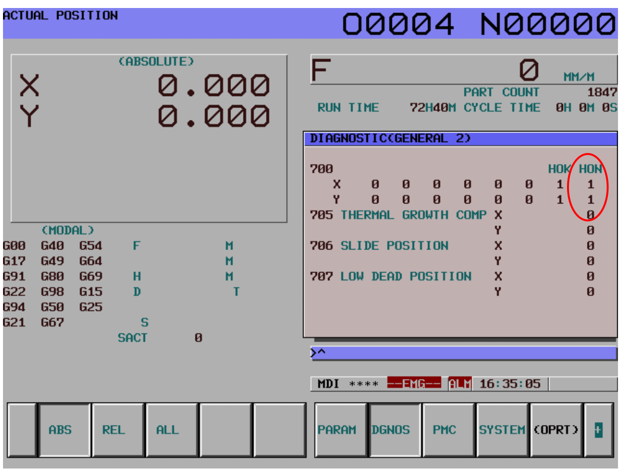
The high-speed HRV current control mode is turned on and off by using a G code (G5.4). The high-speed HRV current control mode is set for cutting commands specified between G5.4Q1 and G5.4Q0.



(2) Checking the high-speed HRV current control mode



Diagnosis No. 700 is used for checking the status of the high-speed HRV current control mode in servo HRV3 control and servo HRV4 control. After setting servo HRV3 or HRV4 control and turning the power off then back on, check that bit 1 (HOK) of diagnosis No. 700 is set. When servo HRV3 or HRV4 control can be used, HOK is set to 1.



When HOK is set to 1, specifying G5.4Q1 sets bit 0 (HON) of diagnosis DGN700 to 1 during the cutting feed command. If NOG54 is set to 1, bit 0 is set to 1 during the cutting feed command even if G5.4Q1 is not specified.

When HON is set to 1, a high-speed current control cycle is set, and the current gain magnification for high-speed HRV current control is applied.

4.3 CUTTING/RAPID SWITCHING FUNCTION

(1) Overview

Increasing the gains of the position loop and velocity loop is effective in the improvement of cutting profiles. However, the maximum feedrate and the acceleration of acc./dec. in rapid traverse are generally higher than those in cutting feed. So, vibration in the velocity loop or hunting in the position loop may occur in rapid traverse even when stable cutting feed can be performed with the same settings. To prevent this problem, the functions below are provided with a function for switching between parameters for cutting feed and parameters for rapid traverse.

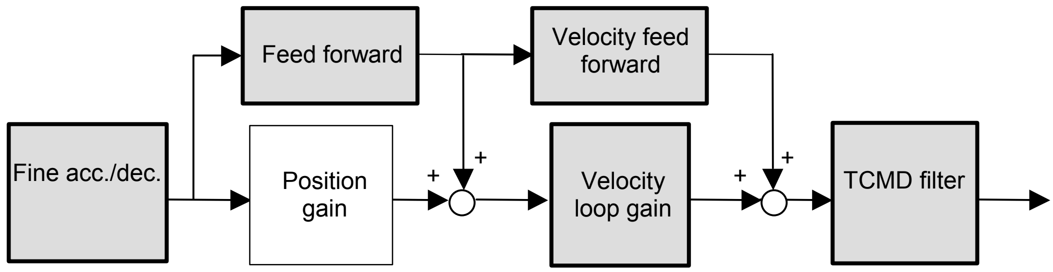


Fig. 4.3 Parameters that can be switched between parameters for cutting feed and for rapid traverse

NOTE
1 The TCMD filter and resonance elimination filter can be used at the same time by parameter setting.
2 The cutting/rapid switching function is not applied to the resonance elimination filter.

(2) Setting procedure

(a) Switching of the velocity loop gain and fine acc./dec.

[Series and editions of applicable servo software]

(Series 30*i*,31*i*,32*i*)

Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)

Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)

Series 90B5/A(01) and subsequent editions

<1> Cutting/rapid velocity loop gain switching function

When TCMD is saturated during acceleration in rapid traverse, oscillation is easily generated in the velocity loop at the end of acceleration in rapid traverse. In some machines, as the feedrate becomes higher, high-frequency oscillation easily occurs. In such cases, switching between the gain for cutting feed and the gain for rapid traverse is effective.

If the cutting/rapid velocity loop gain switching is set, the conventional velocity gain is used in rapid traverse, and the overridden value is used during cutting feed. The override value is usually set to about 150% to 200%. When vibration occurs only in the stopped state, use the variable proportional gain function in the stop state. (With Series 90D0, 90E0, 90B0, 90B1, 90B6, and 90B5, the variable proportional gain function in the stop state and the velocity loop high cycle management function can be used together.)

When servo HRV3 control or HRV4 control is used, a separate override value can be specified during high-speed HRV current control. See Section 4.2, "HIGH-SPEED HRV CURRENT CONTROL".

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) **2202 (FS30*i*,16*i*)**							**VGCCR**	

1: Enables the cutting/rapid velocity loop gain switching function.
0: Disables the cutting/rapid velocity loop gain switching function.

1700 (FS15*i*) **2107 (FS30*i*,16*i*)**	**Override value at cutting (%)**

[Valid data range] 50 to 400

[Series30*i*, 16*i*, and so on]

Cutting/rapid velocity loop gain switching function		**Velocity loop gain [%]**
No. 2202#1=0 (disabled)	Always	(1 + No. 2021 / 256) × 100
No. 2202#1=1 (enabled)	Rapid traverse	(1 + No. 2021 / 256) × 100
	Cutting feed	(1 + No. 2021 / 256) × **No. 2107**

[Series15*i*]

Cutting/rapid velocity loop gain switching function		**Velocity loop gain [%]**
No. 1742#1=0 (disabled)	Always	(1 + No. 1875 / 256) × 100
No. 1742#1=1 (enabled)	Rapid traverse	(1 + No. 1875 / 256) × 100
	Cutting feed	(1 + No. 1875 / 256) × **No. 1700**

<2> **Cutting/rapid fine acc./dec. switching function (including feed-forward switching)**
Although the optimum time constant of fine acc./dec. during cutting is about 16 ms, the time constant in rapid traverse should sometimes be set to 32 to 40 ms to reduce the impact applied at the time of acc./dec. The feed-forward coefficient that minimizes cutting profile error and the feed-forward coefficient that minimizes the time for high-speed positioning in rapid traverse are not always the same. In such cases, use the cutting/rapid fine acc./dec. switching function.

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) 2202 (FS30*i*,16*i*)								FADCH

1: Enables the cutting/rapid fine acc./dec. switching function.
0: Disables the cutting/rapid fine acc./dec. switching function.

[Series30*i*, 16*i*, and so on]

Cutting/rapid fine acc./dec. switching function		FAD time constant	Position FF	Velocity FF
No. 2202#0=0 (disabled)	Always	No. 2109	No. 2092	No. 2069
No. 2202#0=1 (enabled)	Rapid traverse			
	Cutting feed	**No. 2143**	**No. 2144**	**No. 2145**

[Series15*i*]

Cutting/rapid fine acc./dec. switching function		FAD time constant	Position FF	Velocity FF
No. 1742#0=0 (disabled)	Always	No. 1702	No. 1985	No. 1962
No. 1742#0=1 (enabled)	Rapid traverse			
	Cutting feed	**No. 1766**	**No. 1767**	**No. 1768**

(b) Feed-forward, TCMD filter, 1/2 PI current control switching

[Series and editions of applicable servo software]

(Series 30*i*,31*i*,32*i*)

Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)

Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)

Series 90B5/A(01) and subsequent editions

<1> Cutting/rapid feed-forward switching function

The position feed-forward coefficient and the velocity feed-forward coefficient can also be changed without using fine acc./dec. To do this, use the cutting/rapid feed-forward switching function.

	#7	#6	#5	#4	#3	#2	#1	#0
2602 (FS15*i*) 2214 (FS30*i*,16*i*)				FFCHG				

1: Enables the cutting/rapid feed-forward switching function.
0: Disables the cutting/rapid feed-forward switching function.

[Series30*i*, 16*i*, and so on]

Cutting/rapid feed-forward switching function		Position FF	Velocity FF
No. 2214#4=0 (disabled)	Always	No. 2092	No. 2069
No. 2214#4=1 (enabled)	Rapid traverse		
	Cutting feed	**No. 2144**	**No. 2145**

[Series15*i*]

Cutting/rapid feed-forward switching function		Position FF	Velocity FF
No. 2602#4=0 (disabled)	Always	No. 1985	No. 1962
No. 2602#4=1 (enabled)	Rapid traverse		
	Cutting feed	**No. 1767**	**No. 1768**

<2> TCMD filter switching

When high frequency vibration occurs only in rapid traverse, use of the TCMD filter, rather than the resonance elimination filter, is sometimes effective. On the other hand, in cutting feed, inserting an unnecessary TCMD filter lowers the vibration limit of the velocity loop gain because of the delay in the filter. In such a case, using the TCMD filter only for rapid traverse is effective.

1895 (FS15*i*)	TCMD filter coefficient
2067 (FS30*i*,16*i*)	

1779 (FS15*i*)	TCMD filter coefficient for rapid traverse
2156 (FS30*i*,16*i*)	

[Series30*i*, 16*i*, and so on]

Cutting/rapid feed-forward switching function		TCMD filter
No. 2156=0 (disabled)	Always	No. 2067
No. 2156≠0 (enabled)	Rapid traverse	**No. 2156**
	Cutting feed	No. 2067

[Series15*i*]

Cutting/rapid feed-forward switching function		TCMD filter
No. 1779=0 (disabled)	Always	No. 1895
No. 1779≠0 (enabled)	Rapid traverse	**No. 1779**
	Cutting feed	No. 1895

<3> Switching of the current loop 1/2 PI control function in cutting feed and rapid traverse
When the cutting/rapid velocity loop gain switching function is enabled, the current loop 1/2 PI control function is turned off at the time of rapid traverse. Only when current loop 1/2 PI control must be used also for rapid traverse while the cutting/rapid velocity gain switching function is enabled, set the bit for always enabling the current loop 1/2 PI control function.

	#7	#6	#5	#4	#3	#2	#1	#0
1743 (FS15*i*) / 2203 (FS30*i*,16*i*)						CRPI		

1: Enables the current loop 1/2 PI control function.
0: Disables the current loop 1/2 PI control function.

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) / 2202 (FS30*i*,16*i*)							VGCCR	

1: Enables the current loop 1/2 PI control function for cutting only.
0: Enables the current loop 1/2 PI control function for both cutting and rapid traverse.

> **NOTE**
> This function bit has double meanings. One is above and another is the cutting/rapid velocity loop gain switching function.

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) / 2202 (FS30*i*,16*i*)						PIAL		

1: Always enables the current loop 1/2 PI control function.

[Series30*i*, 16*i*, and so on]

No. 2203#2=1	No. 2202#1	No. 2202#2
Always enables the current loop 1/2 PI control function.	0	0
	1	**1**
Enables the current loop 1/2 PI control function for cutting only.	1	0

[Series15*i*]

No. 1743#2=1	No. 1742#1	No. 1742#2
Always enables the current loop 1/2 PI control function.	0	0
	1	**1**
Enables the current loop 1/2 PI control function for cutting only.	1	0

NOTE

To disable the current loop 1/2 PI control function, set bit 2 of parameter No. 1743 to 0 (Series 15*i*) or bit 2 of parameter No. 2203 to 0 (Series 30*i*, 16*i*, etc.).

4.4 VIBRATION SUPPRESSION IN THE STOP STATE

4.4.1 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

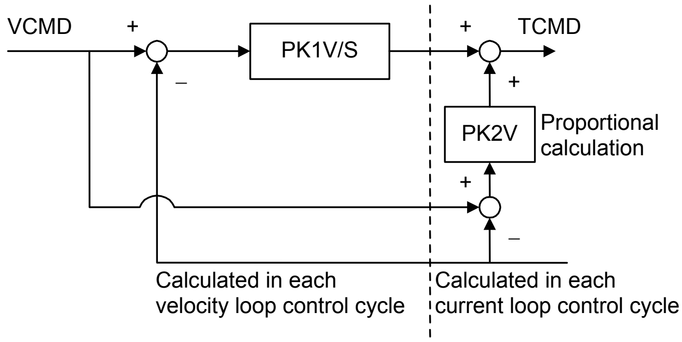
(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1959 (FS15*i*) 2017 (FS30*i*, 16*i*)	PK2V25							

PK2V25 (#7) 1: The velocity loop high cycle management function is used.

Configuration of the control system (for PI function)



(4) Performance comparison with the acceleration feedback function

	Acceleration feedback function	Velocity loop high cycle management function
Control method	Acceleration feedback is performed at high speed.	Only a velocity loop proportional calculation is made at high speed.
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 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 cannot be used with Series 9096. To use velocity loop high cycle management function with Series 9096, 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	Function with restricted usage
Velocity loop gain override	Machine speed feedback; normalization not performed
Variable proportional gain function in the stop state (*)	Observer used for unexpected disturbance torque detection
Non-linear control	
Notch filter	
Acceleration feedback	
N pulses suppression function	

* With Series 9096, this function cannot be used together with the variable proportional gain function in the stop state. With other series, this function can be used together. (See Subsec. 4.4.3.)

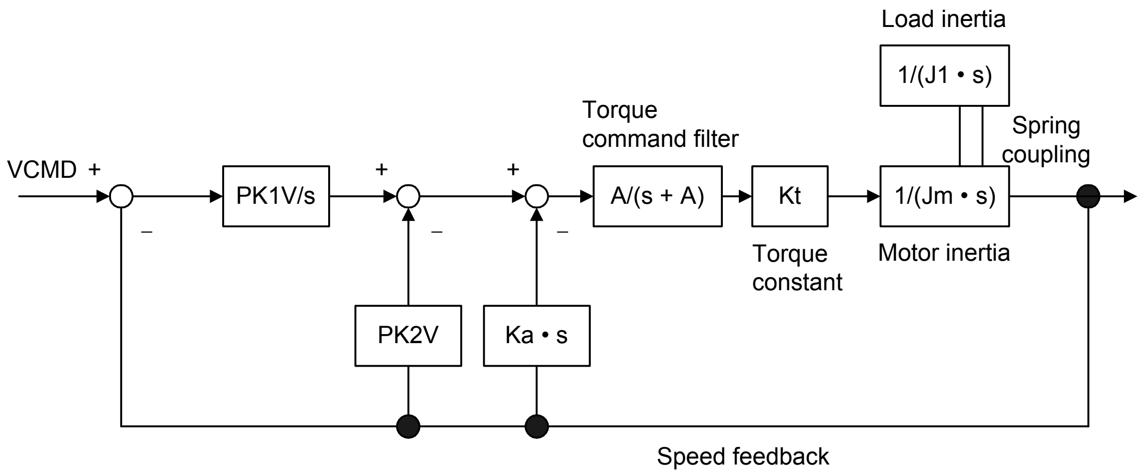
4.4.2 Acceleration Feedback Function

(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 4.4.2 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. 4.4.2 Velocity loop block diagram that includes acceleration feedback function

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Setting parameters

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

1894 (FS15*i*)	**Acceleration feedback gain**
2066 (FS30*i*, 16*i*)	

[Valid data range] -10 to -20

(4) Caution and note

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

> **NOTE**
> This function is disabled when the velocity loop high cycle management function (see Subsec. 4.4.1) is used.

4.4.3 Variable Proportional Gain Function 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 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent edition
Series 90E0/A(01) and subsequent edition
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
Series 9096/A(01) and subsequent edition
Series 90B0/A(01) and subsequent edition
Series 90B1/A(01) and subsequent edition
Series 90B6/A(01) and subsequent edition
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent edition

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1958 (FS15*i*) 2016 (FS30*i*, 16*i*)					PK2VDN			

PK2VDN (#3) 1: The variable proportional gain function in the stop state is used.

1730 (FS15*i*) 2119 (FS30*i*, 16*i*)	Variable proportional gain function in the stop state : Stop judgment level

[Unit of data] Detection unit
[Recommended value] 2 to 10 (Detection unit: 1 μm)
20 to 100 (Detection unit: 0.1 μm)

With Series 90B0, 90B6, or 90B5, a function for decreasing a set proportional gain in the stop state to 50% as well as 75%, and a function for setting an arbitrary magnification only in cutting feed are available. 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 (FS15*i*)					**PK2D50**			
2207 (FS30*i*, 16*i*)								

PK2D50 (#3) When the variable proportional gain function in the stop state enabled (K2VDN = 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%.

When an arbitrary magnification is used for a proportional gain in the stop state during cutting feed, set the function bit for stop judgment level of the function for changing the proportional gain in the stop state. In addition, set the following parameter:

2737 (FS15*i*)	**Variable proportional gain function in the stop state : Arbitrary magnification in the stop state (during cutting feed only)**
2324 (FS30*i*, 16*i*)	

[Unit of data] %
[Recommended value] 25 to 100

(4) Example of parameter setting

(a) When the cutting feed/rapid traverse switchable velocity loop gain function (Sec. 4.3) is not used, and
Bit 3 of No. 1958 (Series 15*i*) or bit 3 of No. 2016 (Series 30*i*, 16*i*, and so on) = 1
Actual velocity gain in the stop state=(velocity gain setting)×0.75

(b) When the cutting feed/rapid traverse switchable velocity loop gain function (Sec. 4.3) is not used,
Bit 3 of No. 1958 (Series 15*i*) or bit 3 of No. 2016 (Series 30*i*, 16*i*, and so on) = 1, and
Bit 3 of No. 1747 (Series 15*i*) or bit 3 of No. 2207 (Series 30*i*, 16*i*, and so on) = 1
Actual velocity gain in the stop state=(velocity gain setting)×0.5

(c) When the cutting feed/rapid traverse switchable velocity loop gain function (Sec. 4.3) is not used,
Bit 3 of No. 1958 (Series 15*i*) or bit 3 of No. 2016 (Series 30*i*, 16*i*, and so on) = 1, and
No. 2373 (Series 15*i*) or No. 2324 (Series 30*i*,16*i*, and so on) = α
Actual velocity gain in the stop state=(velocity gain setting)×α/100

When the absolute value of an error is lower than the stop judgment 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 judgment level. The function cannot stop the vibration of a machine in the stop state when the current velocity loop proportional gain is too high. If this occurs, reduce the velocity loop proportional gain.

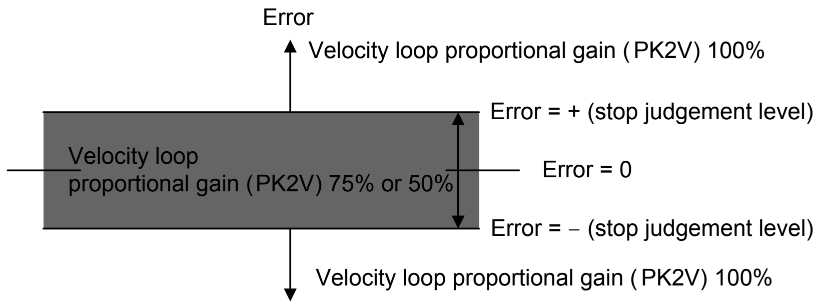


Fig. 4.4.3 Relationship between error and velocity loop proportional gain (PK2V)

> **NOTE**
> This function is disabled when the velocity loop high cycle management function (Subsec. 4.4.1) is used with Series 9096.

[Tip] Example of setting an arbitrary magnification in the stop state

(a) When the cutting feed/rapid traverse switchable velocity loop gain function (Sec. 4.3) is used, and
Bit 3 of No. 1958 (Series 15*i*) or bit 3 of No. 2016 (Series 30*i*, 16*i*, and so on) = 1
- If the mode in the stop state is the cutting mode:
  Actual velocity gain in the stop state = (velocity gain setting for cutting) × 0.75
- If the mode in the stop state is the rapid traverse mode:
  Actual velocity gain in the stop state = (velocity gain setting for rapid traverse) × 0.75

(b) When the cutting feed/rapid traverse switchable velocity loop gain function (Sec. 4.3) is used,
Bit 3 of No. 1958 (Series 15*i*) or bit 3 of No. 2016 (Series 30*i*, 16*i*, and so on) = 1, and
Bit 3 of No. 1747 (Series 15*i*) or bit 3 of No. 2207 (Series 30*i*, 16*i*, and so on) = 1
- If the mode in the stop state is the cutting mode:
  Actual velocity gain in the stop state = (velocity gain setting for cutting) × 0.5
- If the mode in the stop state is the rapid traverse mode:
  Actual velocity gain in the stop state = (velocity gain setting for rapid traverse) × 0.5

(c) When the cutting feed/rapid traverse switchable velocity loop gain function (Sec. 4.3) is used,
Bit 3 of No. 1958 (Series 15*i*) or bit 3 of No. 2016 (Series 30*i*, 16*i*, and so on) = 1, and
No. 2373 (Series 15*i*) or No. 2324 (Series 30*i*,16*i*, and so on) = α
- If the mode in the stop state is the cutting mode:
  Actual velocity gain in the stop state = (velocity gain setting for cutting) × α/100
- If the mode in the stop state is the rapid traverse mode:
  Actual velocity gain in the stop state = (velocity gain setting for rapid traverse) × 0.75

(d) When the cutting feed/rapid traverse switchable velocity loop gain function (Sec. 4.3) is used,
Bit 3 of No. 1958 (Series 15*i*) or bit 3 of No. 2016 (Series 30*i*, 16*i*, and so on) = 1,
Bit 3 of No. 1747 (Series 15*i*) or bit 3 of No. 2207 (Series 30*i*, 16*i*, and so on) = 1, and
No. 2373 (Series 15*i*) or No. 2324 (Series 30*i*,16*i*, and so on) = α

- If the mode in the stop state is the cutting mode:
  Actual velocity gain in the stop state = (velocity gain setting for cutting) $\times$ α/100
- If the mode in the stop state is the rapid traverse mode:
  Actual velocity gain in the stop state = (velocity gain setting for rapid traverse) $\times$ 0.5

4.4.4 N Pulses 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.

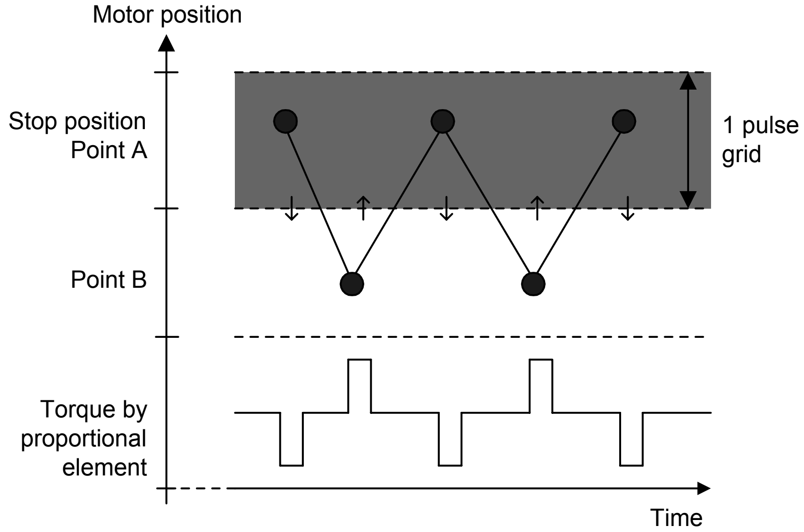


Fig.4.4.4 (a) N pulse suppression function disabled (Torque due to the proportional term keeps up, leading to vibration.)

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.

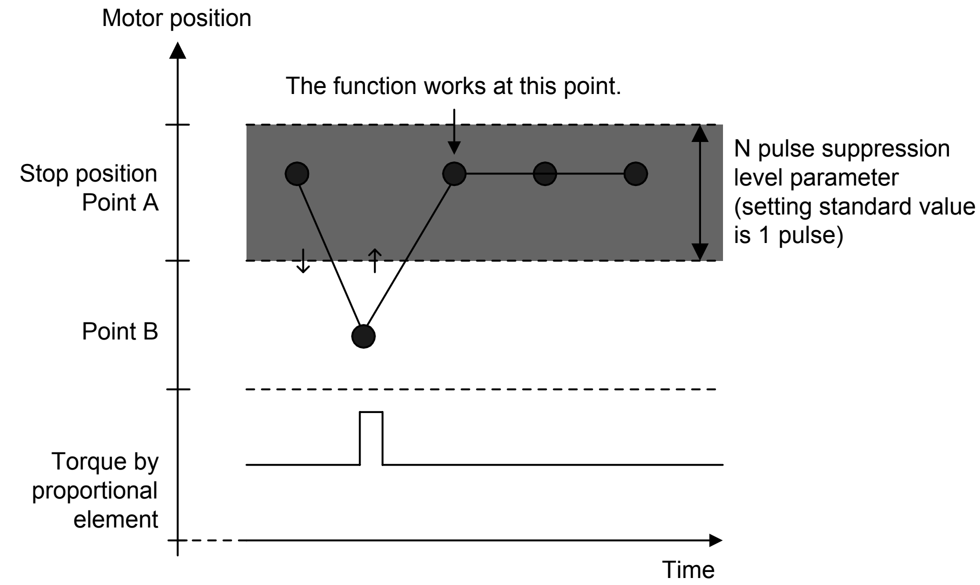


Fig. 4.4.4 (b) N pulse suppression function disabled
(The N pulse suppression function restricts the torques due to the proportional term, thus eliminating vibration.)

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) / 2003 (FS30*i*, 16*i*)				NPSP				

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

1992 (FS15*i*) / 2099 (FS30*i*, 16*i*)	N-pulse suppression level parameter (ONEPSL)

[Valid data range] 0 to 32767
[Standard setting] 400
400 means a single pulse as a detection unit.

4.5 MACHINE RESONANCE ELIMINATION FUNCTION

4.5.1 Torque Command Filter (Middle-Frequency Resonance Elimination Filter)

(1) Overview

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

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Explanation

Fig. 4.5.1 shows the configuration of a velocity loop including the torque command filter.

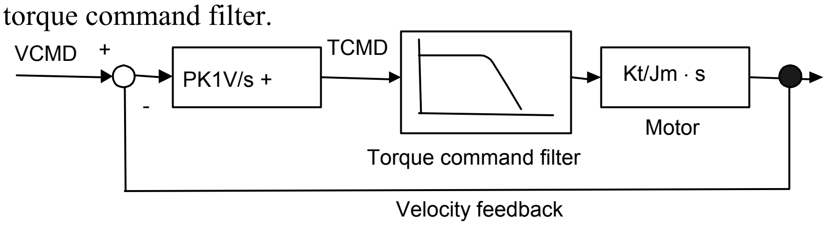


Fig. 4.5.1 Configuration of velocity loop including torque command filter

As shown in Fig. 4.5.1, 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. 4.5.1 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 (FS15*i*)	Torque command filter (FILTER)
2067 (FS30*i*, 16*i*)	

[Setting value] 1166 (200 Hz) to 2327 (90 Hz)

When changing the torque command filter setting, see Table 4.5.1.

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 4.5.1 Parameter setting value of torque command filter

Cutoff frequency (Hz)	Setting value of parameter	Cutoff frequency (Hz)	Setting value of 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.

1779 (FS15*i*)	TCMD filter coefficient for rapid traverse
2156 (FS30*i*, 16*i*)	

[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*i* or No. 2067 for Series 30*i*, 16*i*, and so on) is used at all times.

When a value other than 0 is set, No. 1779 (Series 15*i*) or No. 2156 (Series 30*i*, 16*i*, and so on) is used for stop time, rapid traverse, and jog feed, and No. 1895 (Series 15*i*) or No. 2067 (Series 30*i*, 16*i*, and so on) is used for cutting only.

4.5.2 Resonance Elimination Filter Function (High-Frequency Resonance Elimination Filter)

(1) Overview

A filter function for removing high-speed resonance is added. With this function, high-speed resonance can be removed to set a higher velocity loop gain.

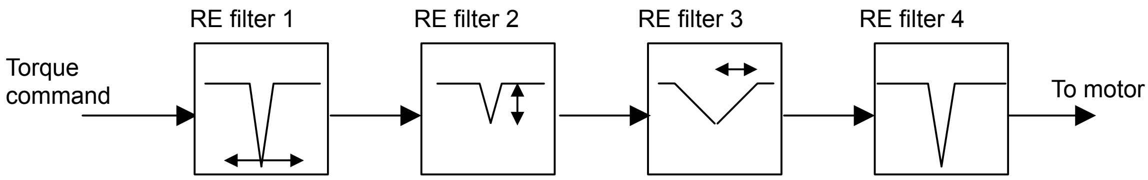
(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
  Series 90D0/A(01) and subsequent editions
  Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
  Series 90B0/P(16) and subsequent editions (*)
  Series 90B1/A(01) and subsequent editions
  Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
  Series 90B5/A(01) and subsequent editions

(*) With Series 90B0, resonance elimination filters that can be used are restricted depending on the edition.

Edition of Series 90B0	Restriction
A(01) to I(09)	Only resonance elimination filter 1 (conventional specification) can be used. Resonance elimination filters 2 to 4, damping setting, and active resonance elimination filter cannot be used.
J(10) to O(15)	Resonance elimination filters 1 to 4 (extended specification) and damping setting can be used. The active resonance elimination filter cannot be used.
P(16) or later	All resonance elimination filter functions can be used.

(3) Control block diagram



This filter can be used as a resonance elimination filter designed to the conventional specification. It can follow the resonance frequency. (RE filter 1 only)

For this filter, it is possible to specify an attenuation ratio. (RE filters 1 to 4)

For this filter, it is possible to specify a bandwidth freely. (RE filters 1 to 4)

This filter can handle up to four resonance frequencies.

Fig. 4.5.2

(4) Setting parameters

> ⚠ **CAUTION**
> 1 If the frequency of a resonance elimination filter is set to a low frequency around 100 Hz, the control system can become unstable, resulting in a large vibration.
> 2 Modify parameters in the emergency stop state.

(5) Setting parameters

<1> Setting for resonance elimination filters 2 to 4

The resonance elimination filter has a function for cutting signals of a particular frequency band. Three parameters are used for this filter. They specify the center frequency of a range to be cut, a bandwidth to be cut, and damping separately.

2773 (FS15*i*) 2360 (FS30*i*, 16*i*)	RE filter 2 : Attenuation center frequency

[Valid data range] 96 to 1000(HRV1 or HRV2), 96 to 2000(HRV3), 96 to 4000(HRV4) (independent of the damping setting)

[Unit of data] Hz

2774 (FS15*i*) 2361 (FS30*i*, 16*i*)	RE filter 2 : Attenuation bandwidth

[Valid data range] 0 to attenuation center frequency (independent of the damping setting)

[Unit of data] Hz

2775 (FS15*i*) 2362 (FS30*i*, 16*i*)	RE filter 2 : Damping

[Valid data range] 0 to 100 (If it is 0, the attenuation ratio is maximized.)

[Unit of data] %

Resonance elimination filters 3 and 4 have the same specification as resonance elimination filter 2.

2776 (FS15*i*) 2363 (FS30*i*, 16*i*)	RE filter 3 : Attenuation center frequency

2777 (FS15*i*) 2364 (FS30*i*, 16*i*)	RE filter 3 : Attenuation bandwidth

2778 (FS15*i*) 2365 (FS30*i*, 16*i*)	RE filter 3 : Damping

2779 (FS15*i*) 2366 (FS30*i*, 16*i*)	RE filter 4 : Attenuation center frequency

2780 (FS15*i*) 2367 (FS30*i*, 16*i*)	RE filter 4 : Attenuation bandwidth

2781 (FS15*i*) 2368 (FS30*i*, 16*i*)	RE filter 4 : Damping

> ⚠ **CAUTION**
> 1 For resonance elimination filters 2 to 4, there is no specification that supports compatibility with conventional resonance elimination filters. Even if damping = 0, an arbitrary attenuation bandwidth can be specified for them.
> 2 Resonance elimination filters 2 to 4 are enabled if a nonzero value is set in the attenuation bandwidth or damping parameters for them. If you do not want use these resonance elimination filters, reset all the three parameters (attenuation center frequency, attenuation bandwidth, and damping) to 0.

<2> Setting for resonance elimination filter 1

Only resonance elimination filter 1 has the conventional specification if the damping is 0 and the improved specification if the damping is not 0.

1706 (FS15*i*) / 2113 (FS30*i*, 16*i*)	RE filter 1 : Attenuation center frequency

[Valid data range] 250 to 992 (if damping = 0)
96 to 1000(HRV1 or HRV2), 96 to 2000(HRV3), 96 to 4000(HRV4) (if damping ≠ 0)

[Unit of data] Hz

2620 (FS15*i*) / 2177 (FS30*i*, 16*i*)	RE filter 1 : Attenuation bandwidth

[Valid data range] 20, 30, 40 (if damping = 0)
0 to attenuation center frequency (if damping ≠ 0)

[Unit of data] Hz

2772 (FS15*i*) / 2359 (FS30*i*, 16*i*)	RE filter 1 : Damping

[Valid data range] 0 (If it is 0, the resonance elimination filer has the conventional specification.)
1 to 100 (If it is 1, the attenuation ratio is maximized. For resonance elimination filer 1.)

[Unit of data] %

> ⚠ **CAUTION**
> 1 If damping = 0 for resonance elimination filter 1, this filter has the same specification as for conventional resonance elimination filters. So, its attenuation bandwidth can be set only to 20, 30, or 40 Hz (specification compatible with conventional resonance elimination filters).
> 2 Resonance elimination filter 1 is enabled if a nonzero value is set in the attenuation bandwidth or damping parameter for it. If you do not want use the resonance elimination filter, reset all the three parameters (attenuation center frequency, attenuation bandwidth, and damping) to 0.

[Parameters for resonance elimination filters]

For Series 30*i* or 16*i*

	Attenuation center frequency [Hz]	Attenuation bandwidth	Damping
Resonance elimination filter 2	No.2360	No.2361	No.2362
Resonance elimination filter 3	No.2363	No.2364	No.2365
Resonance elimination filter 4	No.2366	No.2367	No.2368
Resonance elimination filter 1	No.2113	No.2177	No.2359

For Series 15*i*

	Attenuation center frequency [Hz]	Attenuation bandwidth	Damping
Resonance elimination filter 2	No.2773	No.2774	No.2775
Resonance elimination filter 3	No.2776	No.2777	No.2778
Resonance elimination filter 4	No.2779	No.2780	No.2781
Resonance elimination filter 1	No.1706	No.2620	No.2772

<3> Setting for an active resonance elimination filter

The active resonance elimination filter is a function for setting the center frequency of a resonance elimination filter to the resonance frequency so as to maintain a high stability even when the center frequency deviates from the actual resonance frequency. It takes effect when:

- The resonance frequency shifts as the axis moves.
- The resonance frequency varies from one machine to another because of a difference among the machines.
- The resonance frequency changes with time.

	#7	#6	#5	#4	#3	#2	#1	#0
2683 (FS15*i*) 2270 (FS30*i*, 16*i*)					ACREF			

ACREF(#3) The active resonance elimination filter is:

0 : Disabled

1 : Enabled

> ⚠ **CAUTION**
> 1 The active resonance elimination filter can be used with the conventional specification of resonance elimination filter 1. To use the active resonance elimination filter, specify damping = 0 for resonance elimination filter 1.
> 2 The active resonance elimination filter performs follow-up operation over ±40 Hz with respect to a specified center frequency.
> 3 The active resonance elimination filter becomes enabled when the emergency stop is released.
> 4 The active resonance elimination filter does not perform follow-up operation during acc./dec.
> 5 When the attenuation center frequency of resonance elimination filter 1 is changed, the center frequency is re-set to the specified center frequency, and then the filter restarts follow-up operation using this newly specified center frequency as an initial value.

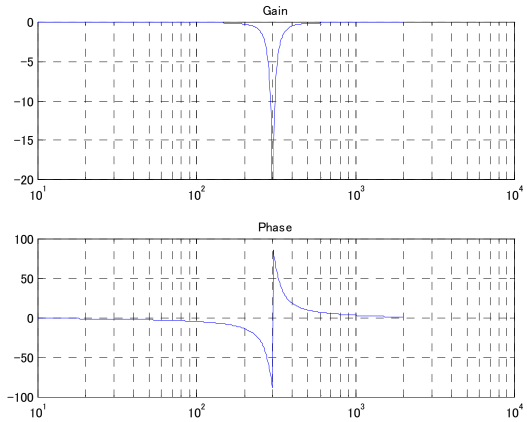
Specify ACREF = 1, and set the center frequency of resonance elimination filter 1 to about (resonance frequency - 30 Hz). Make sure that after the emergency stop is released, resonance is eliminated immediately. If resonance cannot be eliminated immediately, set the following parameter (detection level) to about 5 to 10 to increase the detection sensitivity. If the center frequency does not settle, increase the detection level to about 20 to 100 to decrease the detection sensitivity.

2765 (FS15*i*)	**Active resonance elimination filter : Detection level**
2352 (FS30*i*, 16*i*)	

[Valid data range] 0 to 500
0 is handled as a detection level of 16 inside the servo software.

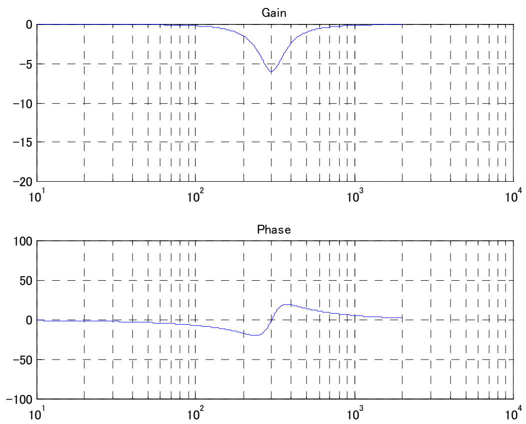
(6) Example of filter characteristics

<1> Conventional resonance elimination filter



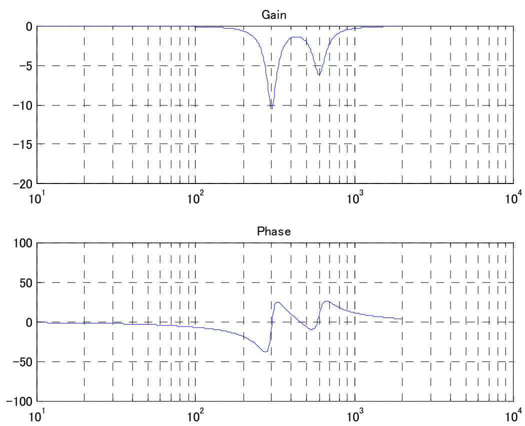
Center frequency = 300 Hz
Bandwidth = 30 Hz
Damping = 0

<2> Improved resonance elimination filter (with damping)



Center frequency = 300 Hz
Bandwidth = 100 Hz
Damping = 50%

<3> Improved resonance elimination filter (with two stages of damping)



(First stage)
Center frequency = 300 Hz
Bandwidth = 50 Hz
Damping = 30%
(Second stage)
Center frequency = 600 Hz
Bandwidth = 100 Hz
Damping = 50%

4.5.3 Disturbance Elimination Filter Function (Low-Frequency Resonance Elimination Filter)

(1) Overview

The disturbance elimination filter function estimates a disturbance by comparing a specified torque with the actual velocity, and feeds forward the estimation to the specified torque to suppress the effect of the disturbance. In particular, this function is useful for a vibration of 50 Hz to 100 Hz.

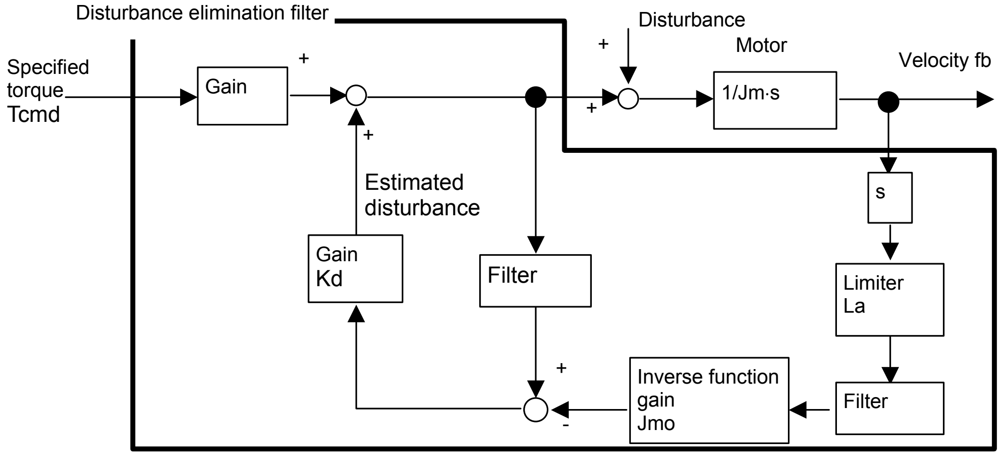


Fig. 4.5.3 Configuration of disturbance elimination filter

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
2611 (FS15*i*) **2223 (FS30*i*, 16*i*)**								**DISOBS**

DISOBS (#0) The disturbance elimination filter function is:
- 0 : Disabled.
- 1 : Enabled.

2731 (FS15*i*) **2318 (FS30*i*, 16*i*)**	**Disturbance elimination filter gain (Kd)**

[Valid data range] 101 to 500
[Typical setting] 500

> **NOTE**
> If a gain of 0 to 100 is set, the disturbance elimination filter function does not operate.

2732 (FS15*i*)	Inertia ratio (Rj) (%)
2319 (FS30*i*, 16*i*)	

[Valid data range] 0 to 32767
[Typical setting] 100
Set an inertia ratio (= machine inertia/motor inertia) in %.
Usually, set 100%.

2733 (FS15*i*)	Inverse function gain (Jmo)
2320 (FS30*i*, 16*i*)	

[Valid data range] 100 to 2000
[Initial setting] 100 (Increase the setting step by step.)
Set an inverse function gain as a conversion coefficient for acceleration-to-TCMD conversion. This parameter needs to be adjusted. As a guideline, set a value not greater than the value obtained by the following expressions:

Linear motor (The detection unit of the scale is assumed to be p μm.)

Jmo = 466048×p×Jm/Kt/Imax

Rotary motor

Jmo = 1396264×Jm/Kt/Imax

Jm: Weight [kg] or inertia [kgm^2]
Kt: Torque constant [N/Ap] or [Nm/Ap]
Imax: Maximum amplifier current [Ap]

> **NOTE**
> If an excessively large gain value is set, an abnormal sound and vibration can occur.

2734 (FS15*i*)	Filter time constant (Tp)
2321 (FS30*i*, 16*i*)	

- When HRV1, HRV2, or HRV3 is used:

[Valid data range] 0 to 4096
[Typical setting] 3700 (equivalent to T = 10 ms).
* Usually, this value does not need to be changed.
Set a filter time constant for determining an estimated disturbance velocity by using the following expression:
Tp = 4096 × exp (-t/T)
T: Setting time constant [sec], t = 0.001 [sec]

- When HRV4 is used:

[Valid data range] 0 to 4096
[Typical setting] 3994 (equivalent to T = 10 ms).
* Usually, this value does not need to be changed.
Set a filter time constant for determining an estimated disturbance velocity by using the following expression:
Tp = 4096 × exp (-t/T)
T: Setting time constant [sec], t = 0.00025 [sec]

2735 (FS15*i*)	Acceleration feedback limit (La)
2322 (FS30*i*, 16*i*)	

[Valid data range] 0 to 7282
[Typical setting] 1000

Set a limiter for a feedback torque calculated from acceleration. This parameter suppresses an excessive motion at the time of adjustment.
The value 7282 represents a maximum amplifier current. When a 160-A amplifier is used, for example, the value 1000 is equivalent to 22 A.

> **NOTE**
> In a case where a value close to the torque limit may be used, the torque is limited if the acceleration feedback limit is not increased.

(4) Procedure

(1) Make an adjustment according to the procedure below. First, disable those functions that operate only in the stop state such as the function for changing the proportional gain in the stop state.
For determining the resonance frequency and adjusting the disturbance elimination filter, use frequency characteristics measurement by SERVO GUIDE.

(2) Enable the disturbance elimination filter function, set the disturbance elimination filter gain to 100 (not functioning), then measure the frequency characteristics.
With SERVO GUIDE, observe the response waveform obtained during the above measurement, and set the input amplitude (to about 500) to allow the waveform to be observed and machine sound to be heard. A sinusoidal torque command is used, so that the command does not generate a torque in one direction. The command is to be executed away from the machine stroke limits.

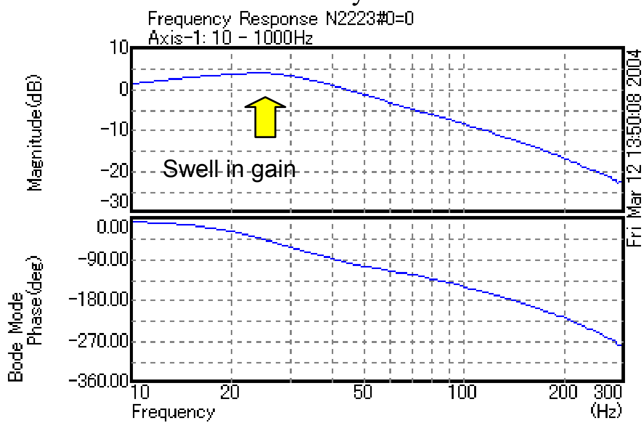


Fig. 4.5.3(a) Measurement example using SERVO GUIDE (before adjustment)

(3) Set the disturbance elimination filter gain to 500, and check the frequency characteristics with SERVO GUIDE while increasing the gain for inverse model starting with 100 in steps of 100. Adjust the value so that the amplitude of the gain swell part becomes small.

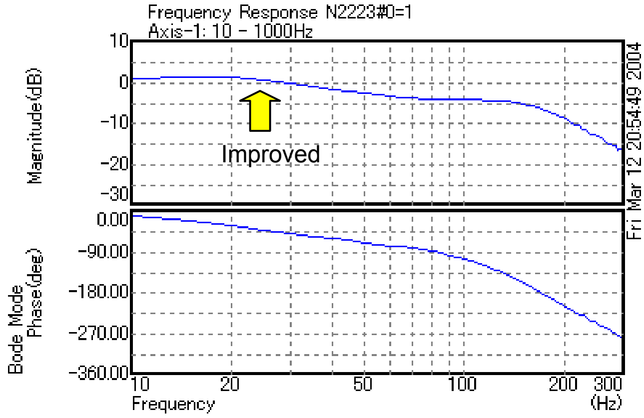


Fig. 4.5.3(b) Measurement example using SERVO GUIDE (after adjustment)

(4) Note that the velocity loop gain of higher frequencies is increased and even a violent vibration may be caused simply by enabling the disturbance elimination filter function. If a vibration occurs, increase the inverse function gain gradually, and check the vibration of the torque command. If the vibration becomes greater, decrease the inverse function gain. If the vibration can not be reduced by increasing and decreasing the inverse function gain, change the filter time constant by ±50 to eliminate the vibration.

(5) If the frequency of vibration is higher than 100 Hz, use a separate machine resonance prevention function such as the vibration suppression filter and torque command filter.

4.5.4 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. 4.5.4 (a) shows a block diagram of the velocity loop including an observer.

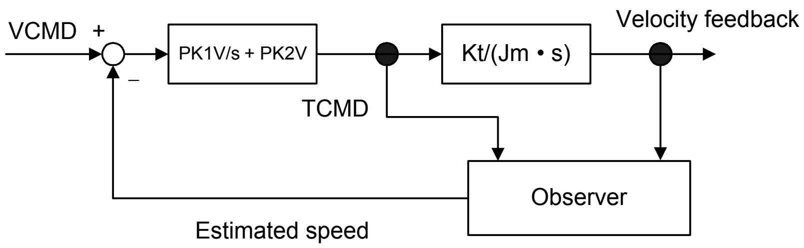


Fig. 4.5.4 (a) Configuration of velocity loop including observer

Fig. 4.5.4 (b) shows a block diagram of the observer.

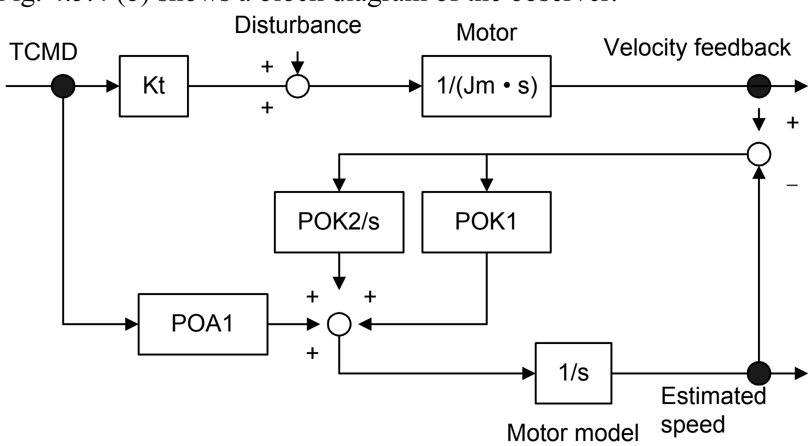


Fig. 4.5.4 (b) Block diagram of the observer

POA1, POK1, and POK2 in Fig. 4.5.4 (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. 4.5.4 (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. (7) of this section.

(3) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)

Series 90D0/A(01) and subsequent editions

Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)

Series 9096/A(01) and subsequent editions

Series 90B0/A(01) and subsequent editions

Series 90B1/A(01) and subsequent editions

Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)

Series 90B5/A(01) and subsequent editions

(4) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) / 2003 (FS30*i*, 16*i*)						OBEN		

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

1859 (FS15*i*) / 2047 (FS30*i*, 16*i*)	Observer coefficient (POA1)

[Setting value] Keep the standard setting unchanged.

1862 (FS15*i*)	Observer coefficient (POK1)
2050 (FS30*i*, 16*i*)	

- When HRV1, HRV2, or HRV3 is used:
  [Setting value] Usually, use the standard setting.
- When HRV4 is used:
  [Setting value] 956 → To be changed to 264

1863 (FS15*i*)	Observer coefficient (POK2)
2051 (FS30*i*, 16*i*)	

- When HRV1, HRV2, or HRV3 is used:
  [Setting value] Usually, use the standard setting.
- When HRV4 is used:
  [Setting value] 510 → To be changed to 35

(5) 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 4.5.4:
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 4.5.4 Changing the observer cutoff frequency

Cutoff frequency (Hz)	HRV1, HRV2, HRV3		HRV4	
	POK1	POK2	POK1	POK2
10	348	62	90	4
20	666	237	178	16
30	956	510	264	35
40	1220	867	348	62
50	1460	1297	430	96
60	1677	1788	511	136
70	1874	2332	1874	183

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

The unexpected disturbance torque detection function (see Sec. 4.12) uses the observer circuit shown in Fig. 4.5.4 (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 torque detection function are used together, however, the defaults for POK1 and POK2 must be used.

(7) Stop time observer disable function

If the observer function is enabled, the machine may fluctuate and become unstable when it stops. Such a fluctuation or unstable operation can be prevented by disabling the observer function only in the stop state.

(8) Setting parameters

<1> Function bit

	#7	#6	#5	#4	#3	#2	#1	#0
1960 (FS15*i*) **2018 (FS30*i*, 16*i*)**							**MOVOBS**	

MOVOBS (#1) The function for disabling the observer in the stop state is:
0: Disabled
1: Enabled ← Set this value.

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

1730 (FS15*i*) **2119 (FS30*i*, 16*i*)**	**Level at which the observer is determined as being disabled**

[Unit of data] Detection unit
[Typical setting] 1 to 10
If the absolute value of the position error 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)
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 position error.

4.5.5 Current Loop 1/2 PI Control Function

(1) Overview

To improve servo performance in high-speed and 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 1/2 PI control function enables the response of the current loop to be improved.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Control method

As shown in Fig. 4.5.5, 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.

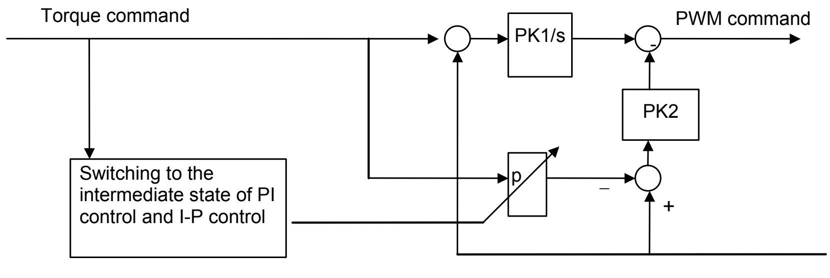


Fig. 4.5.7 Block diagram of current loop 1/2PI control

(4) Setting parameters

<1> Enabling the current loop 1/2 PI control function at all times

	#7	#6	#5	#4	#3	#2	#1	#0
1743 (FS15*i*) / 2203 (FS30*i*, 16*i*)						CRPI		

CRPI (#2) 1: To enable the current loop 1/2 PI control function

<2> To enable the function for cutting only, use the following bit in addition to the previous bit:

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) 2202 (FS30*i*, 16*i*)							VGCCR	

VGCCR (#1) 1: To enable the current loop 1/2 PI control function for cutting only (This function is used together with the cutting feed/rapid traverse velocity loop gain switch function.)

<3> To enable the function at all times while using bit 1 of parameter No. 1742 (Series 15*i*) or No. 2202 (Series 16*i* and so on), use the following bit in addition to the settings of <1> and <2>:

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) 2202 (FS30*i*, 16*i*)						PIAL		

PIAL (#2) 1: To enable the current loop 1/2 PI control function at all times (When this function is used together with the cutting feed/rapid traverse velocity loop gain switch 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).

(5) Current control PI rate modification

The current control PI rate (p in Fig. 4.5.5) is usually fixed at 1/2, but can be changed freely.

* This function cannot be used with Series 9096.

2736 (FS15*i*) 2323 (FS30*i*, 16*i*)	Current control PI rate

[Valid data range] 0 to 4096

[Unit of data] 4096 represents p = 1.0 (complete PI).
When the value 0 is specified, the specification of 2048 (1/2PI), which is equivalent to p = 0.5, is assumed.

> ⚠ **CAUTION**
> If you need to increase the velocity gain, in particular, a value greater than 1/2PI may be set. However, do not use this parameter usually.

4.5.6 Vibration Damping Control Function

(1) Overview

In a closed-loop system, the Pulsecoder on the motor is used for velocity control and a separate detector is used for position control.
During acc./dec., 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.
This function has the effect of the machine velocity feedback function, but is superior to the machine velocity feedback function in that restrictions as imposed with the machine velocity feedback function are eliminated.

(2) Control method

The following figure shows the block diagram for vibration damping control:

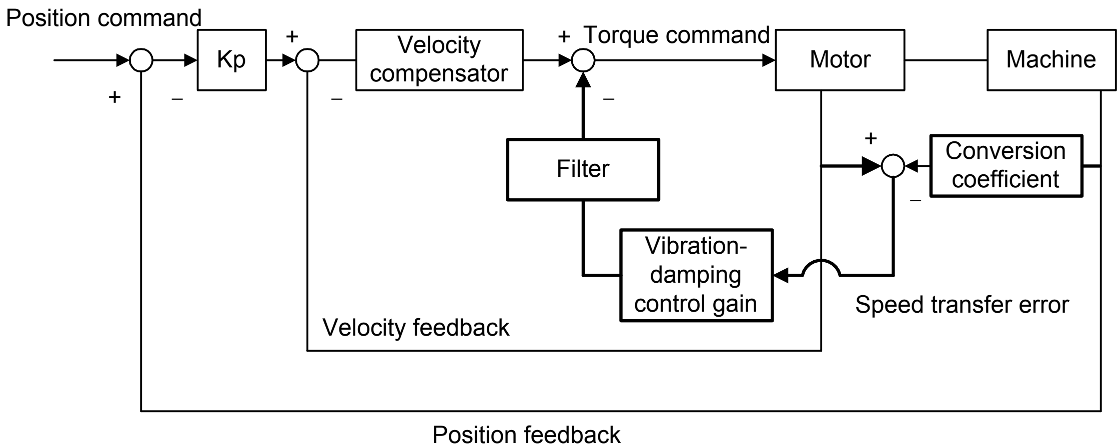


Fig. 4.5.5 Block diagram for vibration damping control

(3) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(4) Setting parameters

1718 (FS15*i*) 2033 (FS30*i*, 16*i*)	**Number of position feedback pulses for vibration damping control conversion coefficient**

[Valid data range] -32767 to 32767

When 0 is set, this function is disabled.

If a negative value is specified, it is internally read as 10 times the specified value. (-1000=10000)

When a flexible feed gear (F·FG) is used (In the case of using the A/B phase separate type detector and analog SDU)
Set value = Number of feedback pulses per motor revolution, received from a separate detector/8

(Example 1)

With a 5 mm/rev ball screw, 0.5 μm/pulse separate detector, and a detection unit of 1 μm, F·FG = 1/2

Then,

Set value = 10,000 × 1/8 = 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

(Example 2)

If a flexible feed gear is used under the conditions described in example 1 above,

Set value = 10,000 × 1/2 × 1/8 = 625

When a flexible feed gear (F·FG) is used (In the case of using the analog SDU)
Set value = (Travel distance per motor revolution [mm]) / (detector signal pitch [mm]) × 512 / 8

(Example 3)

When travel distance per motor revolution=10 [mm], and detector signal pitch=20 [μm]

Set value = 10 / 0.020 × 512 / 8 = 32000

> ⚠ **CAUTION**
> If the above expression is indivisible, set the nearest integer.

1719 (FS15*i*) 2034 (FS30*i*, 16*i*)	**Vibration-damping control gain**

[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.

4.5.7 Dual Position Feedback Function

Optional function

(1) Overview

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

(2) Control method

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

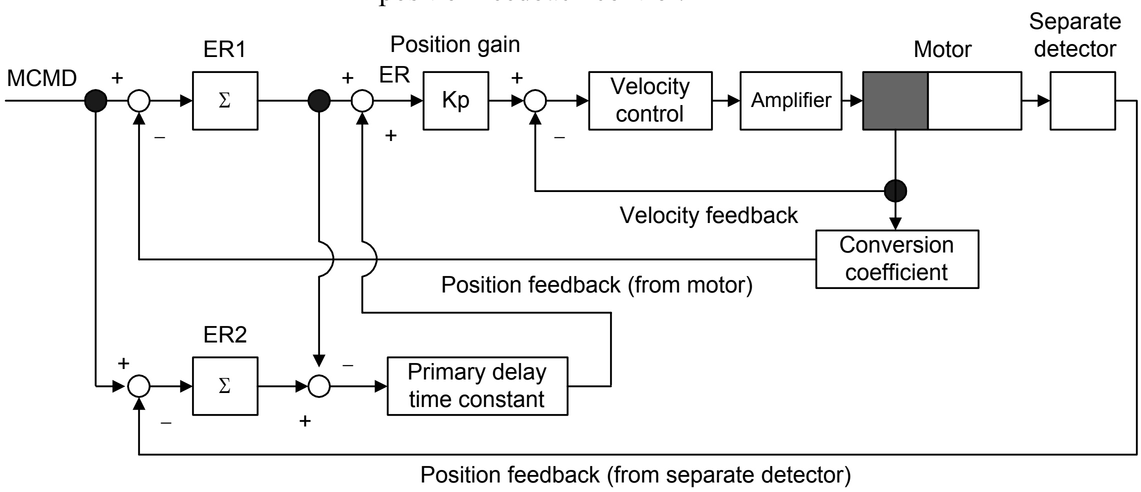


Fig. 4.5.7 Block diagram of dual position feedback control

As shown in Fig. 4.5.7, 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 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 20*i*-B)
Series 90B5/A(01) and subsequent editions

(4) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1709 (FS15*i*) / 2019 (FS30*i*, 16*i*)	DPFB							

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

1861 (FS15*i*) / 2049 (FS30*i*, 16*i*)	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.

[Unit of data] 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 (FS15*i*) / 2078 (FS30*i*, 16*i*)	Dual position feedback conversion coefficient (numerator)

1972 (FS15*i*) / 2079 (FS30*i*, 16*i*)	Dual position feedback conversion coefficient (denominator)

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

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

With this setting method, however, cancellation in the servo software internal coefficient may occur depending on constants such as the machine deceleration ratio, causing the motor to vibrate. In such a case, the setting must be changed.
For details, see Art. (6) in this section.

(Example)

When the αi Pulsecoder 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 (FS15*i*)	Dual position feedback primary delay time constant
2080 (FS30*i*, 16*i*)	

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

[Unit of data] msec

Normally, set a value of around 100 msec as the initial value. If hunting occurs during acc./dec., 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 (FS15*i*)	Dual position feedback zero-point amplitude
2081 (FS30*i*, 16*i*)	

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

[Unit of data] 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 position error may remain. For details, see Art. (5) in this section.

1729 (FS15*i*)	Dual position feedback: Level on which the difference in error between the semi-closed and full-closed modes becomes too large
2118 (FS30*i*, 16*i*)	

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

[Unit of data] Minimum detection unit (μm/p) for full-closed mode

If the difference between the Pulsecoder 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.

> **NOTE**
> The function for monitoring the difference in error between the semi-closed and full-closed modes is useful also for monitoring for a problem such as the feedback pulse missing of a separate detector. When only the monitoring of the difference in error between the semi-closed and full-closed modes is to be performed on a machine for which dual position feedback is not required as a stabilization function, the function for monitoring the difference in error between the semi-closed and full-closed modes can be used by not only making an ordinary full-closed loop setting but also setting a conversion coefficient for dual position feedback and the parameter for the monitoring level of the difference in error between the semi-closed and full-closed modes. (No option setting and function bit setting need to be made.)

	#7	#6	#5	#4	#3	#2	#1	#0
1954 (FS15*i*) 2010 (FS30*i*, 16*i*)			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)

	#7	#6	#5	#4	#3	#2	#1	#0
1746 (FS15*i*) 2206 (FS30*i*, 16*i*)				HBSF				

HBSF (#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. 1954 (Series 15*i*) or No. 2010 (Series 30*i*, 16*i*, and so on)).

When this parameter is set to 1, the settings of No. 1954 (Series 15*i*) and No. 2010 (Series 30*i*, 16*i*, and so on)are ignored.

NOTE

1 If a setting is made to perform the function for monitoring the difference in error between the semi-closed and full-closed modes for an axis placed in a simple full-closed loop, the specification for addition of a backlash compensation and pitch error compensation is the same as in the case of using the dual position feedback function. In this case, it is recommended to make the setting above to "Add a backlash compensation and pitch error compensation to the closed loop side and semi-closed loop side at the same time".

2 When the dual check safety function is used with Series 16*i*, 18*i*, or 21*i*, a conversion coefficient for dual position feedback is used. In this case as well, make the setting above to "Add a backlash compensation and pitch error compensation to the closed loop side and semi-closed loop side at the same time".

(5) Zero-width setting for a machine with a large backlash or twist

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 position error 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:

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*)				DUAL0W				
2202 (FS30*i*, 16*i*)								

DUAL0W (#4) The zero-width determination is performed with:
0: Setting = 0 only.
1: Setting. ← Set this value.

(6) 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.

Number of position feedback pulses per motor revolution

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

↓

Is $A = 8{,}000{,}000 \times \dfrac{n}{d}$ an integer?

No ↓

Obtain the smallest m so that the result of m × A 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.

Yes ↓

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 B.

4.5.8 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 Pulsecoder 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 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B, Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Control block diagram

Fig. 4.5.8 is a control block diagram

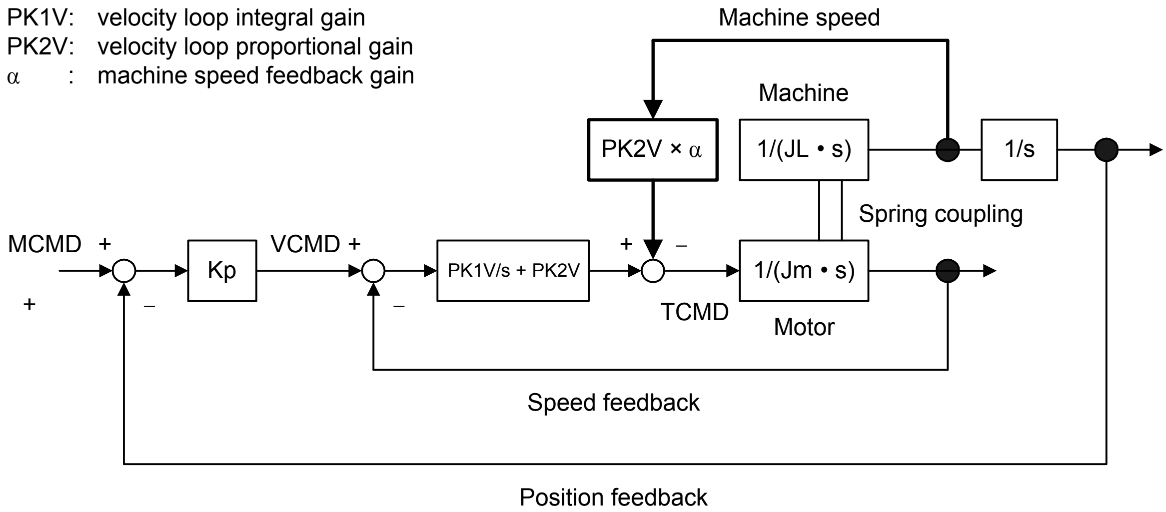


Fig. 4.5.1 Position loop block diagram that includes machine speed feedback function

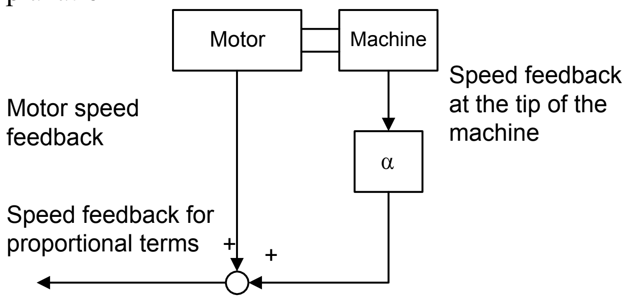
As shown in Fig. 4.5.8, this function corrects the torque command by multiplying the machine speed by machine velocity feedback gain, α, as shown by the bold line. When α = 1, the torque command is corrected equally by the motor speed and the machine speed.

(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 above 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.

* The normalization function cannot be used when the velocity loop proportional high-speed processing function is used.

(5) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1956 (FS15*i*) / 2012 (FS30*i*, 16*i*)							MSFE	

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

1981 (FS15*i*) / 2088 (FS30*i*, 16*i*)	Machine speed feedback gain (MCNFB)

- When a serial output type separate detector is used or when the flexible feed gear (parameters Nos. 2084 and 2085, parameter Nos. 1977 and 1978) is set to 1/1
  (Setting range: 1 to 100 or –1 to –100)
  (Typical 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)
  (Typical setting)
  When the normalization function is not used: MCNFB = 3000 to 10000
  When the normalization function is used: MCNFB = –3000 to –10000

(6) Note

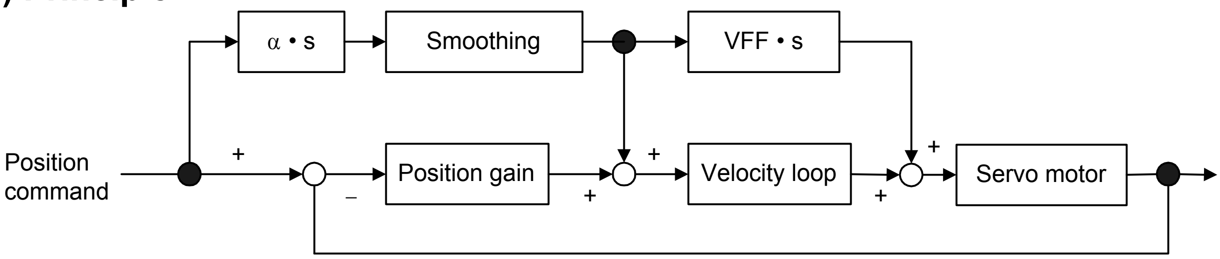
It the machine has a resonance frequency of 200 to 400 Hz, using this function may result in a resonance being amplified, thus leading to abnormal vibration or sound. If this happens, take either of the following actions to prevent resonance.

- Using an observer (⇒ Subsec. 4.5.4)
  (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. 4.5.1)

4.6 CONTOUR 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 acc./dec. 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 and 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.

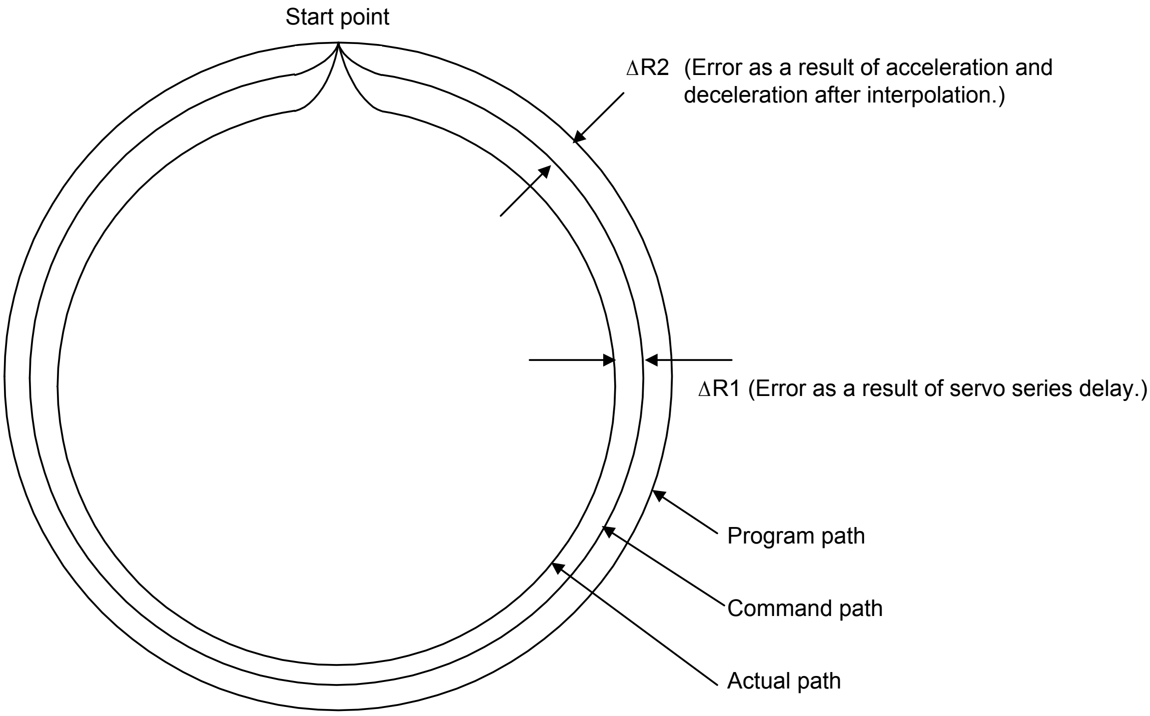


Fig. 4.6.1 (b) Path error during circular cutting

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)

Series 90D0/A(01) and subsequent editions(*)

Series 90E0/A(01) and subsequent editions(*)

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)

Series 9096/A(01) and subsequent editions

Series 90B0/A(01) and subsequent editions

Series 90B1/A(01) and subsequent editions

Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)

Series 90B5/A(01) and subsequent editions

(*) With Series 90D0 and 90E0, the advanced preview feed-forward function is applied unless the EGB synchronous mode is set.

(3) Setting parameters

<1> Enable PI control and the feed-forward function.

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) **2003 (FS30*i*, 16*i*)**					**PIEN**			

PIEN (#3) 1: To enable PI control

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) **2005 (FS30*i*, 16*i*)**							**FEED**	

FEED (#1) 1: To enable the feed-forward function

<2> Specify the feed-forward coefficient.

1961 (FS15*i*) **2068 (FS30*i*, 16*i*)**	**Feed-forward coefficient (FALPH)**

FALPH = $\alpha \times 100$ 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 (FS15*i*) **2069 (FS30*i*, 16*i*)**	**Velocity feed-forward coefficient (VFFLT)**

VFFLT = 50 (50 to 200)

<4> Run a program to move the axis for cutting feed at maximum feedrate. Under this condition, check whether the VCMD waveform observed on the Servo Guide or 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 acc./dec. time constant, or reduce α.
⇒ If an overshoot does not occur, and the shock is small, reduce the acc./dec. time constant, or increase α.
Linear acc./dec. is more effective than exponential acc./dec.
Using acc./dec. 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 (FS15*i*) / 1800 (FS30*i*, 16*i*)					FFR			

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 acc./dec. In such a case, use fine acc./dec. (⇒ Subsec. 4.8.3) at the same time, or make adjustments such as increasing the acc./dec. time constant.
Moreover, a feed-forward coefficient can be set separately for each of cutting and rapid traverse. (See Subsection 4.6.4, "Cutting/Rapid Feed-forward Switching Function".)

<6> To use the EGB function, set the following parameter:

	#7	#6	#5	#4	#3	#2	#1	#0
1955 (FS15*i*) / 2011 (FS30*i*, 16*i*)							FFAL	

FFAL (#1) Feed-forward control is:

1: Always enabled regardless of the mode.

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 and 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.

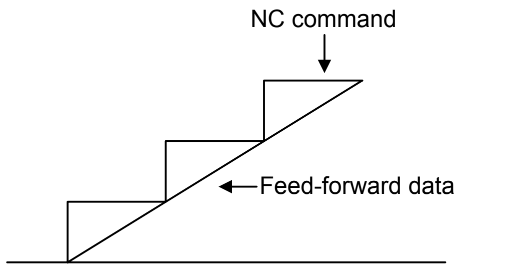


Fig. 4.6.2 (a) Conventional feed-forward control

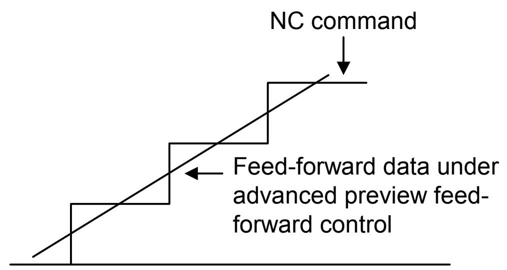


Fig. 4.6.2 (b) Advanced preview feed-forward control

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(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 (FS15*i*) / **2003 (FS30*i*, 16*i*)**					**PIEN**			

PIEN (#3) 1: PI control is selected.

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) / **2005 (FS30*i*, 16*i*)**							**FEED**	

FEED (#1) 1: The feed-forward function is enabled.

1962 (FS15*i*) / **2069 (FS30*i*, 16*i*)**	**Velocity feed-forward coefficient (VFFLT)**

[Recommended value] 50 (50 to 200)

<2> Set the coefficient for advanced preview feed-forward control.

1985 (FS15*i*) / **2092 (FS30*i*, 16*i*)**	**Advanced preview feed-forward coefficient (ADFF1)**

[Recommended value] 9800 to 10000

> Advanced preview feed-forward coefficient (0.01% unit)
> = $\alpha \times 10000$ ($0 \leq \alpha \leq 1$)

(Example)

When α equals 98.5%, ADFF1 is 9850.

Advanced preview control is configured as shown below:

Advanced preview control
- Deceleration algorithm and function of acc./dec. before interpolation of CNC
  - Acc./dec. 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.

<3> By specifying the G codes listed below, the modes related to high-speed and high precision machining such as advanced preview control can be turned on/off. In each mode, advanced preview feed-forward is enabled.

> **NOTE**
> While the fine acc./dec. (FAD) function is being used, the advanced preview feed-forward function is always used, and the advanced preview feed-forward function cannot be turned on and off by G codes.

G code		Mode
Mode ON	Mode OFF	
G08P1	G08P0	Advanced preview control mode
G05.1Q1	G05.1Q0	Acc./dec. mode before look-ahead interpolation
		AI nano-contour control mode
		AI contour control mode
		AI advanced preview control mode
G05P10000	G05P0	High-precision contour control (⇒ Subsec.4.6.3)
		AI high precision contour control
		AI nano high precision contour control
		Fine HPCC
G05.1Q1	G5.1Q0	AI contour control I mode
		AI contour control II mode

* With the Series 30*i*/31*i*/32*i* (servo software Series 90D0 and 90E0), the advanced preview feed-forward function is always applied regardless of G codes.

* For a CNC that supports this function, see Appendix D.

(Example)

G08P1; Advanced preview control mode on
. . .
. . . 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) or AI contour control (AICC mode) in order to shorten the interpolation cycle, improving the performance of high-speed, high precision machining.
(This function is insignificant for AI nano-contour control complying with nano-interpolation as a distribution system, AI high-precision contour control, AI nano high-precision contour control, and fine HPCC.)
By using this function, the response of the servo side can be improved when the distribution period is 4 ms, 2 ms, or 1 ms.

(2) Series and editions of applicable servo software

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions(*)
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(*) Series 9096 supports distribution periods of 1 ms and 2 ms only, and it does not support 4 ms.

(3) Setting parameters

<1> Set the following parameters in the same way as for the advanced preview feed-forward function.
<2> Set the parameters (RISCFF and RISCMC) below.

	#7	#6	#5	#4	#3	#2	#1	#0
1959 (FS15*i*) / 2017 (FS30*i*, 16*i*)			RISCFF					

RISCFF (#5)
1: Feed-forward response improves when RISC is used.
0: Feed-forward response remains unchanged when RISC is used.

	#7	#6	#5	#4	#3	#2	#1	#0
1740 (FS15*i*) / 2200 (FS30*i*, 16*i*)			RISCMC					

RISCMC (#5) When RISC is used:
1: Feed-forward response improves.
0: Feed-forward response remains unchanged.

<3> By specifying a G code in the program, each mode is enabled, and the advanced preview feed-forward function set above is applied.

G code		Mode
Mode ON	Mode OFF	
G05.1Q1	G05.1Q0	AI contour control mode
G05P10000	G05P0	HPCC mode

* Appendix D lists the supported CNCs.

If the modes above are off, the normal feed-forward coefficient is enabled.

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.
(To set a detection unit of 0.1 μm, the IS-C system must be used, or the CMR and flexible feed gear must be multiplied by 10 with the IS-B system.)

4.6.4 Cutting/Rapid Feed-forward Switching Function

(1) Overview

To use a separate feed-forward coefficient for each of cutting feed and rapid traverse, the use of the cutting/rapid fine acc./dec. switching function has been required conventionally. The cutting feed/rapid traverse switchable feed-forward function allows a separate coefficient to be used for each of cutting feed and rapid traverse, without using the cutting feed/rapid traverse switchable fine acc./dec. function.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Cautions

This function is usable with the modes below. Note that this function cannot be used with the normal mode.
[Usable modes]
- Advanced preview control mode
- AI contour control mode
- AI nano contour control mode
- High precision contour control mode
- AI high precision contour control mode
- AI nano high precision contour control mode

(*) With the Series 30*i*/31*i*/32*i*, this function can be used regardless of the specified mode.

(4) Setting parameters

<1> First, set the parameters below in the same way as for the current feed-forward function.

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) 2003 (FS30*i*, 16*i*)					PIEN			

PIEN(#3) 1: A switch is made to PI control.

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) 2005 (FS30*i*, 16*i*)							FEED	

FEED (#1) 1: The feed-forward function is enabled.

<2> Next, set the cutting/rapid feed-forward switching function.

	#7	#6	#5	#4	#3	#2	#1	#0
2602 (FS15*i*) / **2214 (FS30*i*, 16*i*)**				**FFCHG**				

FFCHG (#4) 1: The cutting/rapid feed-forward switching function is enabled.

<3> With the setting of the parameters above, the parameters below are enabled in cutting.

1768 (FS15*i*) / **2145 (FS30*i*, 16*i*)**	**Velocity feed-forward coefficient for cutting**

1767 (FS15*i*) / **2144 (FS30*i*, 16*i*)**	**Advanced preview feed-forward coefficient for cutting**

The parameters below are enabled in rapid traverse.

1962 (FS15*i*) / **2069 (FS30*i*, 16*i*)**	**Velocity feed-forward coefficient for rapid traverse**

1985 (FS15*i*) / **2092 (FS30*i*, 16*i*)**	**Advanced preview feed-forward coefficient for rapid traverse**

4.6.5 Feed-forward Timing Adjustment Function

(1) Overview

If the feed-forward function is applied with the aim of decreasing contour errors, the same feed-forward coefficient must be used for all axes. Even if a unified feed-forward coefficient is used, however, the axes may not necessarily behave in the same manner because of differences in the mechanical characteristic and velocity loop response among the axes.
The feed-forward timing adjustment function is intended to change the feed-forward timing so as to make the characteristics of each axis at high-speed movement. It does not change the feed-forward coefficient. So it can change the characteristic of a portion where the acceleration is high without affecting the operation for straight portions.
If the radius of an arc subjected to high-speed cutting differs among axes, resulting in a vertical or horizontal oval, this function is useful in improving roundness through fine adjustment.

(2) Control method

When an arc is cut at high speed, delaying the feed-forward timing causes the path to bulge. On the contrary, advancing the feed-forward timing causes the path to shrink. The feed-forward timing adjustment function lets you make fine adjustments on the characteristic of servo axes.

Let the radius, feedrate, and position gain be, respectively, R, V, and Kp. Delaying the feed-forward timing by τ(s) increases the radius of the arc by:
$\Delta R = \tau \times V^2/(Kp \times R)$
To be specific, assume radius R = 10 mm, feedrate V = 4000 mm/min, and position gain Kp = 40/s. Shifting the timing by 1 ms corresponds to:
$\Delta R = 11\ \mu m$

(3) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(4) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
– / 2415(FS30*i*)							IAHDON	

IAHDON(#1) The default value of the feed-forward timing adjustment parameter is:

0: 0.

1: Compatible with that of Series 16*i*. (See the table below.)

* By setting IAHDON=1 and No. 2095=0, the feed-forward timing becomes compatible with that of Series 16*i*.

The actually applied feed-forward timing is "setting of No. 2095 + default value".
When newly setting bit 1 of No. 2415 to 1 for a system that already has a value set in No. 2095, set a value calculated from the following formula in No. 2095:

No.2095 (new setting) =
No.2095 (value determined by setting bit 1 of No. 2415 to 0) - default value (table below)

	Default feed-forward timing value	
	No.2415#1=0	No.2415#1=1
HRV2 control	0	3900
HRV3 control	0	3900
HRV4 control	0	3792 (*1)

(*1) When HRV4 control is used and any of the following functions is used, the default value is -240:
- High-speed processing
- AI contour control II
- High-speed cycle machining

Series and editions of applicable servo software
(Series 30*i*,31*i*,32*i*)
Series 90D0/J(10) and subsequent editions
Series 90E0/J(10) and subsequent editions

1988 (FS15*i*) / 2095 (FS30*i*, 16*i*)	Feed-forward timing adjustment coefficient (*1)

Specifying +4096 causes the feed-forward timing to advance by 1 ms.
Specifying -4096 causes the feed-forward timing to delay by 1 ms.
If you want to decrease the radius of an arc at high-speed cutting, increase the coefficient by about 300 at each step.
If you want to increase the radius of an arc at high-speed cutting, decrease the coefficient by about 300 at each step.
This parameter is valid for advanced preview feed-forward control (parameter Nos. 1985 and 1767 (Series 15*i*) and parameter Nos. 2092 and 2144 (Series 30*i*, 16*i*, and so on). It is invalid for conventional feed-forward control type (parameter No. 1961 (Series 15*i*) and parameter No. 2068 (Series 16*i* and so on)).

(*1) Old documents may refer to this function as "machine distortion compensation coefficient."

With the following servo software, the feed-forward timing slightly differs when the fine acc./dec. function is used, so a separate parameter is prepared for independent setting.

Series and editions of applicable servo software
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B0/J(10) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

2808 (FS15*i*)	Feed-forward timing adjustment coefficient (to be used when fine acc./dec. is enabled)
2395 (FS30*i*, 16*i*)	

* If fine acc./dec. is specified and is used in one of the following modes:

- Simple cutting feed (no high-precision mode)
- Advanced preview control
- AI advanced preview control (Series 21*i*)

This parameter can set the timing adjustment coefficient to parameter No. 1988 + parameter No. 2808 (for the Series 15*i*) and
parameter No. 2095 + parameter No. 2395 (for the Series 16*i* and so on).

In other high definition modes (modes in which fine acc./dec. is disabled, such as AI contour control), the timing adjustment coefficient is set to
parameter No. 1988 (for the Series 15*i*)
parameter No. 2095 (for the Series 16*i* and so on).
This parameter allows setting of different timing adjustment coefficients depending on whether fine acc./dec. is enabled or disabled.

4.6.6 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.

(2) Series and editions of applicable servo software

Backlash acceleration function
(Series 30*i*,31*i*,32*i*)
    Series 90D0/A(01) and subsequent editions
    Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
    Series 9096/A(01) and subsequent editions
    Series 90B0/A(01) and subsequent editions
    Series 90B1/A(01) and subsequent editions
    Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
    Series 90B5/A(01) and subsequent editions

Override function
(Series 30*i*,31*i*,32*i*)
    Series 90D0/J(10) and subsequent editions
    Series 90E0/J(10) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
    Series 90B0/W(23) and subsequent editions
    Series 90B1/A(01) and subsequent editions
    Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
    Series 90B5/A(01) and subsequent editions

(3) Setting parameters

<1> Set the backlash compensation.

1851 (FS15*i*)	**Backlash compensation**
1851 (FS30*i*, 16*i*)	

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 (FS15*i*)								**FCBL**
2006 (FS30*i*, 16*i*)								

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 (FS15*i*)			**BLEN**					
2003 (FS30*i*, 16*i*)								

BLEN (#5) 1: To enable backlash acceleration

1860 (FS15*i*)	**Backlash acceleration amount**
2048 (FS30*i*, 16*i*)	

[Typical setting] 20 to 600
Offset for the velocity command that is to be added immediately after a reverse.

1964 (FS15*i*)	**Period during which backlash acceleration remains effective (in units of 2 msec)**
2071 (FS30*i*, 16*i*)	

[Typical setting] 20 to 100
The period during which the acceleration amount is added. At the start of adjustment, set 20. When a long quadrant protrusion is found, gradually increase the setting in steps of 10.

<3> When the optimum backlash acceleration amount varies with the machining feedrate, use the acceleration amount override and the limit of the acceleration amount.

1725(FS15*i*)	**Acceleration amount override**
2114(FS16*i*)	

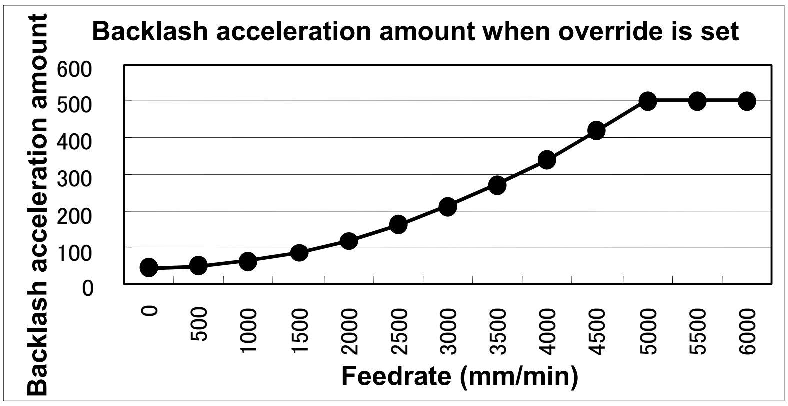
[Valid data range] 0 to 32767

2751(FS15*i*)	**Limit of acceleration amount**
2338(FS16*i*)	

[Valid data range] 0 to 32767 (When 0 is set, the acceleration amount is not limited.)

[Example] Example of setting the acceleration amount when a model such as the Series 16*i* is used

Acceleration amount (parameter No. 2048) = 46, acceleration amount override (parameter No. 2114) = 23, limit of acceleration amount (parameter No. 2338) = 500



<4> Setting the direction-based backlash acceleration function

When the optimum acceleration amount differs between a reverse operation in the positive direction and a reverse operation in the negative direction, set the acceleration amount used for the reverse operation from the negative direction to positive direction in the following parameter:

1987(FS15*i*) / 2094(FS16*i*)	Backlash acceleration amount (for reverse from negative to positive direction)

[Typical setting] 20 to 600

2753(FS15*i*) / 2340(FS16*i*)	Acceleration amount override (for reverse from negative to positive direction)

[Valid data range] 0 to 32767

2754(FS15*i*) / 2341(FS16*i*)	Limit of acceleration amount (for reverse from negative to positive direction)

[Valid data range] 0 to 32767 (When 0 is set, the acceleration amount is not limited.)

[Parameters used for direction-based setting]

Series30*i*,16*i*, and so on

Direction-based setting	Reverse direction	Backlash acceleration amount	Acceleration amount override	Limit of acceleration amount
None	Common	No. 2048	No. 2114	No. 2338
Present	From + to -			
	From - to +	**No. 2094**	**No. 2340**	**No. 2341**

Series 15*i*

Direction-based setting	Reverse direction	Backlash acceleration amount	Acceleration amount override	Limit of acceleration amount
None	Common	No. 1860	No. 1725	No .2751
Present	From + to -			
	From - to +	**No. 1987**	**No. 2753**	**No. 2754**

<5> If a reverse cut occurs, use the backlash acceleration stop function.

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*) 2009 (FS30*i*, 16*i*)	BLST							

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(FS15*i*) 2082(FS30*i*,16*i*)	Backlash acceleration stop distance

[Typical setting] 2 to 5 (detection unit of 1μm), 20 to 50 (detection unit of 0.1μm)
This parameter is related to the distance until backlash acceleration ends. Determine the parameter value by checking the actual profile.

This completes the general setting procedure for the backlash acceleration function.

(4) Setting parameters

There are two methods for setting the acceleration amount override as listed below. Normally, use setting method 1.

- Setting method 1 (calculation not required)
  <1> With an assumed minimum acceleration, obtain the optimum backlash acceleration amount while observing quadrant protrusions. Set the obtained value as the backlash acceleration amount (setting).
  <2> Set the acceleration to a middle point between the minimum and maximum levels, and while increasing the override value, observe quadrant protrusions to determine the optimum override value.
  <3> Finally, set the maximum acceleration, and observe the arc figure. If an undercut is generated at the switching point of quadrants, set the acceleration amount limit to prevent the acceleration amount from increasing excessively.

- Setting method 2 (strict calculation required)
  Obtain an optimum backlash acceleration amount for two different accelerations (an assumed minimum acceleration and an intermediate acceleration between the minimum and maximum accelerations), and substitute the obtained value in the following equation for the backlash acceleration amount override:

$$\text{Backlash acceleration amount} = \text{Backlash acceleration amount (setting)} \times \left(1 + \frac{\text{Acceleration amount override} \times \text{Acceleration}}{2048}\right)$$

$$\text{Acceleration} = \frac{(\text{Feedrate [mm/min]})^2}{\text{Radius [mm]}} \times \frac{128}{\text{Detection unit [}\mu\text{m]} \times 1000}$$

Find a solution of the simultaneous equations. The results are as follows:

$$\text{Acceleration amount override} = \frac{(\text{Acceleration amount 2}) - (\text{Acceleration amount 1})}{(\text{Acceleration amount 1}) \times (\text{Acceleration 2}) - (\text{Acceleration amount 2}) \times (\text{Acceleration 1})} \times 2048$$

$$\text{Backlash acceleration amount (setting)} = \frac{(\text{Acceleration amount 1}) \times (\text{Acceleration 2}) - (\text{Acceleration amount 2}) \times (\text{Acceleration 1})}{(\text{Acceleration 2}) - (\text{Acceleration 1})}$$

Finally, operate at the maximum acceleration, and adjust the limit of the acceleration amount.

(5) Ignoring the backlash acceleration function at handle feed

To disable the backlash acceleration function at handle feed, set the following:

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*) / 2009 (FS30*i*, 16*i*)		BLCU						

BLCU (#6) 1: To enable the backlash acceleration function during cutting feed only

> **NOTE**
> If bit 3 of parameter No. 1800 is set to 1, the backlash acceleration function is always enabled, and it cannot be disabled.

With following series and editions of servo software, the bit shown below can also be used to enable the backlash acceleration function only during cutting.

- Series 90B0/C(03) and subsequent editions
- Series 90B6/A(01) and subsequent editions
- Series 90B5/A(01) and subsequent editions
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

Use of this bit enables and disables the backlash acceleration function even when bit 3 of parameter No. 1800 is set to 1. Backlash acceleration is enabled even at the hole bottom during rigid tapping.

	#7	#6	#5	#4	#3	#2	#1	#0
2611 (FS15*i*)	BLCUT2							
2223 (FS30*i*, 16*i*)								

BLCUT2 (#7) 1: To enable the backlash acceleration function during cutting feed only

[Reference]
Adjustment the backlash acceleration
Run a program for an arc, and make an adjustment while checking the arc figure on SERVO GUIDE.

(6) Disabling backlash acceleration after a stop

When using the function for disabling backlash acceleration after a stop, make the setting below. For details, see "(7) Adjustment of backlash acceleration" in Appendix H.

	#7	#6	#5	#4	#3	#2	#1	#0
2696(FS15*i*)	BLSTP2							
2283(FS30*i*,16*i*)								

BLSTP2(#7) 1 : Disables backlash acceleration after a stop.

4.6.7 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	First stage:	The friction torque is canceled when the motor reverses.
	Second stage:	The friction torque in the machine is canceled.

Furthermore, optimum compensation can be performed at all times for first stage against changing speed and load.
The two-stage backlash acceleration function performs compensation as shown below:

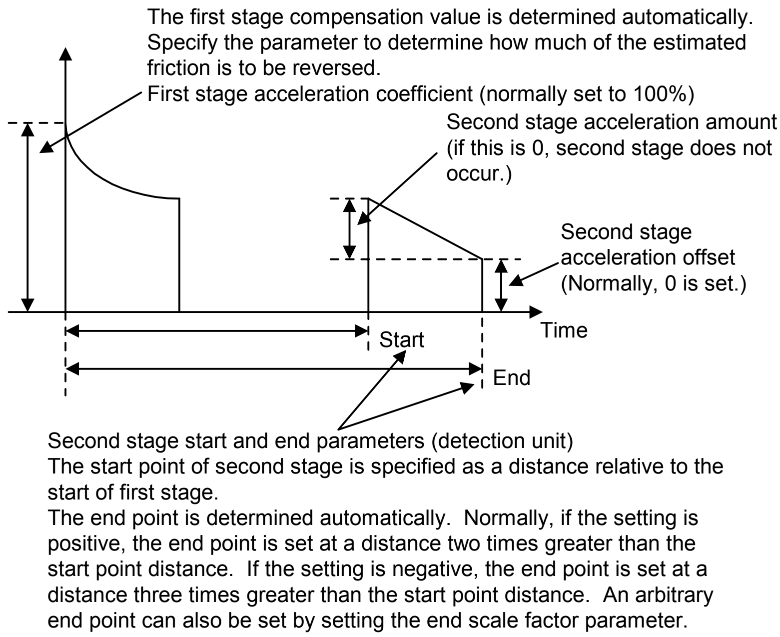


Fig. 4.6.7 (a) Backlash acceleration under control of the two-stage backlash acceleration function

(2) Series and editions of applicable servo software

Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
(specifying a direction-specific second stage acceleration amount and a limit value)
Series 90B0/J(10) and subsequent editions
Series 90B6/A(01) and subsequent editions
Series 90B5/A(01) and subsequent editions

(3) Setting parameters

<1> With SERVO GUIDE, make settings for measuring the motor speed and estimated disturbance value.
(See Sec. 4.20 for SERVO GUIDE.)
<2> Turn on the power to the NC.
<3> Specify the backlash compensation value.

1851 (FS15*i*)	Backlash compensation value
1851 (FS30*i*, 16*i*)	

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 (FS15*i*)								FCBL
2006 (FS30*i*, 16*i*)								

FCBL (#0) Backlash compensation is not performed for the position in the full-closed mode.
1: Valid
0: 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 (FS15*i*)			BLEN					
2003 (FS30*i*, 16*i*)								

BLEN (#5) 1: To enable the backlash acceleration function

	#7	#6	#5	#4	#3	#2	#1	#0
1957 (FS15*i*)		**BLAT**						
2015 (FS30*i*, 16*i*)								

BLAT (#6) 1: To enable the two-stage backlash acceleration function

<6> Set the observer-related parameters.

> The procedure of this adjustment is the same as for an observer-related parameter adjustment made with the unexpected disturbance torque detection function (Subsec. 4.12.1). Make an adjustment according to steps <5> and <6> of the parameter adjustment procedure described in (3) in Subsec. 4.12.1 of this manual. The unexpected disturbance torque detection function is used, so that if an adjustment is already made, a readjustment need not be made.

(Related parameters)

1862 (FS15*i*)	**Observer gain**
2050 (FS30*i*, 16*i*)	

- When HRV1, HRV2, or HRV3 control is used:
  [Setting value] No change is required.
- When HRV4 control is used:
  [Setting value] 956 → To be changed to 264

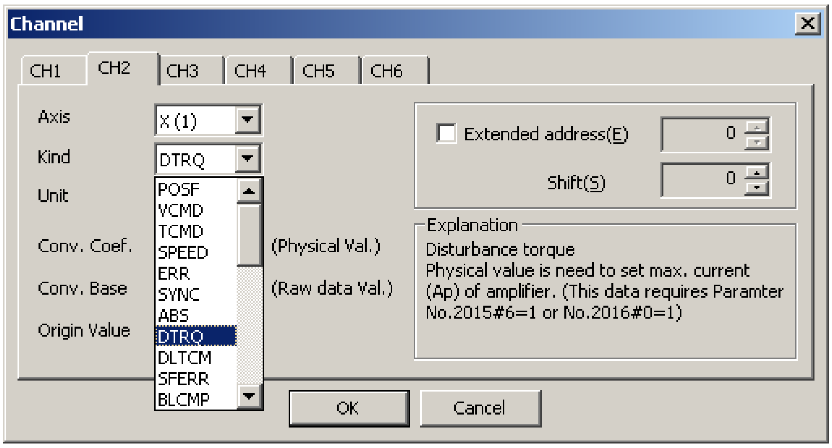
1863 (FS15*i*)	**Observer gain**
2051 (FS30*i*, 16*i*)	

- When HRV1, HRV2, or HRV3 control is used:
  [Setting value] No change is required.
- When HRV4 control is used:
  [Setting value] 510 → To be changed to 35

* When setting an observer gain, follow the settings of other functions (observer, unexpected disturbance torque detection). When the two-stage backlash acceleration function is used, the settings need not be changed.

<7> Adjust observer parameter POA1.
The 2-stage backlash acceleration function takes the friction torque as an estimated disturbance value by using the observer circuit and determines the first stage acceleration amount. Therefore, observer parameter POA1 must be adjusted to obtain correct acceleration. While observing estimated disturbance value DTRQ, perform acc./dec. to adjust POA1 to the optimum value.

The procedure for this adjustment is similar to the procedure for adjusting observer-related parameters in the unexpected disturbance torque detection function (Subsection 4.12.1). Make an adjustment by following steps <5> and <6> in (3), "Parameter adjustment methods", in Subsection 4.12.1 in this parameter manual. When the unexpected disturbance torque detection function is used, and the adjustment has already been made, re-adjustment is not needed.



1859 (FS15*i*) / 2047 (FS30*i*, 16*i*)	**Observer parameter (POA1)**

[Setting value] Adjusted value (Make an adjustment according to steps <5> and <6> in (3) in Subsec. 4.12.1.)

1980 (FS15*i*) / 2087 (FS30*i*, 16*i*)	**Torque offset parameter**

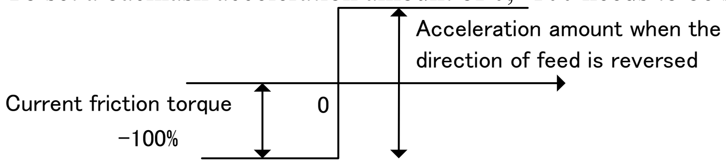
[Setting value] Adjusted value (If the center of an estimated disturbance value does not become zero on an axis such as the gravity axis, make an adjustment according to step <6> in (3) in Subsec. 4.12.1.)

<8> Adjusting the first stage acceleration
Specify the following parameters.

1860 (FS15*i*) / 2048 (FS30*i*, 16*i*)	**First stage backlash acceleration amount (%)**

[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%.)
To set a backlash acceleration amount of 0, -100 needs to be set.



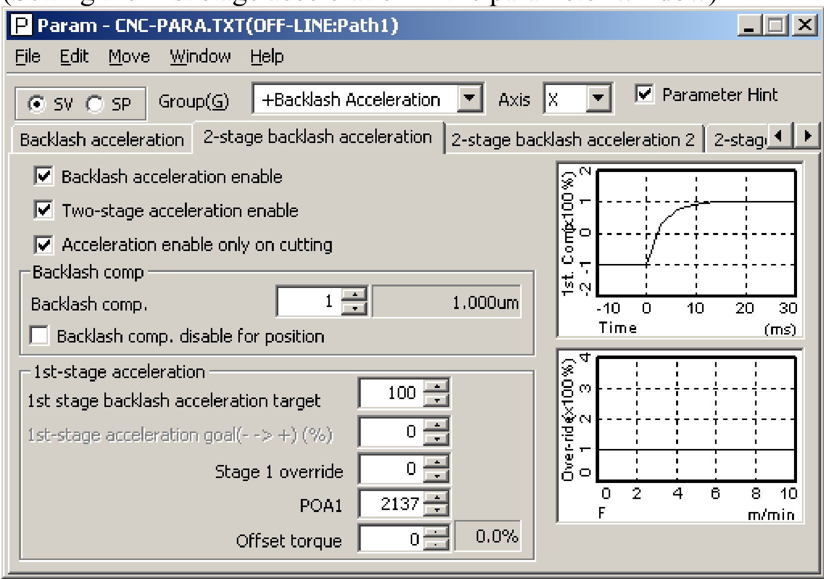
1987 (FS15*i*) 2094 (FS30*i*, 16*i*)	First stage acceleration amount from negative direction to positive direction (%)

[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*i*) or No. 2048 (Series 30*i*, 16*i*, and so on) specifies the first stage positive-to-negative backlash acceleration amount.

(Setting the first stage acceleration in the parameter window)



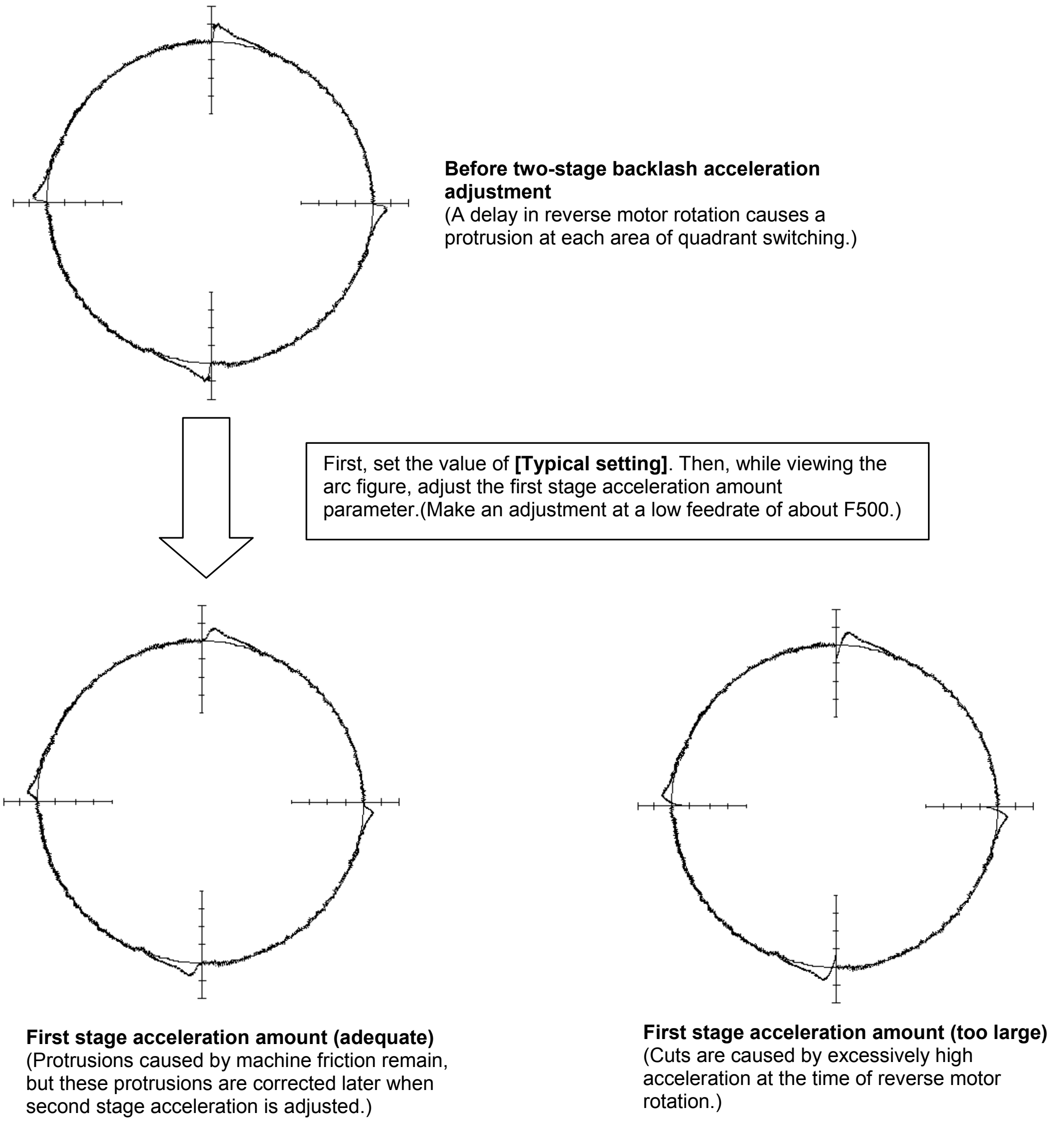


Fig. 4.6.7 (b) Two-stage backlash acceleration (first stage acceleration amount adjustment)

1975 (FS15*i*)	**Second stage start position (detection unit)**
2082 (FS30*i*, 16*i*)	

[Unit of data] Detection unit

[Typical setting] 10 (For a detection unit of 1 μm)
100 (For a detection unit of 0.1 μm)

NOTE
1 As the second stage start position, the absolute value of the setting is used.
2 When setting = 0, the specification of 100 is internally assumed.

1982 (FS15*i*)	Second stage end scale factor
2089 (FS30*i*, 16*i*)	

[Unit of data] In units of 0.1

[Valid data range] Series 90B0, 90B6, 90B5, 90D0, 90E0: 0 to 10279 (multiplication by 0 to 1027.9)
Series 9096: 0 to 642 (multiplication by 0 to 64.2)

[Typical setting] Normally, this value may be set to 0.

When the second stage end scale factor is set to 0, the second stage acceleration distance is assumed as follows:
If a positive value is set as the second stage start position, a value obtained by multiplying the start position by 2 is assumed.
If a negative value is set as the second stage start position, a value obtained by multiplying the start position by 3 is assumed.
By setting the second stage end scale factor, the second stage acceleration distance may be set to any value.

(Setting example)

When the second stage start position is set to 10, and the second stage end scale factor is set to 50 (meaning multiplication by 5), second stage acceleration is performed as shown below.

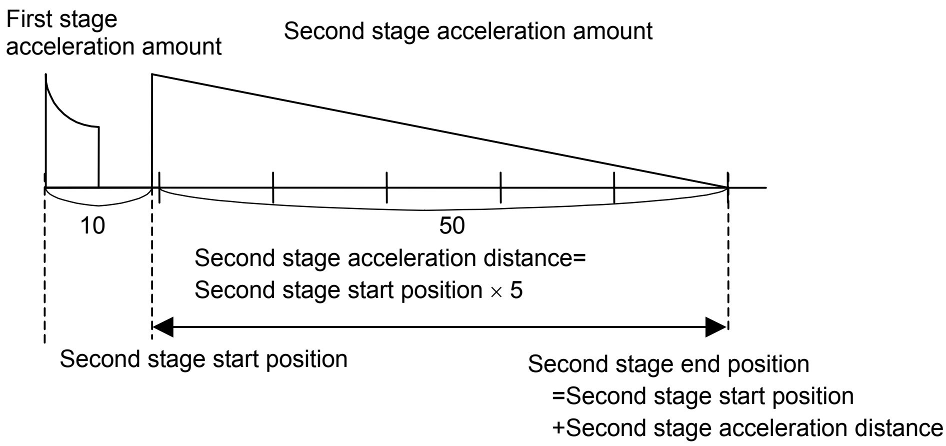
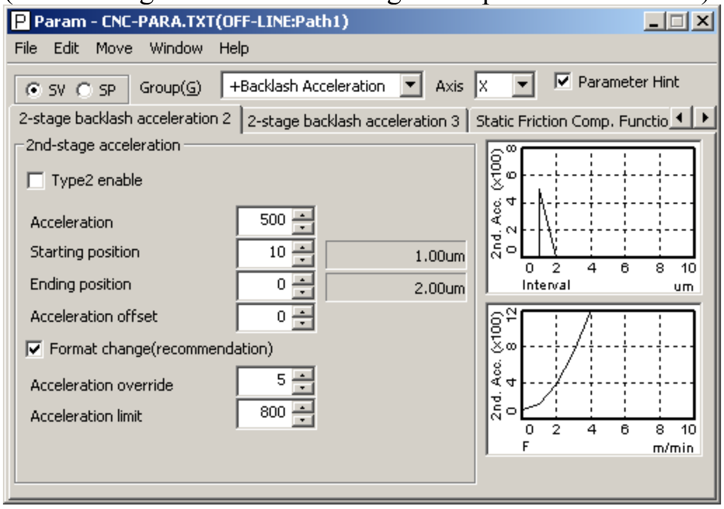
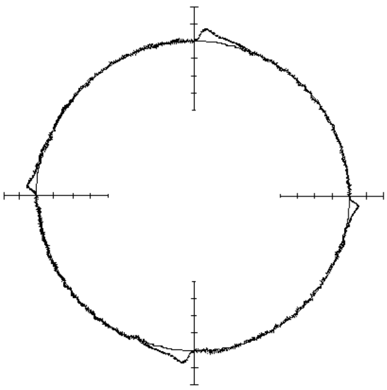


Fig. 4.6.7 (c) Second stage end scale factor

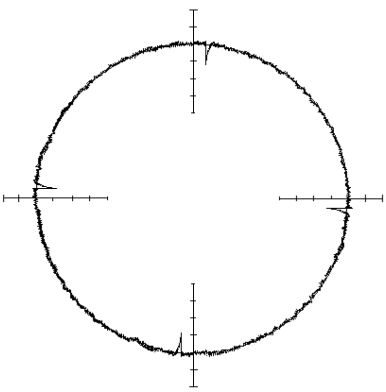
(Second stage acceleration setting in the parameter window)



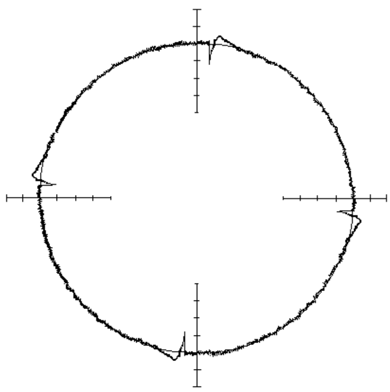


Before start/end parameter adjustment

Set the following:
Start/end parameter = Value of **[Typical setting]**
Second stage acceleration amount = 500
Then, adjust the start/end parameter while viewing the timing of second stage acceleration from the arc figure.



Start/end parameter (adequate)
(A larger second stage acceleration amount is set to view the timing of second stage acceleration, so that cuts occur. This is corrected later.)



Start/end parameter (insufficient)
(The time for second stage acceleration is too short, so that second stage protrusions are not fully eliminated.)

Fig. 4.6.7 (d) Two-stage backlash acceleration (adjustment of start position and end scale factor)

> **NOTE**
> Note that the two-stage backlash acceleration cannot be used together with the backlash stop function.

Second stage acceleration is not completed by nature until a distance specified by "Second stage end scale factor" is moved. For example, if only several microns are moved after the direction is reversed, second stage acceleration continues. To prevent such continued acceleration from occurring, set a maximum allowable duration of time with the parameter below.

1769 (FS15*i*)	Two-stage backlash acceleration end timer
2146 (FS30*i*, 16*i*)	

[Unit of data] ms
[Typical setting] 50

<9> Second stage acceleration adjustment
The two-stage backlash acceleration function has effect even if only first stage is used. However, a protrusion may linger because of machine friction. In such a case second stage is useful.
Adjust the second stage acceleration so that it falls in a range where no cut occurs.

1724 (FS15*i*)	Second stage acceleration amount for two-stage backlash acceleration
2039 (FS30*i*, 16*i*)	

[Typical setting] 100 (Too large a value could cause a cut at low feedrate.)

> **NOTE**
> When second stage acceleration is not used, set second stage acceleration amount = 0. The setting of second stage start position = 0 alone cannot disable second stage acceleration.

1790 (FS15*i*)	Second stage offset for two-stage backlash acceleration
2167 (FS30*i*, 16*i*)	

Normally, set 0.

Offset for the second stage acceleration amount. See Fig. 4.6.7 (a).

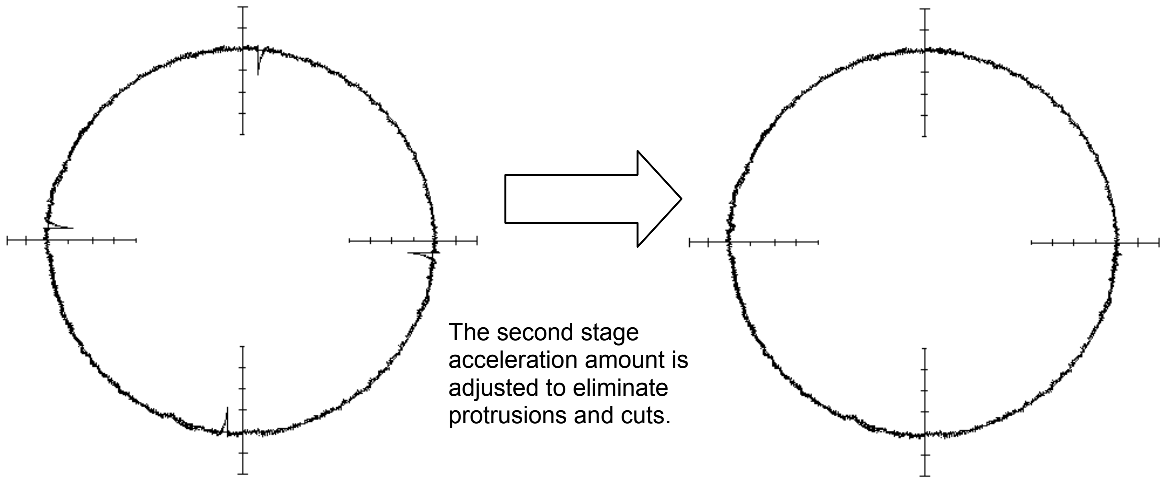


Fig. 4.6.7 (e) Two-stage backlash acceleration (second stage acceleration amount adjustment)

<10>Second stage acceleration override adjustment
Second stage acceleration amounts can be overridden according to the circular acceleration.

When using the second stage acceleration override function, set the following.

	#7	#6	#5	#4	#3	#2	#1	#0
1960 (FS15*i*) / 2018 (FS30*i*, 16*i*)						OVR8		

OVR8 (#2)
0: The format of the second stage acceleration override is in reference to 4096.
1: The format of the second stage acceleration override is in reference to 256.

Normally, set it to 1.

1725 (FS15*i*)	Second stage acceleration override
2114 (FS30*i*, 16*i*)	

[Valid data range] 0 to 32767

When the second stage acceleration override function is used, the second stage acceleration amount of two-stage backlash acceleration is found from the following formula:

(Second stage acceleration amount)=

$$\text{(Second stage acceleration amount setting)} \times \left\{ 1 + \alpha \times \frac{\text{(Second stage override setting)}}{\text{a}} \right\}$$

If OVR8 = 1, a = 256
If OVR8 = 0, a = 4096
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:

$$\alpha = \left\{ \frac{2}{R} \left(F / 60 \times 0.008 \right)^2 \right\} / P$$

So, the second stage override setting and acceleration amount are related as follows:

$$\text{(Second stage override setting)} = \frac{\text{a}}{\alpha} \times \left\{ \frac{\text{(Second stage acceleration amount)}}{\text{(Second stage acceleration amount setting)}} - 1 \right\}$$

Example)
When using a second stage acceleration amount override, adjust the backlash second stage acceleration amount for two types of feedrates. Suppose that the adjusted values below are obtained.
No. 1960#2 (Series 15*i*)=1, No. 2018#2 (Series 30*i*, 16*i*, and so on)=1

i) In the case of R10, F1000 (detection unit of 1 μm), the optimal second stage acceleration amount is 40.
ii) In the case of R10, F6000 (detection unit of 1 μm), the optimal second stage acceleration amount is 100.

From the results above, the expressions below are obtained.
For i)

$$\alpha = \left\{ \frac{2}{10} \left(1000/60 \times 0.008 \right)^2 \right\} \Big/ 0.001 = 3.56$$

Expressions <1>

$$\text{(Second stage override setting)} = \frac{256}{3.56} \times \left\{ \frac{40}{\text{(Second stage acceleration amount setting)}} - 1 \right\}$$

For ii)

$$\alpha = \left\{ \frac{2}{10} \left(6000/60 \times 0.008 \right)^2 \right\} \Big/ 0.001 = 128$$

Expressions <2>

$$\text{(Second stage override setting)} = \frac{256}{128} \times \left\{ \frac{100}{\text{(Second stage acceleration amount setting)}} - 1 \right\}$$

From expressions <1> and <2>, the following is obtained:

$$\frac{256}{3.56} \times \left\{ \frac{40}{\text{(Second stage acceleration amount setting)}} - 1 \right\}$$
$$= \frac{256}{128} \times \left\{ \frac{100}{\text{(Second stage acceleration amount setting)}} - 1 \right\}$$

Accordingly, (second stage acceleration amount setting) = 38.3 ≒ 38
From expression <2> (or from expression <1>), (second stage override setting) = 3.3 ≒ 3
Set these values in No. 1724 and No. 1725 (Series 15*i*) or No. 2039 and No. 2114 (Series 30*i*, 16*i*, and so on). This completes the setting of a second stage acceleration override.

NOTE
Second stage override is effective for second stage offset.

<11>Setting a limit to the second stage acceleration amount

Making an optimum override setting for low-speed and high-speed ranges may result in an insufficient acceleration amount in a medium-speed range. To avoid this problem, adjust overriding for low-speed and medium-speed ranges, and set an optimum value for the high-speed range in the following parameter as a limit value.

2751 (FS15*i*)	**Limit value for the two-stage backlash second stage acceleration amount**
2338 (FS30*i*, 16*i*)	

[Valid data range] 0 to 32767 (if this parameter is 0, no limit is placed to the second stage acceleration amount.)

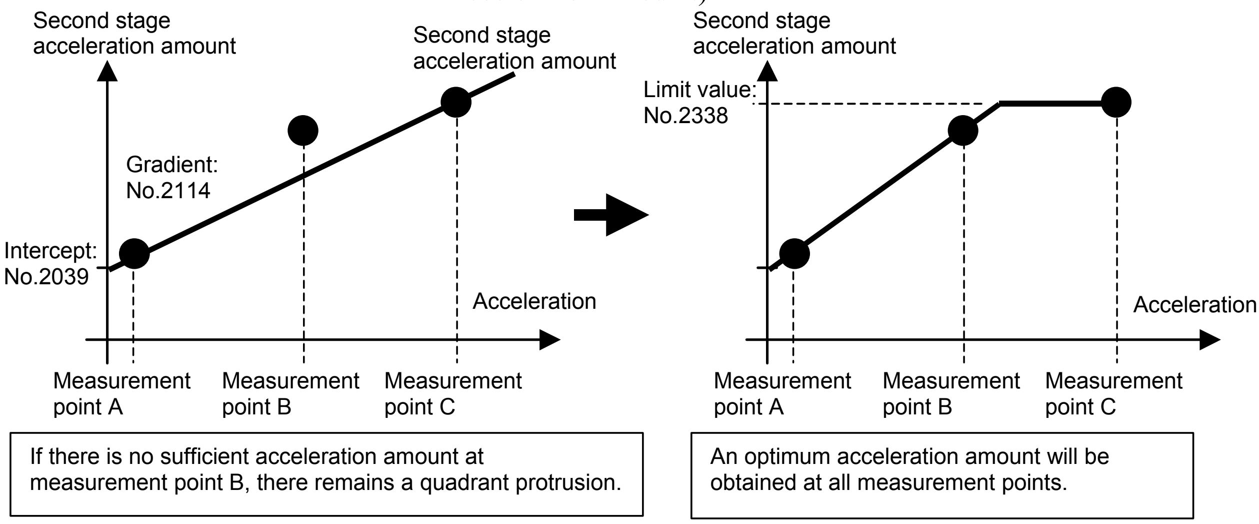


Fig. 4.6.7 (f) Override adjustment for the second stage acceleration amount of two-stage backlash acceleration

<12>Direction-specific setting for second stage acceleration

If the optimum second stage acceleration amount varies depending on the direction in which turn-over occurs, specify the following parameters.

2752 (FS15*i*)	**Two-stage backlash second stage acceleration amount override for turn-over from the negative direction to the positive direction**
2339 (FS30*i*, 16*i*)	

[Recommended value] 100

2753 (FS15*i*)	**Second stage acceleration amount override for turn-over from the negative direction to the positive direction**
2340 (FS30*i*, 16*i*)	

[Valid data range] 0 to 32767

Not used if the two-stage backlash second stage acceleration amount from the negative direction to the positive direction (parameter No. 2752 (for the Series 15*i*) and No. 2339 (for the Series 30*i*, 16*i*, and so on)) is 0.

This parameter takes effect when a reverse from the negative direction to the positive direction takes place if the two-stage backlash second stage acceleration amount from the negative direction to the positive direction (parameter No. 2752 (for the Series 15*i*) and No. 2339 (for the Series 30*i*, 16*i*, and so on)) is not 0.

It is not overridden if the setting is 0.

2754 (FS15*i*) / 2341 (FS30*i*, 16*i*)	Second stage acceleration limit value for turn-over from the negative direction to the positive direction

[Valid data range] 0 to 32767

Not used if the two-stage backlash second stage acceleration amount from the negative direction to the positive direction (parameter No. 2752 (for the Series 15*i*) and No. 2339 (for the Series 30*i*, 16*i*, and so on)) is 0. This parameter takes effect when a reverse from the negative direction to the positive direction takes place if the two-stage backlash second stage acceleration amount from the negative direction to the positive direction (parameter No. 2752 (for the Series 15*i*) and No. 2339 (for the Series 30*i*, 16*i*, and so on)) is not 0.

If the setting is 0, the second stage acceleration amount is not limited.

[Parameters used for direction-based setting]

Series30*i*,16*i*, and so on

Direction-based setting	Reverse direction	Second stage acceleration	Acceleration amount override	Acceleration limit value
None	Common	No.2039	No.2114	No.2338
Present	From + to -			
	From - to+	**No.2339**	**No.2340**	**No.2341**

Series 15*i*

Direction-based setting	Reverse direction	Second stage acceleration	Acceleration amount override	Acceleration limit value
None	Common	No.1724	No.1725	No.2751
Present	From + to -			
	From - to+	**No.2752**	**No.2753**	**No.2754**

(4) Neglecting backlash acceleration during feeding by the handle

By enabling the bit below, the backlash acceleration function can be enabled only during cutting feed.

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*) / 2009 (FS30*i*, 16*i*)		BLCU						

BLCU (#6) 1: To enable backlash acceleration only during cutting feed

> **NOTE**
> When bit 3 of No. 1800 is set to 1, the backlash acceleration function is enabled at all times, and switching is disabled.

With following series and editions of servo software, the bit 7 of parameter No. 2752 (for the Series 15*i*) or bit 7 of No. 2339 (for the Series 30*i*, 16*i*, and so on) can also be used to enable the backlash acceleration function only during cutting feed.

- Series 90B0/C(03) and subsequent editions
- Series 90B6/A(01) and subsequent editions
- Series 90B5/A(01) and subsequent editions
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

By using this bit, switching is enabled even when bit 3 of No. 1800 is set to 1. Backlash acceleration is enabled even at the hole bottom during rigid tapping.

	#7	#6	#5	#4	#3	#2	#1	#0
2611 (FS15*i*) 2223 (FS30*i*, 16*i*)	BLCUT2							

BLCUT2(#7) 1: The backlash acceleration function is enabled only during cutting feed.

(5) Two-stage backlash acceleration function (type 2)

When the 2-stage backlash acceleration function is used, quadrant protrusions may be reduced more effectively by starting the second stage acceleration as early as possible. The 2-stage backlash acceleration function type 2 enables the second stage acceleration immediately after a reverse operation takes place.

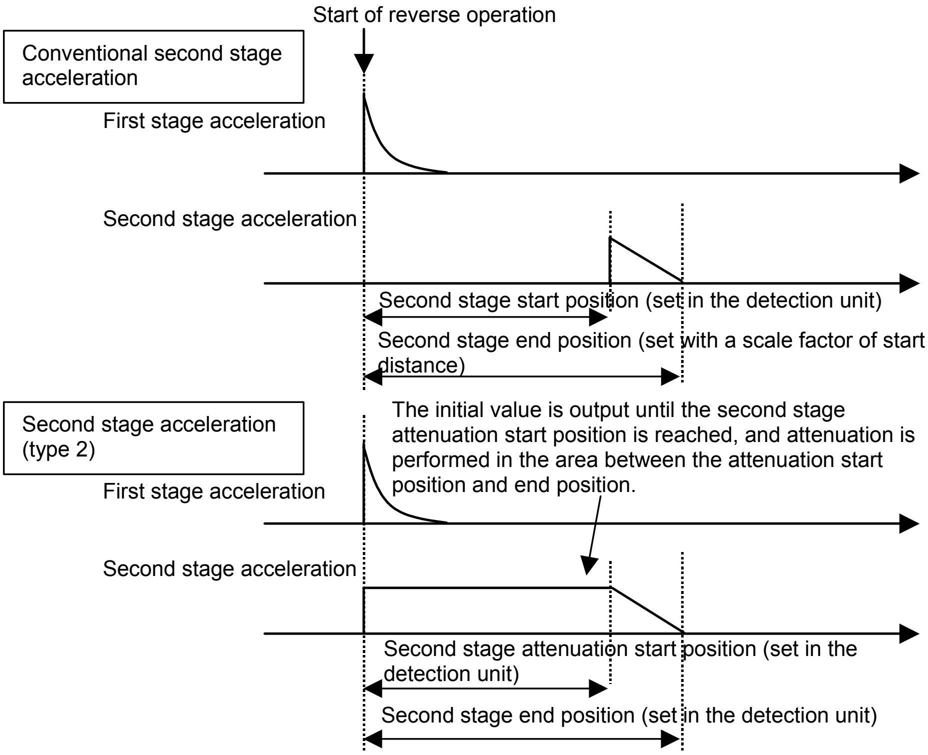
- Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- 90D0/A(01) and subsequent editions
- 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- 90B0/W(23) and subsequent editions
- 90B1/A(01) and subsequent editions
- 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- 90B5/A(01) and subsequent editions

- Comparison with the conventional second stage acceleration



Normally, second stage acceleration is not output until the second stage start distance is reached. The 2-stage backlash acceleration type 2 starts outputting the acceleration amount immediately after the reverse operation, and starts attenuation after the start distance.

- Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
2684(FS15*i*) / 2271(FS30*i*,16*i*)			2NDTMG					

2NDTMG(#5) 0: Does not use the 2-stage acceleration type 2.
1: Uses the 2-stage acceleration type 2.

1975(FS15*i*) / 2082(FS30*i*,16*i*)	Second stage attenuation start position

[Valid data range] 0 to 32767
[Unit od data] Detection unit
[Typical setting] 0 to 10 μm

1982(FS15*i*) / 2089(FS30*i*,16*i*)	Second stage end position

[Valid data range] 0 to 32767
[Unit od data] Detection unit
[Typical setting] 20 to 30 μm

> **NOTE**
> For the 2-stage backlash acceleration function type 2, the second stage end position is set directly in the detection unit.

4.6.8 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. 4.6.6 and Subsec. 4.6.7) 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.

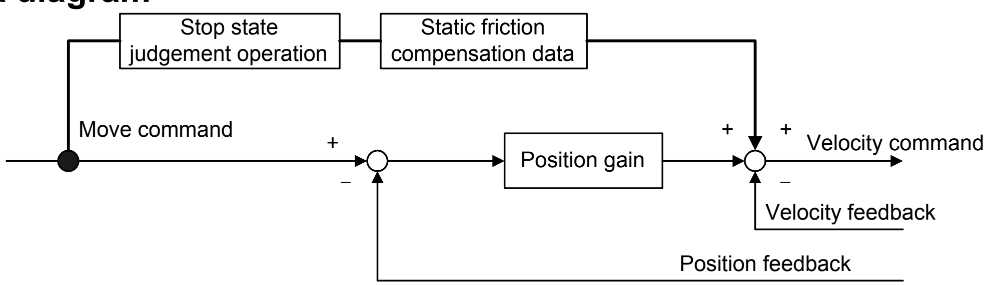
(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Block diagram



(4) Setting parameters

<1> Enable this function.

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) / 2003 (FS30*i*, 16*i*)			BLEN					

BLEN (#5) 1: The backlash acceleration function is enabled.

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) / 2005 (FS30*i*, 16*i*)	SFCM							

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

<2> Set adjustment parameters.

1964 (FS15*i*) / 2071 (FS30*i*, 16*i*)	Time during which the static friction compensation function is enabled (in 2-ms units)

[Valid data range] 0 to 32767
[Recommended value] 10

1965 (FS15*i*) / 2072 (FS30*i*, 16*i*)	Static friction compensation

[Valid data range] 0 to 32767
[Recommended value] 100
Offset for the velocity command that is to be added at the start of travel from a stopped state

1966 (FS15*i*) / 2073 (FS30*i*, 16*i*)	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.

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*) / 2009 (FS30*i*, 16*i*)	BLST							

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

1990 (FS15*i*) / 2097 (FS30*i*, 16*i*)	Parameter for stopping static friction compensation

[Valid data range] 0 to 32767
[Recommended value] 5
Parameter related to the distance the tool travels until the end of the static friction compensation function. Determine the setting by looking at the actual shape.

-	Static friction compensation (minus direction)
2347(FS30*i*)	

[Valid data range] 0 to 32767

Speed command offset applied when a movement is started from a stop in the minus (-) direction.

When No. 2347≠0, direction-by-direction static friction compensation is enabled. When a movement is made in the minus (-) direction, the value set in parameter No. 2347 is applied as a static friction compensation value. When a movement is made in the plus (+) direction, the value set in parameter No. 2072 is applied.

When No. 2347=0, the value set in parameter No. 2072 is used as a static friction compensation value.

No.2347	Applied static friction compensation		Remarks
	Movement in + direction	Movement in − direction	
0	No.2072	No. 2072	Disables direction-by-direction static friction compensation.
Non-zero value	No.2072	No. 2347	Enables direction-by-direction static friction compensation.

Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)

Series 90D0/J(10) and subsequent editions

Series 90E0/J(10) and subsequent editions

4.6.9 Torsion Preview Control Function

(1) Overview

For relatively large machines having torsion, torsion occurs between the motor and the machine end during acceleration and deceleration. In machines of this type, positional deviation is caused by torsion during acceleration and deceleration.
Torsion preview control compensates the speed command by estimating the amount of torsion from the position command. This reduces the amount of positional deviation during acceleration and deceleration.

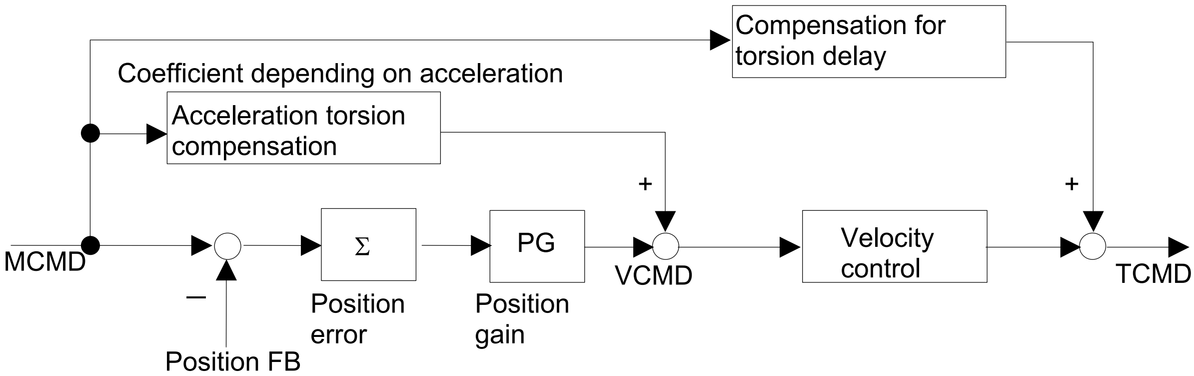


Fig. 4.6.9(a) Torsion preview control structure

(2) Series and editions of applicable servo software

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B0/W(23) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Notes

- This function works only in the nano interpolation mode.
- Because this function requires the user to observe the machine operation at the time of adjustment, a separate detector is needed.
- Enable the feed-forward function.
- The function is more effective when the time constant of acc./dec. is set so that acceleration changes smoothly. (Example: Bell-shaped acc./dec. before interpolation plus linear-shaped acc./dec. after interpolation)

(4) Setting parameters

<1> Setting feed-forward

Torsion preview control uses feed-forward processing. Therefore, the following parameter must be set:

	#7	#6	#5	#4	#3	#2	#1	#0
1883(FS15*i*) / 2005(FS16*i*)							FEED	

FEED(#1) The feed-forward function is:
0: Not used.
1: Used.
Set the parameter to use the feed-forward function. Since an error amount is observed to determine the compensation value during the adjustment, set 100% as the feed-forward coefficient for the feed for which torsion preview control is used.

1985(FS15*i*) / 2092(FS16*i*)	Advanced preview feed-forward coefficient (ADFF1)
1961(FS15*i*) / 2068(FS16*i*)	Feed-forward coefficient (FALPH)
1767(FS15*i*) / 2144(FS16*i*)	Position advanced preview feed-forward coefficient for cutting

When enabling torsion preview control also in rapid traverse, set FFR to 1 to enable feed-forward control during rapid traverse.

	#7	#6	#5	#4	#3	#2	#1	#0
1800(FS15*i*) / 1800(FS16*i*)					FFR			

FFR(#3) Feed-forward control during rapid traverse is:
0: Enabled.
1: Disabled.

<2> Operation measurement and time constant setting

To make adjustments, measure the velocity waveform and error amount.
The waveform may be measured using either the waveform display screen or SERVO GUIDE. When operating the machine at a feedrate of about F10 m/min, check that the following waveform is observed:

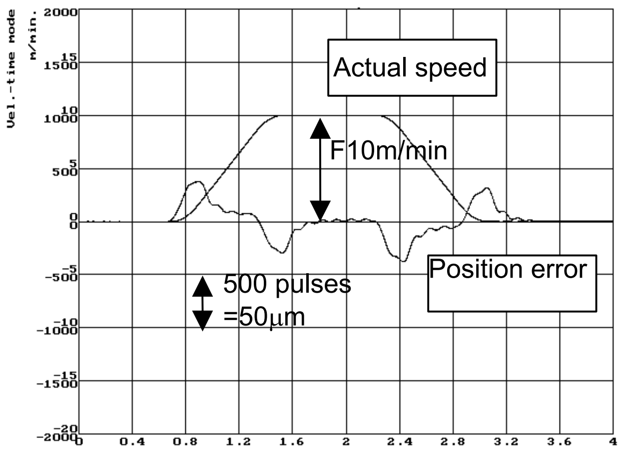


Fig. 4.6.9(b) Position error and actual speed

Torsion preview control differentiates position commands, so attention should be given to the command mode and time constant setting.
To ensure continuity of position command differential values, the bell-shaped time constant and the time constant of acc./dec. after interpolation must be set as well as the time constant of acc./dec. before interpolation. The adjustment examples presented here assume a large machine with a low resonance frequency of about 10 Hz and set a time constant that prevents the machine from shaking largely at the time of acc./dec.

Time constant of acc./dec. before interpolation
750 ms taken to reach F12000 mm/min
Acc./dec. before interpolation: bell-shaped time constant
200ms
Time constant of acc./dec. after interpolation
100ms

By setting the three time constants as explained above, the acceleration component of position commands form a bell shape, and the compensation value of torsion preview control also becomes smooth. The values of the time constants depend on the vibration status of the machine. So, set the time constants not to allow acc./dec. to cause large vibration.

For position command data resolution and smoothness, nano interpolation is used. When using torsion preview control, be sure to perform operation in a nano interpolation mode such as AI nano contour control or AI nano high precision contour control (when nano interpolation is disabled, torsion preview control is also disabled.)

<3> Setting the acceleration

In torsion preview control, three acceleration areas can be specified, and compensation coefficients can be set separately for these areas.
In a machine having the spring characteristic assumed by torsion preview control, there are almost proportional relationships between the acceleration and the torsion amount and position error. Therefore, setting the acceleration set for the time constant of acc./dec. before interpolation and one acceleration which is about 1/2 to 3/4 of the acceleration is normally sufficient.

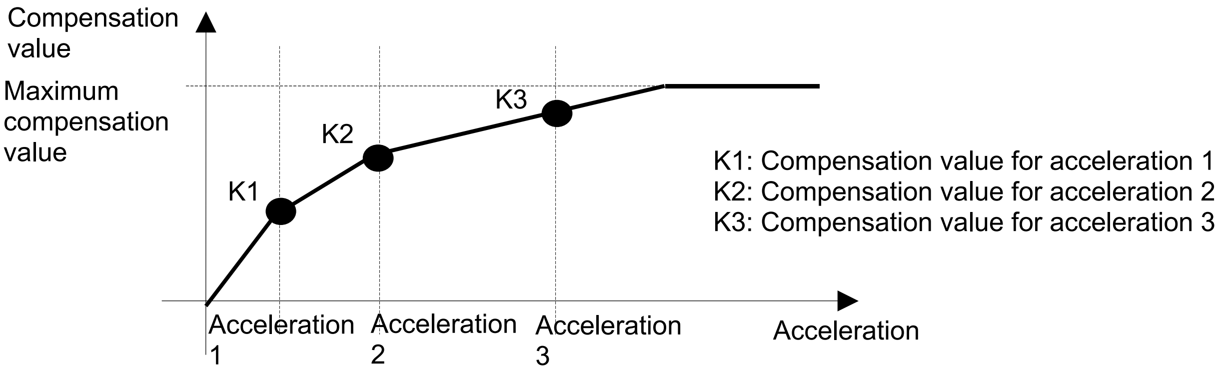


Fig. 4.6.9(c) Acceleration dependent compensation curve

2796(FS15*i*) / **2383(FS16*i*)**	**Torsion preview control: acceleration 1 (LSTAC1)**
2797(FS15*i*) / **2384(FS16*i*)**	**Torsion preview control: acceleration 2 (LSTAC2)**
2798(FS15*i*) / **2385(FS16*i*)**	**Torsion preview control: acceleration 3 (LSTAC3)**

[Unit of data] D × 1000 [mm/s^2] unit (D: detection unit (mm))
[Valid data raneg] 0 to 32767

- If the detection unit is 1 μm, the unit is 1 mm/s^2; if the detection unit is 0.1 μm, the unit is 0.1 mm/s^2.
- If the acceleration is set to 0, the setting is ignored.
- Set acceleration values so that acceleration 1 is smaller than acceleration 2, and acceleration 2 is smaller than acceleration 3. If acceleration 1 is greater than acceleration 2, the setting of acceleration 2 is ignored.

In this example, set the acceleration for the time constant of acc./dec. before interpolation and another lower acceleration.

- LSTAC2
  Time constant of acc./dec. before interpolation is 750ms taken to reach F12000mm/min
  → Acceleration = 12000/60/0.75 = 266.7mm/s^2
  If the detection unit is 0.1 μm, a value is set in units of 0.1 mm/s^2. Therefore,
  LSTAC2 = 2667

- LSTAC1
  Acceleration that is 3/4 of LSTAC2, 1000 ms taken to reach F12000 mm/min
  → Acceleration = 12000/60/1 = 200 mm/s^2, therefore, LSTAC1 = 2000
- LSTAC3
  LSTAC3 = 0 because LSTAC3 is not used.

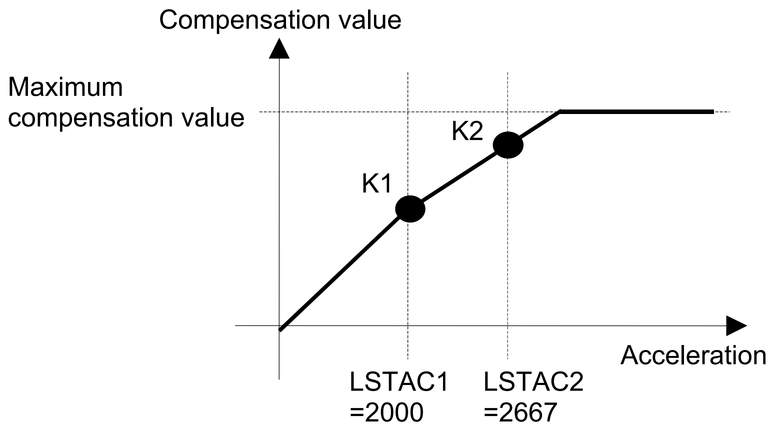


Fig. 4.6.9(d) Example of compensation curve

<4> Setting the acceleration torsion compensation value

The acceleration torsion compensation value is used to compensate the amount of torsion generated at a constant acceleration. While changing the acceleration setting, measure the position error generated at a constant acceleration.

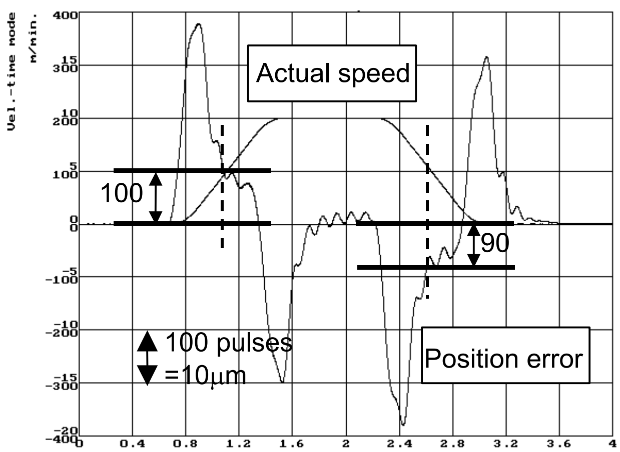


Fig. 4.6.9(e) Position error at LSTAC2

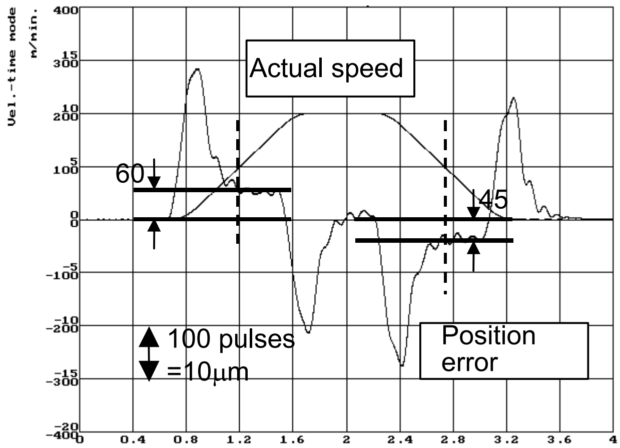


Fig. 4.6.9(f) Position error at LSTAC1

Set the values measured in Fig. 4.6.9 (e) and Fig. 4.6.9 (f) above in the acceleration torsion compensation values shown below.

(Acceleration torsion amount)

2799(FS15*i*) / 2386(FS16*i*)	**Torsion preview control: Acceleration torsion compensation value K1 (LSTK1)**

[Unit of data] Detection unit

[Valid data raneg] 0 to 32767

Set the torsion amount generated at acceleration 1 in the detection unit.
When 0 is set, compensation is disabled.

2800(FS15*i*) / 2387(FS16*i*)	**Torsion preview control: Acceleration torsion compensation value K2 (LSTK2)**

[Unit of data] Detection unit

[Valid data raneg] 0 to 32767

Set the torsion amount generated at acceleration 2 in the detection unit.
When 0 is set, acceleration 1 and the K1 setting are applied. (See Fig. 4.6.9(g).)

2801(FS15*i*) / 2388(FS16*i*)	**Torsion preview control: Acceleration torsion compensation value K3 (LSTK3)**

[Unit of data] Detection unit

[Valid data raneg] 0 to 32767

Set the torsion amount generated at acceleration 3 in the detection unit.
When 0 is set, acceleration 2 and the K2 setting are applied. (See Fig. 4.6.9(h).)
The compensation values are corrected automatically so that the following is satisfied: K1 ≤ K2 ≤ K3. (See Fig. 4.6.9(i).)

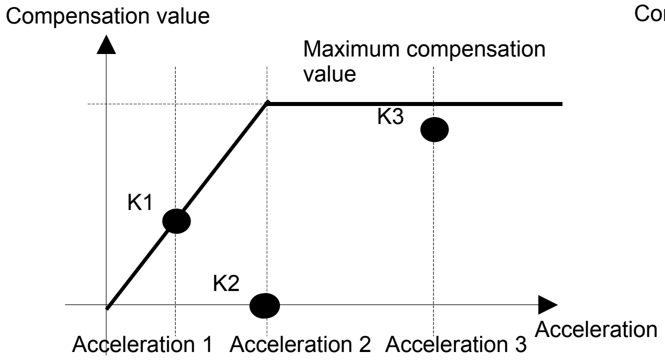


Fig. 4.6.9(g) Compensation curve when K2 = 0

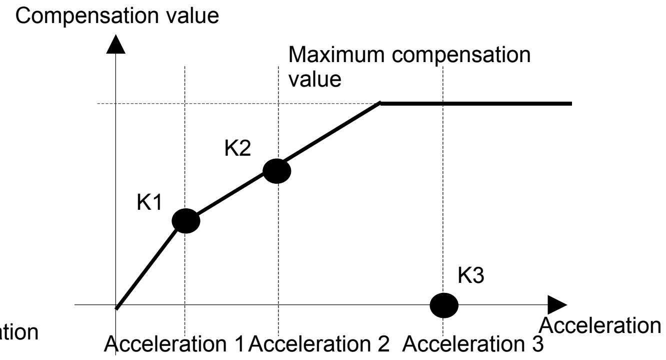


Fig. 4.6.9(h) Compensation curve when K3 = 0

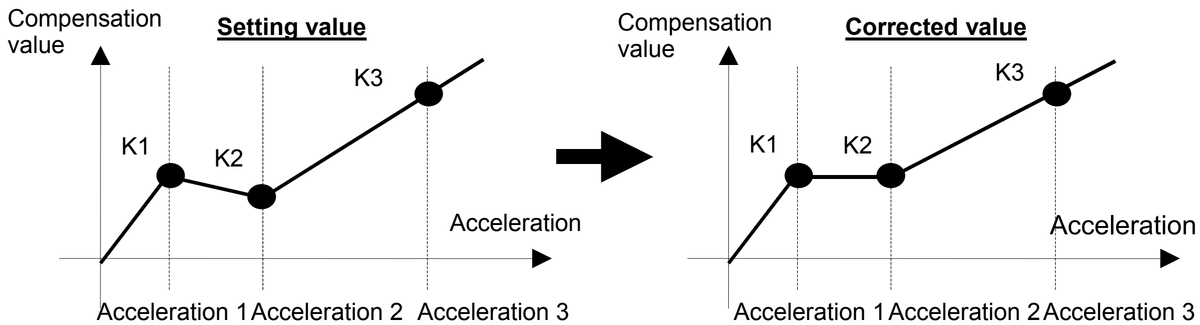


Fig. 4.6.9(i) Automatic compensation of the compensation curve

(Acceleration torsion amount for each direction)

2804(FS15*i*)	Torsion preview control: Acceleration torsion compensation value K1N (LSTK1N)
2391(FS16*i*)	

[Unit of data] Detection unit
[Valid data raneg] 0 to 32767

Set the amount of torsion generated at acceleration 1 (when the acceleration is a negative value) in the detection unit.

2805(FS15*i*)	Torsion preview control: Acceleration torsion compensation value K2N (LSTK2N)
2392(FS16*i*)	

[Unit of data] Detection unit
[Valid data raneg] 0 to 32767

Set the amount of torsion generated at acceleration 2 (when the acceleration is a negative value) in the detection unit.

2806(FS15*i*)	Torsion preview control: Acceleration torsion compensation value K3N (LSTK3N)
2393(FS16*i*)	

[Unit of data] Detection unit
[Valid data raneg] 0 to 32767

Set the amount of torsion generated at acceleration 3 (when the acceleration is a negative value) in the detection unit. If 4 is set, acceleration 2 and the settings up to K2 apply.

> ⚠ **CAUTION**
> When all the three accelerations are not used, set 0 in the parameter of the acceleration not used.

From Fig. 4.6.9 (e) and Fig. 4.6.9 (f), LSTK1 through LSTK3 and LSTK1N through LSTK3N are set as follows:

LSTK1=60, LSTK2=100, LSTK3=0
LSTK1N=45, LSTK2N=90, LSTK3N=0

<5> Setting the maximum compensation value (enabling torsion preview control)

2795(FS15*i*)	Torsion preview control: Maximum compensation value (LSTCM)
2382(FS16*i*)	

[Unit of data] Detection unit
[Valid data raneg] 0 to 32767

Set the maximum value of the compensation value to be added to the velocity command in the detection unit. By setting the parameter to a value greater than 0, torsion preview control is enabled. Set a value greater than the maximum position error value measured (a value obtained by multiplication by about 1.2 to 2).

LSTCM=500

The above setting enables this compensation, which reduces the position error generated at the time of acc./dec.

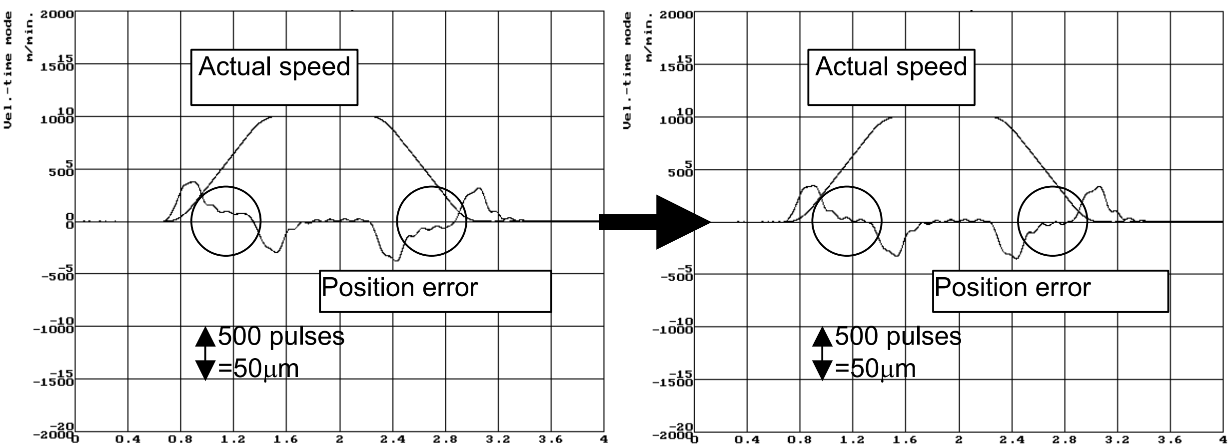


Fig. 4.6.9(j) Effect of acceleration torsion compensation

<6> Setting the torsion delay compensation value

Just with the acceleration torsion compensation value, the torsion amount generated at the start of acc./dec. due to delay in velocity control cannot be corrected, therefore there is a position error still left. Adjust the torsion delay compensation value while observing the waveform plotted at the time of acc./dec.

2802(FS15*i*)	Torsion preview control: Torsion delay compensation value KD (LSTKD)
2389(FS16*i*)	

2809(FS15*i*)	Torsion preview control: Torsion delay compensation value KDN (LSTKDN)
2396(FS16*i*)	

LSTKDN is used when there is a difference in delay between the start of acceleration and the start of deceleration.

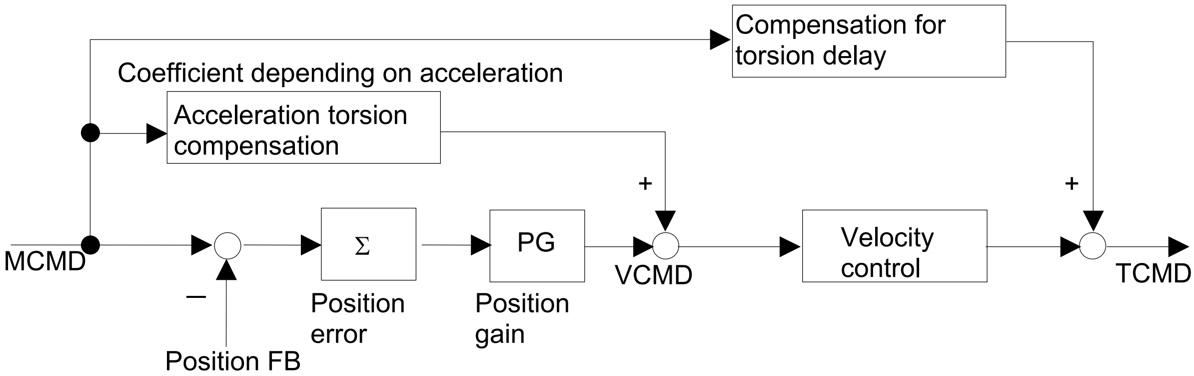


Fig. 4.6.9(k) Compensation for torsion delay

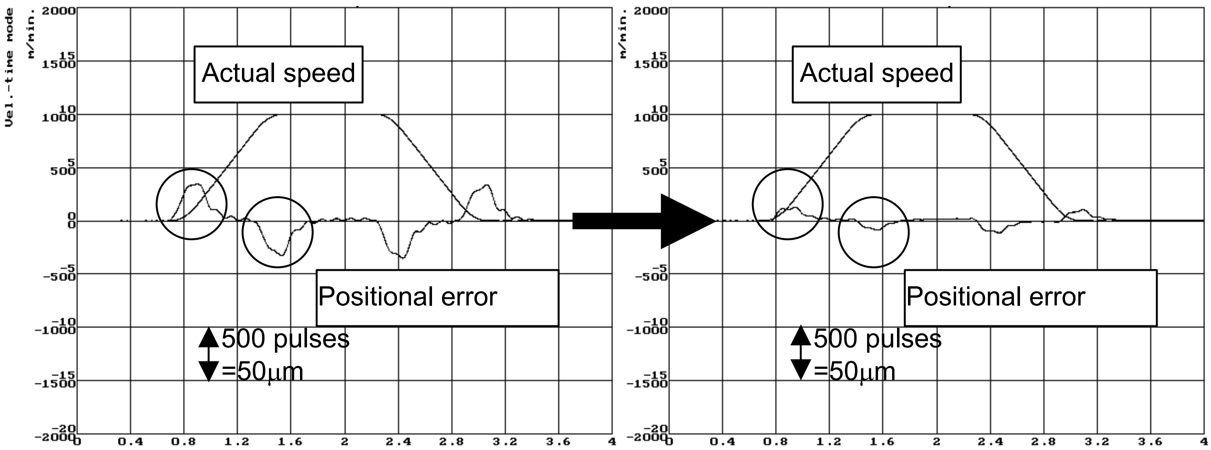


Fig. 4.6.9(l) Effect of compensation for torsion delay - 1

When the torsion delay compensation value is set to 2000, there is slight position error still left, so a fine adjustment is made. Then, the position error is decreased to 10 μm or less as shown in the figure below.

(Torsion delay compensation value =3000 / 2500)

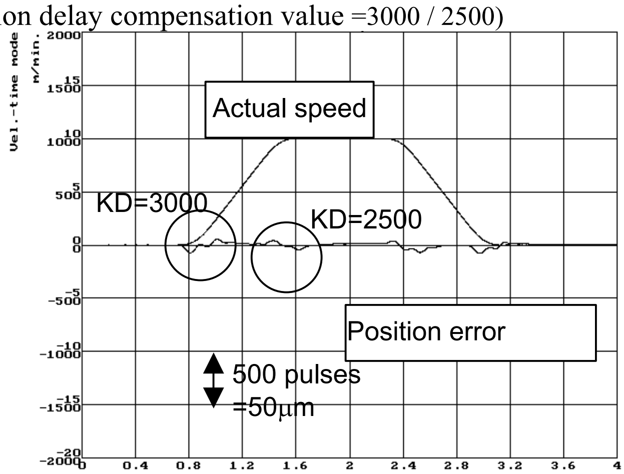


Fig. 4.6.9(m) Effect of compensation for torsion delay - 2

<7> Setting the torsion torque compensation coefficient

Torsion torque compensation is set when an adequate velocity loop gain cannot be obtained and acceleration torsion compensation does not work efficiently. The delay in velocity control can be compensated by adding the differential of the compensation value to TCMD.

2815(FS15*i*)	**Torsion preview control: Torsion torque compensation coefficient LSTKT**
2402(FS16*i*)	

[Unit of data] %

[Valid data range] 0 to 1000

Compensation coefficient used when the compensation value of VCMD is differentiated to compensate TCMD. When 100% is set as the compensation coefficient for TCMD, the acceleration amount of the motor itself is indicated.

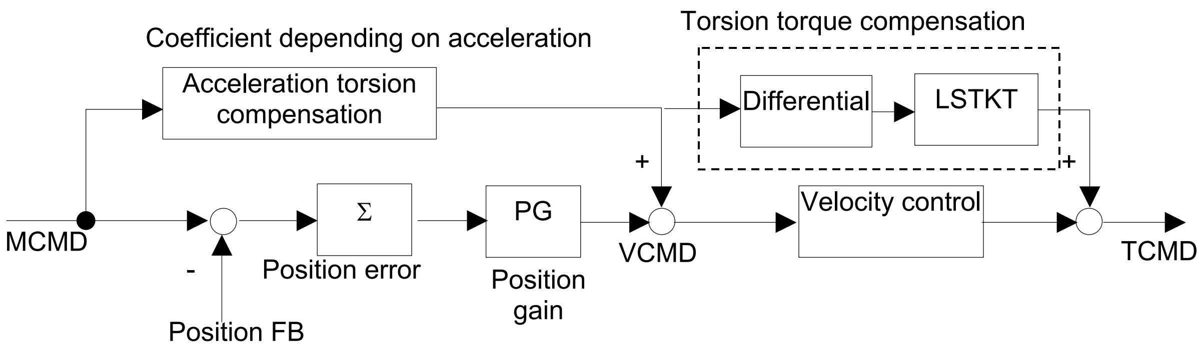


Fig. 4.6.9(n) Torsion torque compensation

4.7 OVERSHOOT COMPENSATION FUNCTION

(1) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) / 2003 (FS30*i*, 16*i*)		OVSC						

OVSC (#6) 1: To enable the overshoot compensation function

1857 (FS15*i*) / 2045 (FS30*i*, 16*i*)	Velocity loop incomplete integral gain (PK3V)

[Valid data range] 0 to 32767
[Recommended value] 30000

* Basically, reset the parameter to 0 if you do not use the overshoot compensation function.

1970 (FS15*i*) / 2077 (FS30*i*, 16*i*)	Overshoot compensation counter (OSCTP)

[Valid data range] 0 to 32767
[Recommended value] 20

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Explanation

(a) Servo system configuration

Fig. 4.7 (a) shows the servo system configuration. Fig. 4.7 (b) shows the velocity loop configuration.

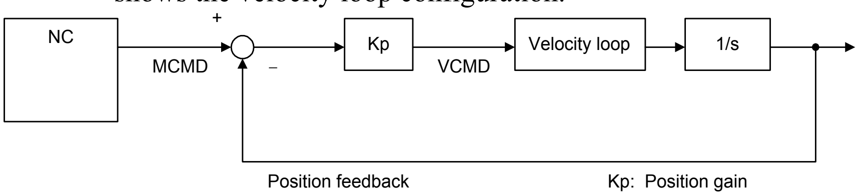


Fig. 4.7 (a) Digital servo system configuration

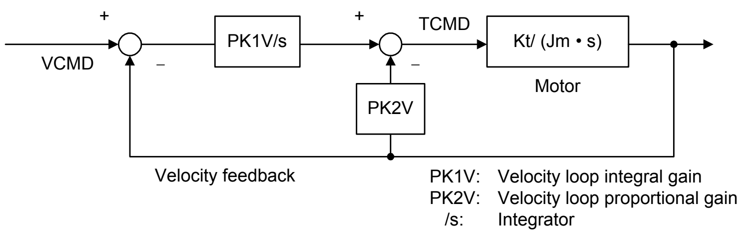


Fig. 4.7 (b) Velocity loop configuration

(b) When incomplete integration and overshoot compensation are not used.

First, 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 overcome 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).

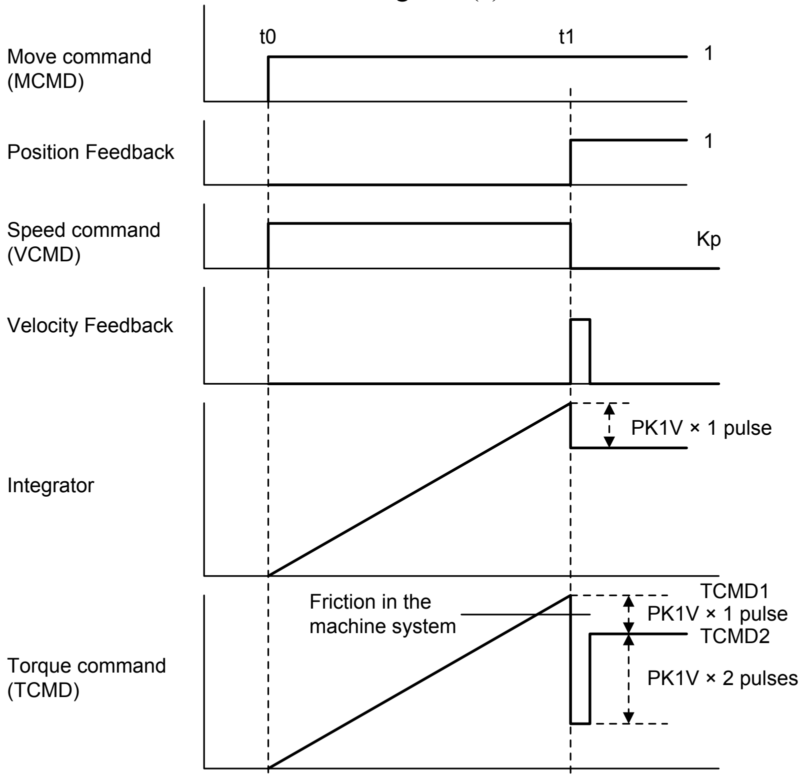


Fig. 4.7 (c) Response to 1 pulse movement commands

If Fig. 4.7 (c) on the previous page, the torque (TCMD1) when movement has started becomes greater than the machine static friction level. The motor will move 1 pulse, and finally stops 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)

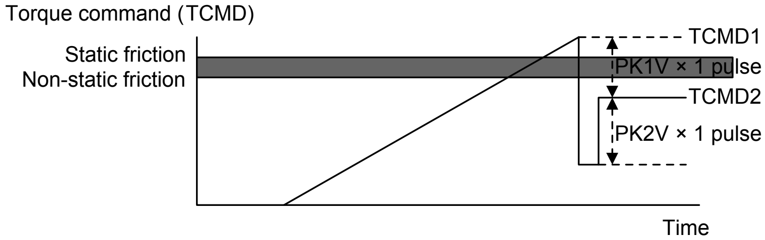


Fig. 4.7 (d) Torque commands (when there is no overshoot)

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

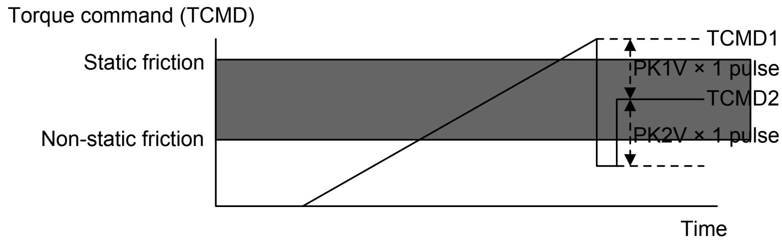


Fig. 4.7 (e) Torque commands (during overshoot)

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

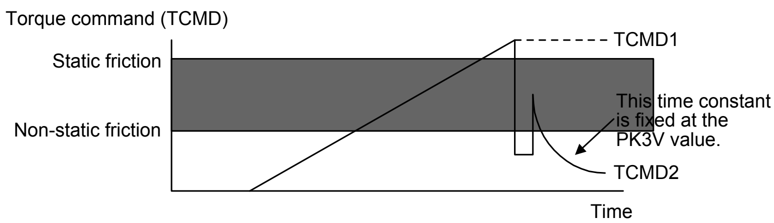


Fig. 4.7 (f) Torque command (when overshoot is used)

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.

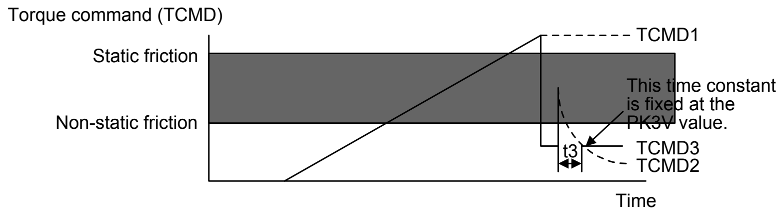


Fig. 4.7 (g) Torque command (using improved type overshoot compensation)

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) Setting parameters

1994 (FS15*i*)	Overshoot compensation enable level
2101 (FS30*i*, 16*i*)	

[Valid data range] 0 to 32767

[Unit of data] Detection unit

[Recommended value] 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.

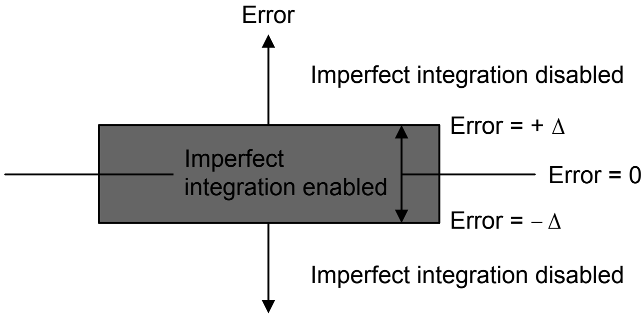


Fig. 4.7 (h) Relationship between error and overshoot compensation

(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 integration is set.

This is caused by the repeated occurrence of the following phenomena:

- While the machine is in the stopped state, the position error 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 position error to exceed the compensation valid level.
- While the position error is beyond the threshold, a torque command is output to decrease the position error, then it decreases to below the threshold again.

In such a case, set the bit indicated below to suppress the minute vibration.

(b) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) / **2202 (FS30*i*, 16*i*)**					**OVS1**			

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

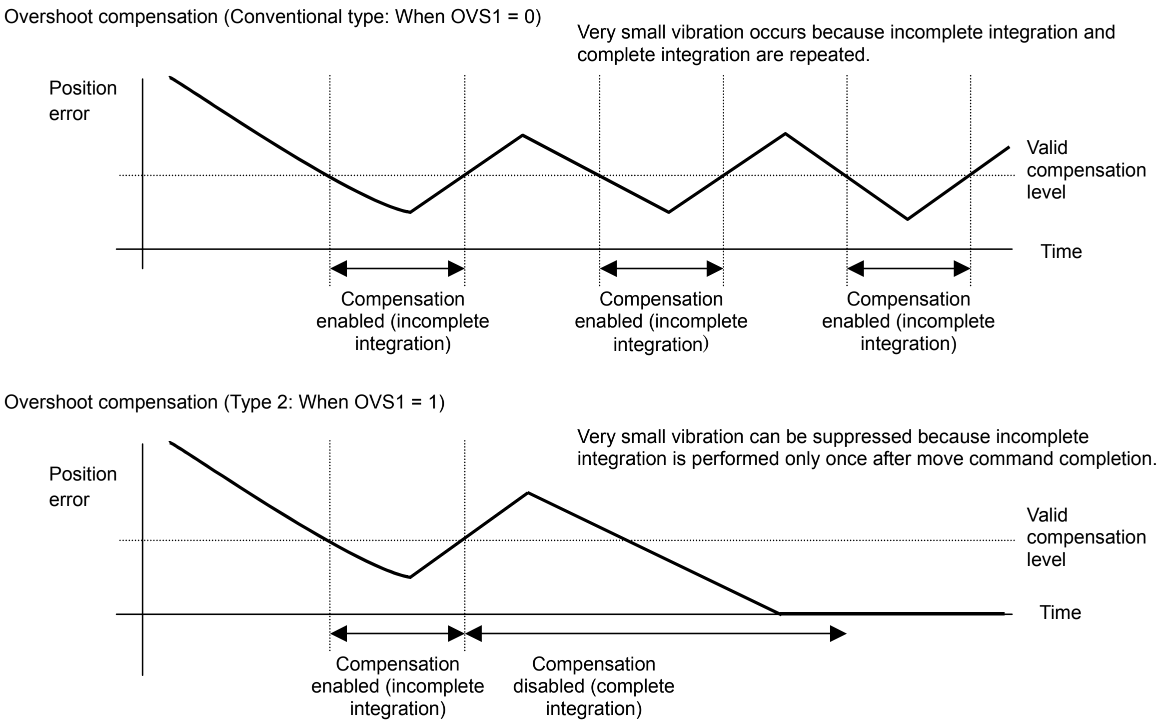


Fig. 4.7 (i) Overshoot compensation type 2

4.8 HIGH-SPEED POSITIONING FUNCTION

High-speed positioning is used in the following cases:

<1> To perform point-to-point movement quickly, where the composite track of two or more simultaneous axes can be ignored such as, for example, in a punch press

<2> To speed up positioning in rapid traverse while errors in the shape during cutting must be minimized (reduction of cycle time)

In case <1>, the position gain switching function and the low-speed integral function are effective (⇒ See Subsec. 3.3.2, "High-Speed Positioning Adjustment Procedure"). For the application of <2> above, a combination of the fine acc./dec. (FAD) function and rapid traverse feed-forward is useful. In the Series 30*i*, 31*i*, and 32*i*, nano interpolation is always enabled, so the fine acc./dec. function is unnecessary. For the use in <2> above, only the setting of the feed-forward function is required.

This section explains these functions.

4.8.1 Position Gain Switching 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 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

<1> This parameter specifies whether to enable the position gain switching function as follows:

	#7	#6	#5	#4	#3	#2	#1	#0
1957 (FS15*i*) 2015 (FS30*i*, 16*i*)								PGTW

PGTW (#0) The position gain switching function is used.
1: Valid
0: Invalid

<2> This parameter specifies whether to set the velocity at which position gain switching is to occur, as follows:

1713 (FS15*i*) 2028 (FS30*i*, 16*i*)	Limit speed for enabling position gain switching

The position gain is doubled with a speed lower than or equal to the speed specified above.

[Unit of data] Rotary motor: 0.01 min^{-1}
Linear motor: 0.01 mm/min
[Valid data range] 0 to 32767
[Recommended value] 1500 to 5000

> **REFERENCE**
> Using the high-speed positioning velocity increment system magnification function (→ (5) in Subsec. 4.8.1) can increase the effective velocity to ten times.

Fig. 4.8.1 (a) shows the relationships between the position error and velocity command.

(4) When the feed-forward function is used at the same time (position gain switching function type 2)

When using the position gain switching function together with the feed-forward function, make the setting below.

(a) Overview

When the conventional position gain switching 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) Setting parameters

In addition to the parameter of the position gain switching function described earlier, set the following parameter.

	#7	#6	#5	#4	#3	#2	#1	#0
1744 (FS15*i*) / 2204 (FS30*i*, 16*i*)			PGTWN2					

PGTWN2 (#5) Specifies whether to double the feed-forward-based effect at position gain switching as follows:

1: Not to double
0: To double

> **NOTE**
> This function is invalid when the VCMD interface is in use.
> (When the VCMD interface is in use, set PGTWN2 = 0.)

(5) 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 integral functions) to ten times.

(b) Setting parameters

Using the following parameter can change the increment system for the effective velocity.

	#7	#6	#5	#4	#3	#2	#1	#0
1744 (FS15*i*) / 2204 (FS30*i*, 16*i*)							HSTP10	

HSTP10 (#1) Specifies the effective velocity increment system for the high-speed positioning functions (position gain switch and low-speed integral functions) as follows:

1: 0.1 min^{-1} (rotary motor), 0.1 mm/min (linear motor)
0: 0.01 min^{-1} (rotary motor), 0.01 mm/min (linear motor)

> **NOTE**
> 1 The value set in this function applies to the increment system of both the "position gain switching function" and "low-speed integral function."
> 2 When this function is set, the error amount in constant-speed feed and the actual position gain indication on the CNC do not match the logical values.

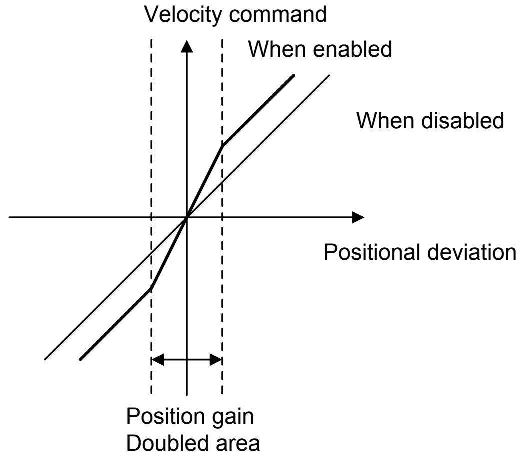


Fig. 4.8.1 (a) Position gain switching

4.8.2 Low-speed Integral 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 integral 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 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

<1> Specify whether to enable the low-speed integral function.

	#7	#6	#5	#4	#3	#2	#1	#0
1957 (FS15*i*) 2015 (FS30*i*, 16*i*)							SSG1	

SSG1 The low-speed integral function is used.
1: Valid
0: Invalid

<2> Specify whether to enable integration at acc./dec. time.

1714 (FS15*i*) 2029 (FS30*i*, 16*i*)	Limit speed for disabling low-speed integral at acceleration

The integral gain is invalidated during acceleration at a speed higher than or equal to the specified speed.

[Unit of data] Rotary motor: 0.01 min^{-1}
Linear motor: 0.01 mm/min

[Valid data range] 0 to 32767

[Recommended value] 1000

1715 (FS15*i*)	Limit speed for enabling low-speed integral at deceleration
2030 (FS30*i*, 16*i*)	

The integral gain is validated during deceleration at a speed lower than or equal to the specified speed.

[Unit of data] Rotary motor: 0.01 min^{-1}
Linear motor: 0.01 mm/min

[Valid data range] 0 to 32767

[Recommended value] 1500

REFERENCE

Using the high-speed positioning velocity increment system magnification function (→ (5) 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).

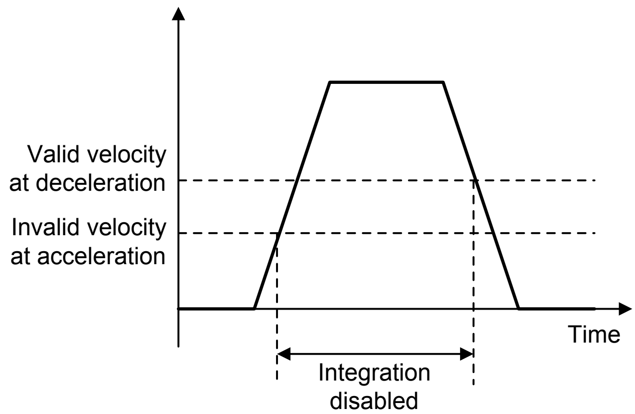


Fig. 4.8.1 (b) Integration invalid range at low-speed integral

4.8.3 Fine Acceleration/Deceleration (FAD) Function

(1) Overview

The fine acceleration/deceleration (fine acc./dec.) function enables smooth acc./dec. This is done by using servo software to perform acc./dec. processing, which previously has been performed by the CNC. With this function, the mechanical stress and strain resulting from acc./dec. can be reduced.

(2) Features

- Acc./dec. is controlled by servo software at short intervals, allowing smooth acc./dec.
- Smooth acc./dec. 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 acc./dec. command types are supported: bell-shaped and linear acc./dec. types.
- An application of the fine acc./dec. 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

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

> **NOTE**
> In the Series 30*i*, 31*i*, and 32*i*, smooth acc./dec. is always performed by nano interpolation, so the fine acc./dec. function is unnecessary. (The settings for the function are also ignored.)

(4) Setting basic parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1951 (FS15*i*) 2007 (FS30*i*, 16*i*)		FAD						

FAD (#6) 1: Enables the fine acc./dec. 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 (FS15*i*)						FADL		
2209 (FS30*i*, 16*i*)								

FADL (#2) 0: FAD bell-shaped
1: FAD linear type
* Set 1 (linear type) usually .

> **NOTE**
> To enable this bit setting, the power must be turned off then back on.

1702 (FS15*i*)	Fine acc./dec. time constant (ms)
2109 (FS30*i*, 16*i*)	

[Valid data range] 8 to 64 (Standard setting: 24)
A value exceeding the valid data range is clamped to the upper or lower limit of the range.
When the fine acc./dec. 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 (FS15*i*)	Position feed-forward coefficient (in units of 0.01%)
2092 (FS30*i*, 16*i*)	

[Valid data range] 100 to 10000

> **NOTE**
> 1 Feed-forward control is enabled by setting bit 1 of No. 1883 (Series 15*i*) or No. 2005 (Series 16*i* and so on) to 1.
> 2 The velocity feed-forward coefficient is set in parameter No. 1962 (Series 15*i*) or No. 2069 (Series 16*i* and so on) which is the same parameter as that used for normal operation.
> 3 Generally, the fine acc./dec. function is enabled in cutting mode only.
> 4 If bit 3 of No. 1800 is set to 1, the FAD function is enabled both for cutting and rapid traverse mode.

(5) Setting parameters for the fine acc./dec. function, used separately for cutting and rapid traverse

As mentioned above, set the fine acc./dec. 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 (FS15*i*)					FFR			
1800 (FS30*i*, 16*i*)								

FFR (#3) 1: Enables feed-forward in rapid traverse also.

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) / 2202 (FS30*i*, 16*i*)								FADCH

FADCH (#0) 1: Enables the fine acc./dec. 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 (FS15*i*) / 2143 (FS30*i*, 16*i*)	Fine acc./dec. time constant 2 (ms)

[Valid data range] 8 to 64
A value that falls outside this range, if specified, is clamped to the upper or lower limit.

1767 (FS15*i*) / 2144 (FS30*i*, 16*i*)	Position feed-forward coefficient for cutting (in units of 0.01%)

1768 (FS15*i*) / 2145 (FS30*i*, 16*i*)	Velocity feed-forward coefficient for cutting (%)

In rapid traverse mode, the following parameters are used:

1702 (FS15*i*) / 2109 (FS30*i*, 16*i*)	Fine acc./dec. time constant (ms)

[Valid data range] 8 to 64
A value that falls outside this range, if specified, is clamped to the upper or lower limit.

1985 (FS15*i*) / 2092 (FS30*i*, 16*i*)	Position feed-forward coefficient for rapid traverse (in units of 0.01%)

1962 (FS15*i*) / 2069 (FS30*i*, 16*i*)	Velocity feed-forward coefficient for rapid traverse (%)

NOTE
1 When the settings above are made, both of the fine acc./dec. time constant and feed-forward coefficient can be automatically switched for cutting feed or rapid traverse. To switch the feed-forward coefficient only, use the cutting feed/rapid traverse switchable feed-forward function. (See Subsec. 4.6.4.)
2 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.

Table 4.8.3 Feed-forward coefficient and fine acc./dec. time constant parameters classified by use

Series 16*i*, 18*i*, 21*i*, 0*i*

	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 (cutting FF + rapid traverse 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 acc./dec. 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 the synchronization function with the spindle axis and fine acc./dec.

The restrictions listed below are imposed on the combined use of the synchronization function between the servo axis and spindle axis and the fine acc./dec. function.
(Disable the fine acc./dec. function if the combine use is impossible.)

<table>
<tr><th rowspan="2">Function</th><th colspan="2">Use of FAD for servo axis</th><th rowspan="2">Cautions for combined use</th></tr>
<tr><th>When FAD is disabled for spindle axis</th><th>When FAD is enabled for spindle axis</th></tr>
<tr><td>Rigid tapping</td><td>Allowed</td><td>Allowed</td><td>When FAD is disabled for spindle axis :
During rigid tapping, FAD and feed-forward control are disabled. For synchronization, the position gain for the servo axis must be changed. See (7).
When FAD is enabled for spindle axis :
The same FAD time constant, acc./dec. type, feed-forward coefficient, and position gain must be used for the servo axis (during cutting) and the spindle axis.</td></tr>
<tr><td>Advanced preview control rigid tapping</td><td>Not allowed</td><td>Allowed</td><td>The same FAD time constant, acc./dec. type, feed-forward coefficient, and position gain must be used for the servo axis (during cutting) and the spindle axis.</td></tr>
<tr><td>Cs axis contour control</td><td>Not allowed</td><td>Allowed</td><td>The same FAD time constant, acc./dec. type, feed-forward coefficient, and position gain must be used for the servo axis (during cutting) and the spindle axis.</td></tr>
<tr><td>Hob function</td><td>Not allowed</td><td>Not allowed</td><td>Disable the fine acc./dec. function.</td></tr>
<tr><td>EGB function</td><td>Not allowed</td><td>Not allowed</td><td>Disable the fine acc./dec. function.</td></tr>
<tr><td>Flexible synchronization</td><td>Not allowed</td><td>Allowed</td><td>The same FAD time constant, acc./dec. type, feed-forward coefficient, and position gain must be used for the servo axis (during cutting) and the spindle axis.</td></tr>
</table>

NOTE

The spindle FAD function can be used when an αi spindle amplifier and FANUC Series 16*i*/18*i*/21*i* MODEL B CNC are used.

Spindle software : Series 9D50/E(05) and subsequent editions

CNC software : M series : Series B0H1/M(13) and subsequent editions,
Series BDH1M(13) and subsequent editions,
Series DDH1/M(13) and subsequent editions,
Series BDH5/C(03) and subsequent editions

T series : Series B1H1/M(13) and subsequent editions
Series BEH1/M(13) and subsequent editions
Series DEH1/M(13) and subsequent editions

For details of the spindle FAD function, refer to "FANUC AC SPINDLE MOTOR αi series Parameter Manual (B-65280EN)".

Function	Combined use with FAD function	Cautions for combined use
Flexible synchronization (between servo axes)	Allowed	For the axes to be synchronized with each other, the same FAD time constant, feed-forward coefficient, and position gain must be set.

(7) Rigid tapping synchronization when spindle axis FAD is disabled

(a) Overview

Because using fine acc./dec. causes the servo axis delay (error) to increase by 1 ms, rigid tapping with fine acc./dec. 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 acc./dec. In this case, disable fine acc./dec.

(b) Setup procedure

By setting the parameter below, the position gain can be automatically changed only for the servo axis to establish synchronization.

(Parameter)

	#7	#6	#5	#4	#3	#2	#1	#0
1749 (FS15*i*) **2209 (FS30*i*, 16*i*)**					FADPGC			

FADPGC (#3) Specifies whether to perform synchronization in rigid tapping mode when FAD is set up, as follows:

1: <u>To perform ← To be set</u>
0: Not to perform

> **NOTE**
> 1 After setting this bit, switch the power off and on again.
> 2 If this parameter is set, the servo position gain increases by 1 ms even when rigid tapping is not used.
> 3 It is necessary to set this parameter for all axes that are subjected to contouring.

(Reference)

With Series 16*i* and so on, two types of parameters are available for position gain setting. By setting the parameters as described below, a position gain match can be ensured between the servo axis and spindle.

> **NOTE**
> Do not make following setting when FADPGC = 1 is set.

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 acc./dec. 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

(8) Other specifications to note regarding the fine acc./dec. function

- Advanced preview control and fine acc./dec. can be used together. (The time constants before and after advanced preview interpolation, and the fine acc./dec. time constant are effective.)
- If FAD is set, then the G05 P10000 command is issued with HPCC, FAD is disabled.
- Using the FAD function increases the position error as follows:
  - For FAD bell-shaped
    Deviation incerase (pulses) =
    $$\frac{\text{Feedrate (mm/min)}}{60 \times 1000 \times \text{Detection unit (mm)}} \times \left(\frac{\text{FAD time constant (ms)}}{2} + 1 \right)$$
  - For FAD linear type
    Deviation incerase (pulses) =
    $$\frac{\text{Feedrate (mm/min)}}{60 \times 1000 \times \text{Detection unit (mm)}} \times \left(\frac{\text{FAD time constant (ms)} + 1}{2} + 1 \right)$$

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 position error is normally expressed as follows:

Normal deviation (pulses) =

$$\frac{\text{Feedrate (mm/min)}}{60 \times \text{Position gain (1/s)} \times \text{Detection unit (mm)}}$$

$$= \frac{1800}{60 \times 30 \times 0.001} = 1000(pulses)$$

When the FAD function (FAD bell-shaped) is used with the time constant set to 64 ms, the deviation increases as follows:

Deviation incerase (pulses) =

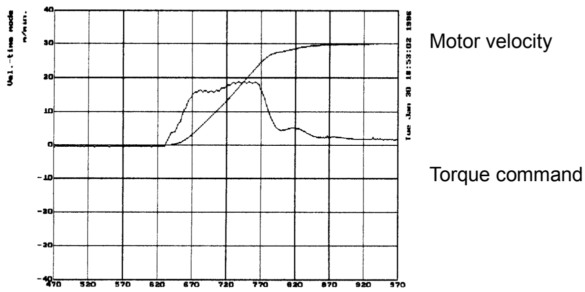
$$\frac{1800}{60 \times 1000 \times 0.01} \times \left(\frac{64}{2} + 1 \right) = 990(pulses)$$

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

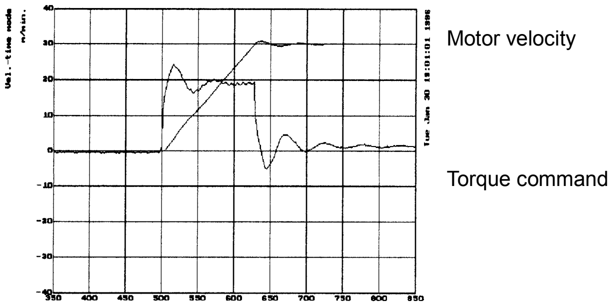
Deviation when FAD is used (pulses) = 1000 + 990
= 1990 (pulses)

The combined use of the FAD function and the feed-forward function does not increase the position error 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.

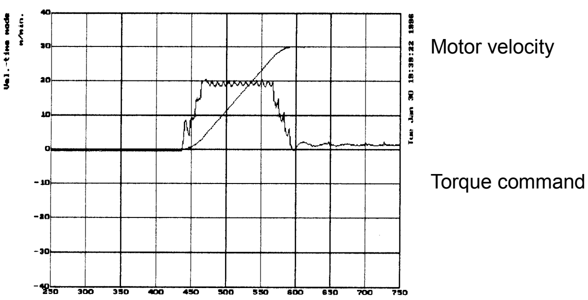
(9) Examples of applying the fine acc./dec. function



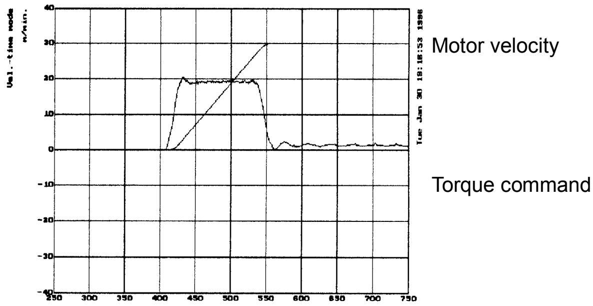
Conventional control in which the feed-forward function is not used



When the feed-forward function is used



When the feed-forward and rapid traverse bell-shaped acc./dec.
(Acc./dec. by the CNC)
functions are used



When the feed-forward and fine acceleration/ deceleration functions are used

4.9 SERIAL FEEDBACK DUMMY FUNCTIONS

4.9.1 Serial Feedback Dummy Functions

(1) Overview

The serial feedback dummy functions ignore servo alarms of non-servo axes.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

Series 9096 does not support the settings of such dummy axes.
(This series is not planed to support this function in the future. If necessary, use a series supporting this function.)

(3) Setting the built-in Pulsecoder-based feedback dummy function

Setting the function bit shown below enables ignoring of alarms related to the servo amplifier and built-in Pulsecoder for an axis not connected to a servo control circuit.

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*)								DMY
2009 (FS30*i*, 16*i*)								

DMY (#0) Specifies whether to enable the serial feedback dummy function as follows:
1: To enable
0: To disable

1788 (FS15*i*)	Set 0.
2165 (FS30*i*, 16*i*)	

To use the serial feedback dummy functions, a non-zero value must be entered as the motor ID number.

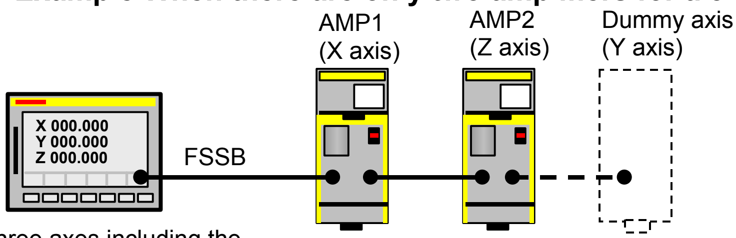
1874 (FS15*i*)	Motor ID number
2020 (FS30*i*, 16*i*)	

Enter an appropriate non-zero value.
Example) 15

(4) Handling of dummy axes in the *i* series CNC

Usually in the *i* series, the number of amplifiers must match that of axes. A dummy axis can be set normally if the axis to be set as the dummy axis has an amplifier. However, if an attempt is made to set an axis that does not have an amplifier as a dummy axis, an alarm may be issued, indicating that amplifiers are insufficient.
In such a case, make FSSB settings as if a series of existing amplifiers were followed by another amplifier.

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:
(Series 15*i*-B,16*i*-B, and so on)

No.1023 X:1 **<u>Y:2</u>** Z:3
No.1902 bit1=0, bit0=1
No.1905 bit0 X:0 Y:0 Z:0
No.1910=0
No.1911=2
<u>No.1912=1</u> ← Add a dummy axis.
Nos.1913 to 1919=40
Nos.1970 to 1989=40
No.2009 bit0 Y:1
No.2165 Y:0

(Series 30*i*,31*i*,32*i*)

No.1023 X:1 **<u>Y:2</u>** Z:3
No.1902 bit1=0, bit0=1
No.1905 bit0 X:0 Y:0 Z:0
No.14340= 0
No.14341= 2
<u>No.14342= 1</u>
Nos.14343 to 14375= -96
No.2009 bit0 Y:1
No.2165 Y:0

* For detailed descriptions about FSSB-related setting, refer to the respective CNC parameter manuals.

(5) 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 (FS15*i*) 2205 (FS30*i*, 16*i*)						FULDMY		

FULDMY (#2) Specifies whether to enable the separate detector-based dummy feedback function as follows:

1: To enable

0: To disable

> **NOTE**
> The relationships of this function with the built-in Pulsecoder-based serial feedback dummy function are as follows:
> - When only the built-in Pulsecoder-based serial feedback dummy function is enabled:
>   Alarms related to the built-in Pulsecoder 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 Pulsecoder, 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.

Information about dummy connector	Location
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

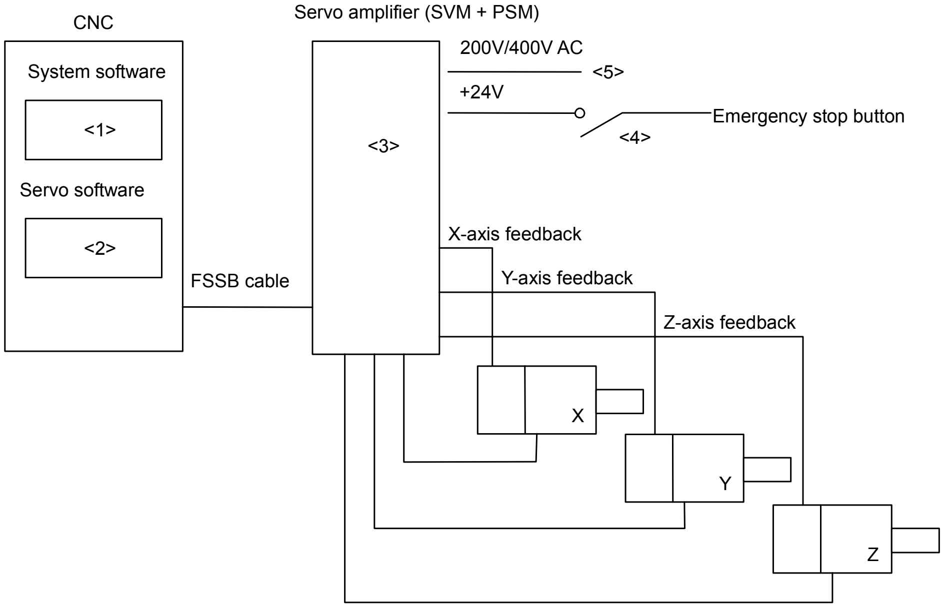


Fig. 4.10 (a) Example of configuration

The numbers of the following descriptions correspond to those in the figure:

<1> Applicable system software
Any system soft can be used.

<2> Applicable servo software
(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

<3> Servo amplifier
Use a single-axis servo amplifier (SVM1) 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**
> If you want to control the brake for an axis with a two- or three-axis amplifier, specify the brake control parameter for all axes on the multiaxis amplifier including the target axis. 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 signal

With the αi series, a timer for the emergency stop signal is built into the SVM. While motor activation is kept by brake control, the timer in the SVM is used to extend the activation time that lasts until the emergency stop signal operates. Motor deactivation can be delayed by the SVM for 50 ms to 400 ms. To delay motor deactivation by brake control for 400 or more, insert a timer in the contact signal of the emergency stop signal and +24V, and delay the emergency stop signal to be input to the PSM, as traditionally done. (For SVM timer setting, see Item (3) "Setting parameters" below.)

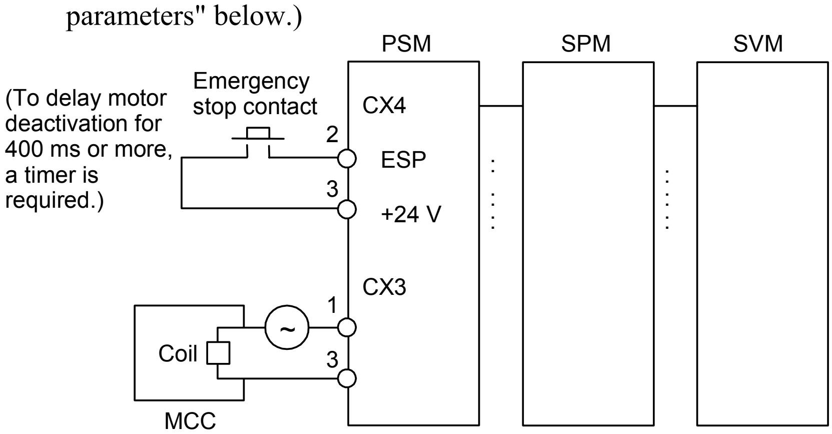


Fig. 4.10 (b) αi series amplifier

<5> 200/400 VAC

If the 200 VAC or 400 VAC supply to the servo amplifier is cut, the brake control function cannot operate.

To cause the brake control function to work effectively even at a power break, apply the power brake machine protection function.

(3) Setting parameters

<1> Brake control function enable/disable bit

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) 2005 (FS30*i*, 16*i*)		BRKC						

BRKC (#6) 1: The brake control function is enabled.

<2> Activation delay

1976 (FS15*i*) / 2083 (FS30*i*, 16*i*)	Brake control timer

[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.

<3> Setting the emergency stop timer built into the α*i* amplifier

	#7	#6	#5	#4	#3	#2	#1	#0
1750 (FS15*i*) / 2210 (FS30*i*, 16*i*)		ESPTM1	ESPTM0					

ESPTM0 (#5), ESPTM1 (#6) Set a period of time from the input of the emergency stop signal into the PSM until emergency stop operation is actually performed in the servo amplifier (SVM).

ESPTM1	ESPTM0	Delay time
0	0	50 ms (default)
0	1	100ms
1	1	200ms
1	1	400ms

When using brake control, set a time longer than the setting of the brake control timer (No. 1976 for Series 15*i* or No. 2083 for Series 16*i* and so on).

NOTE
For those axes that are connected to a two-axis amplifier or three-axis amplifier, the parameters above need to be set in the same way.

(4) Detailed operation

Suppose that there is a machine having horizontal and vertical axes of motion. When a servo alarm (*) occurs on the horizontal axis but no error occurs on the vertical axis, the MCCs of the amplifiers for all axes are turned off. When the emergency stop button is pressed, the MCCs of the amplifiers for all axes are turned off.
Standard machines have a mechanical brake that prevents the tool from dropping vertically in such cases. The mechanical brake may actually function according to the timing shown in Fig. 4.10 (c). If this occurs, the tool will drop vertically, causing the tool or workpiece to be damaged.
This function changes the timing to force MCC off, using a software timer, thus preventing the tool from dropping. Fig. 4.10 (d) shows the timing diagram.

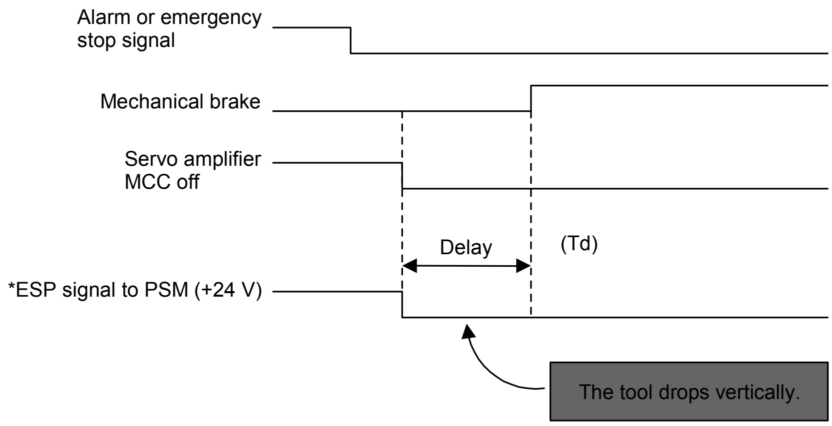


Fig. 4.10 (c)

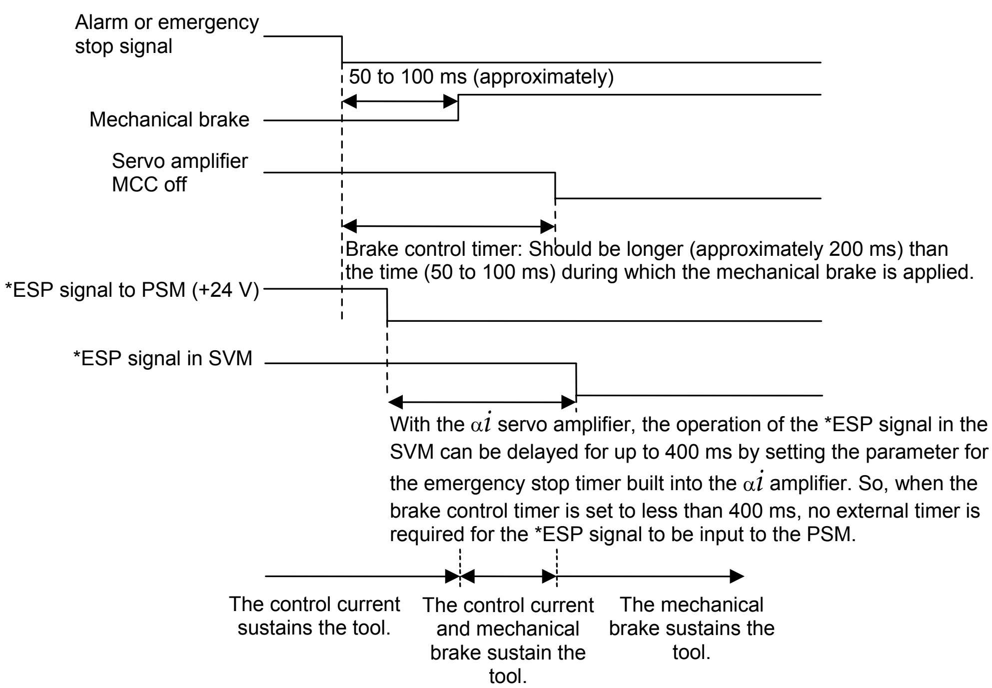


Fig. 4.10 (d)

NOTE

1. The servo alarm mentioned in the above description refers to a servo alarm detected by the software (OVC alarm, motor overheat alarm, software disconnection alarm, etc.), an alarm detected by the servo amplifier, or a servo alarm detected by the CNC (excessive error).
   If a servo alarm occurs on the axis using this function, no brake control is performed on the axis (except for a motor overheat alarm).
2. For brake control, use the SA signal (F0.6, which is common to all axes).

4.11 QUICK STOP FUNCTION

The functions described below prevent the tool from colliding with the machine or workpiece by reducing the distance required for the motor to come to a stop if a usual emergency stop condition occurs or if a separate detector disconnection alarm, overheat alarm, or OVC alarm is issued.

4.11.1 Quick Stop Type 1 at Emergency Stop

(1) Overview

This function reduces the stop distance by resetting the velocity command for a servo motor to 0 at a position where an emergency stop signal is detected for the servo motor. To further reduce the stop distance required for the motor to stop, use quick stop type 2 at emergency stop described in Subsec. 4.11.2.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1959 (FS15*i*) 2017 (FS30*i*, 16*i*)								DBST

DBST (#0) Specifies whether to enable quick stop type 1 at emergency stop as follows:
1: To enable
0: To disable

To use the quick stop at emergency stop, enable the brake control function to all axes, which use the quick stop function.

(Brake control function)

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) 2005 (FS30*i*, 16*i*)		**BRKC**						

BRKC (#6) Specifies whether to enable brake control function as follows:
1: To enable
0: To disable

> **NOTE**
> When only the brake control function is set, a gradual stop occurs with the torque limit reduced to 70%.
> When the quick stop at emergency stop is enabled, a gradual stop occurs with the torque limit set to 100%, so that the stop distance is reduced.

1976 (FS15*i*) 2083 (FS30*i*, 16*i*)	**Brake control timer**

[Unit of data] ms
[Setting value] 50

(4) Timing diagram

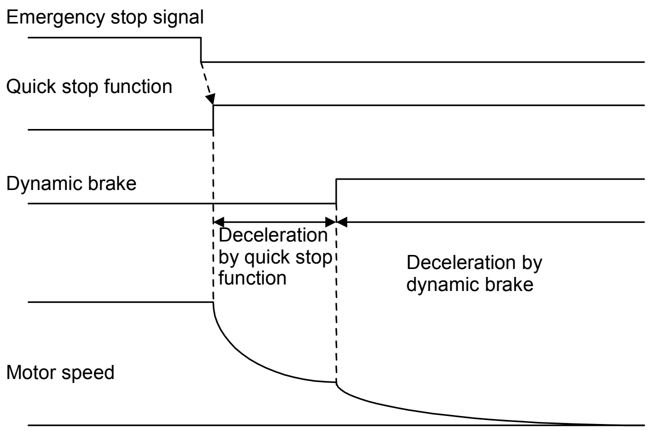


Fig. 4.11.1 (a) Timing diagram of quick stop function

(5) Connection of amplifier

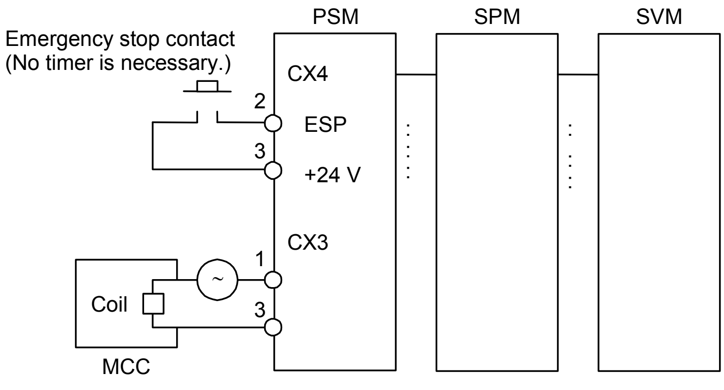


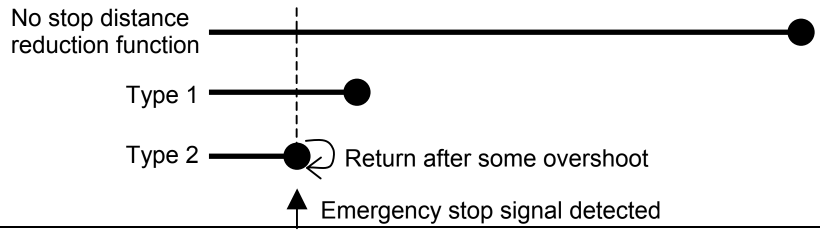
Fig. 4.11.1 (b) α*i* series amplifier

4.11.2 Quick Stop Type 2 at Emergency Stop

(1) Overview

This function returns a servo motor to a position where an emergency stop signal is detected for the servo motor, thereby assuring a shorter stop distance than with quick stop type 1 at emergency stop.

Diagram for comparing stop distances



(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1744 (FS15*i*) / **2204 (FS30*i*, 16*i*)**	**DBS2**							

DBS2 (#7) Specifies whether to enable quick stop type 2 at emergency stop as follows:
1: To enable
0: To disable

> **NOTE**
> 1 Like type 1, type 2 requires that the brake control parameter be set.
> 2 The method of connecting the amplifier for type 2 is the same as for type 1.
> 3 If both type 1 and type 2 function bits are set, type 2 function is assumed.

4.11.3 Lifting Function Against Gravity at Emergency Stop

(1) Overview

This function is intended to lift and stop the vertical axis (Z-axis) of a vertical machining center when the machine comes to an emergency stop or power failure.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B0/P(16) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Setting parameters

Because this function uses quick stop at emergency stop type 2, the following function bit must be set to 1 (enable).

	#7	#6	#5	#4	#3	#2	#1	#0
1744 (FS15*i*) / 2204 (FS30*i*, 16*i*)	DBS2							

DBS2 (#7) Specifies whether to enable quick stop type 2 at emergency stop as follows:
1: To enable
0: To disable

2786 (FS15*i*) / 2373 (FS30*i*, 16*i*)	Distance to lift

This parameter is for determining a distance to lift at an emergency stop. The larger the value, the larger becomes the distance to lift.

[Unit of data] Detection unit
[Valid data range] -32767 to 32767
[Recommended value] Detection unit 1μm : Approximately 500
Detection unit 0.1μm : Approximately 5000

> **NOTE**
> 1 If the brake is in use, it starts working while the vertical axis is being lifted. So the distance through which the axis is actually lifted differs from the setting.
> 2 Whether the parameter values is positive or negative matches whether the machine coordinate value is positive or negative.
> 3 Using this function causes the load to stop after moving it to one side of the machine. So, it should be used for the vertical axis (Z-axis) of a vertical machining center in which an axis retracts in a fixed single direction at an emergency stop.

2787 (FS15*i*)	Lifting time
2374 (FS30*i*, 16*i*)	

This parameter determines the lifting time as measured from the time of an emergency stop. The distortion easing function is executed after the lifting time has elapsed. This function is intended to decrease the amount of machine elastic strain that can increase when a vertical axis is lifted when the machine is about to apply the brake. Executing this function can reduce the shock that may occur when the axis drops because the servo amplifier stops energizing. The initial value of the function is a quarter of the distance to lift.
(See the following figure.)

[Unit of data] ms
[Valid data range] 8 to 32767
[Recommended value] Approximately 16 or 24 ms

> **NOTE**
> 1 Specify an integer multiple of 8 as the lifting time
> 2 To use the lifting function against gravity at emergency stop, specify 8 ms or longer as the lifting time.
> 3 If the distortion easing function is not used, specify the time longer than or equal to the one set in the brake control timer as the lifting time.

- Velocity command

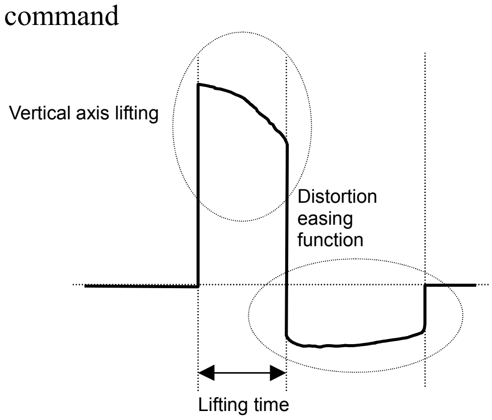


Fig. 4.11.3 (a) Velocity command

- Motor position waveform

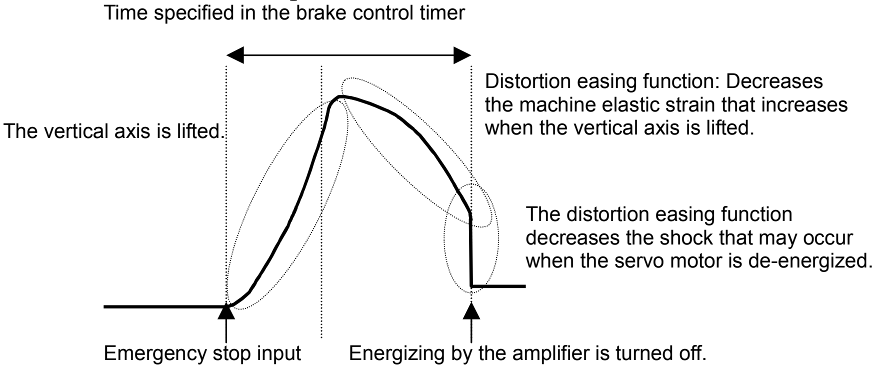


Fig. 4.11.3 (b) Motor position waveform

Using this function requires specifying the following brake control parameters.

Brake control function bit

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) / **2005 (FS30*i*, 16*i*)**		**BRKC**						

BRKC(#6) The brake control function is:

1 : Enabled ← Use this setting.
0 : Disabled.

Energizing delay time

1976 (FS15*i*) / **2083 (FS30*i*, 16*i*)**	**Brake control timer**

[Unit of data] ms
[Recommended value] 100ms

> **NOTE**
> If the Z-axis is connected to a multiaxis amplifier, it is necessary to enable the brake control function for all the axes connected to the multiaxis amplifier.

Set the time from the instant when an emergency stop signal is input to PSM to the instant when the emergency stop function works in the servo amplifier.

	#7	#6	#5	#4	#3	#2	#1	#0
1750 (FS15*i*) / **2210 (FS30*i*, 16*i*)**		**ESPTM1**	**ESPTM0**					

ESPTM1	ESPTM0	Delay time
0	0	50ms (default value)
0	1	100ms
1	0	200ms
1	1	400ms

It is necessary to specify the time longer than or equal to the brake control timer value.
If the brake control timer value is 100 ms, for example, specify ESPTM1 (bit 6) and ESPTM2 (bit 5) to be, respectively, 0 and 1 (100 ms).

NOTE
For a multiaxis amplifier, the largest of the values specified for the axes is assumed to be the delay time.

(4) Example of using the parameter

The following example shows the effect of using the lifting function against gravity at emergency stop for the vertical axis (Z-axis). In this example, the distance to lift is 500, and the lifting time is 16 ms. The vertical axis of the graph is graduated 2 μm/div.

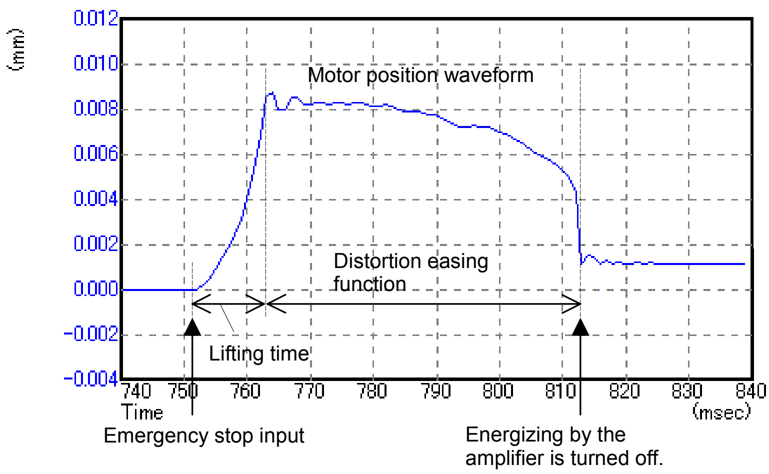


Fig. 4.11.3 (c) Motor position waveform

As seen from the graph, the motor is lifted through a large distance after an emergency stop signal is input. The graph also shows that the distortion easing function decreased the machine elastic strain and kept the motor from falling when the amplifier stopped energizing. Also as seen from the graph, the position where the motor finally rested is higher than the position where the motor was before the emergency stop signal was input.

NOTE
1 In this example, positive coordinates of the machine coordinate system correspond to the direction in which the axis is lifted.
2 Variation occurs in the position where the Z-axis stops depending on the direction in which the Z-axis is moving before an emergency stop. When tuning the parameter, it is necessary to take, into account, both the position where the motor rests before the axis is moved up and the position where the motor rests after the axis is moved down.

4.11.4 Quick Stop Function for Hardware Disconnection of Separate Detector

(1) Overview

This function reduces the stop distance by resetting the velocity command for a servo motor to 0 when the separate detector for the servo motor encounters a hardware disconnection condition. It also causes the other axes to stop sooner than they would when a usual alarm occurs.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1745 (FS15*i*)				HDIS	HD2O			
2205 (FS30*i*, 16*i*)								

HD2O (#5) Specifies whether to apply the quick stop function for hardware disconnection of separate detector to axes subjected to synchronous control, as follows:
1: To apply
0: Not to apply

HDIS (#4) Specifies whether to enable quick stop function for hardware disconnection of separate detector as follows:
1: To enable
0: To disable

1976 (FS15*i*)	Brake control timer
2083 (FS30*i*, 16*i*)	

[Unit of data] ms
[Setting value] 100

NOTE

1 When applying this function to axes under synchronous control (including simple synchronous control), follow the steps below:
   1) Change the servo axis setting (No. 1023) for two axes subjected to simple synchronous control so that the two axes can be controlled on 1DSP.
   2) Set HD2O (bit 3) to 1 for both axes under synchronous control.

2 This function is implemented using part of the "unexpected disturbance torque detection function" option. So, using it requires that option.

3 Usually, when a separate detector disconnection alarm occurs for an axis, not only this axis but also the others are brought to an emergency stop. If an unexpected disturbance torque detection group function (not supported in the Series 15*i*) is set up, however, only the axes in the same group as the axis for which an alarm condition has occurred are brought to an emergency stop.

4 If the value (No. 1738 for the Series 15*i* or No. 1880 for the Series 30*i*, 16*i*, and so on) specified as an interval between the detection of an unexpected disturbance torque and the occurrence of an emergency stop is small, it may impossible to keep the sufficient stop time. The value should be at least greater than or equal to the one specified in the brake control timer parameter (there is no problem with a setting value of 0, because it means 200 ms).

4.11.5 Quick Stop Function at OVL and OVC Alarm

(1) Overview

This function reduces the stop distance for a servo motor when an OVL (motor overheat or amplifier overheat) or OVC alarm condition is detected for the servo motor. It also causes the other axes to stop sooner than they would when a usual alarm occurs.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Series and editions of applicable system software

Completely same as those described in (3) in Subsec. 4.11.4.
If this function is specified in any system software that does not support it, not only the OVC or OVL alarm condition but also an "unexpected disturbance torque detection alarm" condition occurs simultaneously.

(4) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
2600 (FS15*i*) / 2212 (FS30*i*, 16*i*)	OVQK							

OVQK (#7) Specifies whether to enable quick stop function at the OVC and OVL alarm as follows:
1: To enable
0: To disable

> **NOTE**
> The operation of this function is performed by using part of the unexpected disturbance torque detection function. Therefore, to use this function, the option for the unexpected disturbance torque detection function is required.

1976 (FS15*i*) / 2083 (FS30*i*, 16*i*)	Brake control timer

[Unit of data] ms
[Setting value] 100

4.11.6 Overall Use of the Quick Stop Functions

To sum up, setting up the following parameters as stated can reduce the stop distance for an emergency stop, separate detector hardware disconnection, and OVL and OVC alarm occurrence.

<1> Specify the unexpected disturbance torque detection option.
<2> Specify quick stop type 2 at emergency stop.
<3> For a vertical axis, specify the function for lifting up a vertical axis at emergency stop, if required.
<4> For full-closed loop axes, specify the quick stop function for hardware disconnection of separate detector. Also if they are subjected to synchronous control, set the **HD2O** bit.
<5> Specify the quick stop function at the OVC and OVL alarm.
<6> Set the brake control function bit and the brake control timer.

4.12 UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION

Optional function

4.12.1 Unexpected Disturbance Torque Detection Function

(1) Overview

When a tool collides with the machine or workpiece, or when a tool is faulty or damaged, a load torque greater than that experienced during normal feed is imposed.
This function monitors the load torque to the motor at servo high-speed sampling intervals. If it detects an abnormal torque, it brings the axis to an emergency stop by issuing an alarm, or reverses the motor by an appropriate amount.
In addition, the function enables the PMC to be used to switch the speed at warning occurrence or load fluctuation.

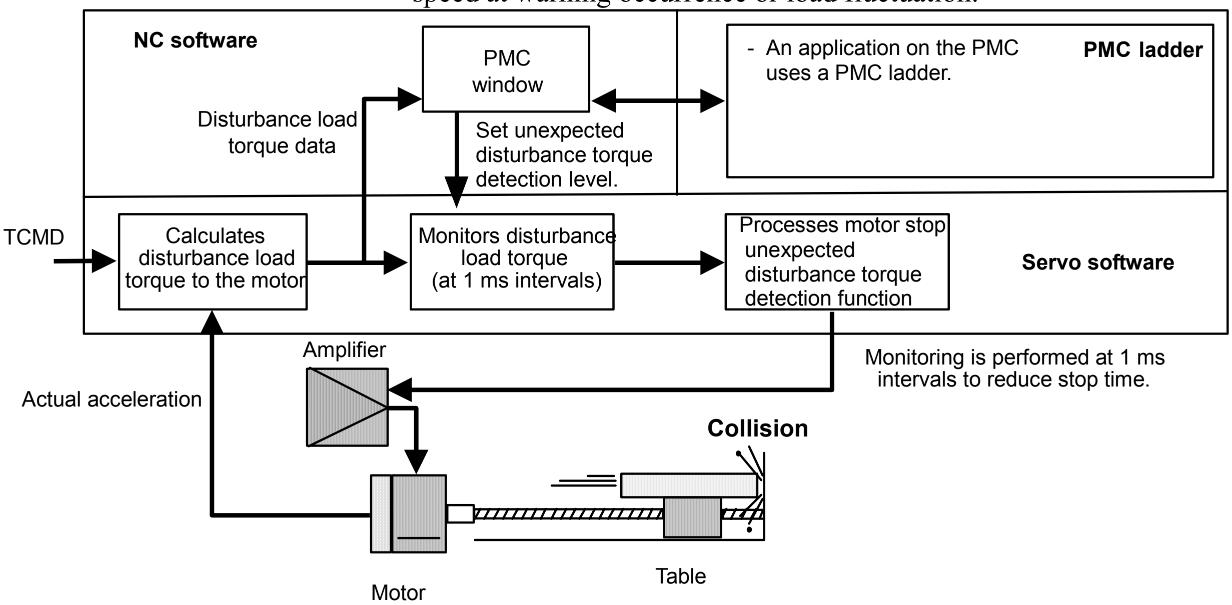


Fig. 4.12.1 Overview of unexpected disturbance torque detection

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

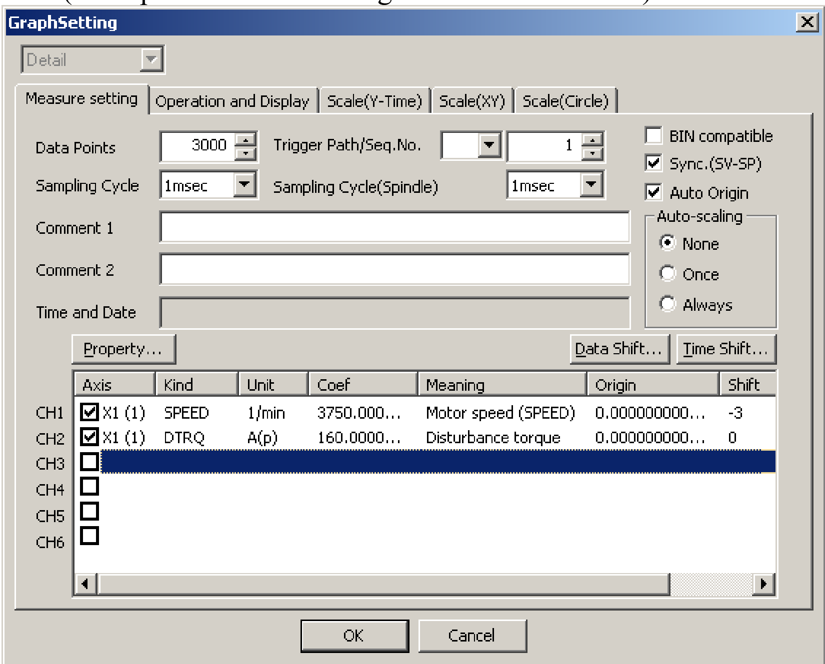
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Parameter adjustment methods

<1> Use SERVO GUIDE to observe the motor speed (SPEED) and estimated disturbance torque (DTRQ).

(Example of channel settings on SERVO GUIDE)



(See Sec. 4.20 for detailed descriptions about how to use the SERVO GUIDE.)

<2> Switch on the CNC.

<3> Enable the unexpected disturbance torque detection function

	#7	#6	#5	#4	#3	#2	#1	#0
1958 (FS15*i*) / **2016 (FS30*i*, 16*i*)**								**ABNT**

ABNT (#0) Specifies whether to enable the unexpected disturbance torque detection function as follows:

1: To enable

0: To disable

Moreover, **be sure to set** also the following parameters.

	#7	#6	#5	#4	#3	#2	#1	#0
1740 (FS15*i*) / **2200 (FS30*i*, 16*i*)**						**IQOB**		

IQOB Specifies whether to eliminate influence of control voltage saturation when estimating disturbance, as follows:

1: To eliminate influence of control voltage saturation when estimating disturbance

0: Not to take influence of control voltage saturation when estimating disturbance into consideration

<4> Set up the parameters related to the observer.

1862 (FS15*i*)	Observer gain
2050 (FS30*i*, 16*i*)	

- When HRV1, HRV2, or HRV3 control is used:

[Standard setting value] 956 → To be changed to 3559.

- When HRV4 control is used:

[Standard setting value] 264 → To be changed to 1420

1863 (FS15*i*)	Observer gain
2051 (FS30*i*, 16*i*)	

- When HRV1, HRV2, or HRV3 control is used:

[Standard setting value] 510 → To be changed to 3329.

- When HRV4 control is used:

[Standard setting value] 35 → To be changed to 332

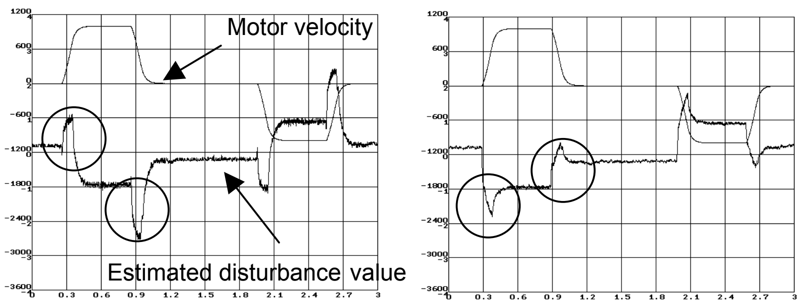
> **NOTE**
> When using this function together with the observer, do not modify the standard setting of the parameter above.
> Observer:
> Bit 2 of No.1808 (Series 15*i*)
> Bit 2 of No.2003 (Series 30*i*, 16*i*, and so on)

<5> Make adjustments on the **POA1** observer parameter.

1859 (FS15*i*)	Observer parameter (POA1)
2047 (FS30*i*, 16*i*)	

Turn the servo motor to perform linear back and forth operation at a speed equal to about 50% of the rapid traverse rate, and observe the motor speed and the estimated disturbance value. The waveform observed before the adjustment should show one of the following features:

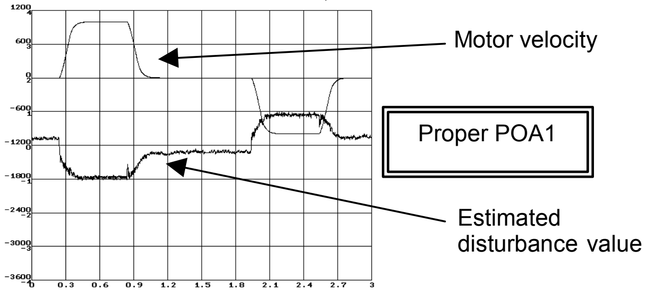
Measurement example: 1000 min^{-1} (rotary motor)



Insufficient POA1 value
At acceleration:
Undershoot on estimated disturbance value
At deceleration:
Overshoot on estimated disturbance value

Excessive POA1 value
At acceleration:
Overshoot on estimated disturbance value
At deceleration:
Undershoot on estimated disturbance value

Make adjustments on the **POA1** parameter so that neither an overshoot nor an undershoot will not be observed on the estimated disturbance value at acc./dec. After adjustment, the waveforms shown below should be obtained.
(A clear waveform like the one shown below may not be obtained in some machines. In such machines, find the POA1 value that can minimize the overshoot and undershoot by watching the estimated disturbance waveform at acc./dec.)



> **NOTE**
> The POA1 parameter is related to the load inertia ratio parameter ("velocity gain" on the servo screen) through the inside of the software. When the load inertia ratio parameter is changed, the POA1 parameter must also be changed. So, first determine the load inertia ratio (velocity gain) when adjusting the servo.
> If you must change the load inertia ratio (velocity gain) after the POA1 parameter is determined, re-set the POA1 parameter using the following expression.
> (New POA1 value) =
> (Previous POA1 value) ×
> (Load inertia ratio value set after adjustment+256) /
> (Load inertia ratio value set before adjustment+256)
> Load inertia ratio:
> No. 1875 (Series 15*i*), No. 2021 (Series 16*i* and so on)
> The velocity gain magnification (in cutting or high-speed HRV current control) does not affect the setting of POA1.

(Details)
The observer estimates a disturbance torque by subtracting the torque required for acc./dec. from the entire torque. The torque required for acc./dec. is calculated using a motor model. The POA1 parameter corresponds to the inertia of the motor model. If the parameter value differs from the actual value, it is impossible to estimate a correct disturbance torque. To detect an unexpected disturbance torque correctly, therefore, you must adjust the value of this parameter.
An estimated disturbance value when a usual condition is supposed to be related only to frictional torque (for the horizontal axis), and proportional to the velocity. Therefore, a program, like the one used for adjustment, that merely repeats simple acc./dec. is supposed to generate a trapezoidal estimated disturbance torque waveform like a velocity waveform.

<6> For the vertical axis, adjust the torque offset. (This is unnecessary for the horizontal axis.)
For the vertical axis, the estimated disturbance value is not centered at level 0. Torque offset adjustment is done to center the estimated disturbance value at level 0.

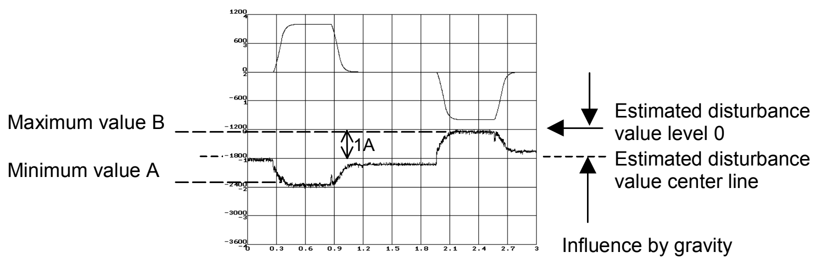
1980 (FS15*i*)	Torque offset parameter
2087 (FS30*i*, 16*i*)	

[Unit of data] TCMD unit (7282 with the maximum current value of the amplifier)
[Valid data range] -7282 to 7282

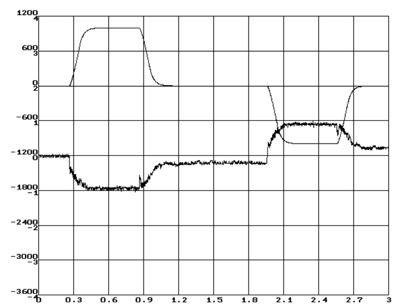
(Example of torque offset setting)

Estimated disturbance values for constant-velocity movements in the + direction and - direction are read. In the figure below, minimum value A (signed) is read in a movement in the + direction, and maximum value B (signed) is read in a movement in the - direction. A torque offset parameter setting is given using the following expressions:

$$\text{Torque offset} = \frac{\text{A [Ap] + B [Ap]}}{\text{Maximum amplifier current value [Ap]}} \times 3641$$



If you read the minimum and maximum values as -1.9 [Ap] and -0.1 [Ap] in the above chart (the amplifier used is rated at 40 [Ap] maximum), the torque offset parameter = -{(-1.9) + (-0.1)}/40 × 3641 = 182. The following chart applies when the parameter is set with 182.



If the torque offset parameter is specified, **be sure to specify** the following parameter also.

	#7	#6	#5	#4	#3	#2	#1	#0
2603 (FS15*i*) **2215 (FS30*i*, 16*i*)**							**TCPCLR**	

TCPCLR(#1) The function for setting a value for canceling the torque offset at an emergency stop in the velocity loop integrator is:

0: Disabled

1: Enabled

<7> Compensate for dynamic friction.

(i) Method of canceling a dynamic friction in proportion to velocity

Measure an estimated disturbance value at a constant velocity. Then, by assuming this measured value as a dynamic friction, set the proportional coefficient for a velocity and dynamic friction compensation value.

1727 (FS15*i*) **2116 (FS30*i*, 16*i*)**	**Dynamic friction compensation coefficient**

[Unit of data] See the equation below.

[Valid data range] 0 to 264 (Series 9096 or Series 90B0/A to /D)

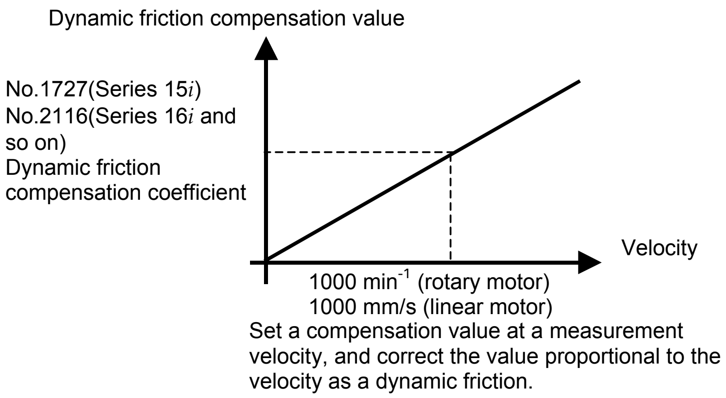
-264 to 264 (Series 90B0/E and subsequent editions, Series 90B1, Series 90B6, Series 90B5, Series 90D0, or Series 90E0)

[Measurement velocity] Rotary motor: 1000 min^{-1}, Linear motor: 1000 mm/s

Measure an estimated disturbance value at a measurement velocity, then set the results of calculations made according to the table below.

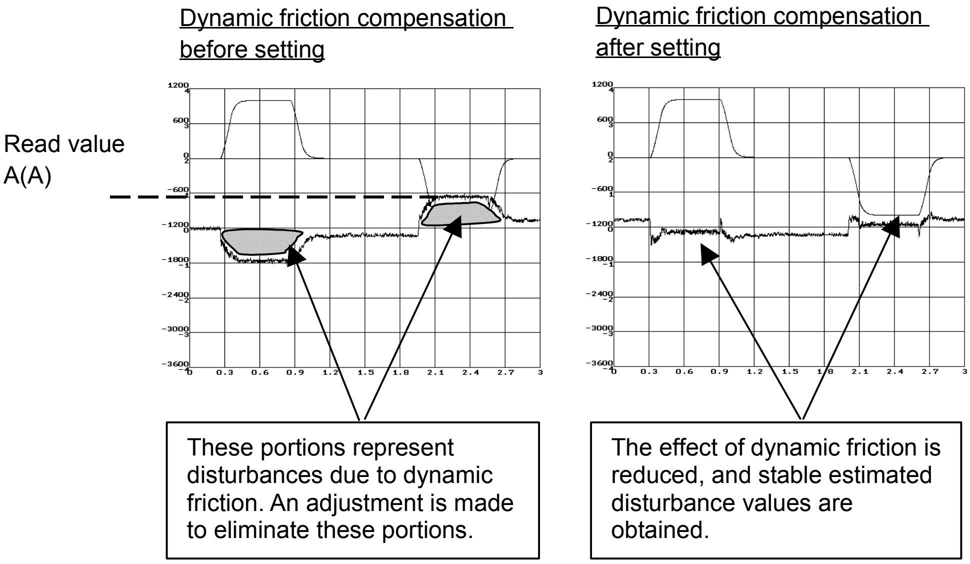
$$\text{Dynamic friction compensation coefficient} = \frac{\text{Estimated disturbance value [Ap]}}{\text{Maximum amplifier current value [Ap]}} \times 440$$

> **NOTE**
> If the measurement velocity is too high, lower the measurement velocity, and measure the estimated disturbance value. By proportional calculation, obtain the estimated disturbance value at the above measurement velocity.



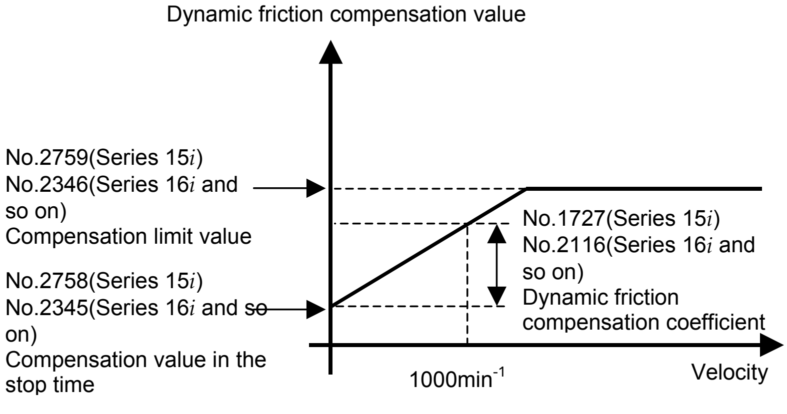
(Example of setting for a rotary motor)

- Suppose that the estimated disturbance value at 1000 min^{-1} is 1 [Ap] (the maximum amplifier current value is 40 [Ap]).
  Dynamic friction compensation coefficient = 1/40 × 440 = 11



(ii) Method of setting a dynamic friction as "portion proportional to velocity + constant portion" and imposing a limit

If the compensation value for stop time to low-velocity movement is insufficient in adjustment of (i), set a dynamic friction compensation value in the stop state. If the compensation value for high-speed movement is excessive, a limit is imposed on the compensation value.



Set a compensation value in the stop time and a compensation limit value in addition to a compensation value at 1000 min^{-1}.

> **NOTE**
> This method can be used with the following servo software:
> (Series 30*i*, 31*i*, 32*i*)
> Series 90D0/A(01) and subsequent editions
> Series 90E0/A(01) and subsequent editions
> (Series 15*i*-B, 16*i*-B, 18*i*-B, 21*i*-B, 0*i*-B, 0*i* Mate-B, Power Mate *i*)
> Series 90B0/E(05) and subsequent editions
> Series 90B1/A(01) and subsequent editions
> Series 90B6/A(01) and subsequent editions
> (Series 0*i*-C, 0*i* Mate-C, 20*i*-B)
> Series 90B5/A(01) and subsequent editions

2758 (FS15*i*)	Dynamic friction compensation value in the stop state
2345 (FS30*i*, 16*i*)	

[Unit of data] TCMD unit (7282 when the estimated disturbance value is equivalent to the maximum current value of the amplifier)

[Valid data range] 0 to 7282

[Measurement velocity] 10 min^{-1} (rotary motor), 10 mm/s (linear motor)
The absolute value of a setting is used.

2759 (FS15*i*)	Dynamic friction compensation limit value
2346 (FS30*i*, 16*i*)	

[Unit of data] TCMD unit (7282 when the estimated disturbance value is equivalent to the maximum current value of the amplifier)

[Valid data range] 0 to 7282

[Measurement velocity] Maximum feedrate
The absolute value of a setting is used.

(Method of setting)

First, measure an estimated disturbance value when a movement is made at a maximum feedrate on the axis, then set the results of calculations made according to the table below in "dynamic friction compensation limit value".

$$\text{Dynamic friction compensation limit value} = \frac{|\text{Estimated disturbance value [Ap]}|}{\text{Maximum amplifier current value [Ap]}} \times 7282$$

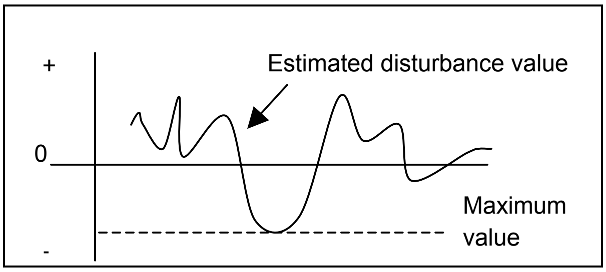
Next, measure an estimated disturbance value when a movement is made on the axis at the measurement velocity (10 min^{-1} or 10 mm/s) for "dynamic friction compensation value in the stop state", then set the results of calculations made according the table below in "dynamic friction compensation value in the stop state".

$$\text{Dynamic friction compensation value in the stop state} = \frac{|\text{Estimated disturbance value [Ap]}|}{\text{Maximum amplifier current value [Ap]}} \times 7282$$

Finally, measure an estimated disturbance value when a movement is made on the axis at the measurement velocity (1000 min^{-1} or 1000 mm/s) for "dynamic friction compensation coefficient", then set the results of calculations made according the table below in "dynamic friction compensation coefficient".

$$\text{Dynamic friction compensation coefficient} = \frac{|\text{Estimated disturbance value [Ap]}|}{\text{Maximum amplifier current value [Ap]}} \times 440$$

<8> Set an unexpected disturbance torque detection alarm level.
Perform several different operations (sample machining program, simultaneous all-axis rapid traverse acc./dec., etc.), and observe estimated disturbance values, and measure the maximum (absolute) value.
Then, set up an alarm level.



1997 (FS15*i*)	Unexpected disturbance torque detection alarm level
2104 (FS30*i*, 16*i*)	

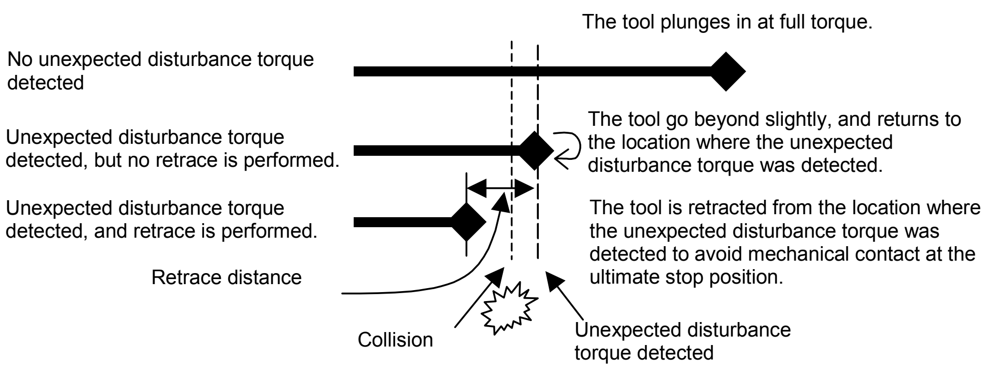
Alarm level conversion uses the following expression.

$$\text{Unexpected disturbance torque detection alarm level} = \frac{|\text{Estimated disturbance value [Ap]}|}{\text{Maximum amplifier current value [Ap]}} \times 7282 + 500 \text{ to } 1000 \text{ approximately}$$

NOTE
1. Add some margin (usually about 500 to 1000) to the alarm level to be set.
2. If the "unexpected disturbance torque detection alarm level" parameter is 32767, no unexpected disturbance torque alarm detection is performed.

<9> Set a distance to be retraced at unexpected disturbance torque detection.
If the retrace amount parameter is 0, the motor stops at the point where an unexpected disturbance torque was detected. To retract the tool from the location of collision quickly, set the retrace distance parameter.

Conceptual diagram illustrating retrace



1996 (FS15*i*)	Retrace distance
2103 (FS30*i*, 16*i*)	

[Unit of data] Detection unit
[Setting value] Approximately 3 mm

NOTE

When the tool is moving faster or slower than the velocity listed below, the tool will not go back even if this parameter is set. It stops at the location where an unexpected disturbance torque was detected.
Let the value set in the retrace distance parameter be A:
Minimum retract velocity =
$A \times$ detection unit (μm) $\times$ 60/512 [mm/min]
Example)
When detection unit = 1 μm, and retract amount setting = 3000, the minimum velocity at which the tool is retracted is:
Minimum retract velocity =
$3000 \times 1 \times 60/512 = 352$ [mm/min]

[2-axis simultaneous retract function at detection of an unexpected disturbance torque]

Because the 2-axis simultaneous retract function at detection of an unexpected disturbance torque is executed only for an axis on which an unexpected disturbance torque is detected, it has conventionally been unable to be applied to a position tandem (simple synchronous control) axis.
The following setting adds a function for retracting an axis in position tandem when an unexpected disturbance torque is detected on the other axis. This function enables a retract function to be applied also to position tandem axes.

(Series and editions of applicable servo software)

(Series 30*i*,31*i*,32*i*)

Series 90D0/A(01) and subsequent editions

Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)

Series 90B0/E(05) and subsequent editions

Series 90B1/A(01) and subsequent editions

Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)

Series 90B5/A(01) and subsequent editions

(Setting parameters)

To use the unexpected disturbance torque detection function, set the following bit to 1 for both the master and slave axes.

	#7	#6	#5	#4	#3	#2	#1	#0
2684 (FS15*i*) 2271 (FS30*i*, 16*i*)						RETR2		

RETR2(#2) With the unexpected disturbance torque detection function, 2-axis simultaneous retraction is:

1: Performed

0: Not performed

In the parameter for the distance to retract, specify the same value for both the master and slave axes. If an unexpected disturbance torque is detected on one of the axes, both axes are retracted.

NOTE

1 This function can be applied only to two axes in position tandem on the same DSP. Do not use this function for any axis that has not been set for position tandem.

2 If different values are specified for the master and slave axes, an invalid parameter alarm is issued. (The detail No. of the alarm is 1033.)

<10> Run the machine with the alarm level set up.
If the unexpected disturbance torque detection function works incorrectly, increase the alarm level.

<11> Now adjustment is completed.

4.12.2 Cutting/Rapid Unexpected Disturbance Torque Detection Switching Function

(1) Overview

An alarm threshold for unexpected disturbance torque detection is set separately for cutting and rapid traverse.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Setting parameters

A threshold can be set separately for cutting and rapid traverse by setting the following bit when the unexpected disturbance torque detection function is used:

	#7	#6	#5	#4	#3	#2	#1	#0
1740 (FS15*i*) 2200 (FS30*i*, 16*i*)					ABG0			

ABG0(#3) The cutting feed/rapid unexpected disturbance torque detection switching function is:
1: Enabled.
0: Disabled.

	#7	#6	#5	#4	#3	#2	#1	#0
2603 (FS15*i*) 2215 (FS30*i*, 16*i*)	ABT2							

ABT2(#7) Cutting feed/rapid unexpected disturbance torque detection switching function type-2 is:
1: Enabled.
0: Disabled.

> **NOTE**
> 1 Set the two bits above. (Servo software was revised in type-2 to be able to switch even if you set bit 3 of No.1800 to 1, feed-forward always enable.)
> 2 With Series 9096, switching is disabled when bit 3 of No. 1800 is set to 1 (to enable feed-forward in rapid traverse). The alarm level for cutting is enabled at all times.

Alarm thresholds for unexpected disturbance torque detection are set in the following parameters:

1997 (FS15*i*) **2104 (FS30*i*, 16*i*)**	**Unexpected disturbance torque detection threshold for cutting** **(This parameter is used both in not switching mode and in switching mode.)**

[Valid data range] 0 to 7282

1765 (FS15*i*) **2142 (FS30*i*, 16*i*)**	**Unexpected disturbance torque detection threshold for rapid traverse**

[Valid data range] 0 to 7282

NOTE

1. When the alarm level for cutting is 32767, unexpected disturbance torque detection is not performed during cutting.
2. When the alarm level for rapid traverse is 32767, unexpected disturbance torque detection is not performed during rapid traverse. When both parameters are 32767, unexpected disturbance torque detection is not performed at any time.

4.13 FUNCTION FOR OBTAINING CURRENT OFFSETS AT EMERGENCY STOP

(1) Overview

The current offset is a current feedback offset value arising from the analog offset voltage of the current detector. If the current offset is measured incorrectly, motor current feedback can be adversely affected, resulting in very small motor rotation fluctuations (four components per motor revolution).
A current offset measurement is made when the power is turned on.
This function performs a current offset measurement not only at power-on time but also in each emergency stop state.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
1741 (FS15*i*) 2201 (FS30*i*, 16*i*)								CROFS

CROFS (#0) 1: Enables the current offset to be obtained upon the occurrence of an emergency stop.

If the above setting is made, the current offset is obtained again during an emergency stop.

4.14 LINEAR MOTOR PARAMETER SETTING

4.14.1 Procedure for Setting the Initial Parameters of Linear Motors

(1) Overview

The following describes the procedure for setting the digital servo parameters to enable the use of a FANUC linear motor.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Warning

⚠ **WARNING**

1. The linear motor can make an unpredictable movement, resulting in a very dangerous situation, if an error is made in linear motor assembly, power line cabling, detector installation direction setting, or basic parameter setting.
2. It is recommended to take the following actions until normal operation is confirmed:
   - Lower the excessive error level so that an alarm is issued immediately when an unpredictable movement is made.
   - Lower the torque limit value to disable abrupt acceleration.
   - Ensure that the emergency stop switch can be pressed immediately.

(4) Linear encoders

The position and velocity of the linear motor are detected using a linear encoder. Two types of linear encoders are available: incremental type and absolute type. The parameter setting and connection vary according to the type of encoder.

For incremental type

The linear encoder of incremental type is connected to a servo amplifier via a position detection circuit (A860-0333-T001, -T002, -T201, -T202, -T301, -T302) for linear motor manufactured by FANUC. Values to be set in parameters vary depending on the signal pitch of the linear encoder. Therefore, check the signal pitch of the encoder first.

If a position detection circuit (A860-0333-T201, -T202, -T301, or -T302) having an interpolation magnification of 2048 is used, it is necessary to specify additional parameters so that both the maintenance of a maximum feedrate and the realization of a higher resolution can be supported.
Table 4.14.1 (a) lists examples of usable incremental linear encoders.

Table 4.14.1 (a) Examples of usable linear encoders (incremental)

Encoder maker	Signal pitch (μm)	Model
HEIDENHAIN	20	LS486, LS186, etc.
	40	LB382, LIDA185, etc.
	2	LIP481
	4	LF481R, LIF181, etc.
	100	LB382
Mitutoyo	20	AT402
Optodyne	40.513167	LDS
Renishaw	20	RGH22
	40	RGH41
SAMTAK (FUTABA CORPORATION)	20	FTV, FMV
Sony Precision Technology Inc.	20	SH12, SH52

When a linear encoder of incremental type is used, a linear motor pole detector (A860-0331-T001, -T002) is also needed.

For absolute type

The linear encoder of absolute type is directly connected to a servo amplifier. Depending on the resolution of an encoder used, the parameter setting varies. First, check the resolution. Table 4.14.1(b) lists examples of absolute type linear encoders currently usable.

Table 4.14.1 (b) Usable linear encoders (absolute)

Encoder maker	Resolution (μm)	Model
HEIDENHAIN	0.05 (0.1)*	LC191F, LC491F
Mitutoyo	0.05	AT353, AT553

* Encoders with resolutions of 0.05 μm and 0.1 μm are available.

NOTE
1. For details of the linear encoders usable with FANUC linear motors, refer to "FANUC LINEAR MOTOR L*i*s series DESCRIPTIONS (B-65382EN)".
2. For details of the linear encoders, contact the manufacturer of each linear encoder.
3. When servo HRV4 control is to be used with a linear motor, the AT553 (Mitutoyo Co., Ltd.) or a high-resolution serial output circuit must be used.

(5) Parameter settings

Set the parameters according to the procedure below. Note the points below when setting the parameters.

[Cautions for using incremental linear encoders]

The following parameter setting procedure involves a parameter to be specified according to the resolution of the linear encoder. If an incremental linear encoder is to be used, convert the encoder signal pitch to the resolution for parameter calculation, using the following equation.

Resolution [μm] = Encoder signal pitch [μm] / 512

Parameter setting procedure (1)

Procedure (1) can be used to initialize the parameters (such as current gain) necessary to drive a linear motor. After initialization, parameters depending on the linear encoder resolution (or the value obtained by dividing the signal pitch of the linear encoder by the interpolation magnification of the position detection circuit) must be set. Set these parameters by following parameter setting procedure (2).

Parameters related to initialization

For incremental type, For absolute type

	#7	#6	#5	#4	#3	#2	#1	#0
1804 (FS15*i*) / 2000 (FS30*i*, 16*i*)							DGPR	PLC0

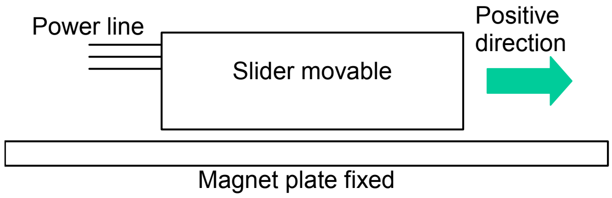
DGPR(#1) Set 0. (After initialization, this bit is set to 1 automatically.)
For PLCO (#0), see Table 4.14.1(d) and Table 4.14.1(e).

1806 (FS15*i*) / 2001 (FS30*i*, 16*i*)	AMR

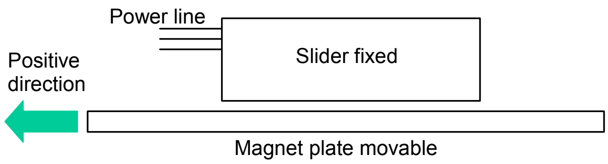
Specify 00000000.

1879 (FS15*i*) / 2022 (FS30*i*, 16*i*)	Movement direction

(a) When the coil slider is movable:
- +111: When the positive direction is specified, the slider moves in the positive direction.
- -111: When the positive direction is specified, the slider moves in the reverse direction.



(b) When the magnet plate is movable:
+111: When the positive direction is specified, the magnet plate moves in the positive direction.
-111: When the positive direction is specified, the magnet plate moves in the reverse direction.



Motor ID number

For incremental type, **For absolute type**

1874 (FS15*i*)	Motor ID number
2020 (FS30*i*, 16*i*)	

Standard parameters are prepared for the linear motors listed below as of February, 2005. When the standard parameters are not included in the servo software used, see the parameter list shown in this manual, and set the parameters.

[200-V driving]

Motor model	Motor specification	Motor ID No.	90B6 90B5	90B1	90D0 90E0
L*i*S300A1/4	0441-B200	351	B(02)	B(02)	G(07)
L*i*S600A1/4	0442-B200	353	B(02)	B(02)	G(07)
L*i*S900A1/4	0443-B200	355	B(02)	B(02)	G(07)
L*i*S1500B1/4	0444-B210	357	B(02)	B(02)	G(07)
L*i*S3000B2/2	0445-B110	360	B(02)	B(02)	G(07)
L*i*S3000B2/4	0445-B210	362	B(02)	B(02)	G(07)
L*i*S4500B2/2	0446-B110	364	B(02)	B(02)	G(07)
L*i*S6000B2/2	0447-B110	368	B(02)	B(02)	G(07)
L*i*S6000B2/4	0447-B210	370	B(02)	B(02)	G(07)
L*i*S7500B2/2	0448-B110	372	B(02)	B(02)	G(07)
L*i*S7500B2/4	0448-B210	374	B(02)	B(02)	G(07)
L*i*S9000B2/2	0449-B110	376	B(02)	B(02)	G(07)
L*i*S9000B2/4	0449-B210	378	B(02)	B(02)	G(07)
L*i*S3300C1/2	0451-B110	380	B(02)	B(02)	G(07)
L*i*S9000C2/2	0454-B110	384	B(02)	B(02)	G(07)
L*i*S11000C2/2	0455-B110	388	B(02)	B(02)	G(07)
L*i*S15000C2/2	0456-B110	392	B(02)	B(02)	G(07)
L*i*S15000C2/3	0456-B210	394	B(02)	B(02)	G(07)
L*i*S10000C3/2	0457-B110	396	B(02)	B(02)	G(07)
L*i*S17000C3/3	0459-B110	400	B(02)	B(02)	G(07)

The motor ID numbers are for SERVO HRV2. Loading is possible with the servo software of the series and edition listed above or subsequent editions.

[400-V driving]

Motor model	Motor specification	Motor ID No.	90B6 90B5	90B1	90D0 90E0
L*i*S1500B1/4	0444-B210	358	B(02)	B(02)	G(07)
L*i*S3000B2/2	0445-B110	361	B(02)	B(02)	G(07)
L*i*S4500B2/2HV	0446-B010	363	B(02)	B(02)	G(07)
L*i*S4500B2/2	0446-B110	365	B(02)	B(02)	G(07)
L*i*S6000B2/2HV	0447-B010	367	B(02)	B(02)	G(07)
L*i*S6000B2/2	0447-B110	369	B(02)	B(02)	G(07)
L*i*S7500B2/HV2	0448-B010	371	B(02)	B(02)	G(07)
L*i*S7500B2/2	0448-B110	373	B(02)	B(02)	G(07)
L*i*S9000B2/2	0449-B110	377	B(02)	B(02)	G(07)
L*i*S3300C1/2	0451-B110	381	B(02)	B(02)	G(07)
L*i*S9000C2/2	0454-B110	385	B(02)	B(02)	G(07)
L*i*S11000C2/2HV	0455-B010	387	B(02)	B(02)	G(07)
L*i*S11000C2/2	0455-B110	389	B(02)	B(02)	G(07)
L*i*S15000C2/3HV	0456-B010	391	B(02)	B(02)	G(07)
L*i*S10000C3/2	0457-B110	397	B(02)	B(02)	G(07)
L*i*S17000C3/2	0459-B110	401	B(02)	B(02)	G(07)

The motor ID numbers are for SERVO HRV2. Loading is possible with the servo software of the series and edition listed above or subsequent editions.

NOTE
For the motor ID number of the conventional models, see Appendix G.

After parameter initialization, check that the function bit for linear motor control is set to 1 (linear motor control is enabled).

	#7	#6	#5	#4	#3	#2	#1	#0
1954(FS15*i*) 2010(FS30*i*,16*i*)						LINEAR		

LINEAR(#2) Linear motor control is:
1: Enabled
0: Disabled

When using position detection circuit H or C for linear motor

For incremental type

When a position detection circuit having an interpolation magnification of 2048 is used with an incremental type linear encoder, the parameter shown below must be set to maintain both the maximum feedrate and high resolution. Set the parameter before proceeding to procedure (2).

Series and editions of applicable servo software
(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,Power Mate *i*)
Series 90B0/Q(17) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C, 20*i*-B)
Series 90B5/A(01) and subsequent editions

	#7	#6	#5	#4	#3	#2	#1	#0
2687(FS15*i*)								HP2048
2274(FS30*i*,16*i*)								

HP2048(#0) A circuit having an interpolation magnification of 2048 (position detection circuit H or C for linear motor) is:
1: Used
0: Not used

NOTE
1 Setting this parameter(No.2274(FS30*i*,16*i*) or No.2687(FS15*i*)) to "enable" lets you make the basic parameter settings as explained in Procedure (2).
2 Changing this parameter results in a power-off alarm being raised.
3 When this parameter is set, the detection unit in the case of FFG=1/1 is (signal pitch/512 [um]).
If a minimum detection unit (signal pitch/2048 [μm]) is necessary, specify:
FFG = 4/1
4 If nano-interpolation is applied, a resolution as high as (signal pitch/2048 [μm]) is applied as decimal-part feedback.
5 When a linear encoder of incremental type is used, a linear motor pole detector is needed.
(A860-0331-T001, -T002)

NOTE

6 With position detection circuit H (A860-0333-T201 or A860-0333-T202) for linear motor, the interpolation magnification can be changed using setting pin SW3.
Setting A: The interpolation magnification is 512.
Setting B: The interpolation magnification is 2048.
(The setting at the time of shipment is Setting B.)

(Parameter setting when Setting B is used)
- HP2048＝1
- Resolution [μm] = encoder signal pitch [μm]/512

In the case of Setting B, the input frequency is 200 kHz. So, the maximum allowable speed dependent on the detector is:
Maximum allowable speed
= Signal pitch [m] × 200000 [Hz] × 3600 [s]
If the maximum allowable speed dependent on the detector needs to be increased, use Setting A.

(Parameter setting when Setting A is used)
- HP2048＝1
- Resolution [μm] = encoder signal pitch [μm]/128

In the case of Setting A, the input frequency is 750 kHz, so that the maximum allowable speed dependent on the detector is:
Maximum allowable speed
= Signal pitch [m] × 750000 [Hz] × 3600 [s]
Thus, the maximum allowable speed is greater than that for Setting B.

For details, refer to the specifications of position detection circuit H.

7 When the position detection circuit C (A860-0333-T301 or -T302) for linear motor is used, no function is available which can change an interpolation magnification according to a set-up pin.
The interpolation magnification is 2048, and the input frequency is 200 kHz.
Linear motor position detection circuit C is connected to the scale with an absolute address origin.

Parameter setting procedure (2)

For incremental type, **For absolute type**

Procedure (2) makes parameter settings that depend on the resolution of the linear encoder (hereafter simply called "the resolution"). Set the parameters according to Table 4.14.1 (d), (e).

When using an incremental type linear encoder, calculate as follows:
Resolution [μm] = encoder signal pitch [μm] / 512

The pole-to-pole span used in calculation varies, depending on the motor model.

- Small linear motors: 30 mm (L*i*S300A, L*i*S600A, L*i*S900A)
- Medium-size and large linear motors: 60 mm (models other than the above)
  (See Table 4.14.1(c).)

	#7	#6	#5	#4	#3	#2	#1	#0
1804 (FS15*i*)								PLC0
2000 (FS30*i*, 16*i*)								

PLC0(#0) The number of velocity pulses and the number of position pulses are:
0: Used without being modified.
1: Used after being multiplied by 10
If the number of velocity pulses is lager than 32767, set the parameter to 1.
If the number of position pulses exceeds 32767, use the following position pulse conversion coefficient.

1876 (FS15*i*)	Number of velocity pulses
2023 (FS30*i*, 16*i*)	

(Parameter calculation expression)
Number of velocity pulses = 3125 / 16 / (resolution [μm])
If the calculation result is greater than 32767, set up PLC0 = 1, and set the parameter (PULCO) with a value of 1/10.

1891 (FS15*i*)	Number of position pulses
2024 (FS30*i*, 16*i*)	

(Parameter calculation expression)
Number of position pulses = 625 / (resolution [μm])
If the calculation result is greater than 32767, determine the parameter setting (PPLS), using the following position pulse conversion coefficient (PSMPYL).

2628 (FS15*i*)	Position pulses conversion coefficient
2185 (FS30*i*, 16*i*)	

This parameter is used if the calculated number of position pulses is greater than 32767.
(It can be specified in the Series 90B0, 90B1, 90B6, 90B5, 90D0, or 90E0.)
(Parameter calculation expression)
PLC0 = 0 → The parameter is set so that the following equation holds: (the number of position pulses) × (position pulses conversion coefficient) = 625/resolution [μm].
PLC0 = 1 → The parameter is set so that the following equation holds: 10 × (the number of position pulses) × (position pulses conversion coefficient) = 625/resolution [μm].
(→ See Supplementary 3 of Subsection 2.1.8.)

	#7	#6	#5	#4	#3	#2	#1	#0
1707 (FS15*i*)	APTG							
2013 (FS30*i*, 16*i*)								

APTG(#7) When using an absolute type linear encoder, set this bit to:
1: Ignores an α Pulsecoder soft disconnection.

Setting AMR conversion coefficients

Calculate the number of feedback pulses per pole-to-pole span of the linear motor, and find AMR conversion coefficients 1 and 2 expressed by the equation shown below.
Number of pulses per pole-to-pole span
= pole-to-pole span [mm] × 1000/resolution [μm]
= (AMR conversion coefficient 1) × $2^{\text{(AMR conversion coefficient 2)}}$

1705 (FS15*i*)	AMR conversion coefficient 1
2112 (FS30*i*, 16*i*)	

1761 (FS15*i*)	AMR conversion coefficient 2
2138 (FS30*i*, 16*i*)	

Supplementary)
If AMR conversion coefficient 1 = (pole-to-pole span [mm]/ resolution [μm]) is an integer and a multiple of 1024, setting of only AMR conversion coefficient 1 is needed. In this case, the following are assumed:
AMR conversion coefficient 1
= (pole-to-pole span [mm]/resolution [μm])
AMR conversion coefficient 2 = 0

The pole-to-pole span depends on the motor model as indicated in the table below.

Table 4.14.1 (c) List of pole-to-pole spans

Classification	Pole-to-pole span (D)	Motor model
Small motors	30mm	L*i*S300A, L*i*S600A, L*i*S900A
Medium-size and large motors	60mm	Model other than the above

1977 (FS15*i*) 2084 (FS30*i*, 16*i*)	Flexible feed gear numerator

1978 (FS15*i*) 2085 (FS30*i*, 16*i*)	Flexible feed gear denominator

Use a unified detection unit for the flexible feed gear (FFG) parameters according to Tables 4.14.1 (d) and 4.14.1 (e).
(Parameter calculation expression)
FFG = (resolution [μm]) / (detection unit [μm])

Table 4.14.1 (d) Parameter setting when an incremental type linear encoder is used

[Medium-size and large motors] (pole-to-pole span: 60mm)

Signal pitch	PLC0 (2000#0)	Number of velocity pulses / Number of position pulses, Conversion coefficient (No.2023 / No.2024, 2185)	AMR conversion coefficient 1 or 2 (No.2112, 2138)	FFG(No.2084/No.2085)	
				1-μm detection	0.1-μm detection
20	0	5000 / 16000, 0	3000, 9	5 / 128	50 / 128
40	0	2500 / 8000, 0	1500, 9	5 / 64	50 / 64
2	1	5000 / 8000, 2	30000, 9	1 / 256	10 / 256
4	1	2500 / 8000, 0	15000, 9	1 / 128	10 / 128
40.513167	0	2468 / 7899, 0	1481, 9	301 / 3804	3010 / 3804

[Small motors] (pole-to-pole span: 30mm)

Signal pitch	PLC0 (2000#0)	Number of velocity pulses / Number of position pulses, Conversion coefficient (No.2023 / No.2024, 2185)	AMR conversion coefficient 1 or 2 (No.2112, 2138)	FFG(No.2084/No.2085)	
				1-μm detection	0.1-μm detection
20	0	5000 / 16000, 0	1500, 9	5 / 128	50 / 128
40	0	2500 / 8000, 0	750, 9	5 / 64	50 / 64
2	1	5000 / 8000, 2	15000, 9	1 / 256	10 / 256
4	1	2500 / 8000, 0	7500, 9	1 / 128	10 / 128
40.513167	0	2468 / 7899, 0	1481, 8	301 / 3804	3010 / 3804

* The parameter Nos. for the Series 15*i* are omitted. See the previous page.

Table 4.14.1 (e) Parameter setting when an absolute type linear encoder is used

[Medium-size and large motors] (pole-to-pole span: 60mm)

Resolution	PLC0 (2000#0)	Number of velocity pulses / Number of position pulses, Conversion coefficient (No.2023 / No.2024, 2185)	AMR conversion coefficient 1 or 2 (No.2112, 2138)	FFG(No.2084/No.2085)	
				1-μm detection	0.1-μm detection
0.1	0	1953 / 6250, 0	9375, 6	1/10	1/1
0.05	0	3906 / 12500, 0	9375, 7	1/20	1/2

[Small motors] (pole-to-pole span: 30mm)

Resolution	PLC0 (2000#0)	Number of velocity pulses / Number of position pulses, Conversion coefficient (No.2023 / No.2024, 2185)	AMR conversion coefficient 1 or 2 (No.2112, 2138)	FFG(No.2084/No.2085)	
				1-μm detection	0.1-μm detection
0.1	0	1953 / 6250, 0	9375, 5	1/10	1/1
0.05	0	3906 / 12500, 0	9375, 6	1/20	1/2

* The parameter Nos. for the Series 15*i* are omitted. See the previous page.

(Cautions)
If the encoder signal pitch is larger than 200 μm, various coefficients used in the servo software may overflow to raise an alarm on invalid parameters, because the setting for the number of velocity pulses becomes very small.
In this case, change the corresponding parameter by referencing Subsection 2.1.8, "Measures for Alarms on Illegal Servo Parameter Settings."

The setting of an AMR conversion coefficient is changed from that described in B-65270EN/04 or earlier. (A change is made starting with B-65270EN/05 to improve the precision of setting.)
The conventional setting method poses no practical problem, but the setting of the new values is recommended.

Parameter setting procedure (3)

When a linear motor is used, the linear encoder must be installed so that the Z phase of the linear encoder matches the origin of the activating phase. Otherwise, the specified motor characteristics cannot be obtained. (For details of installation positions, refer to "FANUC LINEAR MOTOR L*i*s series DESCRIPTIONS (B-65382EN)".)

Procedure (3) describes the method of adjusting the activating phase origin (AMR offset adjustment) when it is difficult to install a linear encoder at a specified position with a specified precision.

Setting the AMR offset

For incremental type, **For absolute type**

- When the learning control function is used (Series 90B3 and 90B7), see "Learning Function Operator's Manual".
- When the learning control function is not used (Series 9096, 90B0, 90B6, 90B5, 90D0, and 90E0), set the AMR offset as follows:

1762 (FS15*i*) / 2139 (FS30*i*, 16*i*)	AMR offset

Specifies an activating phase (AMR offset) for phase Z.

[Unit of data] Degrees
[Valid data range] -45 to +45 (*)

(*) Extended AMR offset setting range (-60 degrees to +60 degrees) can be specified by setting the parameter below. So, if the AMR offset value does not lie within the range -45 degrees to +45 degrees in adjustment processing, set the bit below. (Usually, set the bit below to 0.)
(Series 9096 and Series 90B0/B(02) and earlier editions are not supported.)

	#7	#6	#5	#4	#3	#2	#1	#0
2683 (FS15*i*) 2270 (FS30*i*, 16*i*)								AMR60

AMR60 (#0) Changes the AMR offset setting range.

0: -45 degrees to +45 degrees (standard setting range)

1: -60 degrees to +60 degrees (extended setting range)

The procedure for AMR offset adjustment is described below. The procedure varies according to whether an incremental type linear encoder or absolute type linear enable is used. Before starting an adjustment, check the type of linear encoder used.

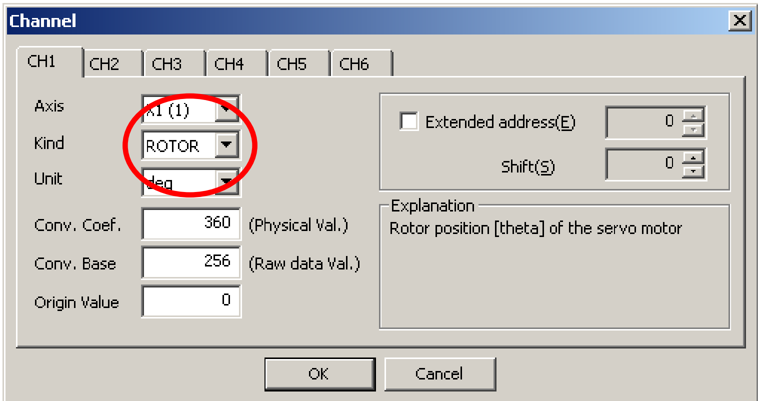
Incremental type

The procedure for AMR offset adjustment when an incremental type linear encoder is used is described below. When using an absolute type linear encoder, see the item of Absolute type described later.

Make a fine activating phase adjustment according to the procedure below.

Measuring the activating phase

(1) Connect SERVO GUIDE to the CNC, and set channel data as shown below.
Select the target axis for measurement, and set the data type to "ROTOR".



* For a linear motor, a value from 0 to 360 degrees is read each time a motion is made over the distance of a pair of the N pole and S pole of the magnet (pole-to-pole span).

(2) Run the linear motor using a JOG operation for example, and observe the behavior of the activating phase (AMR) before, at the moment, and after phase Z is captured. (See Figs. 4.14.1 (a) and (b).)
The activating phase changes to 0 (or 360) degrees at the moment phase Z is captured. Measure the value just before it changes, and let this value be A.

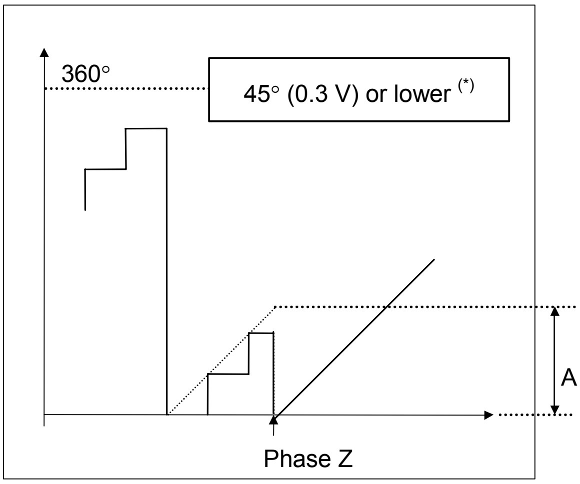


Fig. 4.14.1 (a) If the offset is set with a positive number (before AMR offset adjustment)

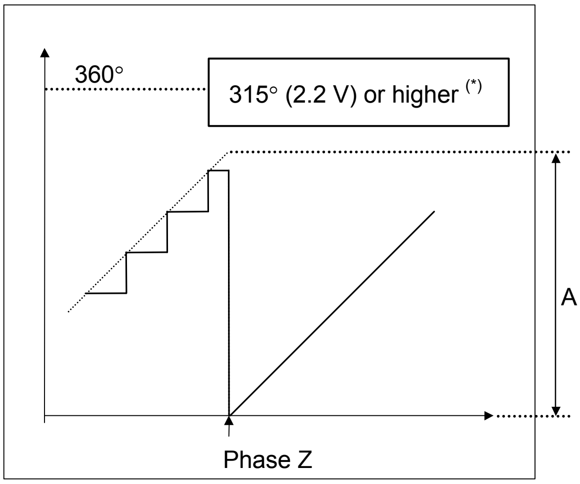


Fig. 4.14.1 (b) If the offset is set with a negative number (before AMR offset adjustment)

(*) The figures above show examples where AMR60 = 0. When AMR60 = 1, "45° (0.3 V) or lower" should read "60° (0.4 V) or lower", and "315° (2.2 V) or higher" should read "60° (2.1 V) or higher".

(3) Set the AMR offset parameter with A (or A - 360).
* The parameter setting range is:
-45 degrees to +45 degrees (when AMR60 = 0)
-60 degrees to +60 degrees (when AMR60 = 1)
When the value of A does not lie within the setting range, the installation position of the linear encoder needs to be readjusted.
The voltage range of A allowing parameter setting, when measured by analog voltage, is as follows:
0 V to 0.3 V and 2.2 V to 2.5 V (when AMR60 = 0)
0 V to 0.4 V and 2.1 V to 2.5 V (when AMR60 = 1)

(4) Switch the power off and on again. Now parameter setting is completed.

(5) Observe the activating phase (AMR) again according to step (2) above, and check that the activating phase changes continuously in the phase Z rising portion.

(6) Switch the power off and on again. This completes parameter setting.

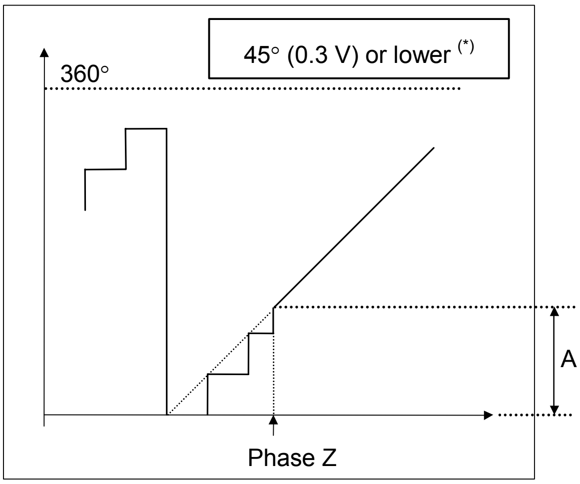


Fig. 4.14.1(c) If the offset is set with a positive number (after AMR offset adjustment)

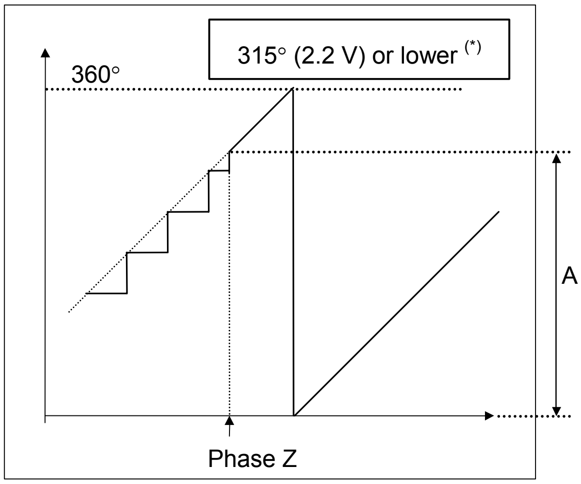


Fig. 4.14.1(d) If the offset is set with a negative number (after AMR offset adjustment)

(*) The figures above show examples where AMR60 = 0. When AMR60 = 1, "45° (0.3 V) or lower" should read "60° (0.4 V) or lower", and "315° (2.2 V) or higher" should read "300° (2.1 V) or higher".

When using the servo check board

(1) Connect the servo check board to the CNC.

(2) Set the 7-segment LED on check board CH1 as follows:
Set the axis number of parameter No. 1023 in the AXIS digit.
Set 5 in the DATA digit.

(3) For activating phase measurement, set the parameter below.

1726 (FS15*i*)	Parameter for internal data measurement
2115 (FS16*i*)	

Series 9096:
326 for an odd-numbered axis and 966 for an even-numbered axis
Series 90B0, 90B1, 90B5, or 90B6:
326 for an odd-numbered axis and 2374 for an even-numbered axis
Under this condition, the activating phase is output from CH1 on the check board.
To use a digital check board to measure data with a personal computer, set up "SD" (servo tuning software) as stated below. The displayed value is in degree units ("360 degrees" is displayed as "360").

DOS prompt > SD INIT [Enter]	
o	(Origin of position)
F9	(System setting)
0	(CH0)
2 [Enter]	(TCMD)
639.84375 [Enter]	(A)
F10	(Return to main menu.)

* See Sec. 4.19 for explanations about how to use the SD software. In addition, the analog voltage from the check board can be observed using an oscilloscope. In output conversion, 2.5 V corresponds to 360 degrees.

(4) The procedure for measuring the activating phase is the same as when SERVO GUIDE is used.

(5) After completing the adjustment, reset to 0 the parameter set in step (3).

Absolute type

The procedure for AMR offset adjustment when an absolute type linear encoder is used is described below. When using an incremental type linear encoder, see the item of Incremental type described earlier. Make a fine activating phase adjustment according to the procedure below.

> ⚠ **CAUTION**
> In this adjustment, the linear motor is driven by current fed from the DC power supply. So, the CNC does not exercise position control. For safety, move the coil slider of the linear motor to near the stroke center and make an adjustment. (Activation by the DC power supply moves a medium-size or large linear motor for up to about 60 mm, and moves a small linear motor for up to about 30 mm.)

(1) For activating phase adjustment, set the parameter below.
- For Series 9096, 90B0, 90B6, 90B5, or 90B1

1726 (FS15*i*)	**For internal data measurement**
2115 (16*i*)	

Series 9096:
320 for an odd-numbered axis, 960 for an even-numbered axis
Series 90B0, 90B1, 90B5, or 90B6:
320 for an odd-numbered axis, 2368 for an even-numbered axis

- For Series 90D0 or 90E0 (If diagnosis No. 762 is available, the activating phase can be directly checked using that data.)

-	**For internal data measurement**
2115 (FS30*i*)	

Set 0.

-	For internal data measurement
2151 (FS30*i*)	

Series 90D0:

532 for an odd-numbered axis, 660 for an even-numbered axis

Series 90E0:

No. 1023 = (4n + 1) axis: 532
No. 1023 = (4n + 2) axis: 660
No. 1023 = (4n + 3) axis: 6676
No. 1023 = (4n + 4) axis: 6804
(n=0,1,2,…)

- Common to all series
  After making the settings above, activating phase data is output to Display No. 353 on the CNC diagnosis screen. Note that display data = 256 on the diagnosis screen corresponds to an activating phase of 360 degrees. The following expression is used for output unit conversion to an activation phase [degrees]:
  Activating phase [degrees] =
  (Value of DGN No. 353) × 360/256

(2) Turn off the power to the CNC and servo amplifier.

(3) Detach the linear motor power line from the servo amplifier, then connect the power line to the DC power supply.
Connect the + terminal of the DC power supply to phase U of the power line, and connect the - terminal of the DC power supply to phase V and phase W of the power line.

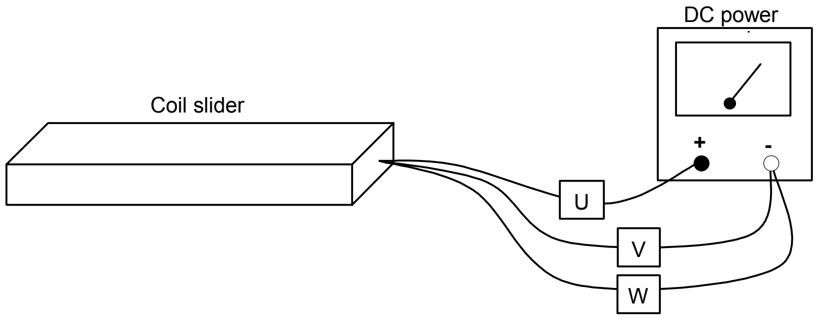


Fig. 4.14.1(e) Connection of DC power supply

(4) In the emergency stop state, turn on the power to the CNC and servo amplifier.

(5) Display No. 353 on the CNC diagnosis screen, and turn on the power to the DC power supply. Next, increase the current gradually (DC activation).
When the force of the linear motor produced by current supplied from the DC power supply exceeds static friction, the linear motor starts moving, and the linear motor automatically stops at a position where activation phase = 0.

A position where activating phase = 0 is present at intervals of 60 mm with medium-size and large linear motors, or at intervals of 30 mm with small linear motors.

> ⚠ **WARNING**
> If a large current flows abruptly, the motor produces a large force, resulting in a very dangerous situation. When making this adjustment, be sure to increase the current value gradually starting from current value = 0 [Ap].

(6) When the linear motor is at rest, read the value of No. 353 on the CNC diagnosis screen. Turn off the power to the DC power supply immediately after reading the value of No. 353.

* Make measurements of (5) and (6) several times by changing the DC activation start position within one pole (medium-size, large linear motor = 60 mm, small linear motor = 30 mm) to fine average activating phase data (value of DGN No. 353).

(7) Based on activating phase data measured with up to step 6) above, set the AMR offset parameter as described below.

* In the description below, the parenthesized values assume AMR60 = 1.

When 0 ≤ Value of DGN No. 353 ≤ 32 (42)

AMR offset setting
= -1 × (value of DGN No. 353) × 360/256

When 224 (214) ≤ Value of DGN No. 353 ≤ 255 (255)

AMR offset setting
= 360 - (value of DGN No. 353) × 360/256

When 32 (42) < Value of DGN No. 353 < 224 (214)

In this case, a soft phase alarm is issued when phase Z is passed. Adjust the linear encoder installation position according to "FANUC LINEAR MOTOR L*i*s series DESCRIPTIONS (B-65382EN)". After adjustment, make an AMR offset adjustment again from step 1).

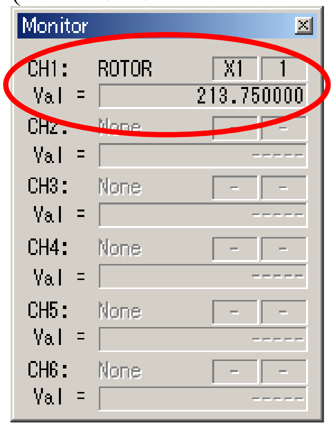
(8) Turn off then turn on the power to the CNC.

(9) Perform steps (5) and (6) again, and check that the activating phase data at a stop position is about 0 or 255.

(10) Turn off the power to the CNC and servo amplifier. Next, connect the power line of the linear motor to the servo amplifier. Then, turn on the power to the CNC and servo amplifier again.

(11) Check that feed operation by jogging and so forth can be performed normally. If no problem is observed, return the parameter set in step (1) to 0. This completes setting.

The activating phase can also be observed by connecting SERVO GUIDE to the CNC and selecting "Monitor" from the "Communication" menu of the graph window.
(Set "ROTOR" as the data type in channel setting.)



(Supplement)

Method for checking the activating phase value in the Series 15*i*
The diagnosis screen of the Series 15*i* has no data that corresponds to No. 353 on the diagnosis screen of the Series 16*i* and so on. So, display an arbitrary data screen by making the following parameter setting to check the activating phase value.

	#7	#6	#5	#4	#3	#2	#1	#0
2208 (FS15*i*)					ARB			
-								

ARB (#3) The arbitrary data screen is:
0: Not displayed
1: Displayed ← Use this setting.

Settings on the arbitrary data screen (see Fig. 4.14.1 (f).)
Parameter 1 of data 1 is loaded with the value set in Procedure (1). Make sure that parameter 2 is 0.

The activating phase is displayed in an enclosed section in the figure.

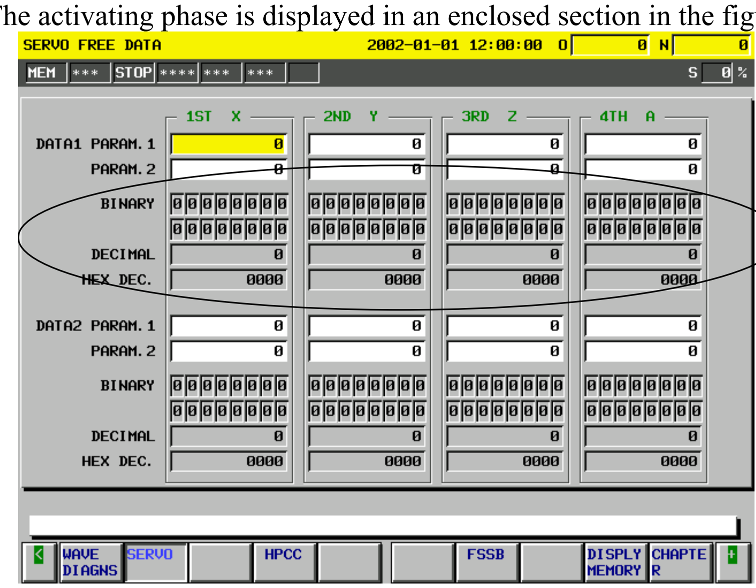


Fig. 4.14.1 (f) Series 15*i* arbitrary data screen

Parameter setting procedure (4)

Incremental type

Procedure (4) explains how to set up parameters for using a linear scale with a distance-coded reference marks in position detection circuit C (A860-0333-T301 or –T302).

- This function is optional.
- This function is supported only for the Series 30*i*/31*i*/32*i*-A, 15*i*-MB, 16*i*/18*i*/21*i*-B as of December 2005.
- For details of parameter setting, refer to the relevant CNC manual or specifications.

(For Series 30*i*/31*i*/32*i*-A)
Refer to the CNC connection manual (B-63943EN).
All software series and editions are applicable.
(For Series 15*i*-MB)
Refer to the CNC specifications (A-79233E).
All software series and editions are applicable.
(For Series 16*i*/18*i*/21*i*-B)
Refer to the CNC specifications (A-78754EN).
Series and editions of applicable CNC software
B0H1/BDH1/DDH1-17 and subsequent editions (Series 16*i*/18*i*/21*i*-MB)
B1H1/BEH1/DEH1-17 and subsequent editions (Series 16*i*/18*i*/21*i*-TB)
BDH5-07 and subsequent editions (Series 18*i*-MB5)

Setting procedure (for the Series 15*i*-MB)

Refer to the CNC specifications (A-79233E).

Setting procedure (for the Series 30*i*/31*i*/32*i*-A, Series 16*i*/18*i*/21*i*-B)

(1) Enable the linear scale with a distance-coded reference marks.

	#7	#6	#5	#4	#3	#2	#1	#0
-						DCLx		
1815 (FS30*i*, 16*i*)								

DCLx (#2) The linear scale interface with absolute address referenced mark is:
0: Not used as a position detector
1: Used as a position detector ← To be set

	#7	#6	#5	#4	#3	#2	#1	#0
-					SDCx			
1818 (FS30*i*, 16*i*)								

SDCx (#3) The linear scale with a distance-coded reference marks is:
0: Not used
1: Used ← To be set

-	Reference counter capacity
1821 (FS30*i*, 16*i*)	

Specify a round figure, such as 10000 or 50000, as the reference counter capacity.

-	Coordinate of the first reference position in the machine coordinate system for each axis
1240 (FS30*i*, 16*i*)	

Specify 0.

-	Distance 1 from the scale mark origin to the reference position
1883 (FS30*i*, 16*i*)	

Specify 0.

-	Distance 2 from the scale mark origin to the reference position
1884 (FS30*i*, 16*i*)	

Specify 0.

(2) Turn the CNC power off and on again.

(3) Follow this procedure to establish a reference position at an appropriate point.
Select the JOG mode, and set the manual reference position return signal ZRN to "1".
Set a feed axis direction selection signal (+J1, -J1, +J2, -J2, ...) for an axis for which a reference position is to be established to "1" and issue the signal.
When an absolute position on the linear scale is detected, the axis stops, causing the reference position-established signal (ZRF1, ZRF2, ...) to be set to "1".
If an overtravel alarm is issued in establishing a reference position, try to establish a reference position by disabling a stored stroke check.

(4) In the JOG or handle feed mode, place the machine accurately on the reference position.

(5) Using the following steps, perform the automatic setting of parameter No. 1883.

	#7	#6	#5	#4	#3	#2	#1	#0
-						DAT		
1819(FS30*i*, 16*i*)								

DAT (#2) At a manual reference position return, the automatic setting of parameter No. 1883 is:
0: Not performed
1: Performed ← To be set
After setting this parameter to "1", perform a manual reference position return.
When the manual reference position return is completed, parameter No. 1883 is specified, and this parameter is automatically reset to "0".

(6) If you want to disable a stored stroke check in establishing a reference position, re-set the necessary parameters to the original setting.

(7) Specify parameter No. 1240 as required.

-	Coordinate of the first reference position in the machine coordinate system for each axis
1240 (FS30*i*, 16*i*)	

Set up the coordinate of the first reference position in the machine coordinate system.

(8) This is the end of setting.

Parameter setting procedure (5)

Procedure (5) can be used to set parameters according to the cooling method used for linear motors.
Change the following parameters as listed in Table 4.14.1 (f). For self-cooling linear motors, the parameters need not be set here, because they are set up at initialization in procedure (1).

1877 (FS15*i*)	OVC alarm parameter (POVC1)
2062 (FS30*i*, 16*i*)	

1878 (FS15*i*)	OVC alarm parameter (POVC2)
2063 (FS30*i*, 16*i*)	

1893 (FS15*i*)	OVC alarm parameter (POVCLMT)
2065 (FS30*i*, 16*i*)	

1979 (FS15*i*)	Current rating parameter (RTCURR)
2086 (FS30*i*, 16*i*)	

1784 (FS15*i*)	OVC magnification in stop state (OVCSTP)
2161 (FS30*i*, 16*i*)	

Table4.14.1 (f) Setting OVC and current rating parameters by cooling method

[200-V driving]

Model	Cooling method	Rated (N)	POVC1	POVC2	POVCLMT	RTCURR	OVCSTP
L*i*S300A1/4	No cooling	50	32704	802	793	655	0
	Water cooling	100	32512	3199	3172	1310	0
L*i*S600A1/4	No cooling	100	32704	802	793	655	0
	Water cooling	200	32512	3199	3172	1310	0
L*i*S900A1/4	No cooling	150	32705	785	1784	983	0
	Water cooling	300	32518	3129	7136	1966	0
L*i*S1500B1/4	No cooling	300	32698	873	2590	1184	0
	Water cooling	600	32490	3481	10358	2368	0
L*i*S3000B2/2	No cooling	600	32711	719	2131	1074	0
	Water cooling	1200	32539	2867	8523	2148	0
L*i*S3000B2/4	No cooling	600	32698	873	2590	1184	0
	Water cooling	1200	32490	3481	10358	2368	0
L*i*S4500B2/2	No cooling	900	32707	758	1199	805	0
	Water cooling	1800	32526	3023	4794	1611	0
L*i*S6000B2/2	No cooling	1200	32711	719	2131	1074	0
	Water cooling	2400	32539	2867	8523	2148	0
L*i*S6000B2/4	No cooling	1200	32698	873	2590	1184	0
	Water cooling	2400	32528	3003	8932	2368	140
L*i*S7500B2/2	No cooling	1500	32707	765	832	671	0
	Water cooling	3000	32524	3053	3329	1342	0
L*i*S7500B2/4	No cooling	1500	32687	1010	799	658	0
	Water cooling	3000	32446	4026	3197	1316	0
L*i*S9000B2/2	No cooling	1800	32707	758	1199	805	0
	Water cooling	3600	32526	3023	4794	1611	0
L*i*S9000B2/4	No cooling	1800	32696	895	1151	789	0
	Water cooling	3600	32482	3570	4604	1579	0
L*i*S3300C1/2	No cooling	660	32708	749	1184	801	0
	Water cooling	1320	32529	2987	4738	1602	0
L*i*S9000C2/2	No cooling	1800	32729	489	1112	776	0
	Water cooling	3600	32612	1953	4448	1552	0
L*i*S11000C2/2	No cooling	2200	32723	560	1661	948	0
	Water cooling	4400	32589	2236	6644	1897	0
L*i*S15000C2/2	No cooling	3000	32729	483	621	579	0
	Water cooling	7000	32558	2623	3378	1352	0
L*i*S15000C2/3	No cooling	3000	32732	452	1340	852	0
	Water cooling	7000	32572	2455	7296	1988	140
L*i*S10000C3/2	No cooling	2000	32722	580	1719	964	0
	Water cooling	4000	32583	2314	6875	1929	0
L*i*S17000C3/3	No cooling	3400	32711	709	981	729	0
	Water cooling	6800	32542	2829	3925	1458	0

[400-V driving]

Model	Cooling method	Rated (N)	POVC1	POVC2	POVCLMT	RTCURR	OVCSTP
L*i*S1500B1/4	No cooling	300	32698	873	2590	1184	0
	Water cooling	600	32490	3481	10358	2368	0
L*i*S3000B2/2*i*	No cooling	600	32711	719	2131	1074	0
	Water cooling	1200	32539	2867	8523	2148	0
L*i*S4500B2/2HV	No cooling	900	32714	681	1549	915	0
	Water cooling	1800	32551	2718	6194	1831	0
L*i*S4500B2/2	No cooling	900	32707	758	1199	805	0
	Water cooling	1800	32526	3023	4794	1611	0
L*i*S6000B2/2HV	No cooling	1200	32706	774	688	610	0
	Water cooling	2400	32521	3085	2753	1221	0
L*i*S6000B2/2	No cooling	1200	32711	719	2131	1074	0
	Water cooling	2400	32539	2867	8523	2148	0
L*i*S7500B2/HV2	No cooling	1500	32714	680	1075	763	0
	Water cooling	3000	32551	2713	4301	1526	0
L*i*S7500B2/2	No cooling	1500	32709	739	658	596	0
	Water cooling	3000	32532	2949	2631	1193	0
L*i*S9000B2/2	No cooling	1800	32709	737	947	716	0
	Water cooling	3600	32533	2940	3788	1432	140
L*i*S3300C1/2	No cooling	660	32708	749	1184	801	0
	Water cooling	1320	32529	2987	4738	1602	0
L*i*S9000C2/2	No cooling	1800	32728	494	879	689	0
	Water cooling	3600	32610	1972	3514	1379	0
L*i*S11000C2/2HV	No cooling	2200	32723	560	1661	948	0
	Water cooling	4400	32589	2236	6644	1897	0
L*i*S11000C2/2	No cooling	2200	32730	474	1312	843	0
	Water cooling	4400	32616	1894	5250	1686	140
L*i*S15000C2/3HV	No cooling	3000	32730	471	1396	869	0
	Water cooling	7000	32563	2557	7601	2029	140
L*i*S10000C3/2	No cooling	2000	32720	597	1358	857	0
	Water cooling	4000	32577	2384	5432	1715	140
L*i*S17000C3/2	No cooling	3400	32711	709	981	729	0
	Water cooling	6800	32542	2829	3925	1458	0

[Conventional linear motors]

Model	Cooling method	Rated (N)	POVC1	POVC2	POVCLMT	RTCURR
1500A/4	No cooling	300	32698	873	2590	1184
	Air cooling	360	32667	1257	3729	1421
	Water cooling	600	32490	3481	10358	2369
3000B/2	No cooling	600	32698	873	2590	1184
	Air cooling	720	32667	1257	3729	1421
	Water cooling	1200	32490	3481	10358	2369
3000B/4	No cooling	600	32698	873	2590	1184
	Air cooling	720	32667	1257	3729	1421
	Water cooling	1200	32490	3481	10358	2368
6000B/2	No cooling	1200	32698	873	2590	1184
	Air cooling	1440	32667	1257	3729	1421
	Water cooling	2400	32490	3481	10358	2369
6000B/4 (160-A driving)	No cooling	1200	32706	777	2304	1117
	Air cooling	1440	32679	1118	3317	1340
	Water cooling	2400	32520	3098	9215	2234
9000B/2 (160-A driving)	No cooling	1800	32729	491	1457	888
	Air cooling	2160	32711	707	2098	1065
	Water cooling	3600	32611	1962	5827	1776
9000B/4 (360-A driving)	No cooling	1800	32737	388	1151	789
	Air cooling	2160	32723	559	1657	947
	Water cooling	3600	32644	1551	4604	1579
15000C/2 (360-A driving)	No cooling	3000	32751	209	621	579
	Air cooling	3600	32744	301	894	695
	Water cooling	7000	32677	1139	3378	1352
15000C/3	No cooling	3000	32732	452	1340	852
	Air cooling	3600	32716	651	1930	1022
	Water cooling	7000	32572	2455	7296	1988

Parameter setting procedure (6)

Procedure (6) provides supplementary information when servo HRV2 is applied with a conventional linear motor. When initialization has been performed with a motor ID number for servo HRV2 control in procedure (1), parameter settings need not be changed.

When servo HRV2 is applied to increase the current loop gain of a linear motor, it is necessary to set the following parameter, because linear motors have a higher current gain compared with rotary motors. This parameter setting must be done whenever the absolute value of the current loop proportional gain (PK2) becomes higher than 16000-20000 (as a rule of thumb) after application of servo HRV2.

	#7	#6	#5	#4	#3	#2	#1	#0
1750 (FS15*i*) 2210 (FS30*i*, 16*i*)						PK12S2		

PK12S2 (#2) Specifies whether to use the quadruple current loop gain function.
0: Not to use
1: To use ← To be set
When setting this function to ON, re-set the current gain parameters (PK1 and PK2) to one-fourth.
(Note: This function is not available with the Series 9096.)

Table 4.14.1 (g) Current gain parameter setting when SERVO HRV2 is applied

Model name	Typical setting (HRV1)				Setting after SERVO HRV2 is applied		
	PK12S2	PK1	PK2		PK12S2	PK1	PK2
1500A/4	0	1890	-7180	⇨	0	1512	-11488
3000B/2	0	4804	-14453		1	961	-5782
3000B/4	0	1620	-11180		1	324	-4472
6000B/2	0	4804	-13138		1	961	-5253
6000B/4 (160-A driving)	0	1751	-6701		0	1401	-10722
9000B/2 (160-A driving)	0	6198	-19692		1	1240	-7877
9000B/4 (360-A driving)	0	7416	-17747		1	1484	-7099
15000C/2 (360-A driving)	1	2130	-8400		1	1704	-13440
15000C/3	0	2392	-8448		1	478	-3379

> ⚠ **CAUTION**
> Before specifying these parameters, be sure to put the machine at an emergency stop.

(6) Illegal servo parameter setting alarms when linear motors are used

The following illegal servo parameter setting alarms are checked additionally when linear motors are used (they are not issued for rotary motors).

Parameter error alarm detail No.	Description
10043	No separate detector can be used for linear motors. Full-closed loop setting results in an alarm being issued.
1123	If no AMR conversion coefficient is set, an alarm is issued. Even when the linear encoder is not relocated after the motor is replaced, the AMR conversion coefficients must be re-set, because initialization accompanying motor replacement causes the AMR coefficients to be erased.
1393	The valid AMR offset data range is below : -45 (degrees) and +45 (degrees) : (AMR60=0) -60 (degrees) and +60 (degrees) : (AMR60=1) If a value out of this range is specified in the parameter, an invalid-parameter alarm is issued.

> ⚠ **CAUTION**
> When an AMR conversion coefficient is not set, an alarm is issued. If it is set, but incorrect, no alarm is issued. In this case, the linear motor fails to drive correctly immediately after it passes phase Z. It may move within one pole-to-pole span (60 mm or 30 mm) in the worst case.

(7) Notes on using high-speed HRV current control or the cutting /rapid velocity loop gain switching function

In general, a higher velocity loop gain (load inertia ratio) is set for a linear motor than for a rotary motor. So, if high-speed HRV current control and the cutting /rapid velocity loop gain switching function are used at the same time to achieve an even higher velocity loop gain, an overflow can occur in the internal value of the post-override velocity load proportional (PK2V: parameter No. 1856 for Series 15*i* or No. 2044 for Series 30*i*, 16*i*, and so on). (The parameter error detail number is 443 (*)). In this case, set the parameter indicated below. Whether an overflow occurs or not can be checked using Fig. 4.14.1(g).

(*) Series 9096 and Series 90B0/C(03) and earlier editions do not support the occurrence of parameter errors in velocity gain override and the display of detail numbers.

	#7	#6	#5	#4	#3	#2	#1	#0
1740 (FS15*i*) **2200 (FS30*i*, 16*i*)**		P2EX						

P2EX(#6) The format of velocity loop proportional gain (PK2V) is:

0: Standard format.

<u>1: Converted. ← To be set</u>

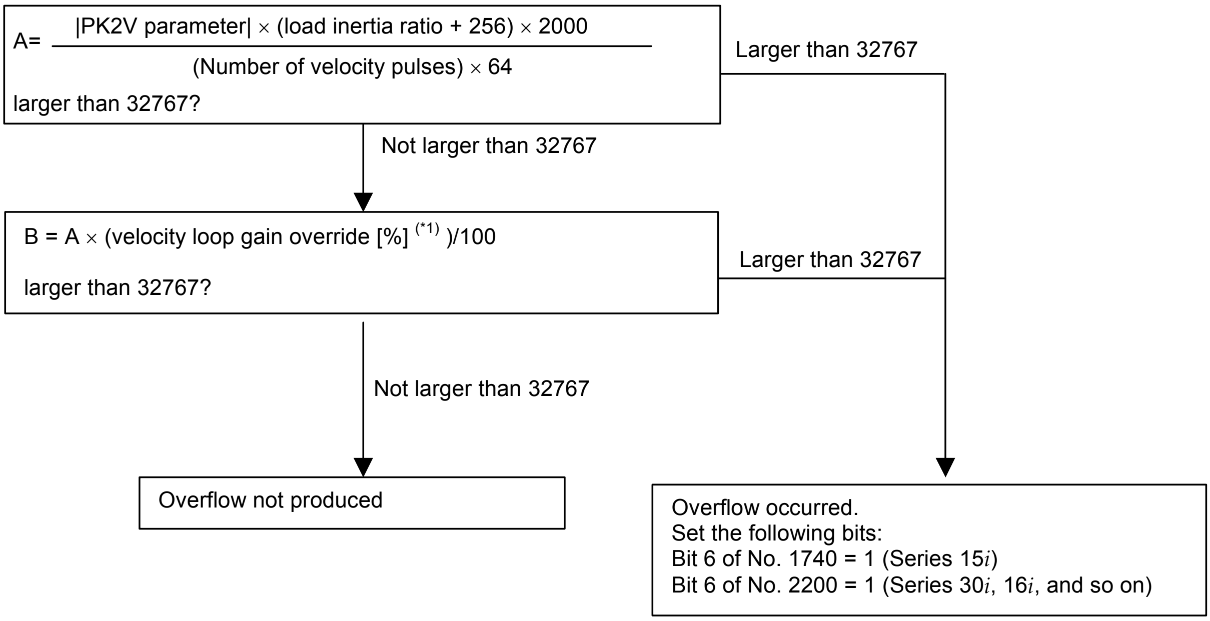


Fig. 4.14.1(g) PK2V overflow check

> ⚠ **CAUTION**
> In the flowchart above, the velocity loop gain override is represented by one of the following parameters:
> Velocity gain magnification when high-speed HRV current control is enabled
> → (No. 2335 for Series 30*i*, 16*i*, and so on or No. 2748 for Series 15*i*)
> Velocity gain override when the cutting feed/rapid traverse switchable velocity loop gain function is enabled
> → (No. 2107 for Series 30*i*, 16*i*, and so on or No. 1700 for Series 15*i*)

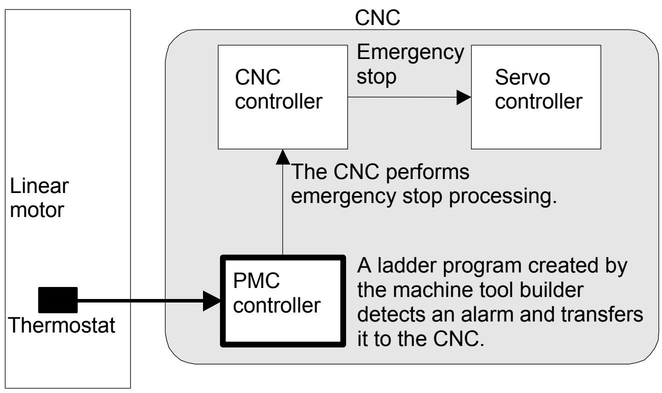
4.14.2 Detection of an Overheat Alarm by Servo Software when a Linear Motor and a Synchronous Built-in Servo Motor are Used

(1) Overview

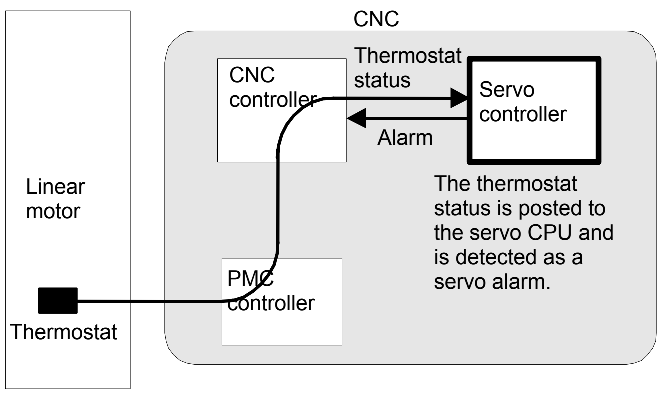
When a linear motor and a synchronous built-in servo motor are used, the motor overheat signal cannot be posted to the CNC via a detector. Therefore, to detect a motor overheat, alarm processing for the thermostat signal had to be performed by a PMC ladder. (For details, refer to Section 2.5, "THERMOSTAT CONNECTION", in Part III, "HANDLING, DESIGN, AND ASSEMBLY", in "FANUC LINEAR MOTOR L*i*S series DESCRIPTIONS (B-65382EN).)

This function uses servo software to monitor the thermostat signal applied to DI and issues a servo alarm (motor overheat) when an overheat occurs. Use of this function eliminates the need to perform alarm processing by using the PMC ladder.
In addition, when an overheat alarm is issued, quick stop processing (quick stop function with velocity command 0) can be used. (For details, see Subsection 4.11.5, "Quick Stop Function at OVL (Motor Overheat) and OVC (Over Current) Alarm".)

Conventional overheat processing



Overheat processing when this function is used



(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/J(10) and subsequent editions
Series 90E0/J(10) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,Power Mate *i*)
Series 90B6/B(02) and subsequent editions
Series 90B1/C(03) and subsequent editions
(Series 0*i*-C, 20*i*-B)
Series 90B5/B(02) and subsequent editions

When this function is used, the following system software is required:
B0H1/BDH1/DDH1-24 and subsequent editions (FS16*i*/18*i*-MB)
B1H1/BEH1/DEH1-24 and subsequent editions (FS16*i*/18*i*-TB)
BDH5-14 and subsequent editions (FS18*i*-MB5)
DDH1-24 and subsequent editions (FS21*i*-MB) (PMC-SB7 required)
DEH1-24 and subsequent editions (FS21*i*-TB) (PMC-SB7 required)
D4A1-07 and subsequent editions (FS0*i*-MB/TB) (PMC-SB7 required)
D6A1-07 and subsequent editions (FS0*i*-MB/TB) (PMC-SB7 required)
D4B1-01 and subsequent editions (FS0*i*-MC) (PMC-SB7 required)
D6B1-01 and subsequent editions (FS0*i*-TC) (PMC-SB7 required)

(*) This function is not supported by the Series 15*i*. The Power Mate *i* is planned to support this function in the future.

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
2713(FS15*i*) 2300(FS30*i*,16*i*)	CKLNOH							

CKLNOH(#7) Overheat is:
1: Determined via the PMC.
0: Not determined via the PMC.

> ⚠ **CAUTION**
> This function bit is included in the motor standard parameters. It is set automatically when servo parameter initialization is performed with a motor ID number set.
> In the CNC that cannot use interface G326 of the PMC, if this function bit is set to 1, a servo alarm (motor overheat) is issued. If this occurs, set the function bit to 0.
> * For the FS15*i*, set bit 7 of parameter No. 2713 to 0; for the Power Mate *i*, set bit 7 of parameter No. 2300 to 0.

(4) Signals

Overheat status signals input via the PMC SVDI61 to SVDI68<G326>

	#7	#6	#5	#4	#3	#2	#1	#0
G326	SVDI68	SVDI67	SVDI66	SVDI65	SVDI64	SVDI63	SVDI62	SVDI61

[Classification] Input signal

[Function] Thermostat signals are input via the PMC. An independent signal is provided for each axis, and the last digit of each name indicates the number of a controlled axis.

[Status] 0: A signal for issuing an overheat alarm or detecting an overheat is not connected.

1: No overheat alarm is issued.

(5) Connection and usage

<1> Parameter setting

Set the function bit of this function, CKLNOH, to 1.

In the standard parameters of the linear motor and synchronous built-in servo motor, CKLNOH is set to 1. So, unless a thermostat is connected, an motor overheat alarm is issued.

<2> Connecting the thermostat and DI signal

The signal of the thermostat mounted on the linear motor and synchronous built-in servo motor is connected to G326, which is a DI signal. The G326 status is automatically transferred to the servo software if the servo software supports this function. The servo software monitors the status, and when an overheat occurs, the servo software issues a servo alarm (motor overheat).

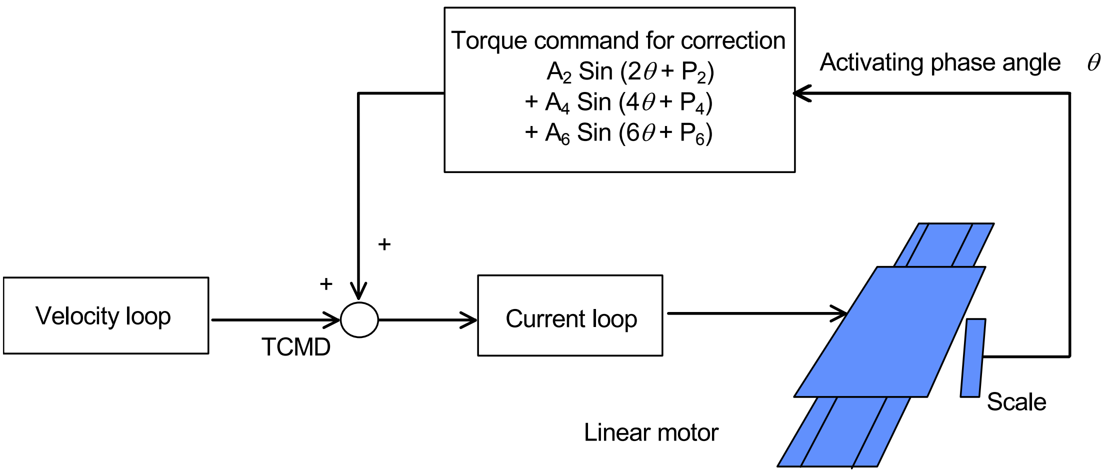
[Alarm detail indication on the servo adjustment screen]

Alarm	Alarm 1 #7(OVL)	Alarm 2 #7(ALD)	Alarm 2 #4(EXP)
Motor overheat alarm via Pulsecoder	1	1	0
Overheat alarm via PMC DI signal	1	1	1

4.14.3 Smoothing Compensation for Linear Motor

(1) Overview

Smoothing compensation for linear motors improves the smoothness in feed of a linear motor by producing a sinusoidal compensation torque with a cycle of 1/2, 1/4, or 1/6 of the pole-to-pole span produced by servo software and by applying such a torque to the current command. Compensation torque can be generated for each motor by setting gain and phase for each component.



(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 20*i*-B)
Series 90B5/A(01) and subsequent editions

(3) Setting parameters

1753 (FS15*i*)	**Smoothing compensation performed twice per pole pair**	
2130 (FS30*i*, 16*i*)	**Correction gain (high-order 8 bits)**	**Correction phase (low-order 8 bits)**

1754 (FS15*i*)	**Smoothing compensation performed four times per pole pair**	
2131 (FS30*i*, 16*i*)	**Correction gain (high-order 8 bits)**	**Correction phase (low-order 8 bits)**

1755 (FS15*i*)	**Smoothing compensation performed six times per pole pair**	
2132 (FS30*i*, 16*i*)	**Correction gain (high-order 8 bits)**	**Correction phase (low-order 8 bits)**

Setting the correction gain of the following parameters with a nonzero value can switch between the negative direction smoothing compensation and the positive direction smoothing compensation. In this case, the smoothing compensation parameter explained above applies only to feeding in the positive direction.
(Series 9096 and Series 90B0/M(13) and earlier editions are not supported.)

2782 (FS15*i*)	**Smoothing compensation performed twice per pole pair (negative direction)**	
2369 (FS30*i*, 16*i*)	**Correction gain (high-order 8 bits)**	**Correction phase (low-order 8 bits)**

2783 (FS15*i*)	**Smoothing compensation performed four times per pole pair (negative direction)**	
2370 (FS30*i*, 16*i*)	**Correction gain (high-order 8 bits)**	**Correction phase (low-order 8 bits)**

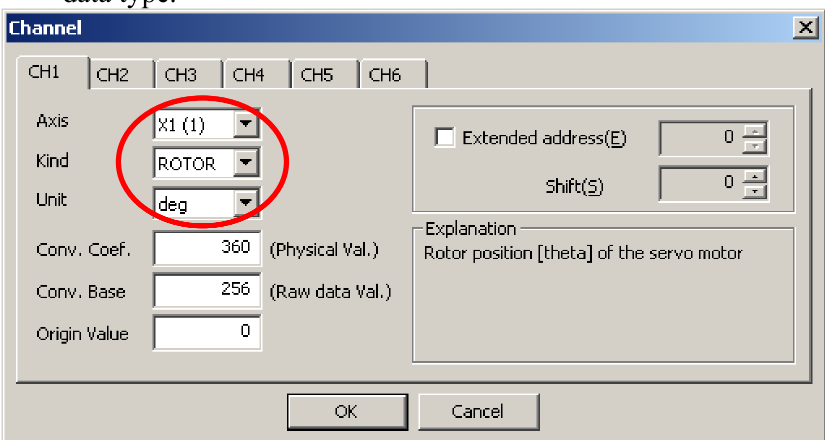
2784 (FS15*i*)	**Smoothing compensation performed six times per pole pair (negative direction)**	
2371 (FS30*i*, 16*i*)	**Correction gain (high-order 8 bits)**	**Correction phase (low-order 8 bits)**

Since the compensation parameters differ from motor to motor (depending on the motor rather than the model), these parameters must be determined for each motor assembled.
In principle, variation in torque command that is generated when the motor is fed at a low speed depends on the position. The application of smoothing compensation cancels this position-dependent characteristic, allowing the motor to move smoothly.
The measuring instruments that can be used to determine these parameters include "SERVO GUIDE" (Ver. 2.00 or later) and "SD" (servo tuning software).

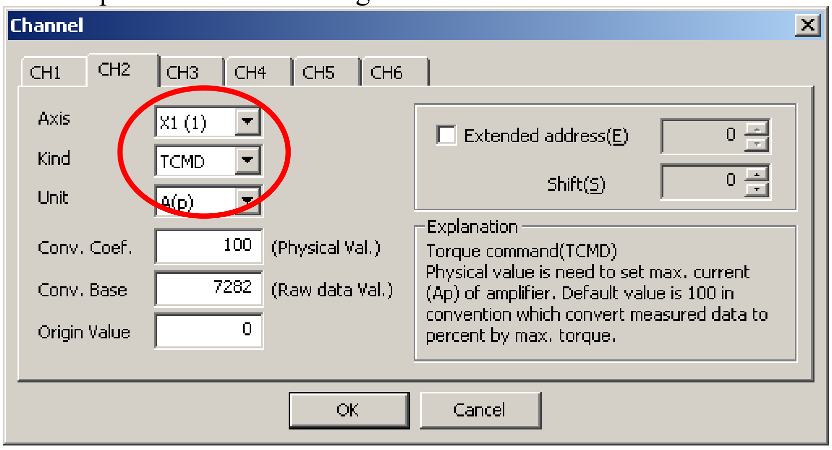
If using SERVO GUIDE (Ver. 2.00 or later)

By using SERVO GUIDE (Ver. 2.00 or later), these parameters can be determined easily. Follow the procedure below to measure the activating phase and torque command, which are required to determine the compensation parameters.

<1> Set channels as follows:
Channel 1: Activating phase
Select the target axis for measurement, and set "ROTOR" as the data type.



Channel 2: Torque command
Select the target axis for measurement, and set "TCMD" as the data type.
As the conversion coefficient, set the maximum current of the amplifier used for the target axis.

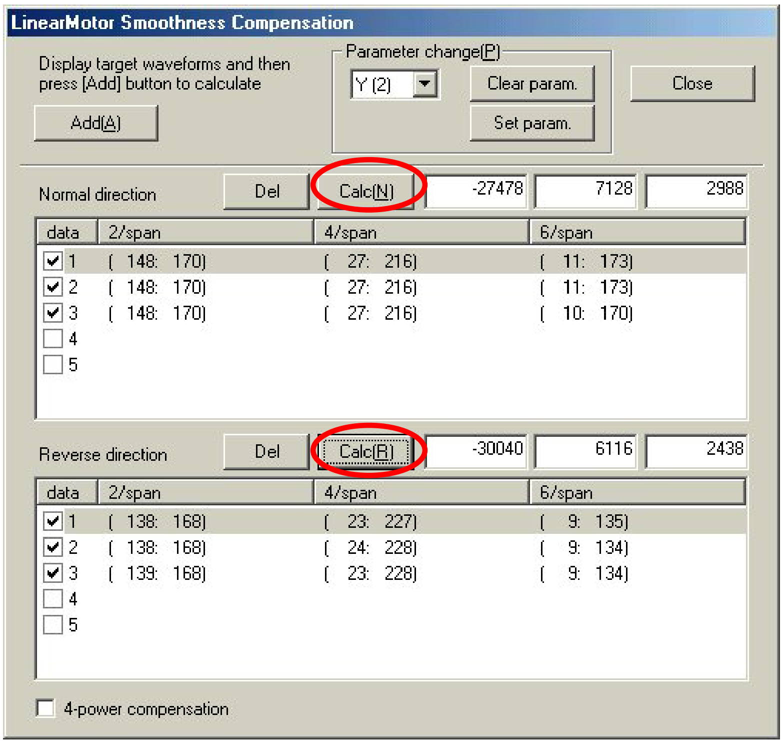


<2> Create a program that performs back and forth motion at a feedrate of F1200 (mm/min).
If the distance of movement is shorter than the pole-to-pole span, it is impossible to automatically calculate smoothing compensation parameters. Therefore, it is recommended that the distance of movement be at least 200 mm for large linear motors or at least 100 mm for small linear motors. For the number of measurement points, provide an enough time to obtain data during one back and forth motion of the motor. (About 15000 to 20000 points in 1-ms sampling)

<3> When making measurements, lower the velocity gain to such an extent that hunting does not occur.

<4> From the "Tools" menu, select "Linear motor compensation calculation".
(The shortcut is [Ctrl] + [L].)

<5> In the displayed dialog box, press the [Add] button. Then waveform data is analyzed, and candidates of the compensation parameters are registered.



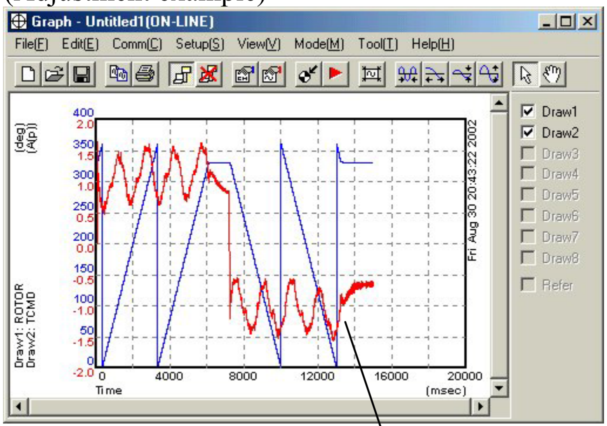
<6> The compensation parameters slightly vary depending on the measurement situation. So, repeat a data measurement and a press of the [Add] button several times in a similar manner while keeping the dialog box open. (Up to five candidates can be registered.)
If the displayed values include an extremely different value, uncheck the corresponding check box on the leftmost side of the list so that the value is not taken into account in the final compensation calculation.

<7> Finally, press the [Calc] button for each of the forward and backward directions. Then, smoothing compensation parameters are displayed.

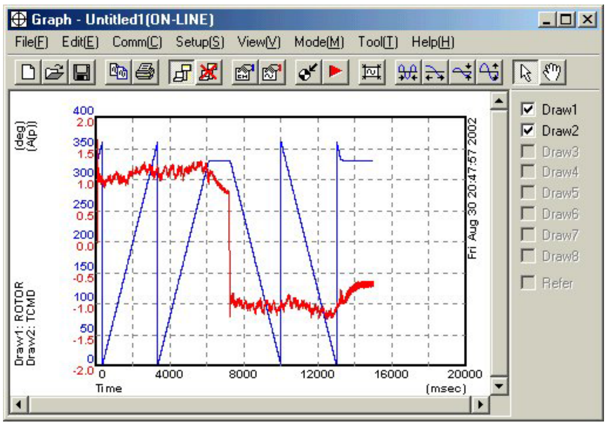
<8> When the target axis for parameter transfer is selected in "Parameter change", and the [Set param.] button is pressed, the presented parameters are set in the CNC.

<9> Measure TCMD again to confirm the effect of smoothing compensation.

(Adjustment example)



Before smoothing compensation adjustment



After smoothing compensation adjustment

Torque command (TCMD)

(*) For details on the use of SERVO GUIDE, refer to the online help of SERVO GUIDE.

If using SD (servo tuning software)

Follow the procedure described below to measure the activating phase angle and torque command necessary to determine the correction parameters.
The following procedure use terms "odd-numbered axis" and "even-numbered axis" in relation to axis numbers specified in parameter No. 1023 (common to the Series 15*i* and Series 16*i* and so on).

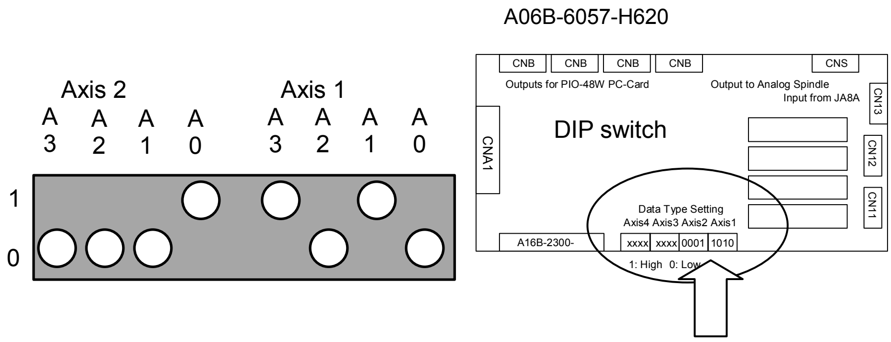
<1> Series 90B0: Does not require step <1>. Go to step <2>.
Series 9096: To measure an odd-numbered axis, set a dummy bit to 1 for the even-numbered axis paired with it.
<u>If a linear motor is used in tandem control, however, do not set a dummy bit for the paired axis</u>.

	#7	#6	#5	#4	#3	#2	#1	#0
-								SERD
2009 (FS16*i*)								

SERD (#0) Specifies whether to enable the dummy serial feedback function.
0: To disable
<u>1: To enable ← To be set</u>
* Do not forget to restore the previous setting after parameter setting is completed.

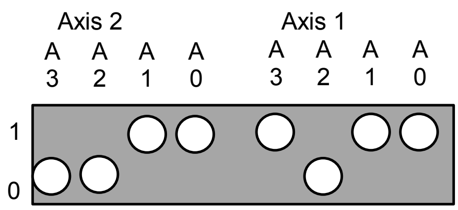
<2>-a When using A06B-6057-H620 (digital check board), set the DIP switches on the check board as follows:

To measure an odd-numbered axis:



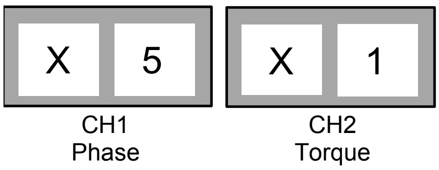
AXIS2: 1 (torque) AXIS1: 10 (phase)

To measure an even-numbered axis:



AXIS2: 3 (torque) AXIS1: 11 (phase)

<2>-b When using A06B-6057-H630 (one-piece analog/digital type), set up the 7-segment LED digits on the check board as shown below:



* Letter X stands for an axis number specified in parameter No. 1023.

<3> To measure the activating phase angle, set the following parameter.

1726 (FS15*i*)	**Parameter for internal data measurement**
2115 (FS16*i*)	

Series 9096: 1328 (for both odd- and even-numbered axes)
Series 90B0, 90B1, 90B6, 90B5:
704 for odd-numbered axis and 2752 for even-numbered axis

Steps <2> and <3> enable CH0 and CH1 of the SD software to be used to measure the motor activating phase angle (CH0) and torque command (CH1).

<4> Start the "SD" software, and make the following setting.

DOS prompt > SD INIT [Enter]	
o	(Origin of position)
F9	(System setting)
0	(CH0)
2 [Enter]	(TCMD)
1.0 [Enter]	(1.0A)
1	(CH1)
2 [Enter]	(TCMD)
40 [Enter]	(Maximum current for servo amplifier to be used)
F10	(Return to main menu.)
(Ctrl)T	(XTYT mode selected)
F2	(Data number)
9000 [Enter]	(Number of data items to be measured)

* This description uses the L*i*S3000B2/2 as an example. It differs from other models only in the current rating of the servo amplifier. For small linear motors, set the number of data items to be measured to 4500.

<5> When determining the correction parameters, set the velocity gain to a rather low value.

<6> For medium-size and large motors, make a reciprocating motion for 200 mm or more at F1200 (mm/min).
For small linear motors, make a reciprocating motion for 100 mm or more at F1200 (mm/min).

<7> Pressing the F1 key (to start measurement) at regular speed displays the data shown below. (Check that the activating phase angle-based sine waveform changes from negative to positive at three points or more.)

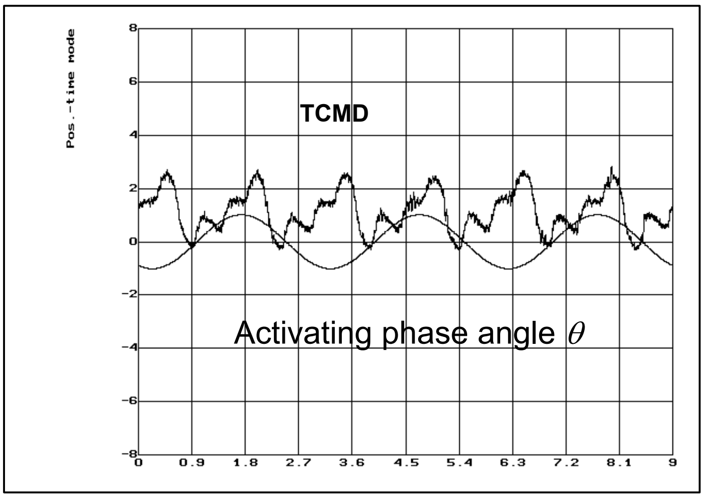
⚠ CAUTION

Measurement direction varies with the setting of the direction-of-movement parameter.

[If a direction-specific smoothing compensation is not used]
When the setting is 111: Measurement is performed during forward movement.
When the setting is -111: Measurement is performed during backward movement.

[If a direction-specific smoothing compensation is used]
(When determining a compensation value for the positive direction)
When the setting is 111: Measurement is performed during forward movement.
When the setting is -111: Measurement is performed during backward movement.
(When determining a compensation value for the negative direction)
When the setting is 111: Measurement is performed during backward movement.
When the setting is -111: Measurement is performed during forward movement.

Measurement in the wrong direction hinders correct calculation of the correction parameter.



<8> Pressing [CTRL]+[L] causes the correction parameter values to be calculated as shown below. Enter the displayed parameter values. Usually, use the correction parameter values displayed on the top row.
The parameter values displayed on the middle and bottom rows are used for special parameter setting.
Middle row: To be used when either quadruple smoothing compensation or quadruple TCMD output is selected.
Bottom row: To be used when both quadruple smoothing compensation and quadruple TCMD output are selected.

```
<< Normal torque ripple compensation >>
   FS15B / FS16C    Parameter
2: #1753 / #2130 -> -25425 (   156:   175)
4: #1754 / #2131 ->  22774 (    88:   246)
6: #1755 / #2132 ->  20504 (    80:    24)

<< Compensation Value x 4 mode >> No.1743 B6=1 (FS15) / No.2203 B6=1 (FS16) or
<< TCMD Serial-Out x 4 mode    >> No.1743 B5=1 (FS15) / No.2203 B5=1 (FS16) ~~
2: #1753 / #2130 ->  10159 (    39:   175)
4: #1754 / #2131 ->   5878 (    22:   246)
6: #1755 / #2132 ->   5144 (    20:    24)

<< Compensation Value x 4 mode >> No.1743 B6=1 (FS15) / No.2203 B6=1 (FS16) and
<< TCMD Serial-Out x 4 mode    >> No.1743 B5=1 (FS15) / No.2203 B5=1 (FS16) ~~~
2: #1753 / #2130 ->   2479 (     9:   175)
4: #1754 / #2131 ->   1526 (     5:   246)
6: #1755 / #2132 ->   1304 (     5:    24)
```

Parameter settings are displayed in a form of, for example:
-25425 (156: 175)
This format means that the correction gain (parameter high byte) and correction phase (parameter low byte) are, respectively, 156 and 175.
Because 156 = 9Ch and 175 = AFh,
parameter setting = 9CAFh = -25425.

When specifying the smoothing compensation (negative direction) parameters (Nos. 2782 to 2784 (Series 15*i*) or Nos. 2369 to 2371 (Series 16*i* and so on)), it is impossible to use the parameter values stated on the previous pages without modifying them. It is necessary to shift the phase by 128.

Example)

Assuming that the correction gain and correction phase measured in the negative direction are, respectively, 10 and 100:

10 = 0Ah

100 **<u>+ 128</u>** = 228 = E4h

Therefore, the parameter value is:

0AE4h = 2788

* If the sum of the phase data and 128 exceeds 255, perform the following calculation:
Phase data = value that was read + 128 - 256

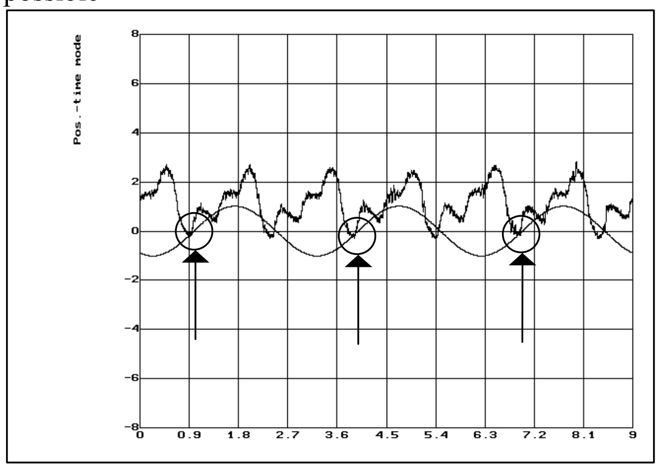
The December 1999 version and later of the SD software can display correction parameters for the negative direction. When using these versions, use the parameter values displayed on the right section without modifying them.

```
<< Normal torque ripple compensation >>
   FS15B / FS16C     Parameter                 OppositeSide(#1999 / #2106)
2: #1753 / #2130 ->   2224 (    8:   176)     2256 (    8:   208)
4: #1754 / #2131 ->   6312 (   24:   168)     6360 (   24:   216)
6: #1755 / #2132 ->  25736 (  100:   136)    25848 (  100:   248)

<< Compensation Value x 4 mode >> No.1743 B6=1 (FS15) / No.2203 B6=1 (FS16) or
<< TCMD Serial-Out x 4 mode    >> No.1743 B5=1 (FS15) / No.2203 B5=1 (FS16)
2: #1753 / #2130 ->    688 (    2:   176)      720 (    2:   208)
4: #1754 / #2131 ->   1704 (    6:   168)     1752 (    6:   216)
6: #1755 / #2132 ->   6536 (   25:   136)     6648 (   25:   248)

<< Compensation Value x 4 mode >> No.1743 B6=1 (FS15) / No.2203 B6=1 (FS16) and
<< TCMD Serial-Out x 4 mode    >> No.1743 B5=1 (FS15) / No.2203 B5=1 (FS16)
2: #1753 / #2130 ->    176 (    0:   176)      208 (    0:   208)
4: #1754 / #2131 ->    424 (    1:   168)      472 (    1:   216)
6: #1755 / #2132 ->   1672 (    6:   136)     1784 (    6:   248)
```

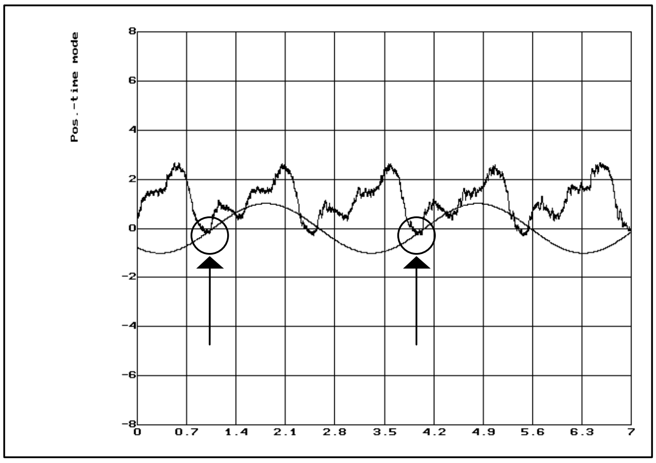
Compensation for the positive direction   Compensation for the negative direction

Example of measurement

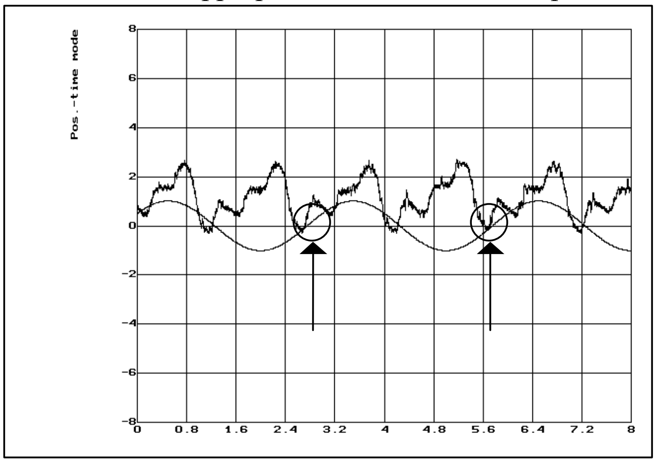
(a) Measured waveform where parameter value calculation is possible



(b) Measured waveform where parameter value calculation is impossible (No. 1)
Two activating phase angle-based sine waves cannot be acquired because of insufficient measurement time.



(c) Measured waveform where parameter value calculation is impossible (No. 2)
Two activating phase angle-based sine waves cannot be acquired because of an inappropriate measurement start position.



4.15 SYNCHRONOUS BUILT-IN SERVO MOTOR PARAMETER SETTING

4.15.1 Procedure for Setting the Initial Parameters of Synchronous Built-in Servo Motors

(1) Overview

The following describes the procedure for setting the digital servo parameters to enable the use of a FANUC synchronous built-in servo motor.
To drive a synchronous built-in servo motor, the optional pole detection function is required.

(2) Series and editions of applicable servo software

- Except α*i*CZ 768S
  (Series 30*i*,31*i*,32*i*)
  Series 90D0/A(01) and subsequent editions
  Series 90E0/A(01) and subsequent editions
  (Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,Power Mate *i*)
  Series 90B1/A(01) and subsequent editions
- α*i*CZ 768S
  (Series 30*i*,31*i*,32*i*)
  Series 90D0/J(10) and subsequent editions
  Series 90E0/J(10) and subsequent editions
  (Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B, Power Mate *i*)
  Series 90B1/C(03) and subsequent editions

NOTE
Series 90B1 does not support RCN727 manufactured by HEIDENHAIN, as a detector for synchronous built-in servo motors.

(3) Warning

⚠ WARNING
1 A synchronous built-in servo motor can make an unpredictable movement or vibration if the basic parameters for pole detection and so forth are not set correctly.
2 It is recommended to take the following actions until normal operation is confirmed:
- Lower the excessive error level so that an alarm is issued immediately when an unpredictable movement is made.
- Lower the torque limit value to disable abrupt acceleration.
- Ensure that the emergency stop switch can be pressed immediately.

(4) Detector

A rotary encoder is used to detect the position and speed of a synchronous built-in servo motor.
Table 4.15.1(a) lists examples of usable rotary encoders.

Table 4.15.1 (a) Examples of usable rotary encoders

Encoder	Number of pulses for parameter setting (*1)	Remarks
α*i*CZ 512S	500,000 p/rev	Manufactured by FANUC
α*i*CZ 768S(*2)	750,000 p/rev	Manufactured by FANUC
α*i*CZ 1024S	1,000,000 p/rev	Manufactured by FANUC
RCN220	1,000,000 p/rev	Manufactured by HEIDENHAIN
RCN223	8,000,000 p/rev	Manufactured by HEIDENHAIN
RCN723	8,000,000 p/rev	Manufactured by HEIDENHAIN
RCN727(*3)	8,000,000 p/rev	Manufactured by HEIDENHAIN

(*1) Number of pulses for parameter setting, which differs from an actual resolution.
(*2) α*i*CZ 768S needs to use DECAMR for AMR setting. Please be careful of software edition.
(*3) Servo software Series 90B1 for Series 16*i* and so forth does not support RCN727 as a detector for synchronous built-in servo motors.

NOTE
1 For details of rotary encoders usable with FANUC synchronous built-in servo motors, refer to "FANUC SYNCHRONOUS BUILT-IN SERVO MOTOR D*i*S series Descriptions (B-65332EN)".
2 For the detailed specifications of each rotary encoder, contact each rotary encoder manufacturer.

(5) Parameter settings

Set the parameters according to the procedure below.

Parameter setting procedure (1)

Procedure (1) can be used to initialize the parameters (such as current gain) necessary to drive a synchronous built-in servo motor. After initialization, the parameters dependent on the type of rotary encoder need to be set. Set the parameters according to procedure (2) described later.

Parameters related to initialization

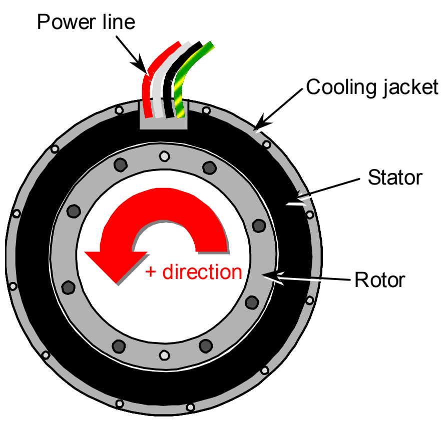
	#7	#6	#5	#4	#3	#2	#1	#0
1804 (FS15*i*) 2000 (FS30*i*, 16*i*)							DGPR	

DGPR(#1) Set 0. (After initialization, this bit is set to 1 automatically.)

1879 (FS15*i*) 2022 (FS30*i*, 16*i*)	Movement direction

+111: When the positive direction is specified, the rotor rotates in the positive direction.
-111: When the positive direction is specified the rotor rotates in the reverse direction.

The positive direction (+ direction) of the D*i*S series motor is the counterclockwise rotation of the rotor as determined by viewing the motor from the power line side.



Motor ID number

1874 (FS15*i*)	Motor ID number
2020 (FS30*i*, 16*i*)	

Table 4.15.1 (b) and Table 4.15.1 (c) indicate the synchronous built-in servo motors for which the standard parameters are available as of December, 2005. When the standard parameters are not included in the servo software used, see the parameter list shown in this manual, and set the parameters.

Table 4.15.1 (b) Synchronous built-in servo motor [200-V driving]

Motor model	Motor specification	Motor ID No.	90B6	90B1	90D0 90E0
D*i*S85/400	0483-B20x	423	-	-	K(11)
D*i*S110/300	0484-B10x	425	-	-	K(11)
D*i*S260/600	0484-B31x	429	-	-	K(11)
D*i*S370/300	0484-B40x	431	-	-	K(11)

Table 4.15.1 (c) Synchronous built-in servo motor [400-V driving]

Motor model	Motor specification	Motor ID No.	90B6	90B1	90D0 90E0
D*i*S85/400	0483-B20x	424	-	-	K(11)
D*i*S110/300	0484-B10x	426	-	-	K(11)
D*i*S260/600	0484-B31x	430	-	-	K(11)
D*i*S370/300	0484-B40x	432	-	-	K(11)

The motor ID numbers are for SERVO HRV2. Loading is possible with the servo software of the series and edition listed above or subsequent editions.

After parameter initialization, check that the function bit for synchronous built-in servo motor control is set to 1 (synchronous built-in servo motor control is enabled).

	#7	#6	#5	#4	#3	#2	#1	#0
2713 (FS15*i*)						DD		
2300 (FS30*i*, 16*i*)								

DD(#2) Synchronous built-in servo motor control is:
1: Enabled
0: Disabled

Parameter setting procedure (2)

Procedure (2) can be used to set the parameters that need to be set according to the type of a rotary encoder used.

Setting of parameters related to feedback

	#7	#6	#5	#4	#3	#2	#1	#0
1804 (FS15*i*) **2000 (FS30*i*, 16*i*)**								**PLC0**

PLC0(#0) The number of velocity pulses and the number of position pulses are:
0: Used without being modified.
1: Used after being multiplied by 10
If the number of velocity pulses is lager than 32767, set the parameter to 1.

1876 (FS15*i*) **2023 (FS30*i*, 16*i*)**	**Number of velocity pulses (PULCO)**

1891 (FS15*i*) **2024 (FS30*i*, 16*i*)**	**Number of position pulses (PPLS)**

2628 (FS15*i*) **2185 (FS30*i*, 16*i*)**	**Position pulses conversion coefficient (PSMPYL)**

This parameter is used if the calculated number of position pulses is greater than 32767.
When this parameter is set to 0, PSMPYL=1 is assumed for processing.

(Parameter calculation expression)
When PLC0=0
→ Set so that Number of position pulses = PPLS × PSMPYL.
When PLC0=1
→ Set so that Number of position pulses = 10 × PPLS × PSMPYL

Table 4.15.1 (d) Setting the number of velocity pulses and number of position pulses

Encoder	PLC0 (No.2000#0)	PULCO (No.2023)	PPLS (No.2024)	PSMPYL (No.2185)
α*i*CZ 512S	0	4096	6250	0
α*i*CZ 768S	0	6144	9375	0
α*i*CZ 1024S	0	8192	12500	0
RCN220	0	8192	12500	0
RCN223	1	6554	10000	0
RCN723	1	6554	10000	0
RCN727	1	6554	10000	0

1977 (FS15*i*)	Flexible feed gear numerator
2084 (FS30*i*, 16*i*)	

1978 (FS15*i*)	Flexible feed gear denominator
2085 (FS30*i*, 16*i*)	

(Parameter calculation expression)

$$FFG = \frac{\text{No. 2084}}{\text{No. 2085}} = \frac{\text{Number of pulses per motor revolution (detection unit)}}{\text{Number of pulses per detector revolution}}$$

For the number of pulses per detector revolution, see Table 4.15.1 (e).

Table 4.15.1 (e) Number of pulses for flexible feed gear setting

Encoder	Number of pulses per detector revolution (*1)	Remarks
α*i*CZ 512S	500,000 p/rev	FFG, maximum value is 36/5.
α*i*CZ 768S	750,000 p/rev	FFG, maximum value is 360/75.
α*i*CZ 1024S	1,000,000 p/rev	FFG, maximum value is 36/10.
RCN220	1,000,000 p/rev	FFG, maximum value is 1/1.
RCN223	8,000,000 p/rev	FFG, maximum value is 1/1.
RCN723	8,000,000 p/rev	FFG, maximum value is 1/1.
RCN727	8,000,000 p/rev	FFG, maximum value is 8/1.

(*1) Number of pulses for parameter setting, which differs from an actual resolution.

1896 (FS15*i*)	Reference counter capacity
1821 (FS30*i*, 16*i*)	

Set the number of pulses per motor revolution (detection unit) or the same number divided by an integer.
With α*i*CZ 768S, however, set the number of pulses per one-third of one motor revolution (detection unit) or the same number divided by an integer.

	#7	#6	#5	#4	#3	#2	#1	#0
2688 (FS15*i*)							RCNCLR	800PLS
2275 (FS30*i*, 16*i*)								

800PLS (#0) A rotary encoder with eight million pulses per revolution is:

1: To be used. (To use the RCN223, RCN723, or RCN727, set the bit to 1.)
0: Not to be used.

RCNCLR (#1) The number of revolution is:

1: To be cleared. (To use the RCN220, RCN223, RCN723, or RCN727, set the bit to 1.)
0: Not to be cleared.

This function bit is to be set in combination with the number of data mask digits, described below.

2807 (FS15*i*)	Number of data mask digits (DMASK)
2394 (FS30*i*, 16*i*)	

[Settings] 8. (To use the RCN223, RCN723, or RCN727)
5. (To use the RCN220)

This parameter need not be set for an α*i*CZ sensor. (When using an α*i*CZ sensor, set this parameter to 0.)
Set this parameter together with RCNCLR above.

Setting of an AMR conversion coefficient

	#7	#6	#5	#4	#3	#2	#1	#0
1806 (FS15*i*) / 2001 (FS30*i*, 16*i*)	0	AMR6	AMR5	AMR4	AMR3	AMR2	AMR1	AMR0

Set the value that matches the type of a rotary encoder used, according to Table 4.15.1 (f).

Table 4.15.1 (f) Setting AMR

Encoder	AMR6-AMR0	Remarks
α*i*CZ 512S	Set the number of motor poles in binary.	
α*i*CZ 768S	Set 0.	
α*i*CZ 1024S	Set the number of motor poles/2 in binary.	
RCN220	Set the number of motor poles/2 in binary.	
RCN223	Set the number of motor poles in binary.	
RCN723	Set the number of motor poles in binary.	
RCN727	Set the number of motor poles in binary.	

	#7	#6	#5	#4	#3	#2	#1	#0
2608 (FS15*i*) / 2220 (FS30*i*, 16*i*)								DECAMR

Set the value that matches the type of a rotary encoder used, according to Table 4.15.1 (g).

Table 4.15.1 (g) Setting DECAMR

Encoder	DECAMR	Remarks
α*i*CZ 512S	Set 0.	
α*i*CZ 768S	Set 1.	Meaning of AMR conversion coefficient 1 and 2 changes.
α*i*CZ 1024S	Set 0.	
RCN220	Set 0.	
RCN223	Set 0.	
RCN723	Set 0.	
RCN727	Set 0.	

1705 (FS15*i*)	AMR conversion coefficient 1 (AMRDL)
2112 (FS30*i*, 16*i*)	

1761 (FS15*i*)	AMR conversion coefficient 2 (AMR2)
2138 (FS30*i*, 16*i*)	

Set the value that matches the type of a rotary encoder used, according to Table 4.15.1 (h).

Table 4.15.1 (h) Setting AMRDL and AMR2

Encoder	AMR conversion coefficient 1 (AMRDL : No.2112)	AMR conversion coefficient 2 (AMR2 : No.2138)
α*i*CZ 512S	Set 0.	Set 0.
α*i*CZ 768S	Set 768.	Set the number of motor poles/2.
α*i*CZ 1024S	Set 0.	Set 0.
RCN220	Set 0.	Set 0.
RCN223	Set 0.	Set -4.
RCN723	Set 0.	Set -4.
RCN727	Set 0.	Set -4.

Summary of parameter setting according to the type of rotary encoder

Tables 4.15.1 (i), (j), (k), (l), and (m) provide summarized examples of parameter setting according to the type of rotary encoder. Set parameters according to the types of a rotary encoder and synchronous built-in servo motor used.

For the number of poles of each motor model, see Table 4.15.1 (n).

Table 4.15.1 (i) For α*i*CZ 512S

Symbol name	Parameter number		Parameter setting	
	FS30*i*,16*i*	FS15*i*	Detection unit 1/1000deg	Detection unit 1/10000deg
AMRDL	2112	1705	0	0
AMR2	2138	1761	0	0
PLC0	2000#0	1804#0	0	0
AMR	2001	1806	Number of poles (binary)	Number of poles (binary)
PULCO	2023	1876	4096	4096
PPLS	2024	1891	6250	6250
REFCOUNT	1821	1896	360000	3600000
FFG	2084	1977	36	36
FFG	2085	1978	50	5
PSMPYL	2185	2628	0	0
DECAMR	2220#0	2608#0	0	0

Table 4.15.1 (j) For αiCZ 768S

Symbol name	Parameter number		Parameter setting	
	FS30*i*,16*i*	FS15*i*	Detection unit 1/1000deg	Detection unit 1/10000deg
AMRDL	2112	1705	768	768
AMR2	2138	1761	Number of poles/2 (binary)	Number of poles/2 (binary)
PLC0	2000#0	1804#0	0	0
AMR	2001	1806	0	0
PULCO	2023	1876	6144	6144
PPLS	2024	1891	9375	9375
REFCOUNT	1821	1896	120000	1200000
FFG	2084	1977	36	360
FFG	2085	1978	75	75
PSMPYL	2185	2628	0	0
DECAMR	2220#0	2608#0	1	1

Table 4.15.1 (k) For αiCZ 1024S

Symbol name	Parameter number		Parameter setting	
	FS30*i*,16*i*	FS15*i*	Detection unit 1/1000deg	Detection unit 1/10000deg
AMRDL	2112	1705	0	0
AMR2	2138	1761	0	0
PLC0	2000#0	1804#0	0	0
AMR	2001	1806	Number of poles/2 (binary)	Number of poles/2 (binary)
PULCO	2023	1876	8192	8192
PPLS	2024	1891	12500	12500
REFCOUNT	1821	1896	360000	3600000
FFG	2084	1977	36	36
FFG	2085	1978	100	10
PSMPYL	2185	2628	0	0
DECAMR	2220#0	2608#0	0	0

Table 4.15.1 (l) For RCN220

Symbol name	Parameter number		Parameter setting	
	FS30*i*,16*i*	FS15*i*	Detection unit 1/1000deg	Detection unit 1/10000deg
AMRDL	2112	1705	0	0
AMR2	2138	1761	0	0
PLC0	2000#0	1804#0	0	0
AMR	2001	1806	Number of poles/2 (binary)	Number of poles/2 (binary)
PULCO	2023	1876	8192	8192
PPLS	2024	1891	12500	12500
REFCOUNT	1821	1896	360000	3600000
FFG	2084	1977	36	36
FFG	2085	1978	100	10
PSMPYL	2185	2628	0	0
DECAMR	2220#0	2608#0	0	0
800PLS	2275#0	2688#0	0	0
RCNCLR	2275#1	2688#1	1	1
DMASK	2394	2807	5	5

Table 4.15.1 (m) For RCN223, RCN723, or RCN727

Symbol name	Parameter number		Parameter setting	
	FS30*i*,16*i*	FS15*i*	Detection unit 1/1000deg	Detection unit 1/10000deg
AMRDL	2112	1705	0	0
AMR2	2138	1761	-4	-4
PLC0	2000#0	1804#0	1	1
AMR	2001	1806	Number of poles/2 (binary)	Number of poles/2 (binary)
PULCO	2023	1876	6554	6554
PPLS	2024	1891	10000	10000
REFCOUNT	1821	1896	360000	3600000
FFG	2084	1977	9	9
FFG	2085	1978	200	20
PSMPYL	2185	2628	0	0
DECAMR	2220#0	2608#0	0	0
800PLS#0	2275#0	2688#0	1	1
800PLS#1	2275#1	2688#1	1	1
DMASK	2394	2807	8	8

NOTE

Servo software Series 90B1 for Series 16*i* and so forth does not support RCN727 as a detector for synchronous built-in servo motors.

Table 4.15.1 (n) Number of poles and number of pole pairs of each motor model

Motor model	Number of poles	Number of pole pairs (number of poles/2)
D*i*S85/400	32	16
D*i*S110/300	40	20
D*i*S260/600	40	20
D*i*S370/300	40	20

Parameter setting procedure (3)

To drive a synchronous built-in servo motor, the pole detection function (option) is required. Procedure (3) describes the pole detection function.

(1) Overview

The pole position detection function detects the pole position of a motor to be driven when the relationship between the pole position of the motor and the phase of the detector is unknown.

> ⚠ **WARNING**
>
> 1 This function may be unable to detect the correct pole position, depending on the detection condition, resulting in an unpredictable motor movement. To avoid this dangerous situation, the following conditions must be satisfied until completion of detection:
>
> <1>The torque limit parameter (FS30*i*, 16*i*: No. 2060, FS15*i*: No. 1872) must be set so that 150% of the current needed for ordinary operation is not exceeded.
>
> <2>The setting of excessive error at stop time must be 100 μm or 0.1 deg or less. Moreover, the setting of excessive error at move time must be 120% of the logical positional deviation or less.
>
> <3>While pole position detection is in progress and a subsequent move operation is specified, the protection doors must be closed.
>
> If these conditions are not satisfied and pole position detection operation is not terminated normally, the motor can make an unpredictable movement with the maximum torque until the NC detects an excessive error alarm.
>
> For safety, create the following sequence with the PMC by using the pole detection state signal:
>
> <1>When the protection doors are open, pole detection is not started.
>
> <2>If a protection door is opened during pole detection (F158=1), a reset is made.
>
> <3>When pole detection is uncompleted (F159=0), no command is issued to relevant axes.
>
> <4>When pole detection is uncompleted (F159=0), the brake for the vertical axis is not released. (For brake operation, monitor not only the SA signal but also the pole detection completion signal.)
>
> In general, this function cannot be applied to the following motors and conditions:
>
> <1>Linear motor
>
> <2>DD motor that has a stroke limit such as a tilt axis
>
> <3>Axis for which the axis separation function (detach) is used
>
> <4>When the joint rigidity between the motor and detector is low
>
> However, when this function needs to be used for an unavoidable reason, pay full attention to safety and use this function with only the following:
>
> <1>Linear motor using an absolute value detector
>
> <2>DD motor that has a stroke limit using an absolute value detector

⚠ WARNING

2 For the following conditions, use a specified servo series/edition. Otherwise, the pole position cannot be detected correctly.
<1>When a detector that has an absolute address referenced mark is used.
<2>When an αiCZ or αA1000S sensor is used.
<3>When this function is applied to an axis such as a vertical axis that is completely locked.
(Specified series/edition)
- Series 90B1/02 and subsequent editions (FS15*i*, 16*i* and so on)
- Series 90D0, 90E0/10 and subsequent editions (FS30*i* and so on)

⚠ CAUTION

1 When two axes are placed under tandem control or simple synchronous control and each of the two axes has a speed detector (Pulsecoder or linear scale for a linear motor), ensure that an axis not detected is placed in the servo-off state and pole detection is performed for each of the main axis and sub-axis.
2 When using the motor feedback sharing function (FS16*i*, 30*i*: No. 2018#7, FS15*i*: No. 1960#7) under tandem control, start pole detection simultaneously for the two axes to avoid incorrect detection.
3 When a resonance elimination filter is used with a machine that has less friction, an excessive error alarm may be issued during detection, or a pole position may not be detected correctly. Turn off all resonance elimination filters or set bit 3 of No. 2283 to 1 (with FS16*i* and 18*i* only).

NOTE

This function is optional function.

(2) Details

Pole detection sequence

- Enable the parameter (FS30*i*, 16*i*: No. 2213#7, FS15*i*: No. 2601#7) for a target axis. Pole position detection is performed only for an enabled axis. For an axis not enabled, the pole position detection request signal (G135) is ignored.
- Set the servo-on state.
  Here, ensure that the brake for a vertical axis must not be released until the detection completion signal (F159) is set to 1.
- Do not perform a pole position detection operation in the servo-off state. Moreover, do not set the servo-off state during pole position detection operation.
- When the pole position detection request signal (G135) is set to 1, pole position detection is started, and the pole position detection in-progress signal (F158) is set to 1.
- Once a pole position detection operation is started, the detection operation is continued even when the pole position detection request signal is set to 0.
- Motor operation during pole position detection is not under control of the CNC. During this period, the CNC performs a follow-up operation.

- Upon completion of pole position detection after several seconds, the pole position detection in-progress signal (F158) is set to 0, and the pole position detection completion signal (F159) is set to 1.
- If pole position detection is terminated abnormally for a mechanical cause or motor characteristics, the servo alarm "POLE DETECTION ERROR" is issued.
- The servo alarm "POLE DETECTION ERROR" cannot be released with a reset. Turn off the power then turn on the power again.
- When a reset is made during pole position detection, the pole position detection is stopped. To restart pole position detection, set the pole position detection request signal to 0 then set the same signal to 1 again.
- Once a pole position detection operation is completed, no additional pole position detection operation can be performed until the power is turned off.
- When using an absolute detector, set the parameter (FS30*i*, 16*i*: No. 2229#0, FS15*i*: No. 2617#0) to 1. In this case, when pole position detection is completed, the result of detection is stored in the parameter (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762). So, pole position detection need not be performed each time the power is turned on.
- In the MDI, MEM, or EDIT mode, the result of detection is reflected on the screen immediately. In the REF or JOG mode, the result of detection is reflected on the screen when the reset key is pressed or the mode is switched to the MDI mode.
- Before restarting pole detection, clear the parameter (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762) to 0.
- When pole position detection is completed and the motor one-rotation signal is detected, the result of detection is stored in the parameter (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762) in the MDI mode by setting the parameter (FS30*i*, 16*i*: No. 2229#0, FS15*i*: No. 2617#0) to 1 also in the case where an incremental detector is used. Thus, a torque constant change due to pole position detection variation can be avoided.

NOTE

1. When an absolute detector is used and the parameter (FS30*i*, 16*i*: No. 2229#0, FS15*i*: No. 2617#0) is set to 1, the pole position detection completion signal (F159) is set to 1 immediately after power-on if the parameter (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762) is not set to 0.
2. Create logic for confirming the pole position detection completion signal (F159) before specifying a move command immediately after power-on.
3. If an alarm such as a count error alarm is issued for a detector fault, the pole position detection completion signal (F159) is returned to 0. In this case, perform another pole position detection operation.

Detection mode and method of application

The three detection modes indicated below are available with servo Series 90B1/Edition 02 or later, or Series 90D0 and 90E0/Edition 10 or later. With other servo series/editions, only the minute operation mode in 1) below can be used.

1) Minute operation mode
   Operation: A pole position is detected with the motor making a minute operation.
   Application: When the friction is less so that the motor can move in a minute range
   Setting: No.2229#4=1, No.2182≧0 (FS30*i*,16*i*)
   No.2617#4=1, No.2625≧0 (FS15*i*)
   Usually, it is recommended to use this mode.
2) Automatic selection mode
   Operation: The minute operation mode is initially used for detection. If the motor is locked or the friction is larger, the detection mode is automatically switched to the stop mode.
   Application: A pole position can be detected, regardless of the machine state.
   Setting: No.2229#4=0, No.2182≧0 (FS30*i*,16*i*)
   No.2617#4=0, No.2625≧0 (FS15*i*)
3) Stop mode
   Operation: A pole position is detected with the motor placed in the stop state.
   Application: Axis such as a vertical axis where the motor is locked
   Setting: No.2229#4=0, No.2182=-1 (FS30*i*,16*i*)
   No.2617#4=0, No.2625=-1 (FS15*i*)

NOTE

As the guideline for stop mode application, the following conditions apply:
1) The motor saliency (=Ld-Lq) is 1 mH or more.
2) Magnetic saturation occurs at a current larger than the rated motor current by a factor of 2 or less. (The torque constant is reduced by 5% or more.)

If these conditions are not satisfied, the precision may be degraded or detection may be disabled. Note that some models of FANUC D*i*S Series do not satisfy these conditions, thus disabling the stop method from being used. When using the stop mode, make a sufficient operation check beforehand.
When the automatic selection mode is used, the mode is switched from the minute operation mode to the stop mode automatically, depending on the axis state. So, before using the automatic selection mode, check that normal operation can be performed in the stop mode.

(3) Parameter

When this parameter has been modified, the power to the NC must be turned off before operation is continued.

	#7	#6	#5	#4	#3	#2	#1	#0
2601 (FS15*i*)	OCM							
2213 (FS30*i*, 16*i*)								

OCM(#0) 0: The pole position detection function is disabled.
1: The pole position detection function is enabled.

	#7	#6	#5	#4	#3	#2	#1	#0
2616 (FS15*i*)					ELSAL			
2228 (FS30*i*, 16*i*)								

ELSAL(#0) 0: The motor saliency is Lq>Ld.
1: The motor saliency is Lq<Ld.

This parameter is related only to a case where the stop mode is used. When a synchronous motor (IPM) of magnet-embedded type is used, the motor saliency is Lq>Ld (reverse saliency). In rare cases, however, a synchronous motor of magnet surface attachment type (SPM) may indicate the saliency Lq<Ld. In this case, the detection phase is shifted 90 degrees relative to the reverse saliency. With many motors, however, saliency information acquisition is presently difficult. So, if the results of repeated detections always indicate a shift of 90 degrees, set this bit.

> **NOTE**
> This function can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.), or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

	#7	#6	#5	#4	#3	#2	#1	#0
2617 (FS15*i*)				FORME	WATRA			ABSEN
2229 (FS30*i*, 16*i*)								

ABSEN(#0) 0: AMR offset (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762) is not used.
1: AMR offset (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762) is used.

If an absolute detector is used, the result of detection is saved to the AMR offset of the parameter (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762). In the case of a second or subsequent power-on operation, pole position detection need not be executed.
If an incremental detector is used, the result of detection is saved to the AMR offset when the one-rotation signal is detected. In this case, pole position detection needs to be performed each time the power is turned on. After the one-rotation signal is detected, however, the value saved to the AMR offset is used, so that an influence due to pole detection variation can be eliminated.

WATRA(#3) 0: After pole detection, an abnormal movement is monitored.
1: After pole detection, no abnormal movement is monitored.

If a detection error occurs, protection against an abnormal operation is provided. Operation is monitored until a command after detection is issued. If an abnormal operation is detected, detection error alarm 454 is issued.

> **NOTE**
> This function can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.), or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

FORME(#4) 0: Automatic selection mode (minute operation mode + stop mode)
1: Minute operation mode

Usually, set this parameter to 1 (minute operation mode).

> **NOTE**
> This function can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.), or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

1762 (FS15*i*)	AMR offset (AMROFS)
2139 (FS30*i*, 16*i*)	

[Unit of data] Degrees
[Valid data range] 0 to 360
[Standard setting] 0

If ABSEN=1, the result of operation is stored in this parameter when the MDI mode is set upon completion of detection.

> ⚠ **WARNING**
> After pole determination, never rewrite the value of this parameter manually. If this parameter is rewritten for adjustment, the power must be turned off before operation is continued.

2625 (FS15*i*)	Current A for pole detection (DTCCRT_A)
2182 (FS30*i*, 16*i*)	

[Unit of data] 7282 is the maximum amplifier current value.
[Valid data range] -1 to 7282
[Standard setting] 0

Set a current value for pole position detection. If this parameter is set to 0, pole position detection is performed according to the value of the rated current parameter (FS30*i*, 16*i*: No. 2086, FS15*i*: No. 1979). If the static friction of the machine is large, and the pole detection error alarm is issued during detection, increase current A for pole detection.

The maximum value of this parameter is limited by the torque limit parameter (FS30*i*, 16*i*: No. 2060, FS15*i*: No. 1872).

> **NOTE**
> When -1 is set, the stop mode is used for detection. The setting of -1 can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.) and Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

2641 (FS15*i*)	Current B for pole detection (DTCCRT_B)
2198 (FS30*i*, 16*i*)	

[Unit of data] % unit

[Valid data range] 0 to 370

[Standard setting] 0

This parameter is related only to a case where the stop mode is used. Set a current value for pole direction detection. When this parameter is set to 0, 100% is set internally.

> **NOTE**
> This function can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.), or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

2642 (FS15*i*)	Current C for pole detection (DTCCRT_C)
2199 (FS30*i*, 16*i*)	

[Unit of data] 7282 is the maximum amplifier current value.

[Valid data range] 0 to 7282

[Standard setting] 0

This parameter is related only to a case where the stop mode is used. Set a current value for pole direction detection. When this parameter is set to 0, 100% is set internally. When this parameter is set to 0, pole position detection is performed using a current value two times greater than the value of the rated current parameter (FS30*i*, 16*i*: No. 2086, FS15*i*: No. 1979).

> **NOTE**
> This function can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.), or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

2681 (FS15*i*) / 2268 (FS30*i*, 16*i*)	Allowable travel distance magnification/stop speed decision value (MFMPMD)

[Unit of data] % unit
[Valid data range] -1000 to 1000
[Standard setting] 0 (100% internally)

During pole position detection, the motion of the rotor is limited to within an allowable travel distance of 5 degrees. If the value of this parameter is positive, set an allowable travel distance by specifying a percentage relative to the default value 5 degrees. If the pole detection error alarm is issued during pole position detection, and no improvement is made by changing the current value for pole detection, set a value greater than 100% in this parameter. For example, to set an allowable travel distance of 10 degrees, set 200%.

If the value of this parameter is negative, the stop speed decision criterion to be used when a low-resolution detector is used can be changed. If pole detection is not started, change the value of this parameter to a greater negative value. For example, set a value from -200 to -500 for adjustment.

> **NOTE**
> A negative value can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.), or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

(4) Signals

Pole position detection request signal
RPREQ1 to RPREQ8

[Classification] Input signal

[Function] Requests pole position detection. This signal is available for each controlled axis, and the suffix at the end of each signal name indicates a controlled axis number.

[Operation] Pole position detection is started by setting this signal to 1. Once a pole position detection operation is started, the operation is continued even when this signal is set to 0.

Pole position detection in-progress signal
RPDET1 to RPDET8

[Classification] Output signal

[Function] Posts that pole position detection is being performed. This signal is available for each controlled axis, and the suffix at the end of each signal name indicates a controlled axis number.

[Output condition] This signal is set to 1 in the following case:
- When pole position detection is being performed

This signal is set to 0 in one of the following cases:
- When pole position detection is completed
- When pole position detection is terminated abnormally
- When pole position detection is stopped by a reset

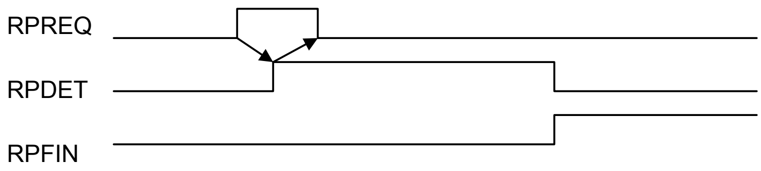
Pole position detection completion signal
RPFIN1 to RPFIN8

[Classification] Output signal

[Function] Posts that pole position detection is completed. This signal is available for each controlled axis, and the suffix at the end of each signal name indicates each controlled axis number.

[Output condition] This signal is set to 1 in the following case:

- When pole position detection is completed after pole position detection is started by setting the pole position detection request signal to 1



> **NOTE**
> 1 If an absolute detector is used, this signal remains set to 1 even when the power is turned off then back on after completion of pole position detection performed by setting the parameter (FS30*i*, 16*i*: No. 2229#0, FS15*i*: No. 2617) to 1. When the power is turned off then back on after setting the parameter (FS30*i*, 16*i*: No. 2139, FS15*i*: No. 1762) to 0, this signal is set to 0.
> 2 If an incremental detector is used, the pole position detection completion signal is not set to 0 unless the power is turned off.

Signal address

For Series 30*i*, 16*i*, and Power Mate *i*

	#7	#6	#5	#4	#3	#2	#1	#0
G135	RPREQ8	RPREQ7	RPREQ6	RPREQ5	RPREQ4	RPREQ3	RPREQ2	RPREQ1

	#7	#6	#5	#4	#3	#2	#1	#0
F158	RPDET8	RPDET7	RPDET6	RPDET5	RPDET4	RPDET3	RPDET2	RPDET1
F159	RPFIN8	RPFIN7	RPFIN6	RPFIN5	RPFIN4	RPFIN3	RPFIN2	RPFIN1

For Series 15i

	#7	#6	#5	#4	#3	#2	#1	#0
G067								RPREQ1
G071								RPREQ2
G075								RPREQ3
G079								RPREQ4
G083								RPREQ5
G087								RPREQ6
G091								RPREQ7
G095								RPREQ8
G099								RPREQ9
G103								RPREQ10
G107								RPREQ11
G111								RPREQ12
G115								RPREQ13
G119								RPREQ14
G123								RPREQ15
G127								RPREQ16
G243								RPREQ17
G247								RPREQ18
G251								RPREQ19
G255								RPREQ20
G259								RPREQ21
G263								RPREQ22
G267								RPREQ23
G271								RPREQ24

	#7	#6	#5	#4	#3	#2	#1	#0
F067							RPFIN1	RPDET1
F071							RPFIN2	RPDET2
F075							RPFIN3	RPDET3
F079							RPFIN4	RPDET4
F083							RPFIN5	RPDET5
F087							RPFIN6	RPDET6
F091							RPFIN7	RPDET7
F095							RPFIN8	RPDET8
F099							RPFIN9	RPDET9
F103							RPFIN10	RPDET10
F107							RPFIN11	RPDET11
F111							RPFIN12	RPDET12
F115							RPFIN13	RPDET13
F119							RPFIN14	RPDET14
F123							RPFIN15	RPDET15
F127							RPFIN16	RPDET16
F291							RPFIN17	RPDET17
F295							RPFIN18	RPDET18
F299							RPFIN19	RPDET19
F303							RPFIN20	RPDET20
F307							RPFIN21	RPDET21
F311							RPFIN22	RPDET22
F315							RPFIN23	RPDET23
F319							RPFIN24	RPDET24

(5) Action for trouble

<table>
<tr><th>Symptom</th><th>State</th><th>Detection request (G135)</th><th>During detection (F158)</th><th>Detection comple-tion (F159)</th><th>Cause</th><th>Action</th></tr>
<tr><td colspan="7">[Before detection completion]</td></tr>
<tr><td rowspan="3">Detection is not started.</td><td rowspan="3">In the minute operation mode, the motor moves slightly.
In the stop mode, a varying activating sound, which is to be heard, cannot be confirmed.</td><td>OFF</td><td>OFF</td><td>OFF</td><td>The pole detection request signal is turned off.</td><td>Turn on the pole detection request signal.</td></tr>
<tr><td rowspan="2">ON</td><td rowspan="2">OFF</td><td rowspan="2">OFF</td><td>The pole detection function is disabled.</td><td>Check bit 7 of No. 2213 or the option.</td></tr>
<tr><td>Servo-off</td><td>Set the servo-on state.</td></tr>
<tr><td rowspan="5">Detection is not completed.</td><td rowspan="4">The motor appears to be moving slightly. However, detection is not completed and no alarm is issued.</td><td rowspan="5">ON</td><td rowspan="5">ON</td><td rowspan="5">OFF</td><td>An αi CZ sensor is used.
An αA1000S is used.</td><td>Use Series 90B1/Edition 02 or later, or Series 90D0 or 90E0/Edition 10 or later.</td></tr>
<tr><td>The detector resolution is low: 100 million/rev or lower</td><td>Set the stop speed decision value (No. 2268) to a value from -200 to -500.</td></tr>
<tr><td>Velocity feedback noise</td><td>Take action for noise protection.</td></tr>
<tr><td>The friction is very small, so that activation causes a vibration to disable stop decision initiation.</td><td>Decrease detection current A (No. 2182) to find an optimal value.</td></tr>
<tr><td>During detection, an abnormally large motion is made and detection is not completed.</td><td>Detector with high resolution</td><td>Increase the stop speed decision value (No. 2268).</td></tr>
<tr><td rowspan="2">Excessive error at stop time</td><td rowspan="2">During detection, the excessive error alarm at stop time is issued.</td><td rowspan="2">ON</td><td rowspan="2">ON</td><td rowspan="2">OFF</td><td>The friction is small.</td><td>Increase the setting of excessive error at stop time or set detection current A (No. 2182) to the rated current or lower.</td></tr>
<tr><td>Influence of resonance elimination filters</td><td>Turn off all resonance elimination filters or set bit 3 of No. 2283 to 1.</td></tr>
<tr><td rowspan="3">Detection error alarm (SV454)</td><td rowspan="3">The pole detection error alarm is issued.</td><td rowspan="3">ON</td><td rowspan="3">ON</td><td rowspan="3">OFF</td><td>The friction is large.</td><td>Set detection current A (No. 2182) to the rated current or higher.</td></tr>
<tr><td>The current gain is small.</td><td>Set a proper current gain.</td></tr>
<tr><td>The motor saliency is small.</td><td>Set detection current B (No. 2198) to 100% or more.</td></tr>
</table>

Symptom	State	Detection request (G135)	During detection (F158)	Detection comple-tion (F159)	Cause	Action
[After detection completion]						
Vibration		ON	ON	ON	The phase order of the power line does not match the direction of the detector.	Change the phase order of the power line.
					Detector setting error	Set a correct detector resolution.
					The number of poles is not set correctly.	Set the correct number of motor poles.
					The velocity gain is high.	Adjust the velocity gain to a proper value.
Excessive error at stop time or excessive error at move time	An unpredictable movement is made, or no movement is made in response to an issued command, so that an excessive error alarm is issued.	ON	ON	ON	The phase order of the power line does not match the direction of the detector.	Change the phase order of the power line.
					The number of poles is not set correctly.	Set the correct number of motor poles.
					The motor saliency is small.	Set detection current B (No. 2198) to 100% or more.
					The motor is not magnetically saturated.	Set detection current C (No. 2199) to a value larger than the rated current by a factor of 2 or more.
					No reverse saliency	Set bit 3 of No. 2228 to 1.
					+ circuit C with a referenced mark	Use Series 90B1/Edition 02 or later, or Series 90D0 or 90E0/Edition 10 or later.
The AMR offset does not change.	After detection completion, the result of detection is not written to the AMR offset.	ON	ON	ON	Bit 0 of No. 2229 = 0	Set bit 0 of No. 2229 to 1.
					The mode is not the MDI mode.	The display is updated in the MDI mode.
					Incremental detector	The motor needs to make one or more revolutions.
Detection error alarm (SV454)	After detection completion, the pole detection error alarm is issued.	ON	ON	ON	The VCMD mode is used for operation.	Set bit 3 of No. 2229 to 1.

Symptom	State	Detection request (G135)	During detection (F158)	Detection comple-tion (F159)	Cause	Action
[After restart]						
No motion	The AMR offset is not 0, but no movement is made in response to an issued command.	-	-	-	Incremental detector	Pole detection needs to be performed each time a start-up operation is performed.
					Detector alarm	Pole detection needs to be performed again.
Detection result variation	The value of the AMR offset varies in each detection operation.	-	-	-	The friction is large.	Set detection current A (No. 2182) to the rated current or higher.
					The motor saliency is small.	Set detection current B (No. 2198) to 100% or more.

(6) Usable software

Usable CNC software

FS30*i* -MB/TB	Usable starting with the first edition
FS31*i* -MB/TB	Usable starting with the first edition
FS32*i* -MB/TB	Usable starting with the first edition
FS16*i* -MB/TB	Usable starting with the first edition
FS18*i* -MB/TB	Usable starting with the first edition
FS21*i* -MB/TB	Usable starting with the first edition
FS15*i* -MB	F0A1-10 or later
FS15*i* -TB	F6A1-10 or later
Power Mate *i*-MODEL D	88E0-21 or later
Power Mate *i*-MODEL H	88F1-12, 88F2-02 or later

NOTE

Please refer to 4.15.1(2) about usable servo software

Parameter setting procedure (4)

Procedure (4) can be used to set parameters according to the cooling method used for synchronous built-in servo motors.
In the case of no cooling, the parameters are set by initialization according to procedure (1), so that the parameters need not be modified.
In the case of liquid cooling only, modify the parameters according to Table 4.15.1 (x) and Table 4.15.1 (y).

1877 (FS15*i*)	OVC alarm parameter (POVC1)
2062 (FS30*i*, 16*i*)	

1878 (FS15*i*)	OVC alarm parameter (POVC2)
2063 (FS30*i*, 16*i*)	

1893 (FS15*i*)	OVC alarm parameter (POVCLMT)
2065 (FS30*i*, 16*i*)	

1979 (FS15*i*)	Current rating parameter (RTCURR)
2086 (FS30*i*, 16*i*)	

1784 (FS15*i*)	OVC magnification in stop state (OVCSTP)
2161 (FS30*i*, 16*i*)	

Table 4.15.1 (x) Setting OVC and current rating parameters by cooling method [200-V driving]

Model	Cooling method	Rated [Nm]	POVC1 (N2062)	POVC2 (N2063)	POVCLMT (N2065)	RTCURR (N2086)	OVCSTP (N2161)
D*i*S85/400	No cooling	17	32683	1069	3172	1310	0
	Liquid cooling	35	32427	4258	12689	2621	0
D*i*S110/300	No cooling	25	32682	1069	3173	1310	0
	Liquid cooling	45	32427	4260	12694	2621	0
D*i*S260/600	No cooling	55	32722	578	1714	963	0
	Liquid cooling	105	32583	2307	6857	1926	119
D*i*S370/300	No cooling	75	32705	782	2322	1121	0
	Liquid cooling	150	32518	3121	9287	2242	0

Table 4.15.1 (y) Setting OVC and current rating parameters by cooling method [400-V driving]

Model	Cooling method	Rated [Nm]	POVC1 (N2062)	POVC2 (N2063)	POVCLMT (N2065)	RTCURR (N2086)	OVCSTP (N2161)
D*i*S85/400	No cooling	17	32683	1069	3172	1310	0
	Liquid cooling	35	32427	4258	12689	2621	0
D*i*S110/300	No cooling	25	32682	1069	3173	1310	0
	Liquid cooling	45	32427	4260	12694	2621	0
D*i*S260/600	No cooling	55	32731	457	1354	856	0
	Liquid cooling	105	32622	1824	5418	1712	0
D*i*S370/300	No cooling	75	32705	782	2322	1121	0
	Liquid cooling	150	32518	3121	9287	2242	0

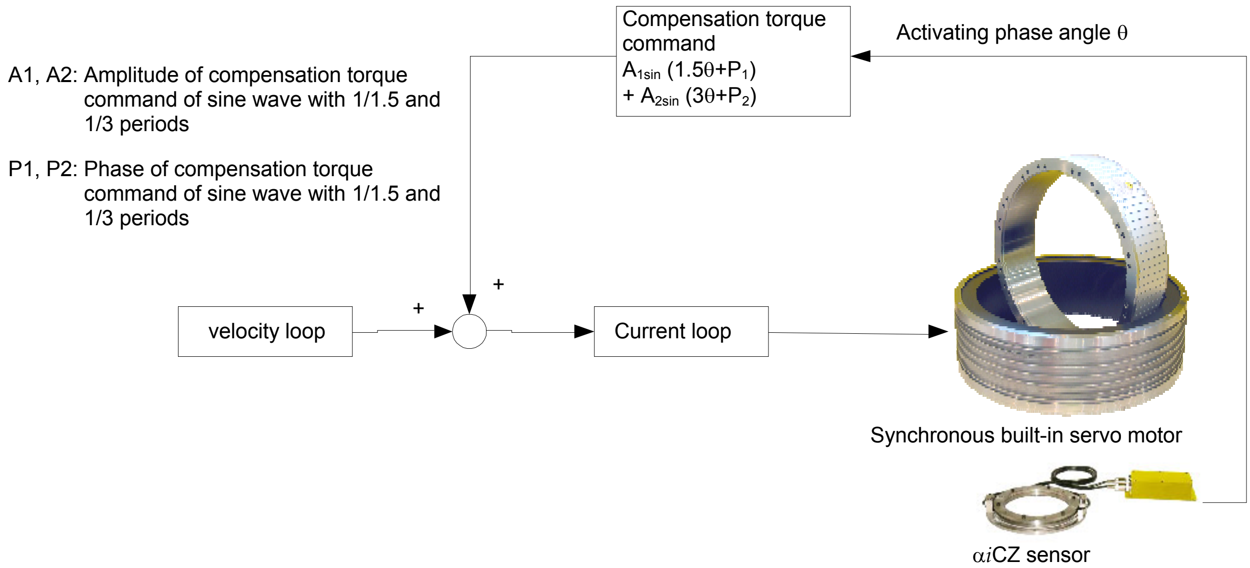
4.15.2 Detection of an Overheat Alarm by Servo Software when a Synchronous Built-in Servo Motor are Used

For this subsection, see Subsection 4.14.2, "Detection of an Overheat Alarm by Servo Software when a Linear Motor and a Synchronous Built-in Servo Motor are Used".

4.15.3 Smoothing Compensation for Synchronous Built-in Servo Motor

(1) Overview

Smoothing compensation for synchronous built-in servo motor is a function used to improve the feed smoothness of a synchronous built-in servo motor by applying, to the current command, a sine wave compensation torque 1.5 times and 3 times per pole pair. By setting a compensation gain and phase with parameters for each component, a compensation torque matching each motor can be obtained. A value to be set in a parameter for compensation is automatically calculated using SERVO GUIDE.



NOTE

1 This function can be used only when an encoder with a minimum resolution of 2^{23} pulses/rev or 8,000,000 pulses/rev or less (for example, RCN223 manufactured by HEIDENHAIN) is used.

2 This function can only be used for synchronous built-in servo motor with encoder whose minimum resolution is lower than or equal to 2^{23}pulse/rev (EX. HEIDENHAIN RCN223). This function can only be used for synchronous built-in servo motor with encoder whose minimum resolution is lower than or equal to 2^{23}pulse/rev (EX. HEIDENHAIN RCN223). Though HEIDENHAIN RCN727 has 16 times higher resolution than that of RCN223, servo software treats it as same as RCN223 in the data point of view. (Of course, even if the servo software treats the data as above, you can use 2^{27}pulse/rev as the minimum resolution.) Therefore, HEIDENHAIN RCN727 is possible for using this function.

(2) Series and editions of applicable servo software

(Series 30*i*, 31*i*, 32*i*,)
Series 90D0/L(12) and subsequent editions
Series 90E0/L(12) and subsequent editions
(Series 15*i*, 16*i*, 18*i*, 21*i*, Power Mate *i*)
Series 90B1/E(05) and subsequent editions

(3) Setting parameters

	#7	#6	#5	#4	#3	#2	#1	#0
2713 (FS15*i*) / 2300 (FS30*i*, 16*i*)						DD		

DD(#2) Synchronous built-in servo motor is:
0: Disabled.
1: Enabled. (Smoothing compensation for synchronous built-in servo motor is also enabled.)

2790 (FS15*i*) / 2377 (FS30*i*, 16*i*)	Smoothing compensation performed 1.5 times per pole pair	
	Correction gain (high-order 8 bits)	Correction phase (low-order 8 bits)

2793 (FS15*i*) / 2380 (FS30*i*, 16*i*)	Smoothing compensation performed three times per pole pair	
	Correction gain (high-order 8 bits)	Correction phase (low-order 8 bits)

Setting the correction gain of the following parameters with a nonzero value can switch between the negative direction smoothing compensation and the positive direction smoothing compensation. In this case, the smoothing compensation parameter explained above applies only to feeding in the positive direction.

2791 (FS15*i*) / 2378 (FS30*i*, 16*i*)	Smoothing compensation performed 1.5 times per pole pair (negative direction)	
	Correction gain (high-order 8 bits)	Correction phase (low-order 8 bits)

2794 (FS15*i*) / 2381 (FS30*i*, 16*i*)	Smoothing compensation performed three times per pole pair (negative direction)	
	Correction gain (high-order 8 bits)	Correction phase (low-order 8 bits)

An optimal value varies from one motor to another (not from one motor model to another). So, compensation parameters need to be determined for each assembled motor. A torque command variation generated when the motor is fed at low speed is dependent on the position. The application of smoothing compensation cancels this position-dependent characteristic, allowing the motor to move smoothly.

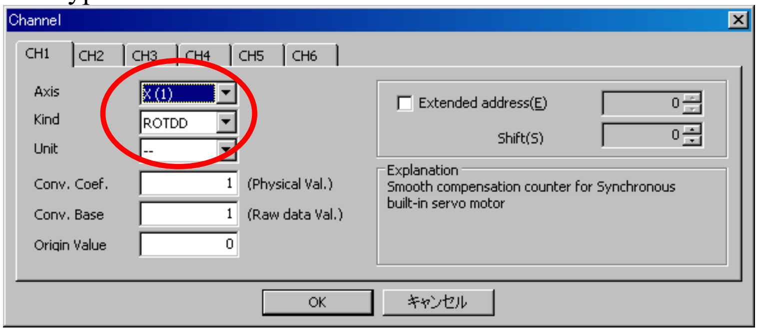
The measuring instruments that can be used to determine these parameters include "SERVO GUIDE" (Ver. 3.20 or later).
By using SERVO GUIDE (Ver. 3.20 or later), these parameters can be determined easily. Follow the procedure below to measure the activating phase and torque command, which are required to determine the compensation parameters.

Measurement procedure

<1> Set channels as follows:

Channel 1: Counter for smoothing compensation for synchronous built-in servo motor

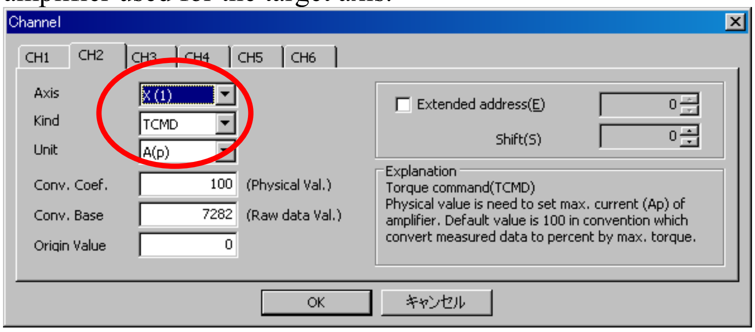
Select the target axis for measurement, and set "ROTDD" as the data type.



Channel 2: Torque command

Select the target axis for measurement, and set "TCMD" as the data type.

As the conversion coefficient, set the maximum current of the amplifier used for the target axis.



<2> With this setting, make bidirectional movements by about ±90 deg at about F (14400/number of poles) deg/min for data measurement. At the time of data measurement, ensure that all smoothing compensation values are set to 0. Smoothing compensation for linear motors may be used. Check this point as well.

Parameters for synchronous built-in servo motor:

No.2377, No.2378, No.2380, No.2381

Parameters for linear motor:

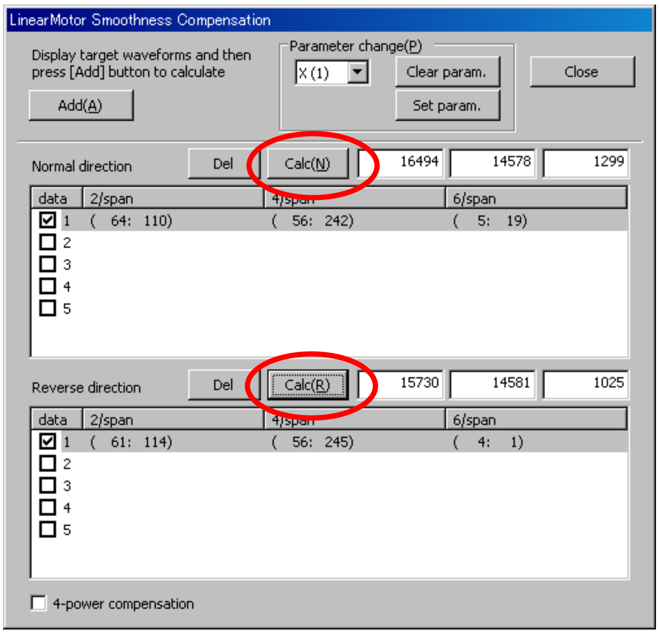
No.2130, No.2131, No.2132, No.2369, No.2370, No.2371

When making measurements, lower the velocity gain to such an extent that hunting does not occur.

<3> From the "Tools" menu, select "Linear motor compensation calculation".

(The shortcut is [Ctrl] + [L].)

<4> Pressing the [ADD] button on the displayed dialog box analyzes waveform data and registers compensation parameter candidates. The "2/span" item and "4/span" item correspond to smoothing compensation performed 1.5 times per pole and smoothing compensation performed 3 times per pole, respectively. "6/span" is not used for smoothing compensation for synchronous built-in servo motor.

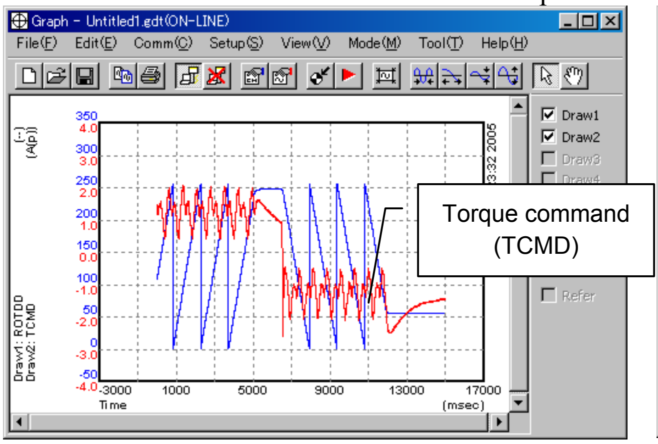


<5> The compensation parameters slightly vary depending on the measurement situation. So, repeat a data measurement and a press of the [Add] button several times in a similar manner while keeping the dialog box open. (Up to five candidates can be registered.)
If the displayed values include an extremely different value, uncheck the corresponding check box on the leftmost side of the list so that the value is not taken into account in the final compensation calculation.

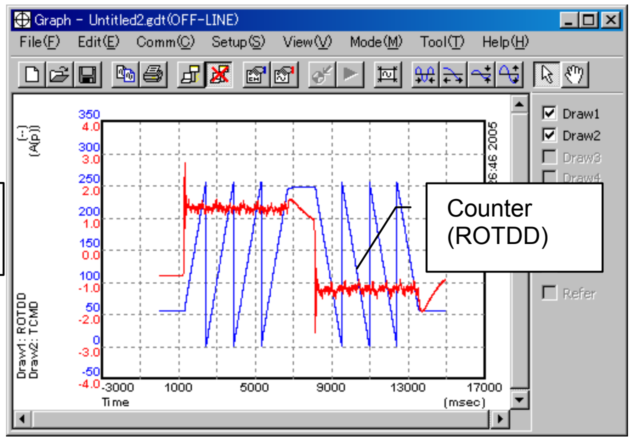
<6> Finally, press the [Calc] button for each of the forward and backward directions. Then, smoothing compensation parameters are displayed.

<7> By pressing the [Set param] button, the smoothing compensation parameters are set in the CNC.

<8> Measure TCMD again to confirm the effect of smoothing compensation.



Before smoothing compensation adjustment



After smoothing compensation adjustment

(*) For details on the use of SERVO GUIDE, refer to the online help of SERVO GUIDE.

4.16 TORQUE CONTROL FUNCTION

(1) Overview

In PMC axis control, the torque control function can be used. The servo motor produces a torque as specified by the NC. Note that the user can switch between position control and torque control.

(2) Control types

Two types of torque control are supported: type 1 and type 2. The two types are explained below.

(i) Torque control type 1
The motor produces a torque according to a torque command specified by the PMC. A servo alarm is issued if the speed of the motor exceeds the excessive speed alarm level specified by the PMC.
A block diagram of torque control type 1 is shown below.

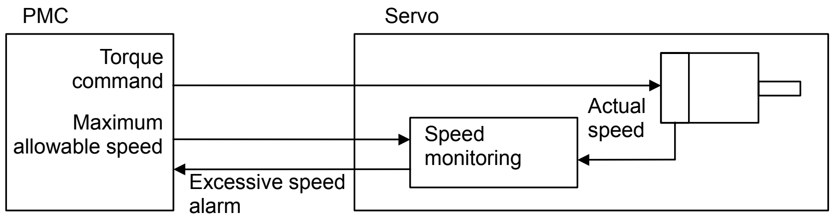


Fig. 4.15 (a) Torque control type 1

(ii) Torque control type 2
The motor produces a torque according to a torque command specified by the PMC.
When the motor is loaded, it produces a torque according to a torque command. When it is not loaded, it rotates at a constant (allowable) speed.

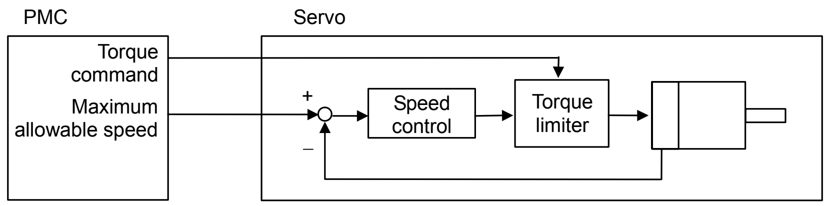


Fig. 4.15 (b) Torque control type 2

* Basically, torque control type 2 performs speed control to cause the limiter to operate on a command from the speed controller according to a torque command specified by the PMC. This causes the motor to produce a torque that matches the torque command when it is loaded and to rotate at a constant (allowable) speed when it is not loaded.

(3) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
Series 90D0/A(01) and subsequent editions
Series 90E0/A(01) and subsequent editions
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 9096/A(01) and subsequent editions
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

(4) Setting parameters

This manual describes servo-related parameters only.

> **NOTE**
> For details about the setting of the torque control function for each CNC, refer to "PMC Axis Control" in the respective CNC Connection Manual (Function).
> The ordering information for each connection manual is as follows:
> - Series 30*i*,31*i*,32*i*-MODEL A
>   Connection Manual (Function) (B-63943EN-1)
> - Series 15*i*-MODEL B
>   Connection Manual (Function) (B-63783EN-1)
> - Series 16*i*,18*i*,21*i*-MODEL B
>   Connection Manual (Function) (B-63523EN-1)
> - Power Mate *i*
>   Connection Manual (Function) (B-63173EN-1)

	#7	#6	#5	#4	#3	#2	#1	#0
1951 (FS15*i*) / 2007 (FS30*i*, 16*i*)	FRCAXS							

FRCAXS (#7) Torque control is:
0: Not used
1: Used ← To be set

	#7	#6	#5	#4	#3	#2	#1	#0
1743 (FS15*i*) / 2203 (FS30*i*, 16*i*)				FRCAX2				

FRCAX2 (#4) Torque control type 2 is:
0: Not used (Torque control type 1 is used.)
1: Used ← To be set (Usually, use type 2.)

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*)					**PIEN**			
2003 (FS30*i*, 16*i*)								

PIEN (#3) The velocity control method to be used is:
0: I-P control
1: PI control ← To be set

1998 (FS15*i*)	**Torque constant**
2105 (FS30*i*, 16*i*)	

This parameter is used to specify a motor-specific torque constant. The units are as follows:

0.00001 N·m/(torque command) for a rotary motor
0.001 N·m/(torque command) for a linear motor

NOTE

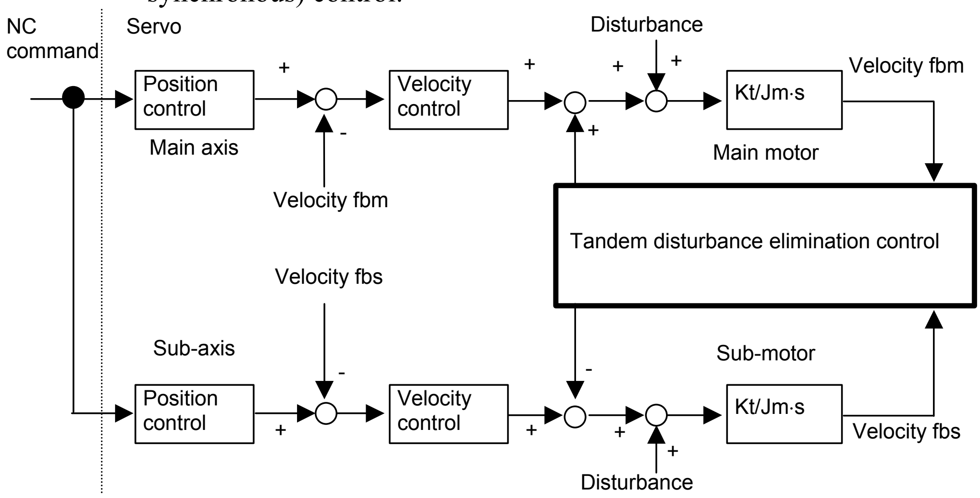
1. When the initial parameter setting function (Sec. 2.1) is used, a motor-specific value is set automatically.
2. When torque control is set, the following functions are disabled:
   - Velocity loop high cycle management function
   - Acceleration feedback function

4.17 TANDEM DISTURBANCE ELIMINATION CONTROL (POSITION TANDEM)

Optional function

(1) Overview

This function suppresses vibration caused by interference between the main axis and sub-axis in position tandem (simple synchronous or synchronous) control.



(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90D3/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

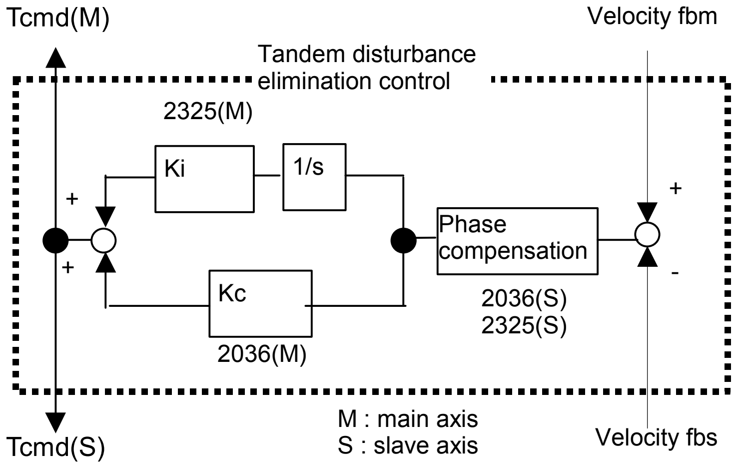
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B3/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions
- Series 90B7/A(01) and subsequent editions

(Series 0*i*-C,0*i* Mate-C,20*i*-B)
- Series 90B5/A(01) and subsequent editions

(3) Cautions

- This function is optional. (To enable the position tandem function, the option of axis synchronous control (FS30*i*), simple synchronous control (FS16*i*), or synchronous control (FS15*i*) is additionally needed.)
- This function can be used only for two-axis (simple) synchronous control. This function cannot be used for more than two axes.
- In servo axis arrangement, the main axis must be an odd-numbered axis, and the sub-axis must be a subsequent even-numbered axis.
- This function cannot be used with a mechanism that allows the mechanical coupling of two axes to be released.
- Servo HRV4 control exercises one-axis control with one CPU, so that this function cannot be used together with servo HRV4 control.

(4) Setting parameters



	#7	#6	#5	#4	#3	#2	#1	#0
1709 (FS15*i*) / 2019 (FS30*i*, 16*i*)							TANDMP	

(Set this parameter for the main axis only.)

TANDMP (#1) Tandem disturbance elimination control is:
0: Not used.
1: Used.

	#7	#6	#5	#4	#3	#2	#1	#0
1952 (FS15*i*) / 2008 (FS30*i*, 16*i*)						VFBAVE		

(Set this parameter for the main axis only.)

VFBAVE (#2) The velocity feedback average function is:

0: Not used.
1: Used.

Usually, set this parameter to 0. The velocity feedback average function has an effect equivalent to that of tandem disturbance elimination control for machines that have a certain rigidity. In general, this function is not used together with tandem disturbance elimination control. When using this function together with tandem disturbance elimination control, set integral gain Ki and proportional gain Kc to 0.

* With Series 90B3 and 90B7, a different bit position is assigned, that is, bit 6 for the sub-axis is used.

1721 (FS15*i*) / 2036 (FS30*i*, 16*i*)	Proportional gain Kc

(Set this parameter for the main axis only.)

[Valid data range] 0 to 32767 (0<Kc<0.5)

[Typical setting] 0

This parameter is not used generally, but is used for machines with a large friction. This parameter has the same function as damping compensation gain Kc of the tandem control function. (See Subsec. 4.19.2.)

1721 (FS15*i*)	Phase compensation coefficient α
2036 (FS30*i*, 16*i*)	

(Set this parameter for the sub-axis only.)

[Valid data range] 51 to 512 (0.1< α <1)

[Typical setting] 0 (512 internally)

This parameter has the same function as damping compensation of the tandem control function. When 512 is specified, the advance amount is 0 degree. (See Subsec. 4.19.2.)

2738 (FS15*i*)	Integral gain Ki
2325 (FS30*i*, 16*i*)	

(Set this parameter for the main axis only.)

[Valid data range] 0 to 4000

This parameter compensates for a machine spring element. Set a large value when the rigidity is high. Set a small value for a motor with a greater torque constant.

2738 (FS15*i*)	Phase compensation coefficient 2T/t
2325 (FS30*i*, 16*i*)	

(Set this parameter for the sub-axis only.)

[Valid data range] 0 to 32767

[Typical setting] 0 (40 internally)

This parameter is used with coefficient α to compensate the compensation delay. When the resonance frequency is 100 Hz or more, set α = 100 and 2T/t = 6.

2746 (FS15*i*)	Incomplete integral time constant
2333 (FS30*i*, 16*i*)	

(Set this parameter for the main axis only.)

[Valid data range] 0 to 32767

[Typical setting] 0 (30877 internally)

As integral gain Ki increases, vibration in the low frequency area (10 Hz or less) may occur. In such a case, set the incomplete integral time constant to decrease the time constant. Set a parameter value listed below.

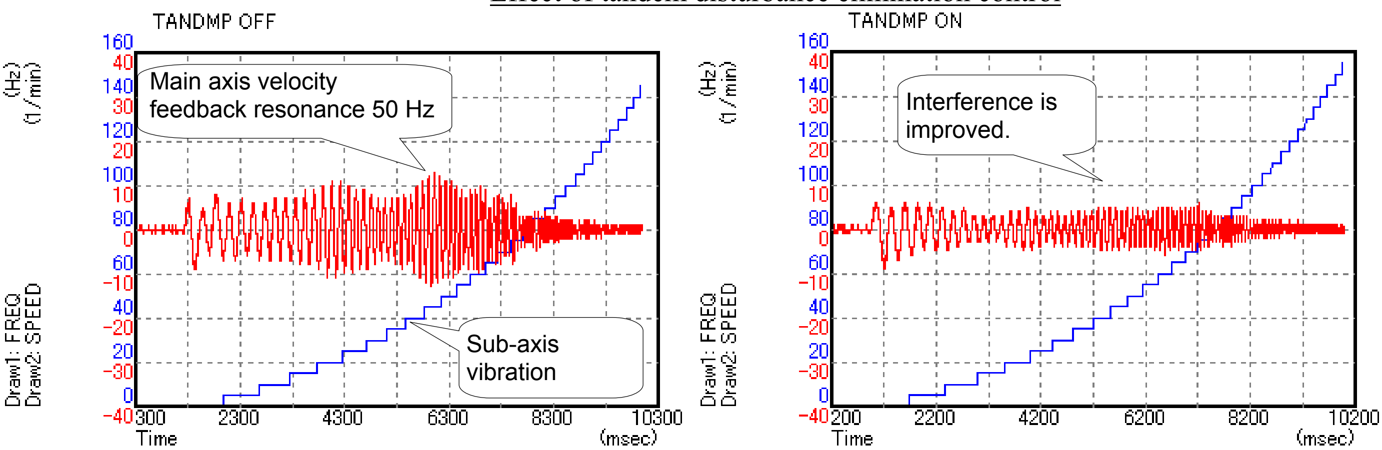
Table 4.16.1 Setting in the incomplete integral time constant parameter (when HRV1, HRV2, HRV3 is used)

Time constant (sec)	Parameter setting
0.1	30887
0.05	29307
0.02	25810

(5) Adjustment method

- Check the torque commands for the main axis and sub-axis and velocity feedback vibration by using a check board. (See Item (6).)
- If the vibration phase is shifted by 180 degrees, the cause of resonance is assumed to be inter-axis interference.
- Enable tandem disturbance elimination control, and adjust integral gain Ki.
- Increase the value of integral gain Ki gradually from 0, and observe vibration. Ki has an optimal value. When the value of Ki is increased excessively, vibration becomes stronger.
- When the velocity loop gain is changed, the frequency of vibration changes. So, adjust Ki to minimize vibration.
- If the frequency of vibration exceeds 100 Hz, the effect of tandem disturbance elimination control decreases. In such a case, set phase compensation coefficients α and 2T/t or increase the current loop gain with the current 1/2 PI control function.

Effect of tandem disturbance elimination control



* Velocity feedback and vibration frequency when the sub-axis is vibrated

(6) Method of checking the frequency of vibration

In this adjustment, use the disturbance input function for the sub-axis, measure the velocity feedback for the main axis, check for interference between the axes, and check and adjust the effect of tandem disturbance elimination control.

The following explains how to use the disturbance input function and how to make settings for data measurement.

(a) Setting parameters related to disturbance input

Parameters related to the disturbance input function are set for the sub-axis.

(About the disturbance input function)
The disturbance input function applies vibration to an axis by inputting a sine wave disturbance to the torque command. In the adjustment of tandem disturbance elimination control, this function is used for the sub-axis to observe the interference status between the axes when vibration is applied to the sub-axis.

For the sub-axis, set parameters related to the disturbance input function.

	#7	#6	#5	#4	#3	#2	#1	#0
2683 (FS15*i*)	**DSTIN**	**DSTTAN**	**DSTWAV**					
2270 (FS30*i*, 16*i*)								

DSTIN(#7) Disturbance input
0: Stop
1: Start (Disturbance input starts on the rising edge from 0 to 1.)

DSTTAN(#6) Set 0.

DSTWAV(#5) Set 0.

2739 (FS15*i*)	**Disturbance input gain**
2326 (FS30*i*, 16*i*)	

[Setting value] 500
(*) Set the amplitude of the applied vibration (torque). (Value 7282 is equivalent to the maximum current of the amplifier.)
First, set about 500 to apply vibration to the machine so that light sound is generated. If it is difficult to observe the vibration status, increase the parameter value gradually.

2740 (FS15*i*)	**Disturbance input function: Start frequency (Hz)**
2327 (FS30*i*, 16*i*)	

[Setting value] 0
(*) If 0 is set, the default (10 Hz) is assumed to be the vibration start frequency.

2741 (FS15*i*) 2328 (FS30*i*, 16*i*)	**Disturbance input end frequency**

[Setting value] 0

(*) If 0 is set, the default (200 Hz) is assumed to be the vibration end frequency.

2742 (FS15*i*) 2329 (FS30*i*, 16*i*)	**Number of disturbance input measurement points**

[Setting value] 0

(*) If 0 is set, the default (3) is assumed as the number of disturbance input measurement points.

[Cautions]

1 Disable the functions that operate only in the stop state, such as the variable proportional gain function in the stop state and the overshoot compensation function.

2 When characteristics at the time of cutting are measured, cutting/rapid switching functions should be treated carefully.

3 Decrease the position gain to about 1000.

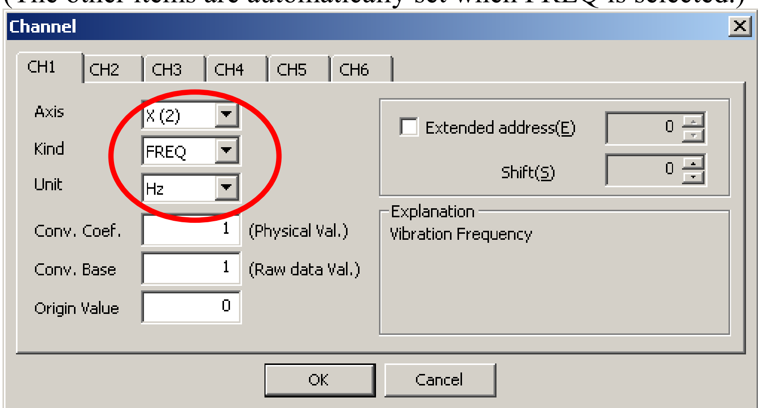
(b) Channel setting with SERVO GUIDE

With SERVO GUIDE, make settings for data acquisition. Two types of data including disturbance frequency data (the main axis) and velocity feedback data (the sub-axis) are acquired at the same time.

From the graph window menu of SERVO GUIDE, select [Setting] then [Channel].

Channel 1: Disturbance frequency

- Specify the sub-axis as the axis, and set the data type to "FREQ". (The other items are automatically set when FREQ is selected.)



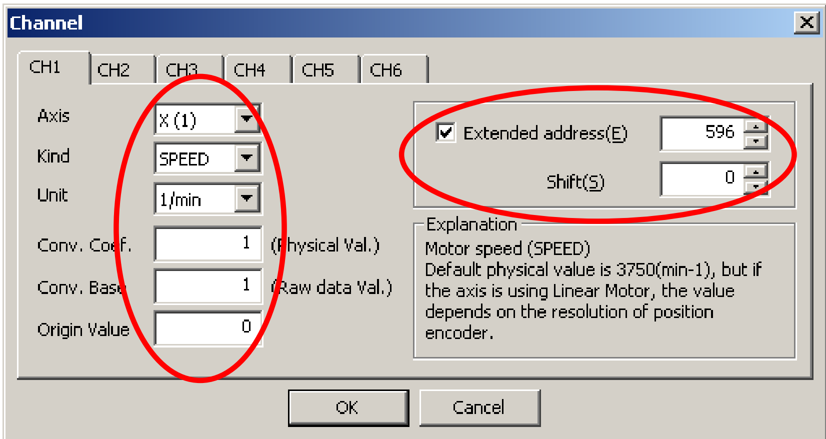
Channel 2: Main axis velocity feedback

- Specify the main axis as the axis, and set the data type to "SPEED".
- Set the conversion coefficient to 1, and set the conversion base data to 1.

- Check the check box of the extended address, and set an address as listed in the table below. (The setting varies depending on the value set in parameter No. 1023.) Set the shift amount to 0.

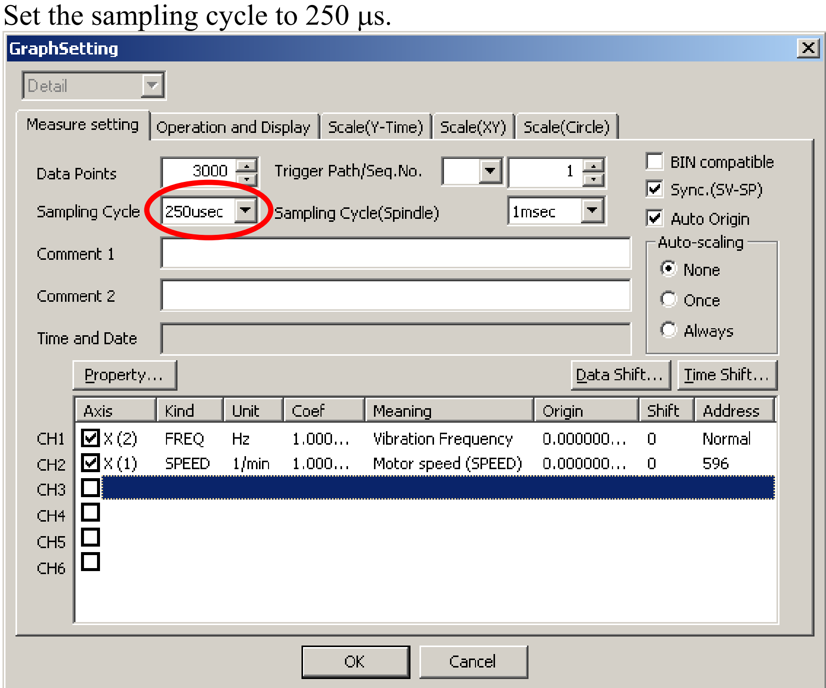
No.1023	Odd	Even
Series 90D0	596	724
Series 90B0, Series 90B1, Series 90B5, Series 90B6	340	468
Series 90B3, Series 90B7	2048	2176

No.1023 (n:0,1,2,..)	4n+1	4n+2	4n+3	4n+4
Series 90E0	596	724	6740	6868



(c) Setting for sampling

Set the sampling cycle to 250 μs.



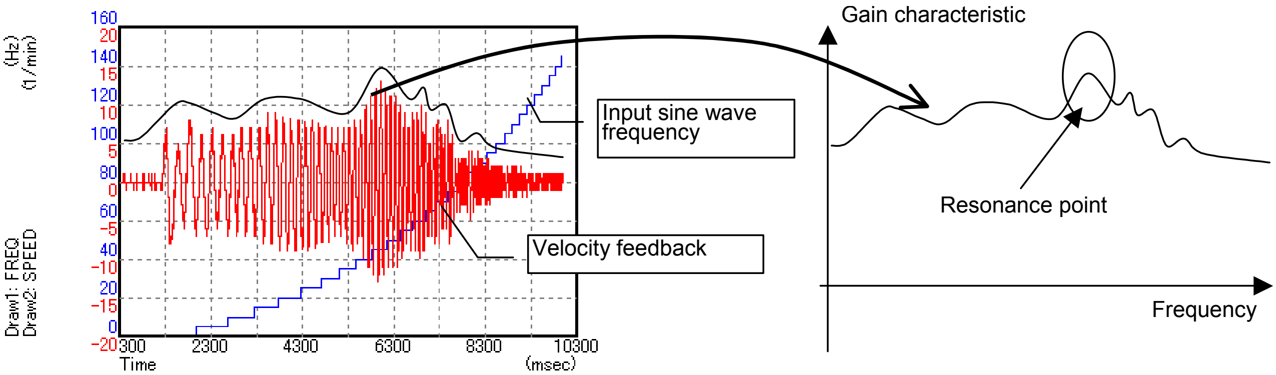
(d) Usage

When the rising edge of the disturbance input bit (**DSTIN**) is detected, application of vibration is started. Vibration is automatically stopped after a sine sweep is performed from the start frequency to the end frequency. The operation is stopped by a reset or an emergency stop. After the emergency stop is released, disturbance input is resumed starting with the start frequency by setting the function bit off then on again.

[Example of setting]

No.2326 = 500 → Gain = 500
No.2327 = 0 → Start frequency = 10Hz
No.2328 = 0 → End frequency = 200Hz
No.2329 = 0 → Number of measurement points = 3

By using SERVO GUIDE, obtain data, and display the frequency (ch1) and velocity feedback (ch2) in the XY-YT mode.



As shown in the above waveform, the envelope of the velocity feedback indicates the gain characteristic at each frequency, and a swell portion in the waveform shows a resonance point.

Adjust the tandem disturbance elimination control parameters so that the degree of the gain swell at the resonance point is reduced.

(7) Notes on Series 90B3 and 90B7

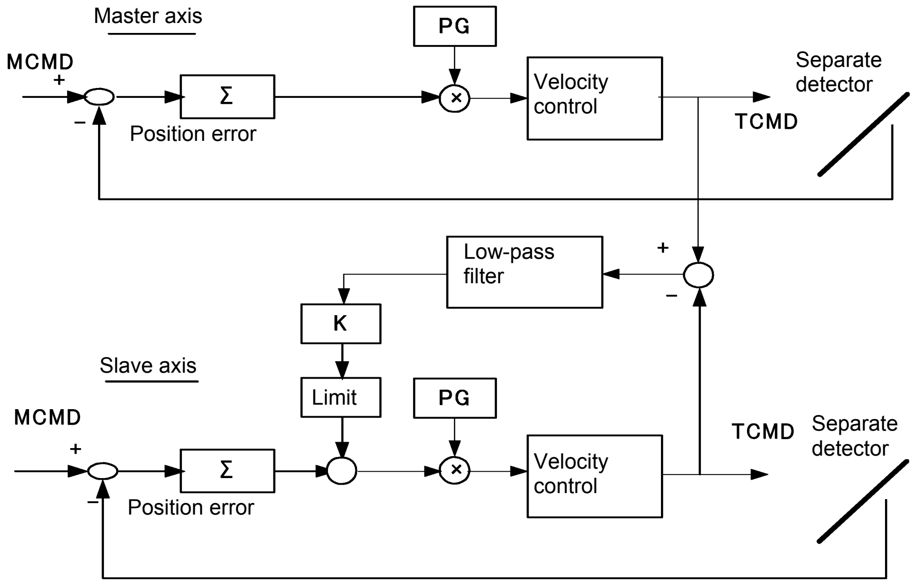
Series 90B3 and 90B7 are used for applications that require learning control. It is assumed that the mechanical coupling between two rotation axes, C1 and C2, is released. So, only when the two axes are mechanically coupled with each other, tandem disturbance elimination control functions. Whether the two axes are mechanically coupled with each other can be checked using the input of the external signal G139 (coupling flag). For details of the external signal interface, refer to the description of "Tandem leaning control" in "Learning Function Operator's Manual (A-63639E-034)".

4.18 SYNCHRONOUS AXES AUTOMATIC COMPENSATION

(1) Overview

With synchronized axes having a long stroke, a machine twist may occur due to the absolute precision of the scale and thermal expansion of the machine. In such a case, the master motor and slave motor of the synchronized axes pull each other, and if a large current flows for the pull, an overheat problem or OVC alarm is raised.
The fundamental cause of this is a measurement position error. Pitch error compensation can compensate for the scale error but cannot compensate for thermal expansion due to change in temperature.
The synchronous axes automatic compensation function is useful for such cases. The function monitors a torque error between the master and slave and corrects the position on the slave side slowly to reduce the torque error.

(Structure of the synchronous axes automatic compensation function)



(2) Series and editions of applicable servo software

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

> **NOTE**
> Servo HRV4 control exercises one-axis control with one CPU, so that this function cannot be used together with servo HRV4 control.

(3) Setting parameters

- The following parameters are all set for the slave axis (the axis for which an even number is set in parameter No. 1023) only.

	#7	#6	#5	#4	#3	#2	#1	#0
2688 (FS15*i*) **2275 (FS16*i*)**					**ASYN**			

ASYN (#3) Synchronous axes automatic compensation function is:
0: Disabled.
1: Enabled.

2816 (FS15*i*) **2403 (FS16*i*)**	**Synchronous axes automatic compensation coefficient (K)**

[Unit of data] Detection unit / TCMD unit × 4096
[Valid data range] -32767 to 32767

From the relationship between the current value generated in the stopped state when this function is disabled and the position error between the synchronized axes, determine the coefficient (K) according to the following expression:

K = position error/current value (in TCMD) × 4096 .... <1>

When the current value is measured on the servo tuning screen, the current value is indicated in amperes or as the percentage to the rated current value. So, use expression <2> or <3> for calculation.

K = position error/{current value (%) × Ir × 7282/6554} × 4096
.... <2>

Ir: Rated current in parameter No. 2086 (Series 16*i*) or No. 1979 (Series 15*i*)

K = position error/{current value (A)/Amax × 7282} × 4096
.... <3>

Amax: Maximum current value of the amplifier

Measure the current value when the problem of a pull is being observed at the release of emergency stop. The position error between the synchronized axes is obtained from the difference in position error between the master axis and slave axis at the time of emergency stop. Normally, the position error of the master axis at the time of emergency stop is 0, so you need to check the position error of the slave axis only.

Example)

Suppose that the position error of the slave at the time of emergency stop is 200, the current value at the release of emergency stop is 60% (the percentage to the rating), and 1437 is set in parameter No. 2086 (rated current value for the Series 16*i*):

Settings = 200 / { 1437 × 60/100 × 7282/6554 } × 4096 = 855

2817 (FS15*i*) **2404 (FS16*i*)**	**Synchronous axes automatic compensation: Maximum compensation**

[Unit of data] Detection unit
[Valid data range] 0 to 5000

Set the maximum compensation amount in synchronous axes automatic compensation.

2818 (FS15*i*)	Synchronous axes automatic compensation: Filter coefficient
2405 (FS16*i*)	

[Valid data range] 32700 to 32767

[Typical setting] 0 (equivalent to a time constant of 1 second)

Set the time constant for reflecting the twist in position compensation. As a larger coefficient is set, compensation to release the twist is performed more slowly.

Table 4.18.1 Setting in the filter coefficient parameter

Time constant (s)	Setting in the parameter
1	0
5	32761
10	32765

NOTE

1. This function reduces the difference in torque between the master and slave axes by adding compensation pulses to the slave axis. In the steady state, position error equivalent to the compensation amount is accumulated in the slave axis.
2. This function cannot be used together with the dual position feedback function.
3. Set parameters on the even-numbered axis side.
4. Be sure to assign the master and slave, which are the synchronized axes, to the odd- and even-numbered axes on the same DSP.

With the following servo software, a dead-band width can be set:
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B1/A(01) and subsequent editions

Set the following parameter for the odd-numbered axis side (the master axis) only:

2817 (FS15*i*)	Synchronous axes automatic compensation: Dead-band width
2404 (FS16*i*)	

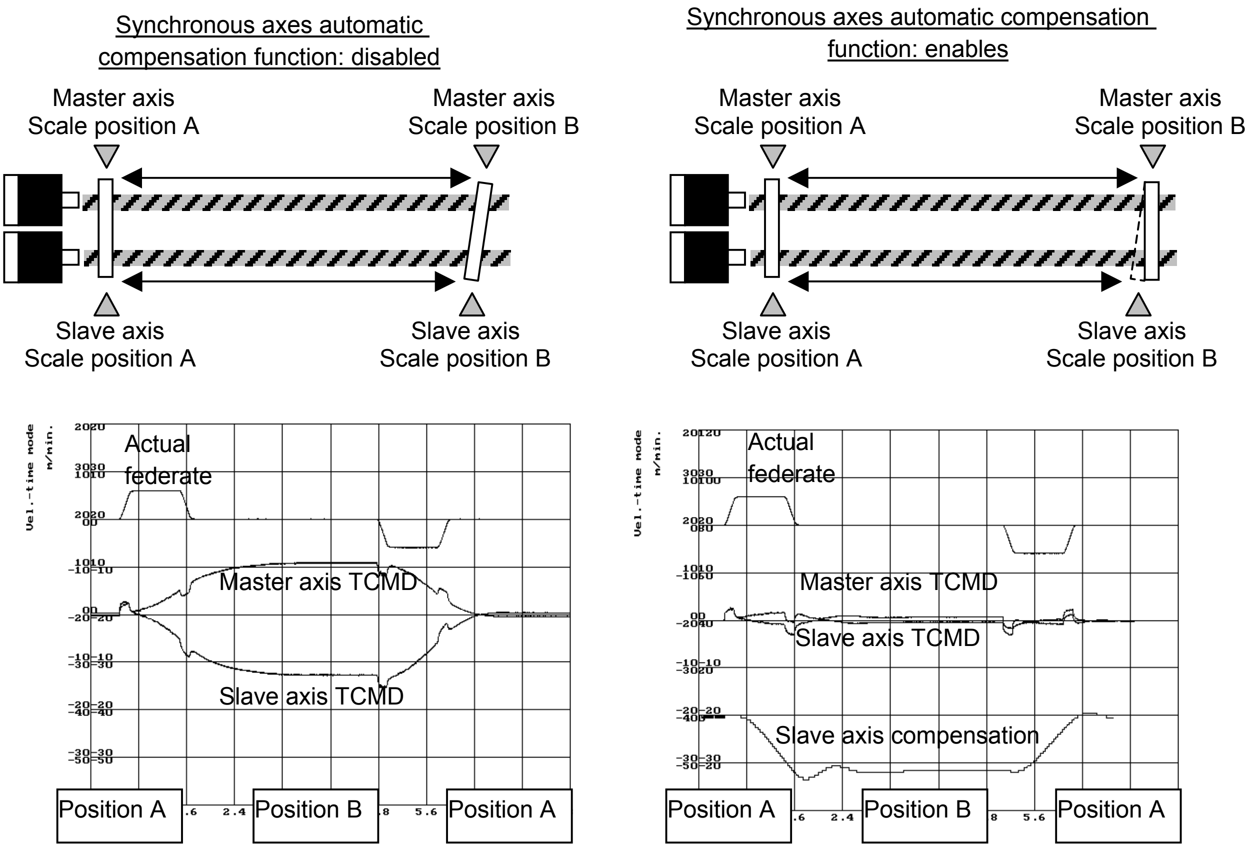
[Unit of data] Percentage (%) with respect to rated current

[Valid data range] 0 to 800

If the difference in torque command between the master axis and slave axis is within the dead-band width, the synchronous axes automatic compensation value becomes 0.

(4) Application example

The figure below shows how synchronous axes automatic compensation works effectively.
When the master axis and slave axis, which are synchronized axes connected mechanically, indicate different positions as position B, the master axis and slave axis pull each other, and their TCMD waveforms increase in the opposite directions.
Use of this function allows the position of the slave axis to move slowly to such a position that is balanced with the master axis position, so the problem that the axes pull each other does not occur.



4.19 TORQUE TANDEM CONTROL FUNCTION Optional function

(1) Overview

If a single motor is not capable of producing sufficient torque to drive a large table, for example, tandem control allows two motors to produce movement along one axis.
A motor of the same specification is used for both the main motor and sub-motor.
Only the main motor is responsible for positioning. The sub-motor only produces a torque. In this way, double the torque can be obtained (load sharing mode).

By applying a preload torque to produce tension between the main motor and sub-motor, the backlash between gears can be reduced (anti-backlash mode).

Tandem control is used to run linked linear motors and motors with a winding tandem (α*i*S300/2000, α*i*S500/2000, α*i*S1000/2000HV).

(2) Applicable servo software series and editions

(Series 30*i*,31*i*,32*i*)
- Series 90D0/A(01) and subsequent editions
- Series 90E0/A(01) and subsequent editions

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,Power Mate *i*)
- Series 9096/A(01) and subsequent editions
- Series 90B0/A(01) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions

(Series 0*i*-C)
- Series 90B5/A(01) and subsequent editions

NOTE
Servo HRV4 control exercises one-axis control with one CPU, so that this function cannot be used together with servo HRV4 control.

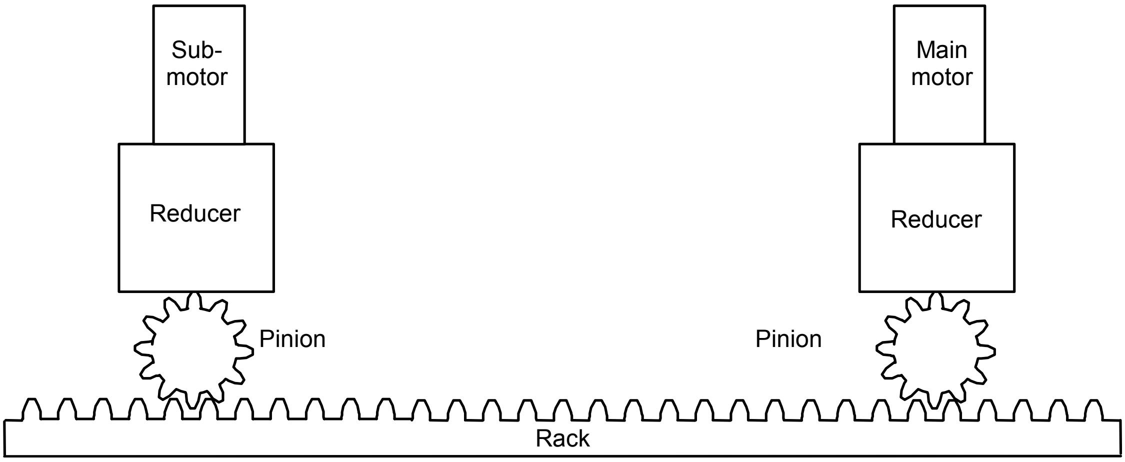


Fig. 4.19 (a) Example of tandem control application (1)

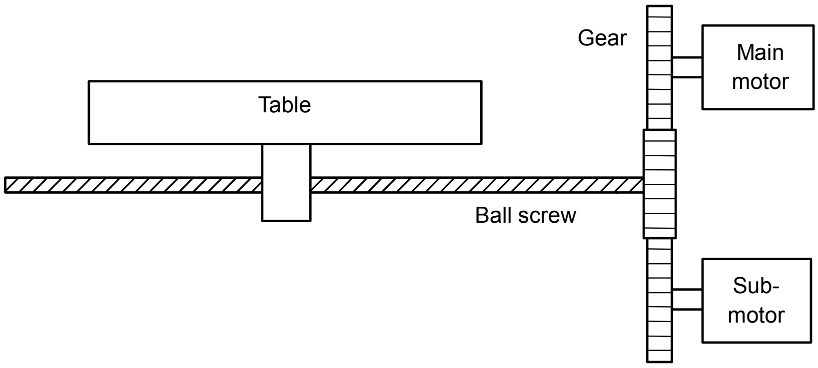


Fig. 4.19 (b) Example of tandem control application (2)

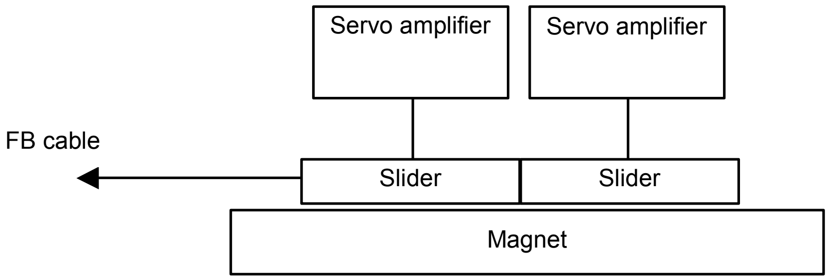


Fig. 4.19 (c) Example of exercising tandem control (linking linear motors)

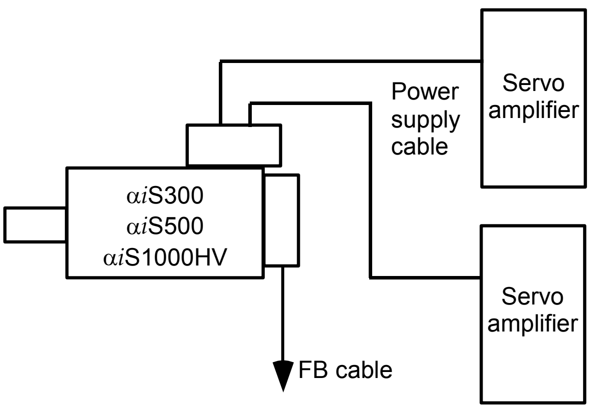


Fig. 4.19 (d) Example of exercising tandem control (winding tandem)

(3) Start-up procedure

To start tandem control, follow the procedure below.

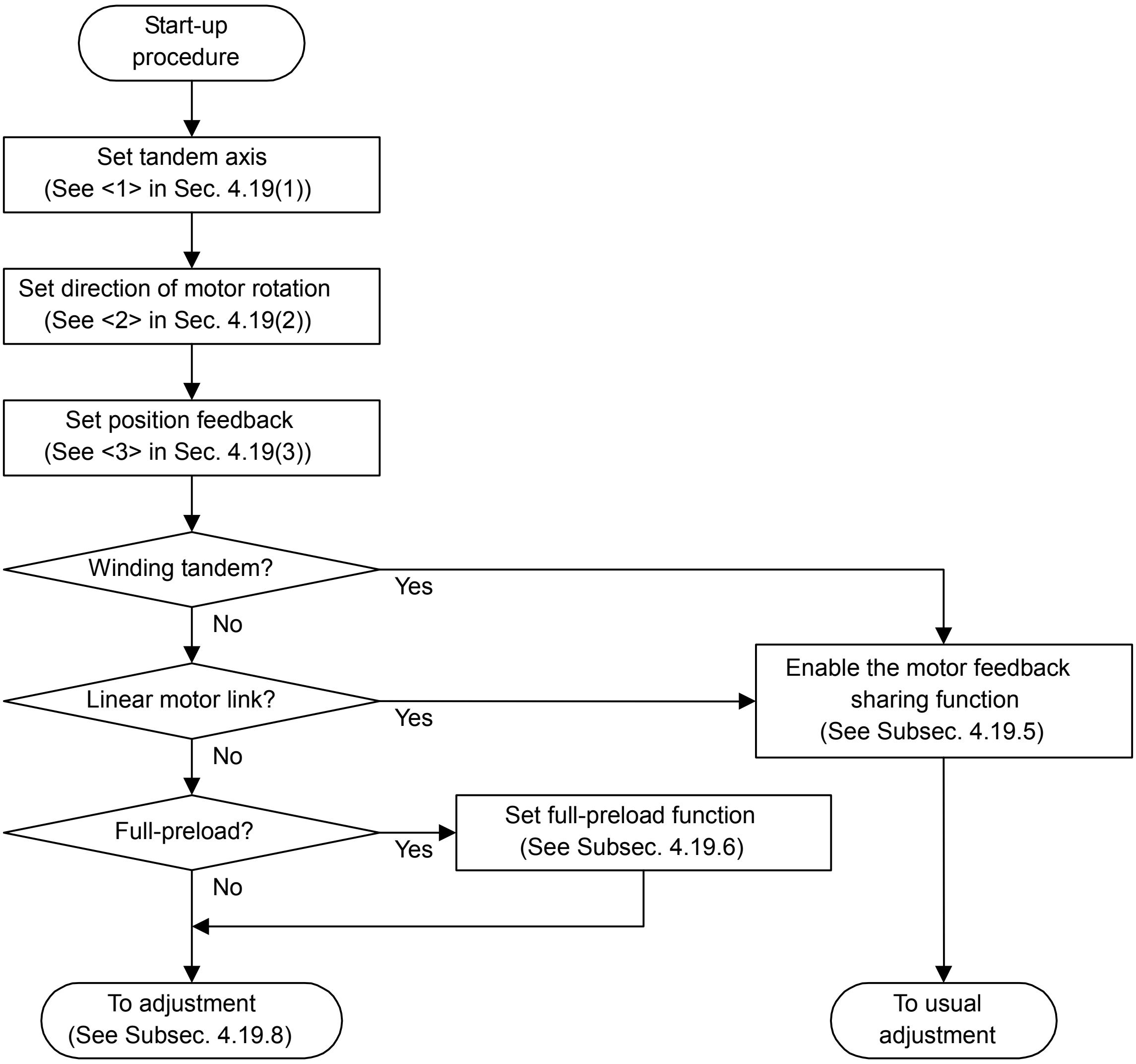


Fig. 4.19 (e) Start-up procedure flowchart

<1> Tandem axis setting

Tandem control is an optional function.
Refer to the Parameter Manual of CNC for details.

	#7	#6	#5	#4	#3	#2	#1	#0
1817 (FS15*i*) 1817 (FS30*i*, 16*i*)		TANDEM						

TANDEM (#6) 1: Enables tandem control. (Set this parameter for the main- and sub-axes.)

-	Number of CNC controlled axes (for Series 16*i* and so on)
1010 (FS16*i*)	

As with the PMC axis, specify a number obtained by subtracting the number of tandem sub-axes from the number of controlled axes.
If an invalid-parameter alarm is occurred, check whether the value set in this parameter is correct.

1021 (FS15*i*)	Parallel-axis name (for Series 15*i* only)
-	

Specify 77 and 83 for the main axis and sub-axis, respectively.

1023 (FS15*i*)	Servo axis arrangement
1023 (FS30*i*, 16*i*)	

This parameter specifies servo axis arrangement.
Set an odd number for a main axis, and the subsequent even number for the sub-axis.
If 3 is set for a main axis, for example, set 4 for the sub-axis.

> **NOTE**
> Specify a tandem sub-axis after a CNC-controlled axis (command axis) (by referencing the following examples of setting).

Example of tandem axis setting

(1) For Series 30*i*, 16*i*, and so on (★ indicates a tandem axis.)
Number of controlled axes = 6
Number of CNC-controlled axes (No. 1010) = 3 (for Series 16*i* and so on)

	Axis number	Axis name	Servo axis arrangement No. 1023	Tandem No. 1817#6	Position display No. 3115#0	Remark
★	1	X	1	1	0	CNC axis (main axis)
★	2	Y	3	1	0	CNC axis (main axis)
	3	Z	5	0	0	CNC axis
★	4	A	2	1	1	Tandem control sub-axis (sub-X-axis)
★	5	B	4	1	1	Tandem control sub-axis (sub-Y-axis)
	6	C	6	0	0	PMC axis

(2) For Series 15*i* (★ indicates a tandem axis.)

	Axis number	Axis name	Servo axis arrangement No. 1023	Tandem No. 1817#6	Parallel axis No. 1021	Remark
★	1	X_M	1	1	77	CNC axis (main axis)
★	2	Y_M	3	1	77	CNC axis (main axis)
	3	Z	5	0	0	CNC axis
	4	A	6	0	0	CNC axis
	5	B	7	0	0	CNC axis
★	6	X_S	2	1	83	Tandem control sub-axis (sub-X-axis)
★	7	Y_S	4	1	83	Tandem control sub-axis (sub-Y-axis)

<2> Direction of motor rotation

1879 (FS15*i*) 2022 (FS30*i*, 16*i*)	Direction of motor rotation (DIRCT)

Main axis: With a forward direction specified, 111 specifies that the main axis motor rotates counterclockwise as viewed from the motor shaft side, while -111 specifies the opposite direction.

Sub-axis: To cause the sub-axis motor to rotate in the same direction as for the main axis, specify the same value for both the sub-axis and the main axis because of their mechanical structure. To cause the sub-axis motor to reverse, specify a value whose sign is opposite to that for the normal direction. For winding tandem, be sure to specify the values with the same sign.

<3> Position feedback setting

Specify position feedback for both main axis and sub-axis. (See Subsec. 4.19.8 for a concrete example.)

* Assume position feedback shown in Fig. 4.19.8 (a) not only for the main axis but also for the sub-axis.

	Series 30*i*,16*i*, and so on	Series 15*i*
• Semi-closed or full-closed loop setting	No. 1815#1	No. 1815#1 No. 1807#3
• CMR setting	No. 1820	No. 1820
• Setting the reference counter capacity	No. 1821	No. 1896
• Setting the high-resolution Pulsecoder	No. 2000#0	No. 1804#0
• Setting the number of velocity detection pulses	No. 2023	No. 1876
• Setting the number of position detection pulses	No. 2024	No. 1891
• Flexible feed gear (numerator) setting	No. 2084	No. 1977
• Flexible feed gear (denominator) setting	No. 2085	No. 1978

(4) Descriptions of servo parameters for adjustment

The load inertia ratio to be specified for axes subjected to tandem control differs from that for ordinary axes.

1875 (FS15*i*) 2021 (FS30*i*, 16*i*)	Load inertia ratio (LDINT)

[Standard setting] (Load inertia/motor inertia) × 256

(NOTE) In typical tandem control, the total load inertia of the machine is borne by two motors. So, calculate the load inertia for the above formula as follows:

(Load inertia) = (Total load inertia of machine)/2

When the full preload function is used, the motor on the driving side is required to bear the total load inertia of the machine and the motor inertia of the other motor. So, calculate the load inertia for the above formula as follows:

(Load inertia) = (Total load inertia of machine) + (Motor inertia)

Example of setting

The example shown in Fig. 4.19 (a) is used. Assume that the inertia of each section applied to the motor shaft as follows:

- Inertias of the reducers of the main- and sub-axes: J_{1m}, J_{1s}
- Inertias of the pinions of the main- and sub-axes: J_{2m}, J_{2s}
- Inertia of the rack: J_3

(Total load inertia of the machine) = $J_{1m} + J_{2m} + J_3 + J_{1s} + J_{2s}$

When the total load inertia of the machine is double that of the motor inertia, for example, set the following:

When typical tandem control is used:

(Load inertia ratio) = $(2/2) \times 256 = 256$

When the full preload function is used:

(Load inertia ratio) = $(2 + 1) \times 256 = 768$

The result obtained from the above formula may cause oscillation due to the mechanical structure. In such a case, set a smaller value.

• Notes on stable tandem control operation

To ensure stable tandem control operation, the machine must be capable of performing back-feed.

Back-feed is the moving of the sub-motor from the main motor, or vice versa, through the connected transmission feature. Then the back-feed capability is disabled, unstable operation results. In this case, machine adjustment becomes necessary.

The user can check whether the back-feed capability is enabled. To make this check in the case of the example shown in Figs. 4.19 (a) and (b), turn the main motor with the power line for the sub-motor disconnected, and check that the main motor can be turned with one-third or less of the rated torque of the motor (See (2) in Subsec. 4.19.8).

4.19.1 Preload Function

By applying an offset to the torque controlled by position (velocity) feedback, torques of opposite directions can be applied to the main- (main motor) and sub-axes (sub-motor) to maintain tension at all times. This function can reduce the backlash between the main- and sub-axes, caused by the tandem connection of two motors through gears. However, this function does not reduce the backlash between the ball screw and table, which are a feature of the machine system.
For example, set preload +Pre for the main axis and preload -Pre for the sub-axis. Then, torques are produced as shown below.
If a torque is required during acc./dec., a torque of the same direction is produced with the two motors. (Load sharing mode)
If no torque is required, for example, during stop state, preload torques produce tension between the two axes. (Anti-backlash mode)
For an application which requires only anti-backlash mode, use the full preload function, described in Subsec. 4.19.6.

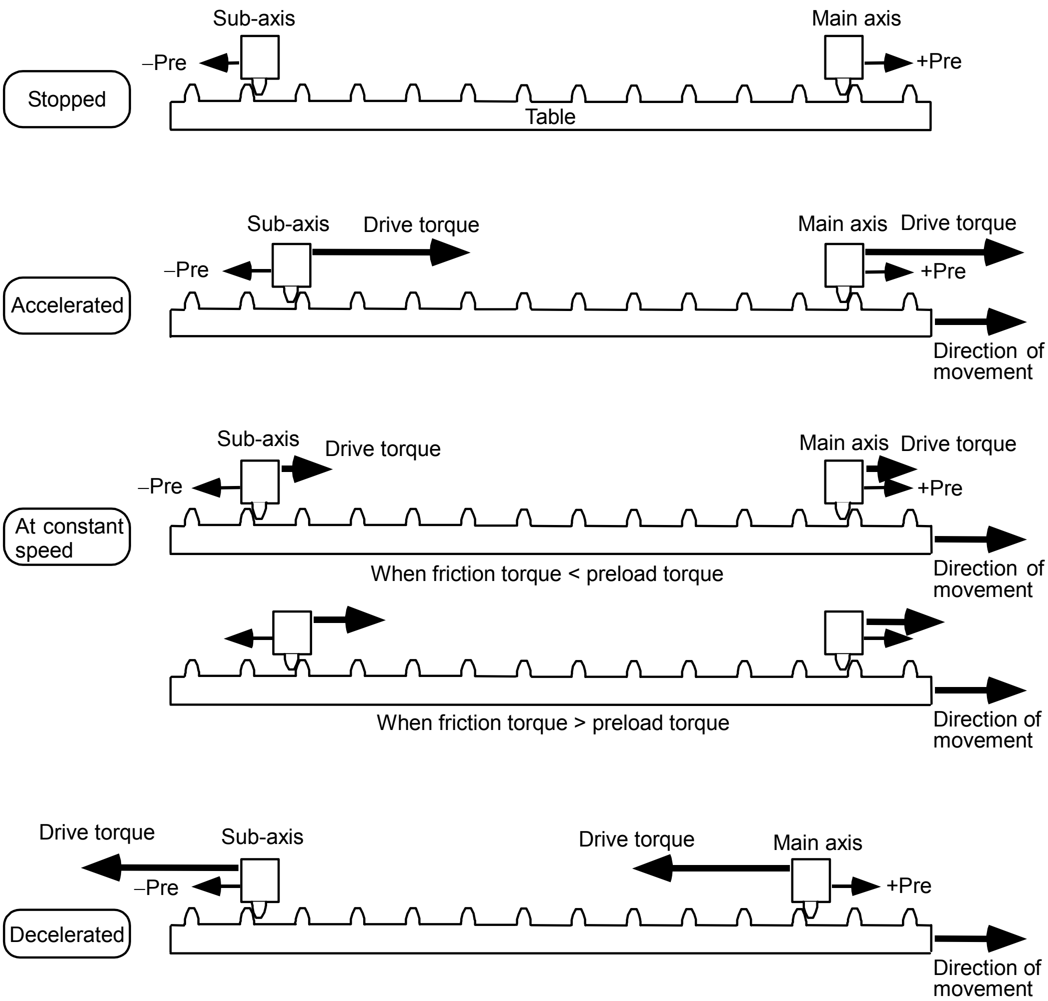


Fig. 4.19.1 (a) Changes of torque during movement

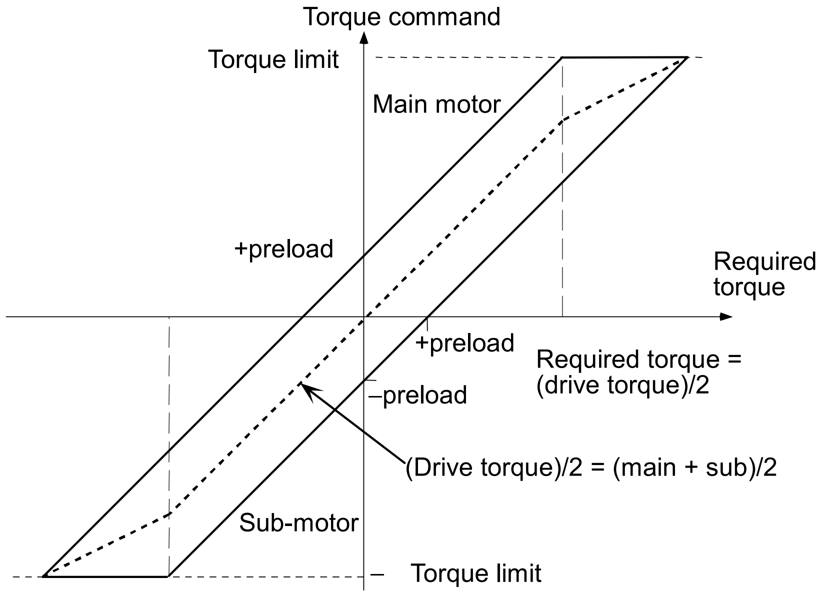


Fig. 4.19.1 (b) Relationship between required torque and torque command for each motor

1980 (FS15*i*)	**Preload value (PRLOAD)**
2087 (FS30*i*, 16*i*)	

Set this parameter for the main- and sub-axes.

> ⚠ **CAUTION**
> Set a value that is as small as possible but greater than the static friction torque. A set preload torque is applied to each motor at all times. So, set a value that does not exceed the rated static torque of each motor. As a guideline, specify a value equal to one-third of the rated static torque.
> As shown in Fig. 4.19.11 (a) in Subsec. 4.19.11, a preload torque is added in any case. So, set the preload torque directions as follows:
> - When the rotation directions of the main axis and sub-axis are the same: Different signs
> - When the rotation directions of the main axis and sub-axis are different: Same sign

Example of setting

For the α*i*F4/4000 (Servo amplifier α*i* SV 40)

When a preload torque of 1 N·m is to be applied, the torque constant is 0.52 N·m/Arms according to the specifications of the servo motor. So, the peak value is 0.368 N·m/Ap. The torque is converted to a current value as follows:

1/0.368 = 2.72 Ap.

The amplifier limit is 40 Ap, so that the value to be set is:

2.72/40 × 7282 = 495

So, set 495 for the main axis, and -495 for the sub-axis (when the directions of rotation of the two motors are the same).

When movement of the table is stopped, check whether the system is in tension. If not, increase this value gradually.

> ⚠ **WARNING**
> When two motors are not connected, always set a preload value of 0.
> The sub-axis motor may rotate at extremely high speed, which is very dangerous.

4.19.2 Damping Compensation Function

To enable more stable tandem control, a torque offset can be applied to the sub-axis, or to both the main- and sub-axes to eliminate a difference in speed, if any, between the main- and sub-axes.
This function is particularly useful for controlling the vibration (with a frequency of several Hz to 30 or 40 Hz) that may occur in a machine system with low spring rigidity.

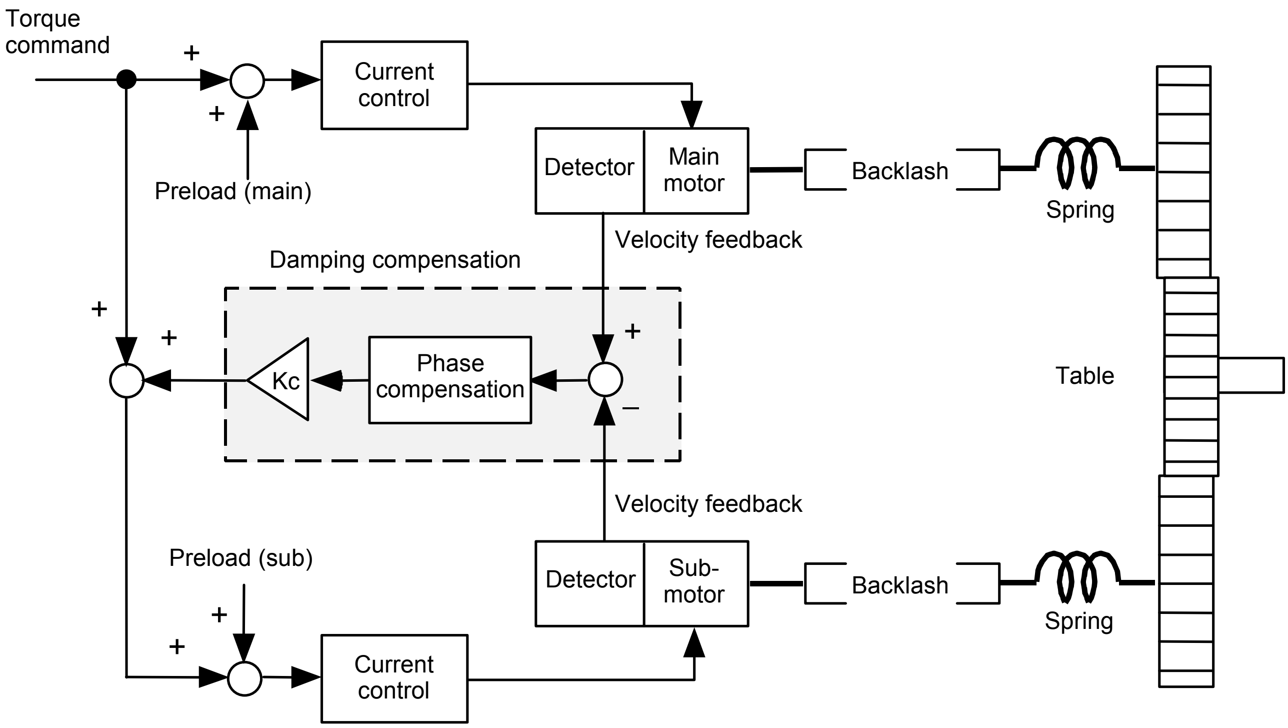


Fig. 4.19.2 (a) Damping compensation function

	#7	#6	#5	#4	#3	#2	#1	#0
1952 (FS15*i*) / 2008 (FS30*i*, 16*i*)	LAXDMP							

LAXDMP (#7)
1: Enables the damping compensation function for the main- and sub-axes.
0: Enables the damping compensation function for the sub-axis only.

Usually, set this bit to 0. (Set this parameter for the main axis only.)

1721 (FS15*i*) / 2036 (FS30*i*, 16*i*)	Damping compensation gain Kc (ABPGL)

Set this parameter for the main axis only.

[Valid data range] 0 to 32767

[Setting method] $Kc \times 32768$ ($0 \le Kc < 0.5$)

A function bit is not supported for the damping compensation function; the damping compensation function is enabled at all times. When 0 is set in this parameter, the damping compensation function is ineffective.

1721 (FS15*i*) 2036 (FS30*i*, 16*i*)	Damping compensation phase coefficient α (ABPHL)

Set this parameter for the sub-axis only.

[Valid data range] 51 to 512

[Setting method] $\alpha \times 512$ ($0.1 \leq \alpha \leq 1.0$)

When 0 is set in this parameter, this setting is internally handled as 512 ($\alpha = 1$), When $\alpha = 1$, phase compensation is not performed. Instead, the set value is output to Kc as is.

(Example of adjustment) The speeds of the motors are checked using the check board (when the motors rotate in the same direction).

This function may be useful when the oscillation frequencies (several Hz to 30 or 40 Hz) are the same, and the phases are opposite as shown below.

NOTE

1 When the directions of rotation of the main motor and sub-motor are different, the phase relationship is reversed.

2 When the phase difference is not 180°, the phase coefficient α must be adjusted. Start with 512, then decrease the value gradually.

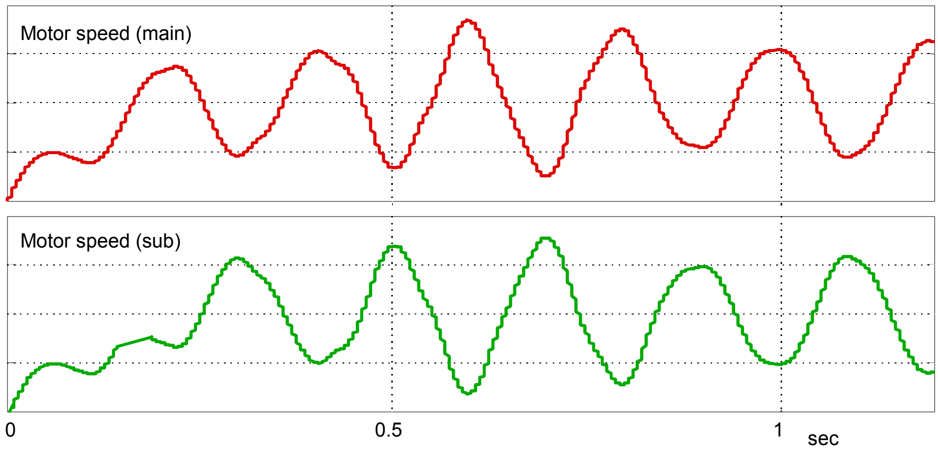


Fig. 4.19.2 (b) Motor speed vibration

- Adjustment procedure for damping compensation

1 Enable the velocity feedback average function.
[No. 1952#2 (Series 15*i*), No. 2008#2 (Series 30*i*, 16*i*, and so on) = 1]

2 Set an adequate preload value.
[No. 1980 (Series 15*i*), No. 2087 (Series 30*i*, 16*i*, and so on)]
Set a value slightly larger than the load applied during movement.

3 If dual-position feedback function is used, set a time constant of 200 [No. 1973 (Series 15*i*), No. 2080 (Series 30*i*, 16*i*, and so on)].
Adjust the setting of the parameter to ensure stable axis movement.

4 Set 0 or 512 as phase coefficient α.
[Sub-axis No.1721 (Series 15*i*), No. 2036 (Series 30*i*, 16*i*, and so on)]
If 512 is set, the value may have to be reduced when the vibration phase difference between the motors is other than 180°. (See Fig. 4.19.2 (b).)

5 Set a damping gain of 3277.
[Main axis No. 1721 (Series 15*i*), No. 2036 (Series 30*i*, 16*i*, and so on)]
To reduce the vibration, this value must be increased or decreased.
Be careful not to increase this value excessively. Otherwise, high-frequency vibration will occur.
When adjusting this parameter, apply the maximum axis load.

6 Repeat steps 2 through 5 until smooth movement is achieved.

4.19.3 Velocity Feedback Average Function

As can be seen from the tandem control block diagram shown in Fig. 4.19.10(a) in Subsec. 4.19.10, velocity control is not applied to the sub-axis motor. For this reason, the sub-axis may vibrate and become unstable due to a backlash such as, for example, in the gears, in a machine with a large backlash. In such a case, the machine can be made stable by applying velocity control to the sub-axis as well. This function is referred to as the velocity feedback average function.

	#7	#6	#5	#4	#3	#2	#1	#0
1952 (FS15*i*) **2008 (FS30*i*, 16*i*)**						**VFBAVE**		

VFBAVE (#2) 1: Enables the velocity feedback average function. Usually, set this bit to 1. (Set this parameter for the main axis only.)

4.19.4 Servo Alarm 2-axis Simultaneous Monitor Function

If an alarm occurs in either of two axis motors used to operate a machine in concert as in synchronization control or tandem control, it is necessary to stop the other axis immediately so as to prevent the machine from being twisted.
This function monitors two axes (controlled by the same DSP) simultaneously for servo alarm conditions. If an alarm condition is detected in either of the two axes, the function can promptly turn off activation (MCC) for the other axis.
This function is not confined to tandem axes. It can be used also axes (controlled by the same DSP) under synchronization control.

	#7	#6	#5	#4	#3	#2	#1	#0
1951 (FS15*i*) **2007 (FS30*i*, 16*i*)**							**IGNVRO**	**ESP2AX**

ESP2AX (#0) 1: Enables the servo alarm two-axis monitor function.
(Set this parameter for the main axis only.)

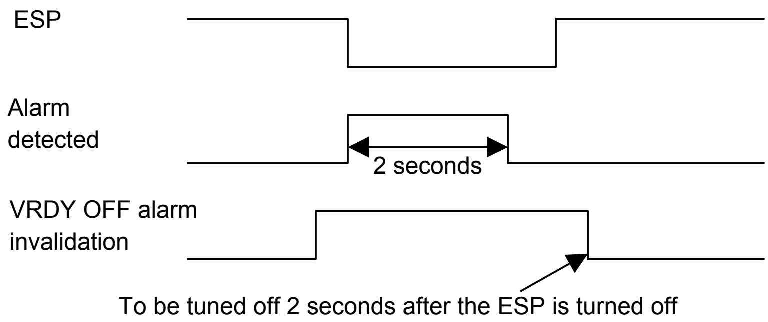
IGNVRO(#1) 1: An alarm condition is released 2 seconds after the servo alarm 2-axis simultaneous monitor function holds the alarm condition.
(Set this parameter for the main axis only.)
(Series 9096, and Series 90B0/B(02) and earlier editions are not supported.)

Some systems have a configuration in which the ESP line of the PSM is cut off with an interlocked machine door, independently of the emergency stop button, for safety purposes. In these systems, the amplifier is turned off with an emergency stop not in effect, and therefore, a "V ready-off alarm" is occurred. This alarm is evaded by using the "VRDY OFF alarm invalidation signal."

Conventionally, however, it was impossible to use "PSM cut-off based on the VRDY OFF alarm invalidation signal" along with the "servo alarm 2-axis simultaneous monitor function." This is because the "servo alarm 2-axis simultaneous monitor function" holds an alarm condition in the servo software and will not activate a motor even after the ESP line is connected.

To evade this problem, a function has been added which clears information about an alarm condition from the servo software 2 seconds after the alarm condition is detected. This way, it is possible to use the "servo alarm 2-axis simultaneous monitor function" along with "PSM cut-off based on the VRDY OFF alarm invalidation signal."

NOTE
It is necessary to release the VRDY OFF alarm invalidation signal 2 seconds after the PSM ESP signal is turned off.



4.19.5 Motor Feedback Sharing Function

To achieve improved thrust, two linear motors may be connected in series.
When linear motors are connected in series, one position feedback signal, which is originally available for the main axis, is to be shared by the sub-axis as well. In this case, the motor feedback sharing function can be used.

This function can also be used when a motor (αiS300/2000, αiS500/2000, αiS1000/2000HV) with the wire tandem specification is used.

> **NOTE**
> When using this function in a full-closed loop system, the main axis shares its separate detector feedback loop with the sub-axis.

	#7	#6	#5	#4	#3	#2	#1	#0
1960 (FS15*i*) **2018 (FS30*i*, 16*i*)**	**PFBCPY**							

PFBCPY (#7) 1: The motor feedback signal for the main axis is shared with the sub-axis motor.
(Set this parameter for the sub-axis only.)

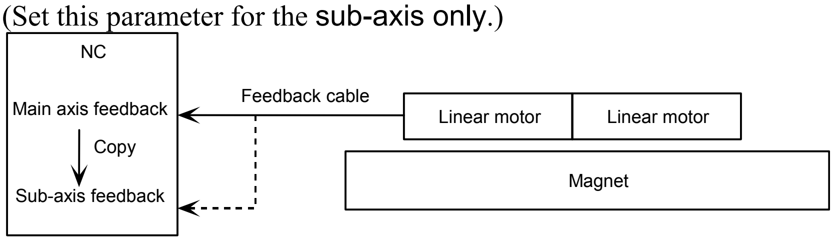


Fig. 4.19.5 Motor feedback sharing function

> **NOTE**
> If the scale of an axis for which this function is used is based on the A/B phase, the sub-axis side cannot perform absolute position communication. Accordingly, note that this function cannot be used with an absolute system.

4.19.6 Full-closed Feedback Sharing Function

If a feedback cable cannot be divided into two as in the case of a serial cable, this function enables one separate position feedback to be shared by the main axis and sub-axis by means of software.

	#7	#6	#5	#4	#3	#2	#1	#0
1740 (FS15*i*) 2200 (FS30*i*, 16*i*)							FULLCP	

FULLCP(#1) 1: A separate position feedback is shared by the main axis and the sub-axis.

(To be set for the sub-axis only.)

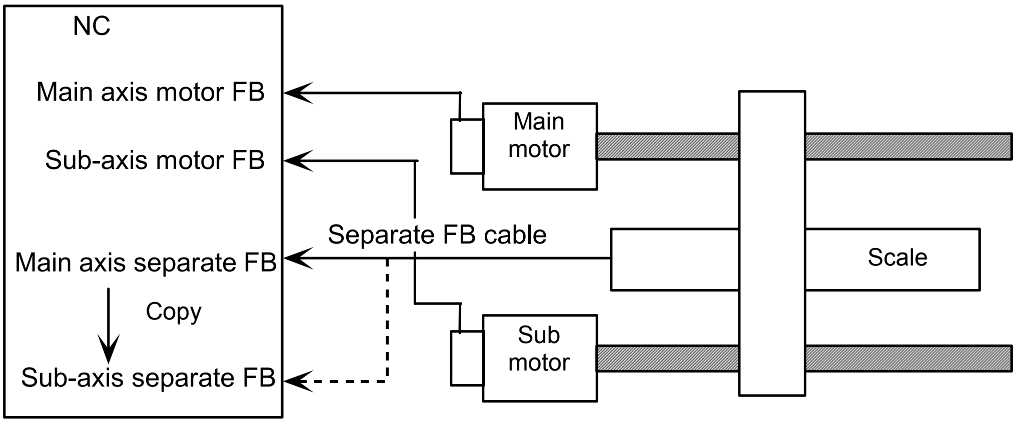


Fig. 4.19.7 (d) Full-closed feedback sharing function

> **NOTE**
> If the scale of an axis for which this function is used is based on the A/B phase, the sub-axis side cannot perform absolute position communication. Accordingly, note that this function cannot be used with an absolute system.

4.19.7 Adjustment

(1) Examples of parameter setting

This section gives examples of parameter setting.

<1> Full-closed loop system using a 1-μm increment system, 8080P/motor revolution for scale feedback, a scale detection unit of 0.5 μm/P, and an α*i*A1000 Pulsecoder (conventional tandem)

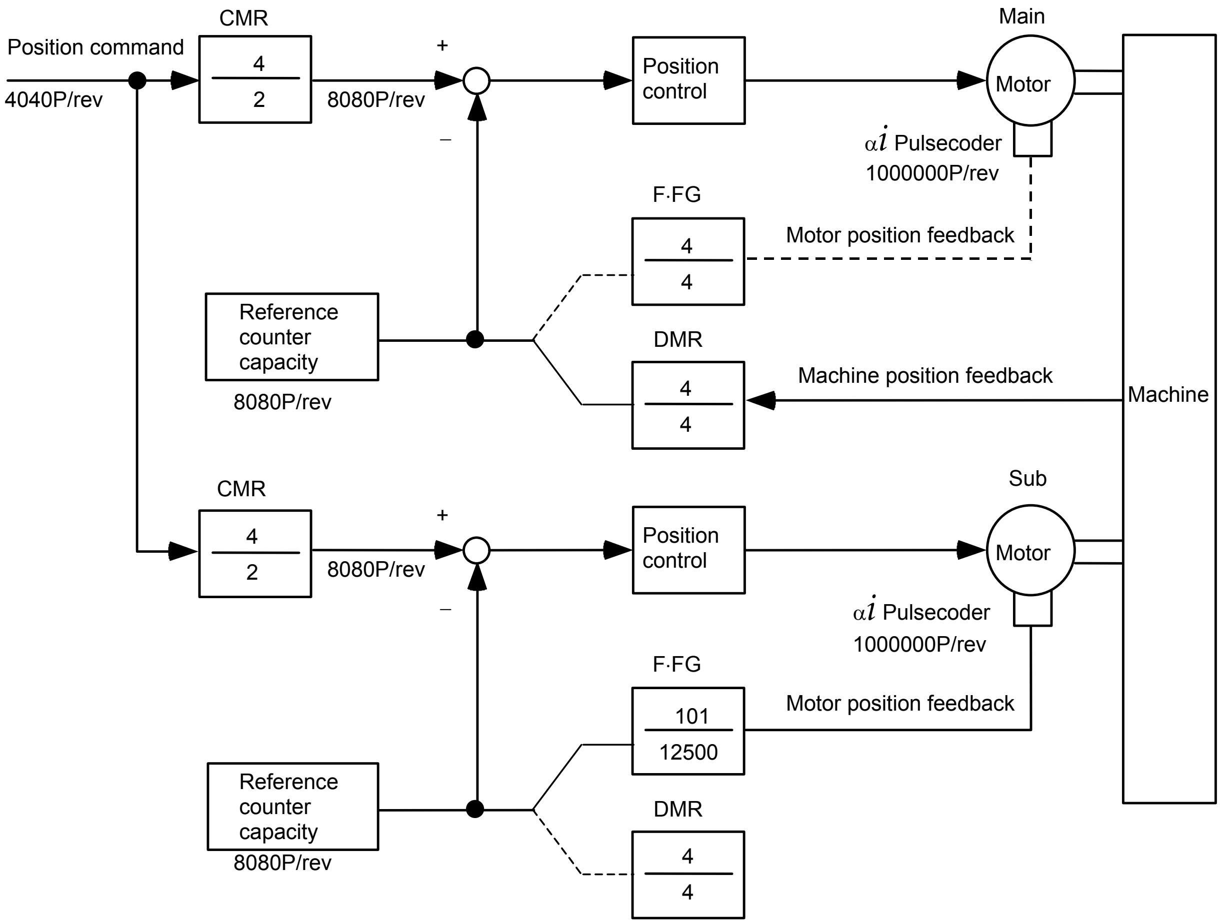


Fig. 4.19.8 (a) Example of position feedback setting

	Series 30*i*, 16*i*, and so on	Series 15*i*	Main	Sub
• Tandem axis	No. 1817#6	No. 1817#1	1	1
• Full-closed loop	No. 1815#1	No. 1815#1	1	0
		No. 1807#3	1	0
• CMR	No. 1820	No. 1820	4	4
• Reference counter capacity	No. 1821	No. 1896	8080	8080
• High-resolution Pulsecoder	No. 2000#0	No. 1804#0	0	0
• Number of velocity detection pulses	No. 2023	No. 1876	8192	8192
• Number of position detection pulses	No. 2024	No. 1891	8080	12500
• Flexible feed gear	No. 2084	No. 1977	0	101
• Flexible feed gear	No. 2085	No. 1978	0	12500

<2> Semi-closed loop system using a 1/1000deg increment system, rotary axis with a gear reduction ratio of 1/984, and an α*i*A1000 Pulsecoder (conventional tandem)

	Series 30*i*, 16*i*, and so on	Series 15*i*	Main	Sub
• Tandem axis	No. 1817#6	No. 1817#1	1	1
• Semi-closed loop	No. 1815#1	No. 1815#1	0	0
		No. 1807#3	0	0
• CMR	No. 1820	No. 1820	2	2
• Reference counter capacity	No. 1821	No. 1896	15000	15000
• High-resolution Pulsecoder	No. 2000#0	No. 1804#0	0	0
• Number of velocity detection pulses	No. 2023	No. 1876	8192	8192
• Number of position detection pulses	No. 2024	No. 1891	12500	12500
• Flexible feed gear	No. 2084	No. 1977	3	3
• Flexible feed gear	No. 2085	No. 1978	8200	8200

(NOTE) $\frac{360000/984}{1000000} = \frac{36}{98400} = \frac{3}{8200}$

<3> Assuming a semi-closed loop system with an increment system of 0.1 μm, 10 mm stroke per motor revolution, and α*i*S300 motor (winding tandem):

	Series 30*i*, 16*i*, and so on	Series 15*i*	Main	Sub
• Tandem axis	No. 1817#6	No. 1817#1	1	1
• CMR	No. 1820	No. 1820	2	2
• Reference counter capacity	No. 1821	No. 1896	100000	100000
• High-resolution Pulsecoder	No. 2000#0	No. 1804#0	1	1
• Motor feedback sharing function	No. 2018#7	No. 1960#7	0	1
• Number of velocity detection pulses	No. 2023	No. 1876	819	819
• Number of position detection pulses	No. 2024	No. 1891	1250	1250
• Flexible feed gear	No. 2084	No. 1977	10	10
• Flexible feed gear	No. 2085	No. 1978	100	100

(2) Back-feed confirmation method

"Back-feed" means the feasibility that the axis can be driven not only from motor side but also from machine table side.

(a) Check whether back-feed is possible when the machine is connected and the power line is removed.
If back-feed is impossible, unstable control will result, and machine adjustment such as a gear box adjustment will be necessary.
<1> Making a check manually
First, turn the shaft of the main motor manually to check that the sub-motor turns. Next, turn the shaft of the sub-motor manually to check that the main motor turns. If these checks are successful, back-feed is possible.
<2> Making a check using NC commands
After checking (b) and (c) below, remove the sub-motor power line. Then, enter a plus (+) command or minus (-) command to rotate the main motor. Check that the main motor can be turned with one-third or less of its rated static torque. When this check is successful, back-feed is possible.

(b) With the machine connected, activate the motors. At this time, release the emergency stop state after reducing the torque limit by a factor of about 10.
Check the motor current on the servo adjustment screen. If the current increases gradually, the directions of rotation of the main- and sub-motors may not be set correctly.

(c) Check the operation by entering a plus (+) command and minus (-) command.
If the error persists due to friction load, increase the torque limit.

(d) If the operation is normal, return the torque limit to its original value, and then set a preload value.

(3) Adjustment items

If vibration occurs:

- Check the position feedback setting (<3> in Sec. 4.19(3)).
- With SERVO GUIDE, check VCMD, TCMD, and SPEED. (When using the check board, check Vcmd (CH1), Tcmd (CH2 and CH4), and speed (CH5 and CH6).

(a) A higher gear reduction ratio tends to produce more backlash, such that unstable operation will result from the sub-axis running between backlashes.
→ Enable the velocity feedback average function.
(No. 1952#2 = 1) Series 15*i*
(No. 2008#2 = 1) Series 30*i*, 16*i*, and so on

(b) The main axis and sub-axis vibrate at the same frequency (several Hz to 30 or 40 Hz) as a result of the spring rigidity being low.
(The twist rigidity is proportional to the second power of the gear reduction ratio, so that the frequency is probably a lower resonant frequency.)
→ Enable damping compensation.
(See the adjustment procedure described in Subsec. 4.19.2.)
(No. 1952#2 = 1) Series 15*i*
(No. 2008#2 = 1) Series 30*i*, 16*i*, and so on

(c) The operation of a full-closed-loop system is unstable.
→ Check the position feedback setting (<3> in Sec. 4.19(3).) If the parameters are set correctly, place the system in semi-closed loop mode, then adjust the system to achieve stable operation.
Then, return the system to full-closed loop mode. If the operation is still unstable, apply a function such as the dual position feedback function.

(d) In the stop state, no tension is established between the main axis and sub-axis.
→ Set a preload value of 0, and check the torque in the stop state.
Then, set a preload value greater than the stop-state torque.
(No. 1980) Series 15*i*
(No. 2087) Series 30*i*, 16*i*, and so on

(e) Position-dependent vibration occurs.
→ Change the feedrate to determine whether the vibration frequency is constant or proportional to the feedrate.
If the vibration frequency is proportional to the feedrate, position-dependent vibration is occurring. Check position-related items such as the number of gear teeth.

4.19.8 Cautions for Controlling One Axis with Two Motors

(1) Tandem control and synchronous control (position tandem control) selection criteria

Two control methods are supported to enable the control of one axis using two motors: tandem control and synchronous control. The (simple) synchronous control method controls the position of the master axis and slave axis by using the same command. Position control is exercised separately on each of the master axis and slave axis. Control exercised when the master axis and slave axis are allocated on the same DSP is particularly referred to as position tandem control.

The tandem control method exercises position control over the main axis only; this method exercises torque control over the sub-axis only.

(For clarity, the terms master and slave are used for synchronous control, while main and sub are used for tandem control.)

When building a machine system, select a suitable control method, paying careful attention to the differences between the control methods. Tandem control is used in the following cases and when back-feed is enabled:

- Two motors are used because sufficient torque cannot be produced by one motor alone.
- Two small motors have an advantage over one large motor in terms of inertia.

In other cases, position tandem control (synchronous control) is usually used.

Position tandem control is also used when two motors are used to improve the precision degraded by a machine position difference.

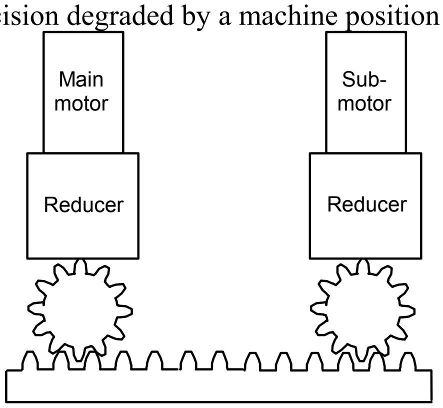


Fig. 4.19.9 (a) Example of tandem control (machine system supporting back-feed)

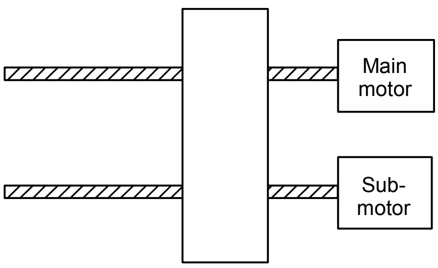


Fig. 4.19.9 (b) Example of synchronous control (to suppress the effect of a position difference)

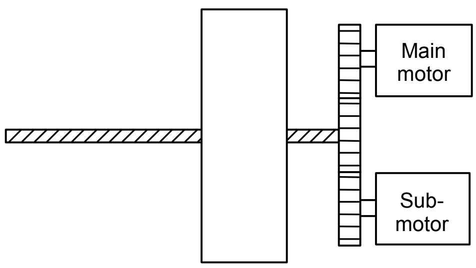


Fig. 4.19.9 (c) Example of tandem control (when a torque two times greater is required)

(2) Velocity loop integrator copy function

If the velocity loop integrator gets unbalanced between the master and slave during synchronous or velocity command tandem control, the axes may get twisted, leading to an OVC alarm.
This problem can be solved using a function that copies the velocity loop integrator from the master axis to the slave axis, thereby preventing integrator imbalance between the master and slave.

	#7	#6	#5	#4	#3	#2	#1	#0
2686 (FS15*i*) **2273 (FS30*i*, 16*i*)**							**WSVCP**	

WSVCP(#1) 1: The loop integrator of the master axis is copied to the slave axis. (Specify only the slave axis.)
(Series 9096, and Series 90B0/M(13) and earlier editions are not supported.)

> ⚠ **CAUTION**
> 1 This function is applicable only to two axes controlled on the same DSP.
> 2 No compatibility problem occurs between this function and the system software.
> 3 This function bit is usable when simple synchronous control or velocity command tandem control is in use.
> 4 This function cannot be used together with the preload function.
> 5 It is impossible to specify functions related to the velocity loop integrator (such as the incomplete integral or low-speed integral function) separately for the master axis and slave axis.
> 6 This function cannot be used together with servo HRV4 control.

4.19.9 Block Diagrams

(1) Tandem control

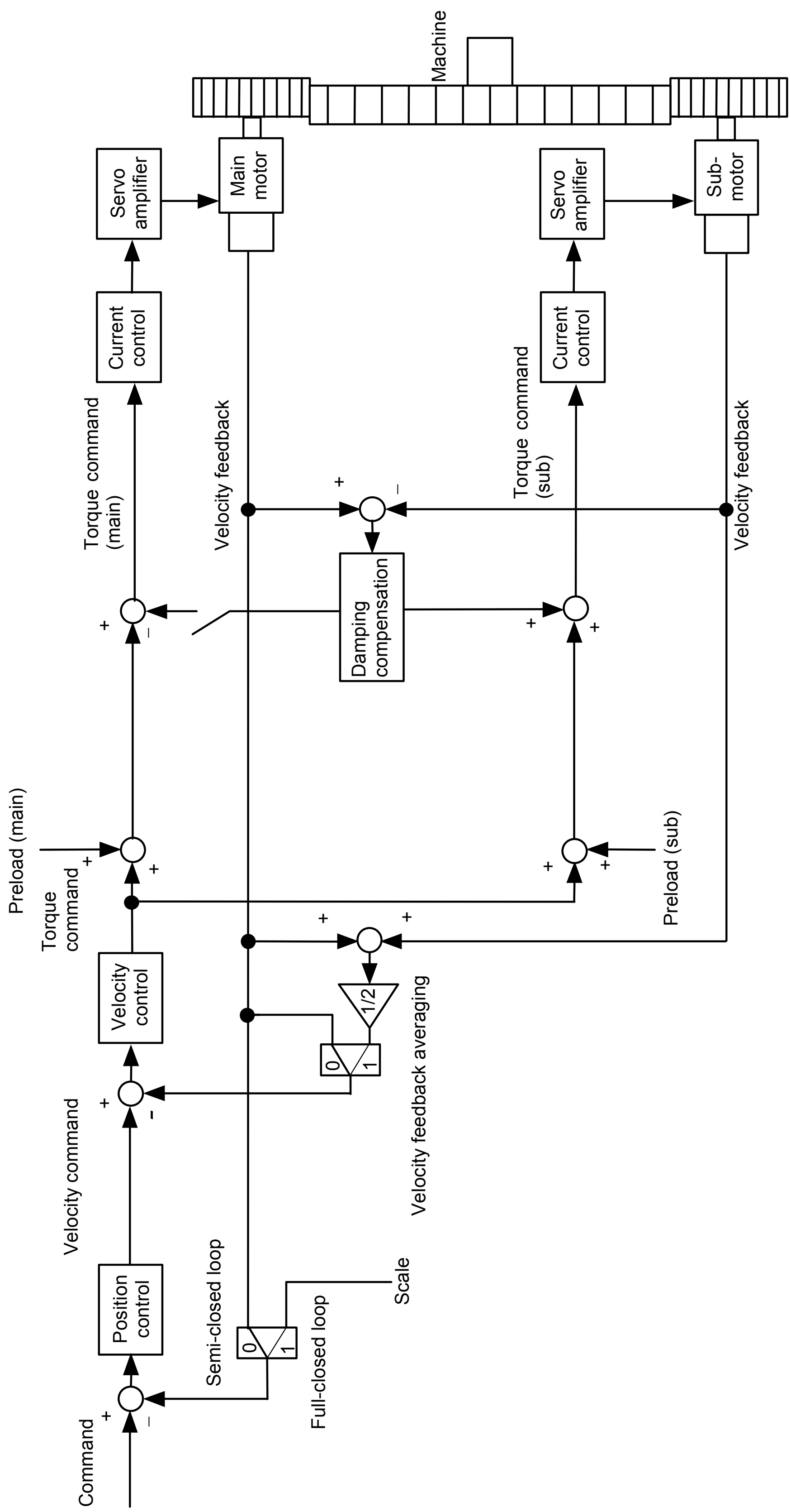


Fig. 4.18.10 (a) Tandem control (typical)

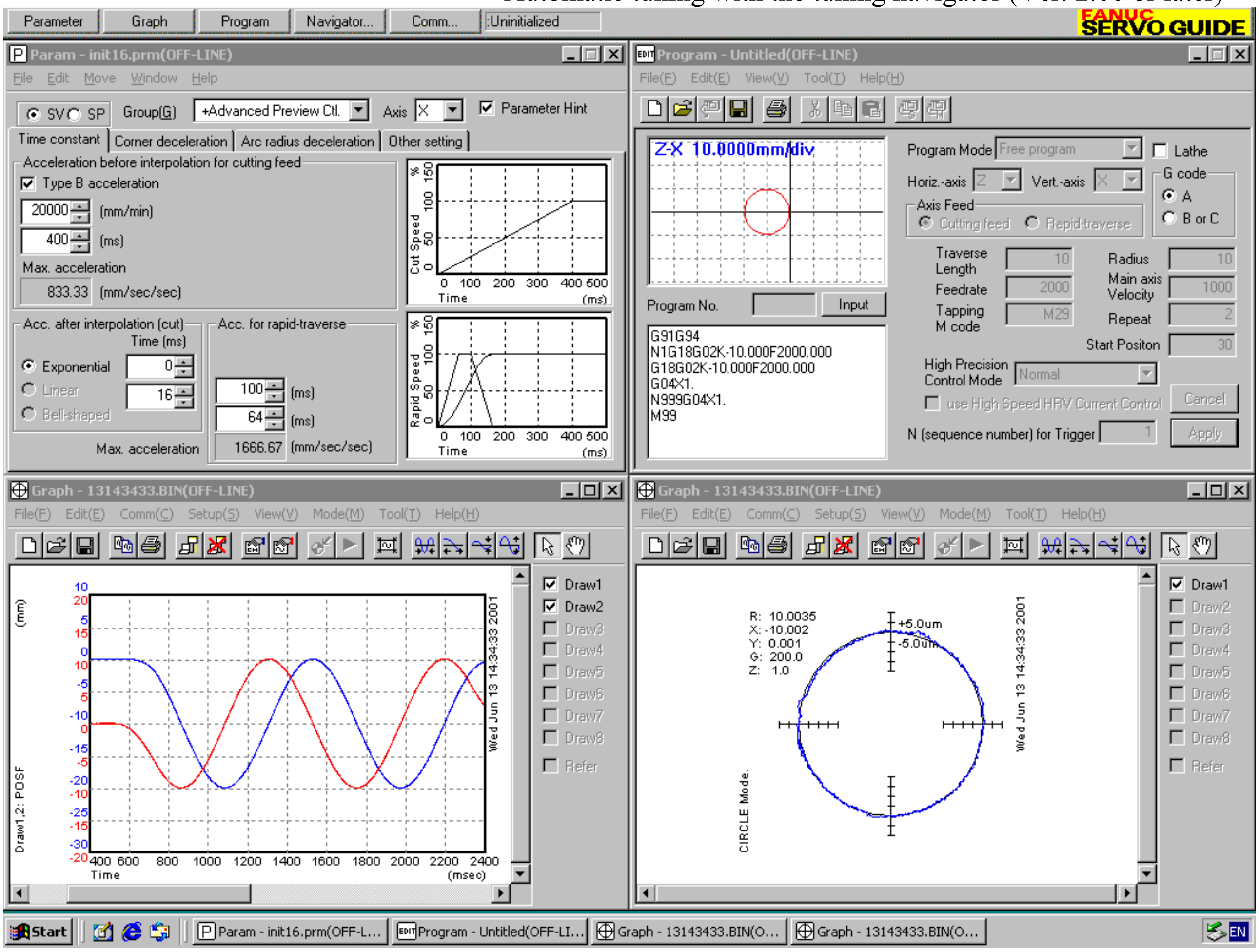
4.20 SERVO TUNING TOOL SERVO GUIDE

4.20.1 SERVO GUIDE

(1) Overview

The servo tuning tool SERVO GUIDE has the following features.

- PC-based integrated tuning tool for servo spindles
- Can be connected easily with a PCMCIA-LAN card from the front of the CNC
- GUI-based ease of use
- Automatic tuning with the tuning navigator (Ver. 2.00 or later)



[Software ordering information]
A08B-9010-J900 (supplied on a CD-ROM)

[Upgrade ordering information]
A08B-9010-J901 (supplied on a CD-ROM)
To install software from an upgrade CD, SERVO GUIDE or *i* TUNE of an older edition must have been installed on the personal computer used.

(2) Operating environment

The following table lists operating environments for the servo tuning tool SERVO GUIDE. The operating environment must be configured with the listed hardware and software.

CNC	Series 30*i*, 31*i*, 32*i* -MODEL A or later Series 16*i*, 18*i*, 21*i*, 20*i* -MODEL B or later Power Mate *i* -MODEL D, H Series 0*i*-MODEL B, 0*i* Mate-MODEL B Series 0*i*-MODEL C, 0*i* Mate-MODEL C (Note 1)
Personal computer	PC/AT compatible Ethernet port (for Ethernet connection) FANUC HSSB board (for HSSB connection) or CNC display unit with PC functions (PANEL *i*)
CPU	Pentium 200MHz or better processor
OS	Microsoft Windows 98/Me (Note 2) Microsoft Windows NT4.0/2000/XP (Note 3) Recommended Microsoft Windows NT4.0/2000/XP (Note 4) Viewing online help requires Internet Explorer 4.01 or later. (Note 5)
Memory	64MB or more (Recommended 128MB or more)
Hard disk	25 MB or more (Note 6) (50 MB during installation)
Display resolution	SVGA (800 × 600) or higher (XGA (1024 × 768) or higher is recommended.) (Note 7)
Printer	Printer added in printer setting on Windows
PCMCIA LAN card (for Ethernet connection)	Card specified by FANUC (A02B-0281-K710) (Note 8)
Others	Cross Ethernet cable and coupler (required for Ethernet connection) (Note 9)

* Microsoft, Windows are registered trademarks of Microsoft Corporation.

* This manual contains the program names or device names of other companies, some of which are registered trademarks of respective owners.

Note 1 The following software series and editions support SERVO GUIDE.

[System software]

Series 30*i*-A G001/23 and subsequent editions,
G011/23 and subsequent editions,
G021/23 and subsequent editions,
G00A/01 and subsequent editions,
G01A/01 and subsequent editions,
G02A/01 and subsequent editions,
G002/01 and subsequent editions,
G012/01 and subsequent editions,
G022/01 and subsequent editions
(SERVO GUIDE Ver. 3.00 or later)

Series 31*i*-A G101/01 and subsequent editions,
G111/01 and subsequent editions
(SERVO GUIDE Ver. 3.00 or later)

Series 31*i*-A5	G121/01 and subsequent editions, G131/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)
Series 32*i*-A	G201/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)
Series 16*i*-MB	B0H1/05 and subsequent editions
Series 16*i*-TB	B1H1/06 and subsequent editions (*)
Series 18*i*-MB	BDH1/05 and subsequent editions
Series 18*i*-MB5	BDH5/01 and subsequent editions
Series 18*i*-TB	BEH1/06 and subsequent editions (*)
Series 21*i*-MB	DDH1/05 and subsequent editions
Series 21*i*-TB	DEH1/06 and subsequent editions (*)
Series 20*i*-FB	D0H1/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)
Series 20*i*-TB	D1H1/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)
Power Mate *i*-D	88E0/18 and subsequent editions (SERVO GUIDE Ver. 2.00 or later)
Power Mate *i*-H	88F2/01 and subsequent editions (SERVO GUIDE Ver. 2.00 or later)
Series 0*i*-MB	D4A1/01 and subsequent editions (SERVO GUIDE Ver. 2.00 or later)
Series 0*i*-TB	D6A1/01 and subsequent editions (SERVO GUIDE Ver. 2.00 or later)
Series 0*i* Mate-MB	D501/01 and subsequent editions (SERVO GUIDE Ver. 2.00 or later)
Series 0*i* Mate-TB	D701/01 and subsequent editions (SERVO GUIDE Ver. 2.00 or later)
Series 0*i*-MC	D4B1/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)
Series 0*i*-TC	D6B1/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)
Series 0*i* Mate-MC	D511/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)
Series 0*i* Mate-TC	D711/01 and subsequent editions (SERVO GUIDE Ver. 3.00 or later)

(*) Measuring rigid tapping synchronization errors on the T Series CNC requires the following system software series and editions.

Series 16*i*-TB	B1H1/15 and subsequent editions
Series 18*i*-TB	BEH1/15 and subsequent editions
Series 21*i*-TB	DEH1/15 and subsequent editions

[Relationship between the Ethernet and open CNC]

For Series 30*i*, 31*i*, 32*i*

656E/06 and subsequent editions

656F/07 and subsequent editions

For Series 30*i*, 31*i*, 32*i* (when a 15” display is used)

Software for 15” display control

A02B-0207-J595#60VB 1.3 and subsequent editions

For Series 310*i*s, 310*i*s, 320*i*s
WindowsCE.NET customized OS
A02B-0207-J594 1.2 and subsequent editions
WindowsCE.NET FOCAS2/HSSB library
A02B-0207-J808 1.2 and subsequent editions
WindowsCE.NET standard application/library
A02B-0207-J809 1.2 and subsequent editions
For Series 16*i*, 18*i*, 21*i*, 0*i*
656A/03 and subsequent editions (For a system with a sub-CPU, 656A/04 or later)
Using Series 0*i* requires 656A/05 or later.
(Edition 656A/07 does not support the use of the PCMCIA LAN card.)
For Power Mate *i*
6567/01 and subsequent editions

[Servo software]
For Series 30*i*,31*i*,32*i*
90D0/03(C) and subsequent editions,
90E0/03(C) and subsequent editions
For Series 16*i*,18*i*,21*i*,20*i*,0*i*,Power Mate *i*
90B0/06(F) and subsequent editions
(Note that using the tuning navigator requires 90B0/20(T) and subsequent editions.)
90B6/01(A) and subsequent editions,
90B5/01(A) and subsequent editions,
90B1/01(A) and subsequent editions
For Series 21*i*, 0*i*, Power Mate *i*
9096/01(A) and subsequent editions
(They do not support the tuning navigator.)

[Spindle software]
For Series 30*i*,31*i*,32*i*
9D70/02 and subsequent editions
(For α*i* series spindle)
For Series 16*i*,18*i*,21*i*,0*i*,Power Mate *i*
9D50/02 and subsequent editions
(For α*i* series spindle)
For Series 16*i*,18*i*,21*i*,0*i*,Power Mate *i*
9D20/11 and subsequent editions
(For α series spindle)
(For some α series spindles, restrictions are placed on data acquisition.)

SERVO GUIDE may operate on combinations other than stated above. For α*i* series models, however, SERVO GUIDE can run only on the combinations stated above.
In SERVO GUIDE version 3.00 and later versions, the parameter window and program window also support the multipath CNC.

Note 2 It has yet to be verified whether SERVO GUIDE operates on Windows 95.

Note 3 To use this software on Windows NT 4.0, install Service Pack 3 or later. Service Pack is available from Microsoft.

Note 4 On Windows 98/Me, opening multiple parameter and graph windows at a time may result in insufficient resources. We recommend Windows NT/2000/XP be used.

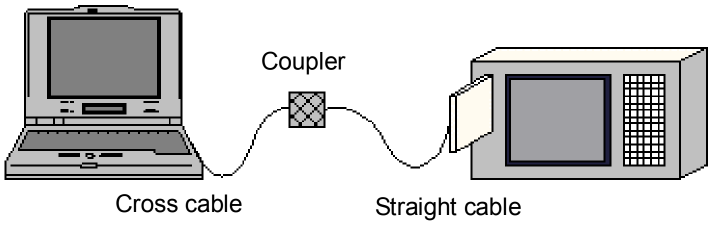
Note 5 Online help cannot be displayed unless Internet Explorer 4.01 or later is available.

Note 6 In addition to the program area, a storage area is necessary to hold measured data.

Note 7 SERVO GUIDE can operate also on SVGA. If multiple windows are open on SVGA, however, they overlap on one another, impairing legibility.

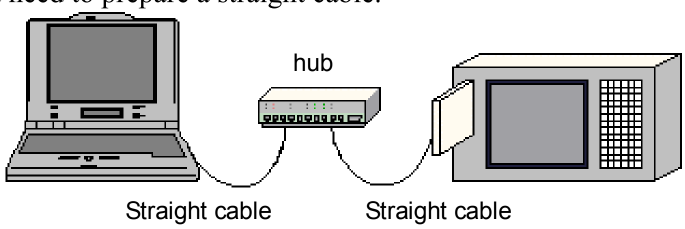
Note 8 If you are using a Windows CE-based "*i*s Series" CNC (160*i*s, 180*i*s, 210*i*s), you do not need this card, because no LAN card can be used to connect between the PC and CNC. (Use a built-in Ethernet port for connection.)
With the *i*s Series of the Series 30*i* (the 300*i*s, 310*i*s, and 320*i*s), connection using a LAN card is also possible.
To use this software on Power Mate *i*, an Ethernet board must be installed on the NC. In this case, the PCMCIA-LAN card is not required. Get ready the following:
- Fast Ethernet board (A02B-0259-J293)
- Fast Ethernet option (A02B-0259-J862)
- Ethernet software (A02B-0259-J555#6567)
- Extended basic 1 function option (A02B-0259-J878)
- Extended driver/library (A02B-0259-J847)

Note 9 A FANUC-supplied LAN card is provided with a straight cable with an RJ45 male connector attached. The following figure shows how the cable is used to connect directly between the PC and CNC.



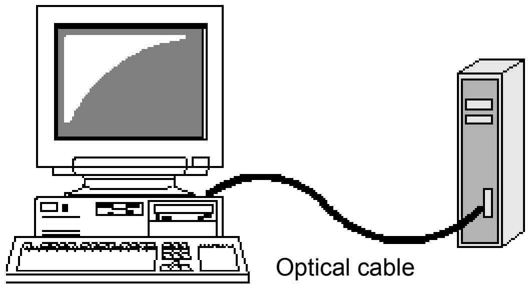
(The cross cable and coupler are available from general PC stores.)

The following figure shows how a hub is used to connect between the PC and CNC. No coupler is needed. However, you need to prepare a straight cable.



If you are using an HSSB, you may probably use an optical cable to connect between the CNC and PC as shown below. Using SERVO GUIDE does not require any additional connection.

* Even if you are using a CNC display unit with PC functions, such as the 160*i*, no additional connection is needed.



(3) Software specification overview

The servo tuning tool SERVO GUIDE has four windows ("parameter window," "graph window," "program window," and "tuning navigator"). The software specification overview of each window follows.

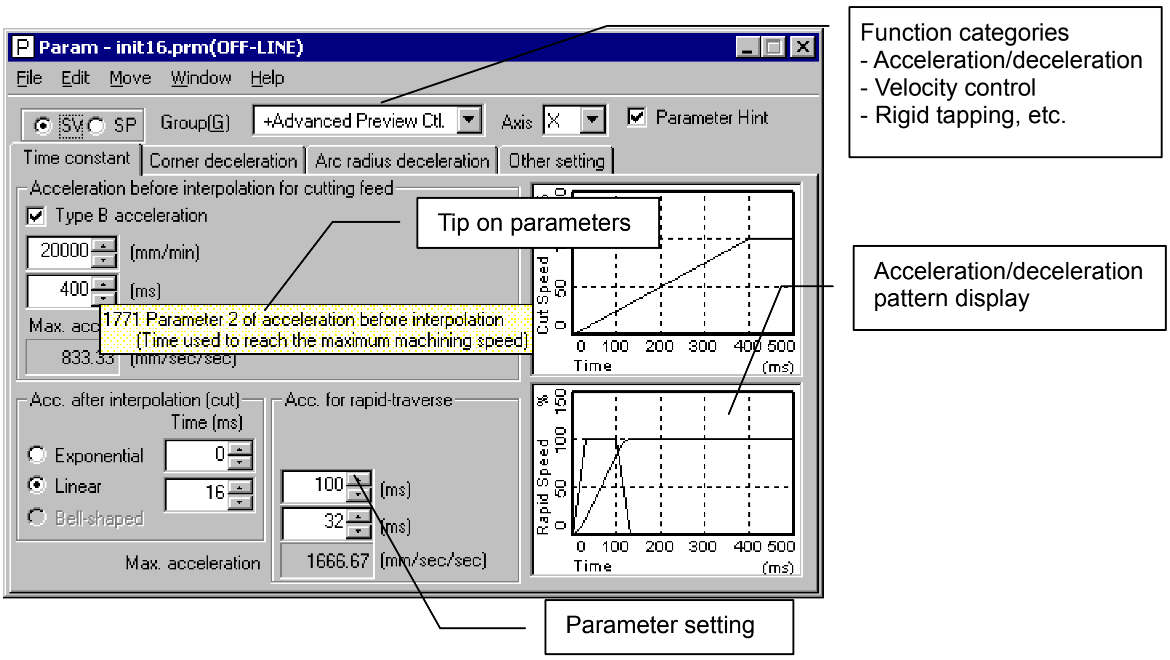
(a) Parameter window

- Collects parameters from the NC, categorizes them by function, and displays them.
- Supports servo and spindle parameters.
- Supports the automatic acc./dec. function for high speed and high precision.
- Lets you modify NC parameters on the PC.
    * The multipath system is supported by Version 3.00 and later versions.

(Details of supported functions)

System setting	Extracting and displaying information related to servo sections from CNC options.
Servo axis setting	Whether there is a separate detector, rotary/linear motor, CMR, flexible feed gear, etc.
Acceleration/deceleration	Time constants for acc./dec. before interpolation and acc./dec. after interpolation, speed difference related to automatic deceleration at corner, arc radius-based feedrate clamp setting, and acceleration-based deceleration setting (ordinary control, advanced preview control, AI advanced preview control, AI contour control, AI nano-contour control, high-precision contour control, AI nano high-precision contour control, AI contour control I/II)
Current control	HRV, HRV2, HRV3, or HRV4 control
Velocity control	Velocity loop gain setting, setting related to filters for measures for vibration in machine sections, vibration control, and dual position feedback
Position control	Setting of position gain
Contour error suppression	Setting related to feed-forward, backlash acceleration, and fine acc./dec. (for Series 16*i* and so on)

Overshoot improvement	Setting for overshoot correction
High-speed positioning	Setting of FAD + advanced preview feed-forward and position gain line graph
Stop	Setting related to brake control and quick stop at emergency stop
Unexpected disturbance torque detection	Estimated disturbance value tuning and alarm detection level
Linear motor	Setting of AMR conversion coefficient and smoothing compensation
Spindle system setting	Extracting and displaying information related to spindles from CNC options.
Spindle system configuration	Motor edge sensor setting, spindle edge sensor setting, and gear ratio setting (main and sub)
Spindle ordinary velocity control	Velocity loop gain setting and filter setting for anti-vibration (main and sub) or resonance elimination filter
Rigid tapping	Command setting, velocity control setting (main and sub), position control setting, and fine acc./dec. (for Series 16*i* and so on)
Cs contour control	Command setting, velocity control setting, position control setting, fine acc./dec. (for Series 16*i* and so on), and resonance elimination filter
Orientation	Velocity control setting, position control setting, acceleration setting (high-speed orientation), and resonance elimination filter
Spindle synchronous control	Velocity control setting, position control setting, and resonance elimination filter



Parameter window (example)

(b) Graph window

- Data measurement and display
  - Horizontal axis time mode
    Ordinary mode, first-order differential mode, second-order differential mode (YT mode)
    Feed smoothness measurement mode (DXDY mode)
    Tangential velocity display mode (XTVT mode)
    Synchronization error measurement mode (Synchro mode)
  - XY mode (also XYR mode for polar coordinate conversion)
  - Arc path error expansion mode (Circle mode)
  - Arbitrary figure path error expansion mode (Contour mode)
  - Frequency spectrum analysis mode (Fourier mode)
  - Velocity loop frequency characteristic measurement mode (Bode mode)

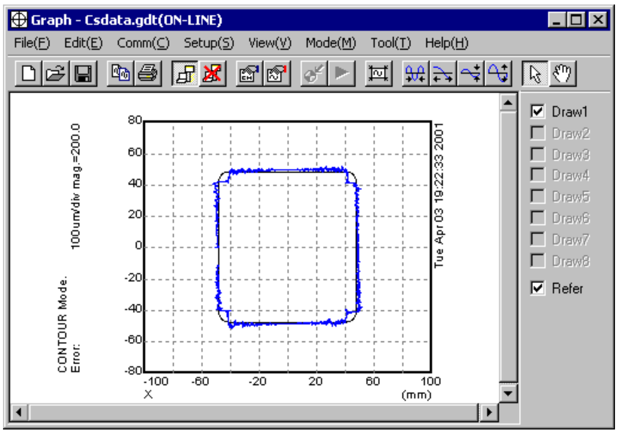
  Data can be measured on both servo and spindle sections (even if mixed)

  * For non-α*i* series spindles, restrictions are placed on measured data.

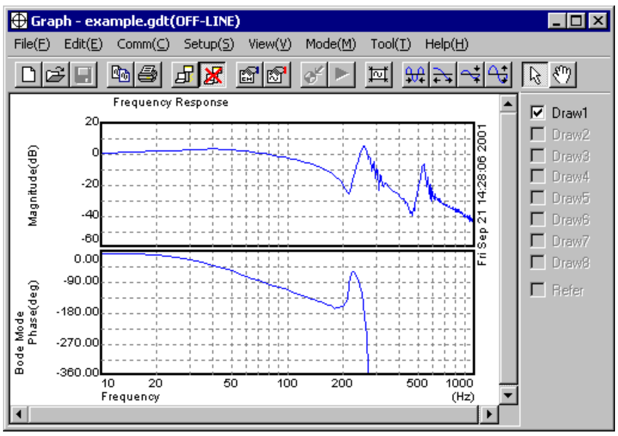
  Simultaneous measurement is possible on up to six channels.

  The fastest sampling period coincides with the current control period. (For servo axes only)

  Displayed data can be printed. Bit maps can also be acquired via the clip board.



Example of measuring contour errors under Cs contour axis control



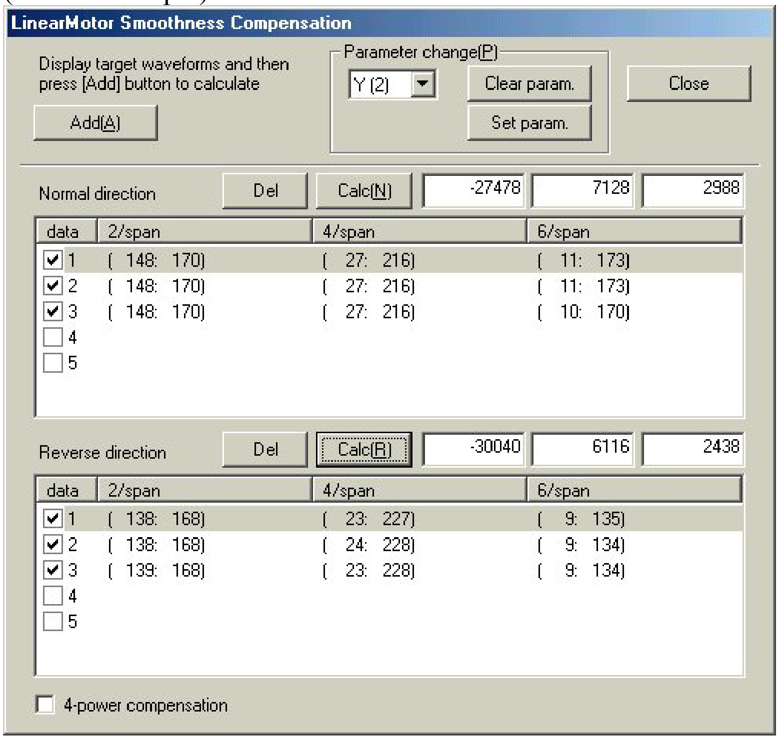
Example of measuring velocity loop frequency characteristics

Graph window (example)

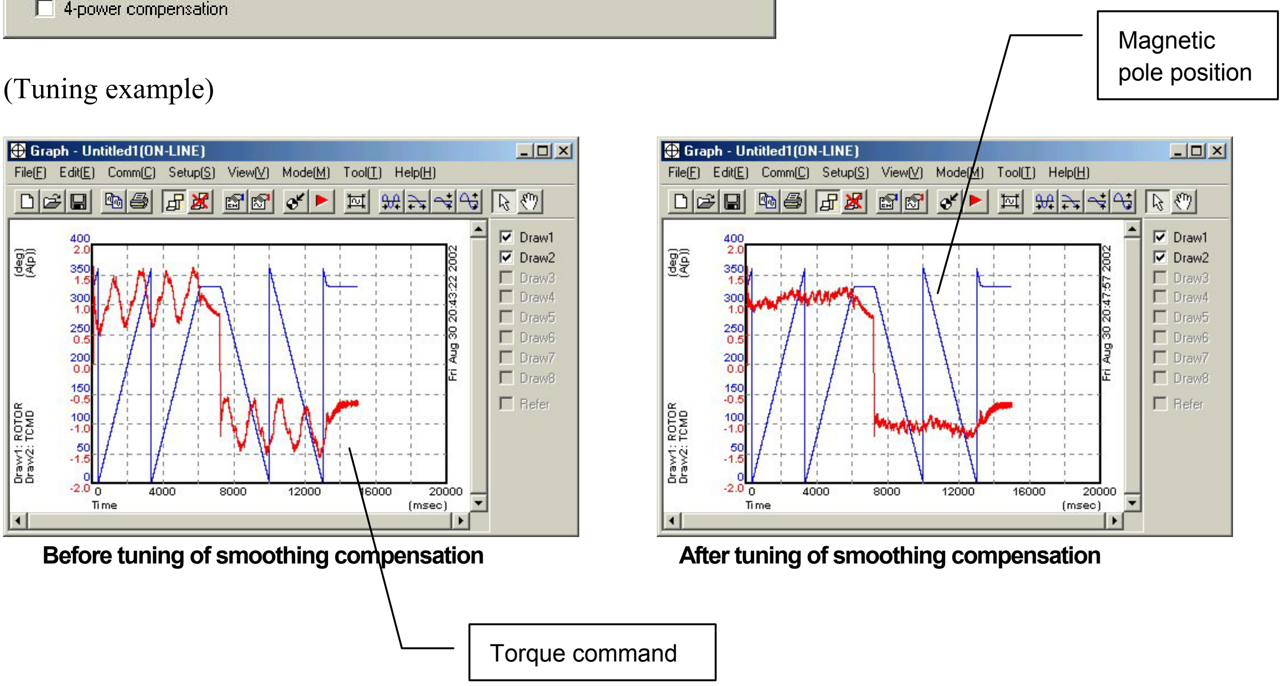
- Linear motor smoothing compensation parameter determination function
  (Can be used with SERVO GUIDE Ver. 2.00 or later)

This function allows easy determination of the parameters for the "smoothing compensation function", which is a function for improving the smoothness of linear motor feed.

(Screen example)



(Tuning example)



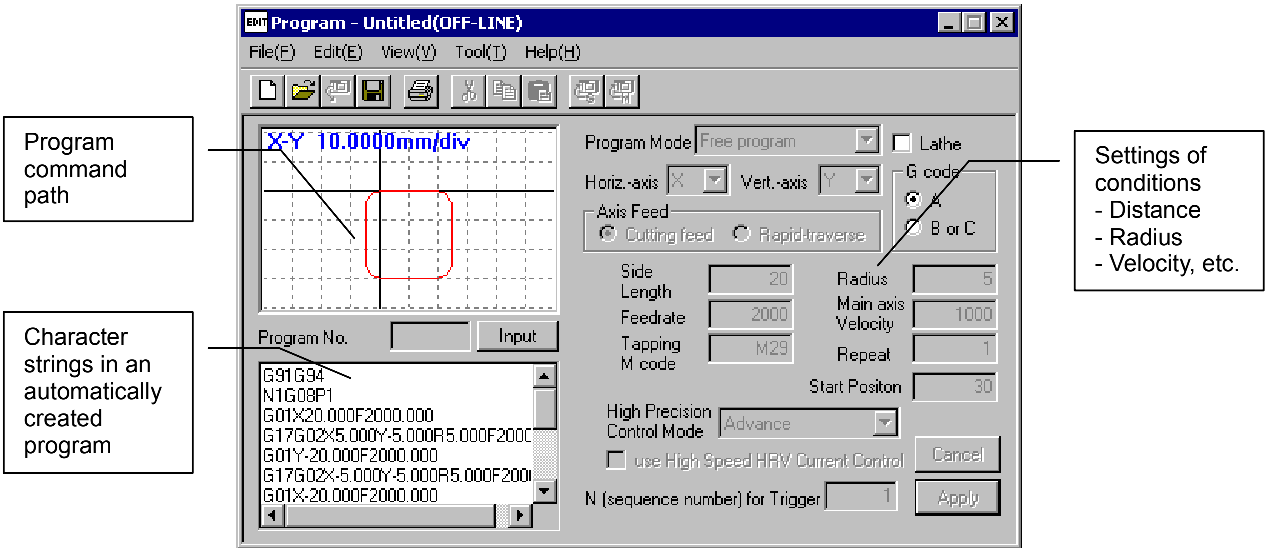
Before tuning of smoothing compensation

After tuning of smoothing compensation

(c) Program window

- Test program creation assistance
  - One-axis linear acc./dec.
  - Arc
  - Rectangle
  - Rectangle with rounded corners
  - Rigid tapping
  - Cs contour
- Test program path display
- Sending test programs to NC memory and executing them (The operator must press the start button.)
- Selecting and executing a program from NC memory (The operator must press the start button.)
- Printing a created program

* The multipath system is supported by Version 3.00 and later versions.



Program window (example)

(d) Tuning navigator

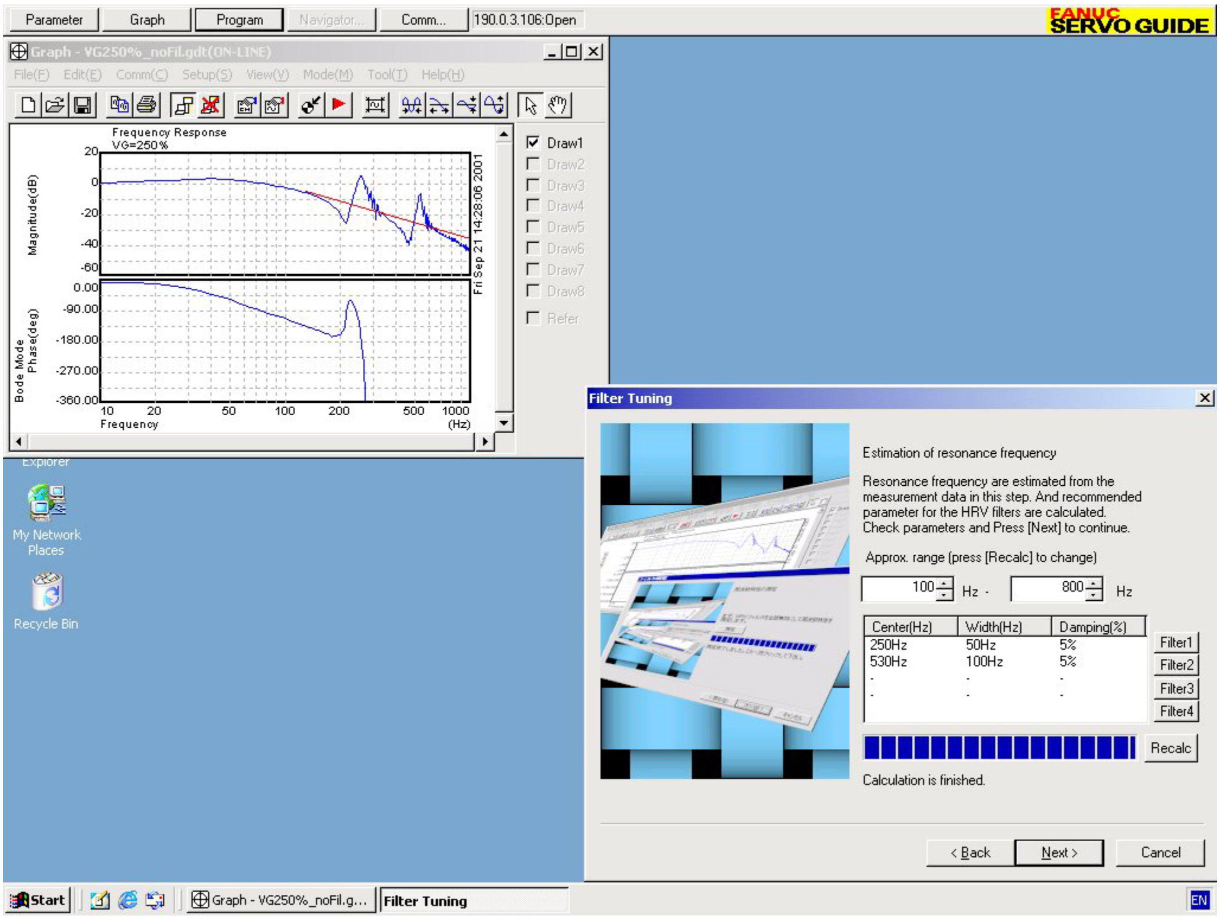
- Conditions for use
  SERVO GUIDE Ver. 2.00 or later
  Servo software Series 90B0/20 and subsequent editions, Series 90B6, Series 90B5, Series 90B1, Series 90D0, Series 90E0

> **NOTE**
> Series 9096 is not supported.

- Automatic tuning of velocity loop gain and filters
- High-speed and high-precision function setup support

[Automatic tuning of velocity loop gain and filters]

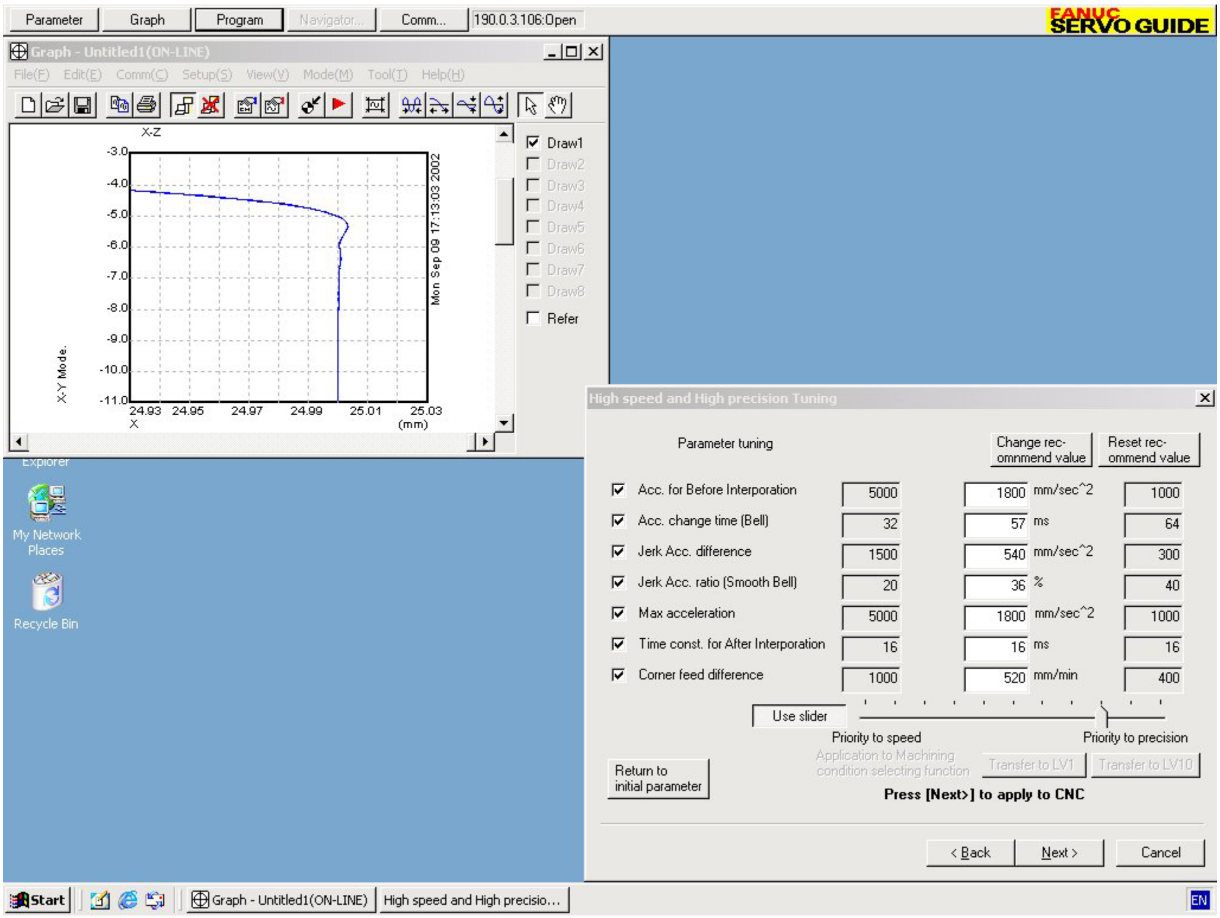
Measures the frequency characteristics of a velocity loop while making the tool move along an axis to automatically determine the values of the velocity loop gain and resonance elimination filter parameters. Submitted parameter values can be fine-tuned to verify their effects.



Filter tuning (example)

[High-speed and high-precision function setup support]

In a program for a square with corner rounding, the support adjusts the parameters for high-speed and high-precision functions while confirming overshoots. High-speed and high-precision functions have multiple tuning parameters. FANUC-recommended parameter sets (sets that give priority to speed and those that give priority to precision) are provided, and values between them can be selected easily with a single operation on the slider.



High-speed and high-precision function tuning (example)

(4) Tuning procedure overview

<1> Specify parameters from the parameter window.
<2> In the program window, create, send, and execute test programs.
<3> In the graph window, measure data.
<4> Repeat steps <1> to <3> to make optimum tunings while watching the graphed data.

For details of usage, refer to "FANUC SERVO GUIDE Operator's Manual (B-65404EN)" or the online manual after software installation.

5 DETAILS OF PARAMETERS

5.1 DETAILS OF THE SERVO PARAMETERS FOR Series 30*i*, 31*i*, 32*i*, 15*i*, 16*i*, 18*i*, 21*i*, 0*i*, 20*i*, Power Mate *i* (SERIES 90D0, 90E0, 90B0, 90B1, 90B6, 90B5, AND 9096)

The descriptions of parameters follow.
For parameters for which a specification method is not described, do not change the parameters from the values set up automatically during servo parameter initialization.
The parameter in the top left cell applies to Series 15*i*; the one in the bottom left cell, to Series 30*i*, 31*i*, 32*i*, 16*i*, 18*i*, 20*i*, 21*i*, 0*i*, 20*i*, Power Mate *i*.

★: Do not change.

	#7	#6	#5	#4	#3	#2	#1	#0
1815 (FS15*i*) / 1815 (FS30*i*, 16*i*)			APCX				OPTX	

OPTX (#1) A separate detector is:
0: Used.
1: Not used.
[Reference item] Subsection 2.1.3

APCX (#5) An absolute detector is:
0: Not used.
1: Used.
[Reference item] Subsection 2.1.3

	#7	#6	#5	#4	#3	#2	#1	#0
1817 (FS15*i*) / 1817 (FS30*i*, 16*i*)		TANDEM						

TANDEM (#6) Tandem control (optional function) is:
0: Disabled.
1: Enabled.
Specify this parameter for both main axis and sub-axis.
[Reference item] Section 4.19

	#7	#6	#5	#4	#3	#2	#1	#0
1804 (FS15*i*) / 2000 (FS30*i*, 16*i*)				PGEX	PRMC		DGPR	PLC0

PLC0 (#0) Specifies whether to multiply the number of velocity and position pulses by ten internally as follows:
0: Not to multiply by ten.
1: To multiply by ten.
[Reference item] Subsection 2.1.3

DGPR (#1) When power is switched on, the motor-specific standard servo parameter is:
0: Specified.
1: Not specified.
[Reference item] Subsection 2.1.3

PRMC (#3) Do not change. (★)

PGEX (#4) The position gain range is:
0: Not expanded.
1: Expanded by 8 times.

[Reference item] Subsection 2.1.5

	#7	#6	#5	#4	#3	#2	#1	#0
1806 (FS15*i*) / 2001 (FS30*i*, 16*i*)	0	AMR6	AMR5	AMR4	AMR3	AMR2	AMR1	AMR0

AMR0 to AMR7 (#0 to #7) Specify the AMR value according to the Pulsecoder model for the motor.

AMR 6	5	4	3	2	1	0	
0	0	0	1	0	0	0	16-pole servo motors α*i*S2000/2000HV, α*i*S3000/2000HV
0	0	0	0	0	0	0	Other than 16-pole servo motor (8-pole servo motors)

[Related parameters] 2608#5 (15*i*), 2220#5 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1807 (FS15*i*) / 2002 (FS30*i*, 16*i*)					PFSE			

PFSE (#3) A separate detector is:
0: Not used.
1: Used.
Specify this parameter only in the Series 15*i*.
In the Series 30*i*, 31*i*, 32*i*, 16*i*, 18*i*, 21*i*, 0*i*, and Power Mate *i*, setting bit 1 of parameter No. 1815 (OPT) to 1 automatically specifies this parameter.

[Reference item] Subsection 2.1.3

	#7	#6	#5	#4	#3	#2	#1	#0
1808 (FS15*i*) / 2003 (FS30*i*, 16*i*)	VOFS	OVSC	BLEN	NPSP	PIEN	OBEN	TGAL	

TGAL (#1) The software disconnection alarm detection level is:
0: Standard setting.
1: Lower sensitivity specified elsewhere.

[Related parameters] 1892 (15*i*), 2064 (16*i* etc.)

OBEN (#2) The velocity control observer function is:
0: Not used.
1: Used.

[Reference item] Subsection 4.5.4

[Related parameters] 1859 (15*i*), 2047 (16*i* etc.), 1862 (15*i*), 2050 (16*i* etc.), 1863 (15*i*), 2051 (16*i* etc.)

PIEN (#3) The velocity control method to be used is:
0: I-P
1: PI

NPSP (#4) The N pulse suppression function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.4.4
[Related parameters] 1992 (15*i*), 2099 (16*i* etc.)

BLEN (#5) The backlash acceleration function is:
0: Not used.
1: Used.
[Reference item] Subsections 4.6.6 and 4.6.7
[Related parameters] 1860 (15*i*), 2048 (16*i* etc.)

OVSC (#6) The overshoot compensation function is:
0: Not used.
1: Used.
[Reference item] Section 4.7
[Related parameters] 1857 (15*i*), 2045 (16*i* etc.)

VOFS (#7) The VCMD offset function is:
0: Not used.
1: Used.
[Related parameters] 1970 (15*i*), 2077 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1809 (FS15*i*) / 2004 (FS30*i*, 16*i*)					TRW1	TRW0	TIB0	TIA0

TIA0 (#0), TIB0 (#1), TRW0 (#2), TRW1 (#3)
The setting of these bits varies according to the HRV control method.

TRW1	TRW0	TIB0	TIA0	
0	1	1	0	For HRV1 control
0	0	1	1	For HRV2, HRV3, HRV4 control

[Related parameters] 1707 (15*i*), 2013 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1883 (FS15*i*) / 2005 (FS30*i*, 16*i*)	SFCM	BRKC					FEED	

FEED (#1) The feed-forward function is:
0: Not used.
1: Used.
[Reference item] Subsections 4.6.1 to 4.6.5
[Related parameters] 1961 (15*i*), 2068 (16*i* etc.), 1985 (15*i*), 2092 (16*i* etc.)

BRKC (#6) The brake control function is:
0: Not used.
1: Used.
[Reference item] Section 4.10.
[Related parameters] 1976 (15*i*), 2083 (16*i* etc.)

SFCM (#7) The static friction compensation function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.6.8
[Related parameters] 1808 (15*i*), 2003 (16*i* etc.), 1965 (15*i*), 2072 (16*i* etc.), 1966 (15*i*), 2073 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1884 (FS15*i*) / 2006 (FS30*i*, 16*i*)				ACCF		PKVE		FCBL

FCBL (#0) During full-closed feedback, backlash compensation is:
0: Applied to the position.
1: Not applied to the position.
[Reference item] Subsections 4.6.6 and 4.6.7

PKVE (#2) Speed-dependent current loop gain variable function is:
0: Not used
1: Used
(★ Do not change)
[Related parameters] 1967 (15*i*), 2074 (16*i* etc.)

ACCF (#4) Specifies the amount of velocity feedback data to be used as follows:
0: Velocity feedback for the latest 2 ms.
1: Velocity feedback for the latest 1 ms.

	#7	#6	#5	#4	#3	#2	#1	#0
1951 (FS15*i*) / 2007 (FS30*i*, 16*i*)	FRCAXS	FAD					IGNVRO	ESP2AX

ESP2AX (#0) The servo alarm 2-axis simultaneous monitor function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.19.4

IGNVRO (#1) An alarm condition is:
0: Not released 2 seconds after the servo alarm 2-axes simultaneous monitor holds the alarm condition.
1: Released 2 seconds after the servo alarm 2-axes simultaneous monitor holds the alarm condition.
[Reference item] Subsection 4.19.4

FAD (#6) The fine acc./dec. function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.8.3
[Related parameters] 1702 (15*i*), 2109 (16*i* etc.)

FRCAXS (#7) Torque control function is:
0: Not used.
1: Used.
[Reference item] Section 4.16

	#7	#6	#5	#4	#3	#2	#1	#0
1952 (FS15*i*) 2008 (FS30*i*, 16*i*)	LAXDMP	PFBSWC	VCMDTM	SPPCHG	SPPRLD	VFBAVE	TNDM	

TNDM (#1) This bit is automatically set to 1 when bit 6 (tandem axis) of parameter No. 1817 is set to 1. (In the Series 15*i*, this bit is kept at 0.) This bit cannot be set directly.

VFBAVE (#2) 1: Enables the velocity feedback average function. (Usually, set this bit to 1. Set this parameter for the main axis only.)

[Reference item] Section 4.17 and Subsection 4.19.3

SPPRLD (#3) 1: Enables the full preload function. (Set this parameter for the main axis only.)

[Reference item] Subsection 4.19.6

SPPCHG (#4) The motor output torque polarities are as follows:

0: Outputs only the positive polarity to the main axis, and outputs only the negative polarity to the sub-axis.

1: Outputs only the negative polarity to the main axis, and outputs only the positive polarity to the sub-axis. (Set this parameter for the main axis only.)

[Reference item] Subsection 4.19.6

VCMDTM (#5) 1: Enables velocity command tandem control.
(Set this parameter for the main axis only.)

PFBSWC (#6) 1: Switches position feedback according to the direction of a torque command. (Set this parameter for the main axis only.)

[Reference item] Subsection 4.19.7

LAXDMP (#7) 0: Enables damping compensation for the sub-axis only.

1: Enables damping compensation with both the main axis and sub-axis. Usually, set this bit to 1. (Set this parameter for the main axis only.)

[Reference item] Subsection 4.19.2

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*) 2009 (FS30*i*, 16*i*)	BLST	BLCU		ANALOG		ADBL		DMY

DMY (#0) The serial feedback dummy function is:

0: Not used.

1: Used.

[Reference item] Subsection 4.9.1

ADBL (#2) The new backlash acceleration function is:

0: Not used.

1: Used.

[Related parameters] 1860 (15*i*), 2048 (16*i* etc.), 1980 (15*i*), 2087 (16*i* etc.)

ANALOG(#4) Analog servo interface function is:
0: Not used
1: Used

BLCU(#6) The function that validates the backlash acceleration function only at cutting is:
0: Invalidated.
1: Validated.
[Reference item] Subsections 4.6.6 and 4.6.7

BLST (#7) The backlash acceleration stop function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.6.6
[Related parameters] 1975 (15*i*), 2082 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1954 (FS15*i*) / 2010 (FS30*i*, 16*i*)	POLE		HBBL	HBPE	BLTE	LINEAR		

LINEAR (#2) 1: Controls a linear motor. This bit is set automatically when the parameters of the linear motor are initialized. Check that this bit is set before the linear motor is driven.
[Reference item] Subsec. 4.14.1.

BLTE (#3) The function to multiply the backlash acceleration amount by 10 is:
0: Invalidated.
1: Validated.
[Reference item] Subsections 4.6.6 and 4.6.7

HBPE (#4) When the dual position feedback function is used, a pitch error compensation is added to the error counter of:
0: Full-closed loop. ← Standard setting
1: Semi-closed loop.
[Reference item] Subsection 4.5.7

HBBL (#5) When the dual position feedback function is used, a backlash compensation amount is added to the error counter of:
0: Semi-closed loop. ← Standard setting
1: Full-closed loop.
[Reference item] Subsection 4.5.7

POLE (#7) The punch/laser switching function is:
0: Not used.
1: Used.

	#7	#6	#5	#4	#3	#2	#1	#0
1955 (FS15*i*) / 2011 (FS30*i*, 16*i*)	TMPABS		RCCL				FFAL	EGB

EGB (#0) The EGB function is:
0: Not used.
1: Used.

FFAL (#1) Feed-forward control always is:
1: Enabled in all modes.
[Reference item] Subsection 4.6.1
[Related parameters] 1961 (15*i*), 2068 (16*i* etc.)

RCCL (#5) The actual current torque limit variable function is:
0: Not used.
1: Used.
[Related parameters] 1995 (15*i*), 2102 (16*i* etc.)
(★ Do not change)

TMPABS (#7) Temporary absolute coordination setting function is:
0: Not used.
1: Used.

	#7	#6	#5	#4	#3	#2	#1	#0
1956 (FS15*i*) **2012 (FS30*i*, 16*i*)**	**STNG**		**VCM2**	**VCM1**			**MSFE**	

MSFE (#1) The machine speed feedback function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.5.8
[Related parameters] 1981 (15*i*), 2088 (16*i* etc.)

VCM1 (#4) The VCMD waveform signal conversion on the check board is switched.

VCM2 (#5) Switches the VCMD waveform conversion value according to the following list:

For rotary type motor

VCM2	VCM1	Number of velocity commandrevolution/5 V
0	0	0.9155 min^{-1}
0	1	14 min^{-1}
1	0	234 min^{-1}
1	1	3750 min^{-1}

For linear motor (P in the table below represents a scale signal pitch.)

VCM2	VCM1	Number of velocity commandrevolution/5 V
0	0	0.00375 × P m/min
0	1	0.06 × P m/min
1	0	0.96 × P m/min
1	1	15.36 × P m/min

[Reference item] Item (5) in Appendix I

STNG (#7) In velocity command mode, a software disconnection alarm is:
0: Detected.
1: Ignored.

	#7	#6	#5	#4	#3	#2	#1	#0
1707 (FS15*i*) / **2013 (FS30*i*, 16*i*)**	**APTG**							**HR3**

HR3 (#0) HRV3 current control is:
0: Not used.
1: Used.

[Reference item] Subsection 4.2.1

APTG (#7) The α Pulsecoder software disconnection monitor is:
0: Not ignored.
1: Ignored.

[Reference item] Section 3.2

	#7	#6	#5	#4	#3	#2	#1	#0
1708 (FS15*i*) / **2014 (FS30*i*, 16*i*)**								**HR4**

HR4 (#0) HRV4 current control is:
0: Not used.
1: Used.

[Reference item] Subsection 4.2.2

	#7	#6	#5	#4	#3	#2	#1	#0
1957 (FS15*i*) / **2015 (FS30*i*, 16*i*)**	**BZNG**	**BLAT**	**TDOU**				**SSG1**	**PGTW**

PGTW (#0) The position gain switching function is:
0: Not used.
1: Used.

[Reference item] Subsection 4.8.1
[Related parameters] 1713 (15*i*), 2028 (16*i* etc.)

SSG1 (#1) The low-speed integral function is:
0: Not used.
1: Used.

[Reference item] Subsection 4.8.2
[Related parameters] 1714 (15*i*), 2029 (16*i* etc.), 1715 (15*i*), 2030 (16*i* etc.)

TDOU (#5) Switches the check board output data as follows:
0: TCMD is output.
1: Estimated load torque is output.

[Reference item] Subsections 4.6.7 and 4.12.1

BLAT (#6) The two-stage backlash acceleration function is:
0: Not used.
1: Used.

[Reference item] Subsection 4.6.7
[Related parameters] 1860 (15*i*), 2048 (16*i* etc.), 1724 (15*i*), 2039 (16*i* etc.)

BZNG (#7) When a separate detector is used, the battery alarm for the built-in Pulsecoder is:
0: Not ignored.
1: Ignored.

	#7	#6	#5	#4	#3	#2	#1	#0
1958 (FS15*i*) **2016 (FS30*i*, 16*i*)**					PK2VDN			ABNT

ABNT (#0) The unexpected disturbance torque detection function (option) is:
0: Not used.
1: Used.
[Reference item] Subsection 4.12.1
[Related parameters] 1997 (15*i*), 2104 (16*i* etc.)

PK2VDN (#3) The variable proportional gain function in the stop state is:
0: Not used.
1: Used.
[Reference item] Subsection 4.4.3
[Related parameters] 1730 (15*i*), 2119 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1959 (FS15*i*) **2017 (FS30*i*, 16*i*)**	PK2V25		RISCFF	HTNG				DBST

DBST (#0) The quick stop type 1 at emergency stop is:
0: Not used.
1: Used.
[Reference item] Subsection 4.11.1
[Related parameters] 1883 (15*i*), 2005 (16*i* etc.), 1976 (15*i*), 2083 (16*i* etc.)

HTNG (#4) In velocity command mode, the hardware disconnection alarm of a separate detector is:
0: Detected.
1: Ignored.

RISCFF (#5) 0: When RISC is used, the feed-forward response characteristics remain as is.
1: When RISC is used, the feed-forward response characteristics are improved.
[Reference item] Subsection 4.6.3

PK2V25 (#7) Velocity loop high cycle management function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.4.1

	#7	#6	#5	#4	#3	#2	#1	#0
1960 (FS15*i*) **2018 (FS30*i*, 16*i*)**	PFBCPY					OVR8	MOVOBS	RVRSE

RVRSE (#0) The signal direction for the separate detector is:
0: Not reversed.
1: Reversed.
Series 90B0 supports the serial type and incremental parallel type.

MOVOBS (#1) The disable function for observer in the stop state is:
0: Not used.
1: Used
[Reference item] Subsection 4.5.4

OVR8 (#2) The stage-2 acceleration amount override format is on the basis of:
0: 4096.
1: 256.
[Reference item] Subsection 4.6.7

PFBCPY (#7) 1: The motor feedback signal for the main axis is shared by the sub-axis. (Set this parameter for the sub-axis only.)
[Reference item] Subsection 4.19.5

	#7	#6	#5	#4	#3	#2	#1	#0
1709 (FS15*i*) 2019 (FS30*i*, 16*i*)	DPFB						TANDMP	

TANDMP (#1) The tandem disturbance elimination control function (option) is:
0: Not used.
1: Used.
[Reference item] Section 4.17

DPFB(#7) The dual position feedback function (option) is:
0: Not used.
1: Used.
[Reference item] Subsection 4.5.7
[Related parameters] 1971 (15*i*), 2078 (16*i* etc.), 1972 (15*i*), 2079 (16*i* etc.), 1973 (15*i*), 2080 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1740 (FS15*i*) 2200 (FS30*i*, 16*i*)		P2EX	RISCMC		ABG0	IQOB		OVSP

OVSP (#0) A feedback mismatch alarm is:
0: Detected.
1: Not detected.

IQOB (#2) 1: Eliminates the effect of voltage saturation on unexpected disturbance torque detection.
[Reference item] Subsection 4.12.1

ABG0(#3) 1: When an unexpected disturbance torque is detected, a threshold is set separately for cutting and rapid traverse.
[Reference item] Subsection 4.12.2
[Related parameters] 1997 (15*i*), 2104 (16*i* etc.), 1765 (15*i*), 2142 (16*i* etc.)

RISCMC (#5) When a RISC processor is used:
0: The response to a positioning command is the same as before.
1: The response to a positioning command is improved.
[Reference item] Subsection 4.6.3

P2EX (#6) The velocity loop proportional gain (PK2V) format is:
0: Standard format. (See Item (5) of Subsec. 4.14.1.)
1: Converted format.
[Reference item] Supplement 4 of Subsection 2.1.5

	#7	#6	#5	#4	#3	#2	#1	#0
1741 (FS15*i*) **2201 (FS30*i*, 16*i*)**		CPEE					RNLV	CROFS

CROFS (#0) The function for obtaining current offsets upon an emergency stop is:
0: Not used.
1: Used.
[Reference item] Section 4.13

RNLV (#1) Specifies the detection level for the feedback mismatch alarm as follows:
0: 600 min^{-1}
1: 1000 min^{-1}

CPEE (#6) The actual current display peak hold function is:
0: Not used
1: Used

	#7	#6	#5	#4	#3	#2	#1	#0
1742 (FS15*i*) **2202 (FS30*i*, 16*i*)**				DUAL	OVS1	PIAL	VGCCR	FADCH

FADCH (#0) The cutting/rapid FAD switching function is:
0: Not used.
1: Used.
[Reference item] Section 4.3 and Subsection 4.8.3
[Related parameters] 1702 (15*i*), 2109 (16*i* etc.), 1766 (15*i*), 2143 (16*i* etc.), 1951 (15*i*), 2007 (16*i* etc.)

VGCCR (#1) The cutting/rapid velocity loop gain switching function is:
0: Not used.
1: Used.
[Reference item] Section 4.3 and Subsection 4.5.5
[Related parameters] 1700 (15*i*), 2107 (16*i* etc.)

PIAL (#2) When rapid traverse is selected by the cutting/rapid velocity loop gain switching function, the 1/2 PI control function is:
0: Automatically disabled.
1: Always enabled.
[Reference item] Subsection 4.5.5

OVS1 (#3) 1: Overshoot compensation is valid only once after the termination of a move command.
[Reference item] Section 4.7

DUAL (#4) Zero width is determined:
0: Only by setting = 0.
1: By setting.
[Reference item] Subsection 4.5.7
[Related parameters] 1974 (15*i*), 2081 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1743 (FS15*i*) / 2203 (FS30*i*, 16*i*)			TCMD4X	FRCAX2		CRPI		

CRPI (#2) The current loop 1/2 PI control function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.5.5

FRCAX2 (#4) Torque control type 2 is:
0: Not exercised.
1: Exercised.
[Reference item] Section 4.16

TCMD4X (#5) The check board output voltage of the TCMD signal is:
0: As usual (default).
1: Multiplied by 4.
[Reference item] Appendix I

	#7	#6	#5	#4	#3	#2	#1	#0
1744 (FS15*i*) / 2204 (FS30*i*, 16*i*)	DBS2		PGTWN2				HSTP10	

HSTP10 (#1) The valid speed increment system for the high-speed positioning function is:
0: $0.01mm^{-1}$ (rotary motor), 0.01mm/min (linear motor).
1: $0.1mm^{-1}$ (rotary motor), 0.1mm/min (linear motor).
[Reference item] Subsections 4.8.1 and 4.8.2

PGTWN2 (#5) Position gain switching type 2 is:
0: Not used.
1: Used.
[Reference item] Subsection 4.8.1
[Related parameters] 1713 (15*i*), 2028 (16*i* etc.)

DBS2 (#7) Quick stop type 2 at emergency stop is:
0: Not used.
1: Used.
[Reference item] Subsection 4.11.2

	#7	#6	#5	#4	#3	#2	#1	#0
1745 (FS15*i*) / 2205 (FS30*i*, 16*i*)				HDIS	HD2O	FULDMY		

FULDMY (#2) The dummy separate detector function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.9.1

HD2O (#3) The quick stop function for hardware disconnection of separate detector is:
0: Not applied to axes under synchronous control.
1: Applied to axes under synchronous control.

[Reference item] Subsection 4.11.4

HDIS (#4) The quick stop function for hardware disconnection of separate detector is:
0: Disabled.
1: Enabled.

[Reference item] Subsection 4.11.4

	#7	#6	#5	#4	#3	#2	#1	#0
1746 (FS15*i*) / 2206 (FS30*i*, 16*i*)	HSSR			HBSF				

HBSF (#4) The backlash compensation amount and pitch error compensation amount are added:
1: Simultaneously for the full-closed and semi-closed sides.
0: Selectively according to the conventional parameter (No. 2010 (Series 16*i* etc.) and No. 1954 (Series 15*i*))If this parameter is set to 1 (enabled), the settings of parameter No. 2010 (Series 16*i* etc.) and parameter No. 1954 (Series 15*i*) are ignored.

[Reference item] Subsection 4.5.7

HSSR (#7) High-speed data output to the check board is:
0: Not performed.
1: Performed.

[Reference item] Appendix I

	#7	#6	#5	#4	#3	#2	#1	#0
1747 (FS15*i*) / 2207 (FS30*i*, 16*i*)					PK2D50			NEGSHC

NEGSHC (#0) Overcurrent alarm (software) is:
0: Not ignored.
1: Ignored .

[Reference item] Section 3.2
[Related parameters] 1749#4 (15*i*), 2209#4 (16*i* etc.)

⚠ CAUTION
If the emergency stop state is released without connecting the power line in a test such as a test for machine start-up, the overcurrent alarm detected by the servo software may be issued. In such a case, the alarm can be avoided temporarily by setting this bit parameter to 1. However, be sure to return the bit parameter to 0 before starting up in the normal operation state after completion of a test.

PK2D50 (#3) Specifies a variable proportional gain function in the stop state as follows:
0: 75% down.
1: 50% down.

[Reference item] Subsection 4.4.3

[Related parameters] 1730 (15*i*), 2119 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
1749 (FS15*i*) / 2209 (FS30*i*, 16*i*)		PGAT		HCNGL	FADPGC	FADL		

FADL (#2)
0: FAD bell-shaped type
1: FAD linear type

[Reference item] Subsection 4.8.3

[Related parameters] 1702 (15*i*), 2109 (16*i* etc.)

FADPGC (#3)
0: Synchronization is not established in the FAD setting rigid tapping mode.
1: Synchronization is established in the FAD setting rigid tapping mode.

[Reference item] Subsection 4.8.3

HCNGL (#4)
0: The overcurrent alarm avoidance function based on amplifier hardware is disabled.
1: The overcurrent alarm avoidance function based on amplifier hardware is enabled.

> **NOTE**
> 1 If an abnormal level of current that causes the overcurrent alarm to be issued is detected momentarily, processing is performed to suppress the level of current without issuing the alarm.
> 2 Even if this function is used, the overcurrent alarm is issued:
> - When a complete short circuit occurs, or
> - When the processing above for suppressing the level of current is continuously performed.

PGAT (#6)
0: Automatic format change for position gain is enabled.1: Automatic format change for position gain is disabled. (available in Series 90B0/01 (A) and later editions)

	#7	#6	#5	#4	#3	#2	#1	#0
1750 (FS15*i*) / 2210 (FS30*i*, 16*i*)		ESPTM1	ESPTM0			PK12S2		

PK12S2 (#2) The current gain internally 4 times function is:
0: Not used.
1: Used.

[Reference item] Subsection 4.14.1

ESPTM0(#5), ESPTM1(#6) Set the timer built into the αi amplifier to delay emergency stop.

ESPTM1	ESPTM0	Delay time
0	0	50ms (default)
0	1	100ms
1	0	200ms
1	1	400ms

[Reference item] Section 4.11

	#7	#6	#5	#4	#3	#2	#1	#0
1751 (FS15*i*) / 2211 (FS30*i*, 16*i*)							PHCP	

PHCP (#1) The phase lag compensation during deceleration is:
0: Not used.
1: Used.

[Related parameters] 1756 (15*i*), 2133 (16*i* etc.), 1757 (15*i*), 2134 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
2600 (FS15*i*) / 2212 (FS30*i*, 16*i*)	OVQK							

OVQK (#7) When a quick stop function at the OVC and OVL alarm is:
0: Not used.
1: Used.

[Reference item] Subsection 4.11.5

	#7	#6	#5	#4	#3	#2	#1	#0
2601 (FS15*i*) / 2214 (FS30*i*, 16*i*)	OCM							

OCM (#7) Pole position detection function (optional) is:
0: Disabled.
1: Enabled.

[Reference item] Subsection 4.15.1

	#7	#6	#5	#4	#3	#2	#1	#0
2602 (FS15*i*) / 2214 (FS30*i*, 16*i*)				FFCHG				

FFCHG (#4) The cutting/rapid feed-forward switching function is:
0: Not used.
1: Used.

[Reference item] Subsection 4.6.4

	#7	#6	#5	#4	#3	#2	#1	#0
2603 (FS15*i*) / 2215 (FS30*i*, 16*i*)	ABT2						TCPCLR	

TCPCLR (#1) A function of setting the velocity loop integrator with a value for canceling a torque offset at an emergency stop is:
0: Disabled.
1: Enabled.

[Reference item] Subsection 4.12.1

ABT2 (#7) Cutting/rapid unexpected disturbance torque detection function type 2 is:
0: Disabled.
1: Enabled.
[Reference item] Subsection 4.12.2

	#7	#6	#5	#4	#3	#2	#1	#0
2608 (FS15*i*) 2220 (FS30*i*, 16*i*)			P16					DECAMR

DECAMR (#0) A non-binary detector is:
0: Not used.
1: Used.
[Reference item] Subsection 4.15.1
[Related parameters] 1705 (15*i*), 2112 (16*i* etc.), 1761 (15*i*), 2138 (16*i* etc.)

P16 (#5) 16-pole servo motor is:
0: Not used.
1: Used.
[Reference item] Subsection 2.1.7
[Related parameters] 1806 (15*i*), 2001 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
2611 (FS15*i*) 2223 (FS30*i*, 16*i*)	BLCUT2							DISOBS

DISOBS (#0) The disturbance elimination filter function is:
0: Not used.
1: Used.
[Reference item] Subsection 4.5.3

BLCUT2 (#7) The backlash acceleration function is:
0: Enabled for both cutting feed and rapid traverse
1: Enabled only for cutting feed
[Reference item] Subsection 4.6.6

	#7	#6	#5	#4	#3	#2	#1	#0
2613 (FS15*i*) 2225 (FS30*i*, 16*i*)						TSA05	TCMD05	

TCMD05 (#1) The check board output voltage of the TCMD signal is:
0: As usual (default).
1: Halved.
[Reference item] Appendix I

TSA05 (#2) The check board output voltage of the SPEED signal is:
0: As usual (default).
1: Halved (7500 min^{-1}/5 V).
[Reference item] Appendix I

	#7	#6	#5	#4	#3	#2	#1	#0
2616 (FS15*i*) / **2228 (FS30*i*, 16*i*)**					ELSAL			

ELSAL (#3) In pole detection, the motor saliency is:
0: Lq>Ld
1: Lq<Ld

[Reference item] Subsection 4.15.1

	#7	#6	#5	#4	#3	#2	#1	#0
2617 (FS15*i*) / **2229 (FS30*i*, 16*i*)**				FORME	WATRA			ABSEN

ABSEN (#0) In pole detection, the AMR offset is:
0: Not used.
1: Used.

[Reference item] Subsection 4.15.1
[Related parameters] 1762 (15*i*), 2139 (16*i* etc.)

WATRA (#3) After pole detection, an abnormal operation is:
0: Monitored.
1: Not monitored.

[Reference item] Subsection 4.15.1

NOTE
This function can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.) or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

FORME (#4) The operation mode for pole detection is:
0: Automatic selection mode (minute operation mode + stop mode)
1: Minute operation mode

[Reference item] Subsection 4.15.1

NOTE
This function can be used with Series 90B1/Edition 02 or later (FS15*i*, 16*i*, etc.) or Series 90D0 and 90E0/Edition 10 or later (FS30*i*, etc.).

	#7	#6	#5	#4	#3	#2	#1	#0
2683 (FS15*i*) / **2270 (FS30*i*, 16*i*)**	DSTIN	DSTTAN	DSTWAV		ACREF			AMR60

AMR60 (#0) The valid setting range of the AMR offset is from:
0: -45 degrees to +45 degrees.
1: -60 degrees to +60 degrees.

[Reference item] Section 4.14

ACREF (#3) The active resonance elimination filter is:
0: Not used.
1: Used.

[Reference item] Subsection 4.5.2

DSTWAV(#5) The input waveform of disturbance input is:
0: Sine wave. (Usually, select the sine wave.) .
1: Square wave.
[Reference item] Appendix H

DSTTAN(#6) Disturbance is:
0: Input for one axis only.
1: Input for both the L and M axes (To be set only for the L axis side of synchronous axes or tandem axes).
[Reference item] Appendix H

DSTIN(#7) The disturbance input function is:
0: Not used.
1: Used.
[Reference item] Appendix H

	#7	#6	#5	#4	#3	#2	#1	#0
2684 (FS15*i*) **2271 (FS30*i*, 16*i*)**						RETR2		

RETR2 (#2) When an unexpected disturbance torque is detected, the simultaneous two-axis retract function is:
0: Not used.
1: Used.

	#7	#6	#5	#4	#3	#2	#1	#0
2686 (FS15*i*) **2273 (FS30*i*, 16*i*)**	DBTLIM	EGBFFG	EGBEX	POA1NG				WSVCP

WSVCP (#0) When the simple synchronous control is used, the loop integrator of the master axis :
0: Can not be copied to the slave axis.
1: Can be copied to the slave axis.
(Specify only the slave axis.)
[Reference item] Subsection 4.19.9

POA1NG (#4) In the calculation of the observer coefficient (POA1), the load inertia ratio (LDINT) is:
0: Considered.
1: Not considered.

EGBEX (#5) The EGB automatic phase matching function is:
0: In the normal mode (deceleration not performed between the master and detector).
1: In the extended mode (deceleration performed between the master and detector).

EGBFFG(#6) FFG is:
0: Not considered in the EGB ratio.
1: Considered in the EGB ratio.

HP2048 (#0) During brake control, the torque limit setting function is:
0: Disabled.
1: Enabled.

[Related parameters] 2788 (15*i*), 2375 (16*i* etc.)

	#7	#6	#5	#4	#3	#2	#1	#0
2687 (FS15*i*) / **2274 (FS30*i*, 16*i*)**								**HP2048**

HP2048 (#0) A 2048-time interpolation circuit (position detection circuit H or C) is:
0: Not used.
1: Used.

[Reference item] Subsection 2.1.4 and Section 4.14

	#7	#6	#5	#4	#3	#2	#1	#0
2688 (FS15*i*) / **2275 (FS30*i*, 16*i*)**				**ASYN**			**RCNCLR**	**800PLS**

800PLS (#0) When the RCN723 or RCN223 is used, the reference counter setting is made in reference to:
0: 1/8 turns of the detector.
1: 1 turn of the detector.

[Reference item] Subsection 2.1.4

RCNCLR (#1) The speed data is:
0: Not cleared.
1: Cleared. (To use the RCN223 or RCN723, set it to 1.)

[Reference item] Subsection 2.1.4
[Related parameters] 2807 (15*i*), 2394 (16*i* etc.)

ASYN (#3) Synchronous axes automatic compensation function is:
0: Disabled.
1: Enabled.

[Reference item] Section 4.18

	#7	#6	#5	#4	#3	#2	#1	#0
2696 (FS15*i*) / **2283 (FS30*i*, 16*i*)**	**BLSTP2**							**NOG54**

NOG54(#0) High-speed HRV current control mode (servo HRV3 control) is:
0: Used only when both G5.4Q1 and G01 are specified.
1: Used when G01 is specified. (G5.4Q1 is not monitored.)

NOTE
This function can be used when servo HRV3 control is used with the servo software for the Series 30*i*/31*i*/32*i* (Series 90D0 and 90E0).
This function cannot be used when servo HRV4 control is used.

[Reference item] Section 4.2

BLSTP2 (#7) The function for disabling backlash acceleration after a stop is:
0: Not used.
1: Used.

	#7	#6	#5	#4	#3	#2	#1	#0
2713 (FS15*i*) **2300 (FS30*i*, 16*i*)**	**CKLNOH**					**DO**		**HRVEN**

HRVEN(#0) The extended HRV function is:
0: Not used.
1: Used.

> **NOTE**
> Set this function when using servo HRV4 control.

[Reference item] Section 4.2

DD (#2) 1: Synchronous built-in servo motor control is exercised.
This bit is automatically set when the synchronous built-in servo motor parameters are initialized. However, before driving a synchronous built-in servo motor, check that this bit is set to 1.

[Reference item] Subsection 4.15.1

CKLNOH (#7) Determination of an overheat via the PMC is:
0: Not performed.
1: Performed.

[Reference item] Subsection 4.14.2

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 15*i*	**Series 30*i*, 16*i*, and so on**		
1896	1821	Reference counter capacity	→2.1.3
1825	1825	Position loop gain (position gain)	→3.1
1851	1851	Backlash compensation value	→4.6.6, 4.6.7
1874	2020	Motor ID No. Motor ID number that can be specified	→ 2.1.2, 4.14.1 Initial setting
1875	2021	Load inertia ratio (LDINT) $\dfrac{\text{Load inertia}}{\text{Rotor inertia}} \times 256$ Increase velocity loop gain parameters PK1V and PK2V by (1 + LDINT/256) times	Adjust for individual machines separately.
1879 1876 1891	2022 2023 2024	Rotation direction of the motor Number of velocity pulse Number of position pulse	→ 2.1.2, 4.14.1 Initial setting
1713 1714 1715	2028 2029 2030	Velocity enabling position gain switching Acceleration-time velocity enabling integral function for low speed Deceleration-time velocity enabling integral function for low speed	→ 4.8.1 → 4.8.2 → 4.8.2
1718 1719	2033 2034	Number of position feedback pulses Vibration damping control gain	→ 4.5.6
1721	2036	Tandem control/damping compensation gain (main axis) Tandem control/damping compensation phase coefficient (sub-axis)	→ 4.19.2, 4.17
1724	2039	2-stage backlash acceleration function : stage 2 acceleration amount	→ 4.6.7
1852 1853 1854	2040 2041 2042	Current loop gain (PK1) Current loop gain (PK2) Current loop gain (PK3)	★ Motor-specific ★ Motor-specific ★ Motor-specific
1855	2043	Velocity loop integral gain (PK1V)	☆ Motor-specific Adjust for individual machines separately.
1856	2044	Velocity loop proportional gain (PK2V)	
1857	2045	Velocity loop incomplete integral gain (PK3V)	☆ Motor-specific → 4.7
1858	2046	Velocity loop gain (PK4V)	★ Motor-specific
1859	2047	Observer parameter (POA1) This parameter is adjusted when the unexpected disturbance torque detection and two-stage backlash functions are used. NOTE: If the velocity gain (load inertia ratio) is changed, this parameter must be re-adjusted.	☆ Motor-specific → 4.6.7, 4.12
1860	2048	Backlash acceleration amount	☆ → 4.6.6, 4.6.7
1861	2049	Maximum dual position feedback amplitude	☆ → 4.5.7
1862 1863	2050 2051	Observer gain (POK1) Observer gain (POK2) When only the unexpected disturbance torque detection function is used, these parameters must be changed.	☆ Motor-specific → 4.12
1864	2052	Not used	★
1865	2053	Current dead-band compensation (PPMAX)	★ Motor-specific

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 15i	Series 30i, 16i, and so on		
1866	2054	Current dead-band compensation (PDDP) The standard setting for αi motors is 1894.	★ Motor-specific
1867 1868 1869 1870 1871	2055 2056 2057 2058 2059	Current dead-band compensation (PHYST) Variable current loop gain during deceleration (EMFCMP) Phase D current at high-speed (PVPA) Phase D current limit (PALPH) Back electromotive force compensation (EMFBAS)	★ Motor-specific
1872	2060	Torque limit The standard setting represents the maximum current of the amplifier.	★ Motor-specific
1873 1877 1878	2061 2062 2063	Back electromotive force compensation (EMFCMP) Overload protection coefficient (POVC1) Overload protection coefficient (POVC2)	★ Motor-specific
1892	2064	Software disconnection alarm level	★ Motor-specific → 3.2
1893	2065	Soft thermal coefficient (POVCLMT)	★ Motor-specific
1894	2066	Acceleration feedback gain	☆ → 4.4.2
1895	2067	Torque command filter	☆ → 4.5.1
1961	2068	Feed-forward coefficient	☆ → 4.6.1 to 4.6.5
1962	2069	Velocity feed-forward coefficient	☆ → 4.6.1 to 4.6.5
1963	2070	Backlash acceleration timing	☆ → 4.6.6
1964	2071	Time during which backlash acceleration is effective, Static friction compensation count	☆ → 4.6.6, 4.6.8
1965	2072	Static friction compensation amount	☆ → 4.6.8
1966	2073	Stop state judgment parameter	☆ → 4.6.8
1967	2074	Current loop gain variable with velocity	★ Motor-specific
1968	2075	Not in use at present.	☆
1969	2076	Not in use at present.	☆
1970	2077	Overshoot compensation counter	☆ → 4.7
 1971 1972 1973 1974	 2078 2079 2080 2081	Dual position feedback Conversion coefficient (numerator) Conversion coefficient (denominator) Constant of first-order lag Zero zone	☆ → 4.5.7
1975	2082	Backlash acceleration stop amount	☆ → 4.6.6, 4.6.7
1976	2083	Brake control timer (msec)	☆ → 4.10
1977 1978	2084 2085	Flexible feed gear (numerator) Flexible feed gear (denominator)	→ 2.1.2, 4.14.1 Initial setting
1979	2086	Rated current parameter	★ Motor-specific
1980	2087	Torque offset Tandem control/Preload value	☆ → 4.6.7, 4.12 ☆ → 4.19.1
1981	2088	Machine speed feedback gain	☆ → 4.5.8
1982	2089	2-stage backlash acceleration function : stage-2 end magnification	☆ → 4.6.7
1984	2091	Nonlinear control parameter	☆
1985	2092	Advanced preview feed-forward coefficient	☆ → 4.6.2
1987	2094	Backlash acceleration amount in the negative direction	☆ →4.6.6, 4.6.7
1988	2095	Feed-forward timing adjustment coefficient	☆ →4.6.5

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 15*i*	Series 30*i*, 16*i*, and so on		
1990	2097	Static friction compensation stop parameter	☆ → 4.6.8
1991	2098	Current phase lead compensation coefficient	★ Motor-specific
1992	2099	N pulses suppression function	★ → 4.4.4
1994	2101	Overshoot compensation valid level	☆ → 4.7
1995	2102	Final clamp value for the actual-current limit	★ Motor-specific
1996	2103	Track back amount applied when an unexpected disturbance torque is detected	☆ → 4.12
1997	2104	Unexpected disturbance torque detection alarm level (cutting when switching is used)	☆ → 4.12
1998	2105	Torque constant	☆ → 4.16
1700	2107	Velocity loop gain override	☆ → 4.3
1702	2109	Fine acc./dec. time constant (rapid traverse when switching is used)	☆ → 4.3 and 4.8.3
1703	2110	Magnetic saturation compensation	★ Motor-specific
1704	2111	Torque limit at deceleration	★ Motor-specific
1705	2112	Linear motor AMR conversion coefficient 1	☆ → 4.14
1706	2113	Resonance elimination filter 1: attenuation center frequency	☆ → 4.5.2
1725	2114	Backlash acceleration function : acceleration amount override 2-stage backlash acceleration function : stage 2 acceleration amount override	→ 4.6.6 → 4.6.7
1726	2115	For internal data output: Usually to be kept at 0.	
1727	2116	Unexpected disturbance torque detection : dynamic friction cancel	→ 4.12
1729	2118	Dual position feedback Semi-closed/full-closed error overestimation level	→ 4.5.7
1730	2119	Variable proportional gain function in the stop state : Stop level	→ 4.4.3, 4.5.4
1732 1733	2121 2122	Not used	
1737	2126	Tandem control/position feedback switching time constant	→ 4.19.7
1735	2127	Non-interference control coefficient (NINTCT)	★ Motor-specific
1736	2128	Coefficient for magnetic flux weaken compensation (MFWKCE)	★ Motor-specific
1752	2129	Coefficient for magnetic flux weaken compensation (MFWKBL)	★ Motor-specific
1753 1754 1755	2130 2131 2132	Smoothing compensation performed twice per pole pair Smoothing compensation performed four times per pole pair Smoothing compensation performed six times per pole pair	☆ → 4.14.3
1756	2133	Coefficient for phase lag compensation during deceleration (PHDLY1)	★ Motor-specific
1757	2134	Coefficient for phase lag compensation during deceleration (PHDLY2)	★ Motor-specific
1760	2137	2-stage backlash acceleration function : stage 1 acceleration amount override	→ 4.6.7
1761 1762	2138 2139	Linear motor AMR conversion coefficient 2 Linear motor AMR offset	→ 4.14
1765	2142	Unexpected disturbance torque detection alarm level in rapid traverse	→ 4.12.2
1766	2143	Fine acc./dec. time constant 2 (in cutting)	→ 4.3, 4.8.3
1767	2144	Position feed-forward coefficient for cutting	→ 4.3, 4.6.4, 4.8.3
1768	2145	Velocity feed-forward coefficient for cutting	→ 4.3, 4.6.4, 4.8.3

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 15*i*	Series 30*i*, 16*i*, and so on		
1769	2146	Two-stage backlash acceleration end timer	→ 4.6.7
1771	2148	Deceleration decision level (HRV control) Usually to be kept at 0.	Usually adjustment is not needed.
1774	2151	For internal data output: Usually, be sure to set 0.	
1775	2152	For internal data output: Usually, be sure to set 0.	
1776	2153	For internal data output: Usually, be sure to set 0.	
1777	2154	Static friction compensation function : decision level for movement restart after stop.	→ 4.6.8
1779	2156	Torque command filter (at rapid traverse)	→ 4.3, 4.5.1
1784	2161	OVC magnification at a stop (OVCSTP)	★ Motor-specific
1785	2162	Soft thermal coefficient 2 (POVC21)	★ Motor-specific
1786	2163	Soft thermal coefficient 2 (POVC22)	★ Motor-specific
1787	2164	Soft thermal coefficient 2 (POVCLMT2)	★ Motor-specific
1788	2165	Maximum amplifier current	★ Motor-specific
1790	2167	2-stage backlash acceleration function : stage 2 acceleration amount offset	→ 4.6.7
2620	2177	Resonance elimination filter 1: attenuation bandwidth	→ 4.5.2
2622	2179	Reference counter size (denominator)	→ 2.1.3
2625	2182	Current A for pole detection (DTCCRT_A)	→ 4.15.1
2628	2185	Position pulses conversion coefficient	→ 2.1, 2.1.8, 4.14.1, Initial setting
2641	2198	Current B for pole detection (DTCCRT_B)	→ 4.15.1
2642	2199	Current C for pole detection (DTCCRT_C)	→ 4.15.1
2681	2268	Allowable travel distance magnification/stop speed decision value (MFMPMD)	→ 4.15.1
2731	2318	Disturbance elimination filter : gain	→ 4.5.3
2732	2319	Disturbance elimination filter : inertia ratio	→ 4.5.3
2733	2320	Disturbance elimination filter : inverse function gain	→ 4.5.3
2734	2321	Disturbance elimination filter : time constant	→ 4.5.3
2735	2322	Disturbance elimination filter : acceleration feedback limit	→ 4.5.3
2736	2323	Variable current PI rate	→ 4.5.5
2737	2324	Variable proportional gain function in the stop state : arbitrary magnification at a stop (for cutting only)	→ 4.4.3
2738	2325	Tandem disturbance elimination control function/integral gain (main axis) Tandem disturbance elimination control function/phase coefficient (sub-axis)	→ 4.17
2739	2326	Disturbance input : gain	→ Appendix H
2740	2327	Disturbance input : start frequency	→ Appendix H
2741	2328	Disturbance input : end frequency	→ Appendix H
2742	2329	Number of disturbance input measurement points	→ Appendix H
2746	2333	Tandem disturbance elimination control function /incomplete integral time constant (main axis)	→ 4.17
2747	2334	Current loop gain magnification (enabled only during high-speed HRV current control)	→ 4.2
2748	2335	Velocity loop gain magnification (enabled only during high-speed HRV current control)	→ 4.2

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 15*i*	Series 30*i*, 16*i*, and so on		
2751	2338	Backlash acceleration function : acceleration amount limit value 2-stage backlash acceleration function : stage-2 acceleration amount limit value	→4.6.6 →4.6.7
2752	2339	2-stage backlash acceleration function : stage-2 acceleration amount (negative direction)	→4.6.7
2753	2340	Backlash acceleration function : acceleration amount override (negative direction) Backlash acceleration function : Acceleration amount override (negative direction)	→4.6.6 →4.6.7
2754	2341	2-stage backlash acceleration function : stage-2 acceleration amount limit value (negative direction) 2-stage backlash acceleration function : stage-2 acceleration amount limit value (negative direction)	→4.6.6 →4.6.7
2758	2345	Disturbance estimation function : dynamic friction compensation value in the stop state	→ 4.12.1
2759	2346	Disturbance estimation function : dynamic friction compensation limit value	→ 4.12.1
2765	2352	Active resonance elimination filter : detection level	→4.5.2
2772	2359	Resonance elimination filter 1 : damping	→4.5.2
2773	2360	Resonance elimination filter 2 : attenuation center frequency	→4.5.2
2774	2361	Resonance elimination filter 2 : attenuation bandwidth	→4.5.2
2775	2362	Resonance elimination filter 2 : damping	→4.5.2
2776	2363	Resonance elimination filter 3 : attenuation center frequency	→4.5.2
2777	2364	Resonance elimination filter 3 : attenuation bandwidth	→4.5.2
2778	2365	Resonance elimination filter 3 : damping	→4.5.2
2779	2366	Resonance elimination filter 4 : attenuation center frequency	→4.5.2
2780	2367	Resonance elimination filter 4 : attenuation bandwidth	→4.5.2
2781	2368	Resonance elimination filter 4 : damping	→4.5.2
2782 2783 2784	2369 2370 2371	Smoothing compensation performed twice per pole pair (negative direction) Smoothing compensation performed four times per pole pair (negative direction) Smoothing compensation performed six times per pole pair (negative direction)	→4.14.3
2785	2372	Serial EGB exponent setting	
2786	2373	Lifting function against gravity at emergency stop : Distance to lift	→4.11.3
2787	2374	Lifting function against gravity at emergency stop : Lifting time	→4.11.3
2788	2375	Torque limit magnification during brake control	→4.10
2790 2791	2377 2378	Smoothing compensation performed 1.5 times per pole pair Smoothing compensation performed 1.5 times per pole pair (negative direction)	→4.15.3
2793 2794	2380 2381	Smoothing compensation performed three times per pole pair Smoothing compensation performed three times per pole pair (negative direction)	→4.15.3
2795	2382	Torsion preview control: maximum compensation value (LSTCM)	→4.6.9

☆: Parameters set up automatically at initialization
★: Parameters that can be kept at the automatically set values

Parameter number		Details	
Series 15*i*	Series 30*i*, 16*i*, and so on		
2796 2797 2798	2383 2384 2385	Torsion preview control: acceleration 1 (LSTAC1) Torsion preview control: acceleration 2 (LSTAC2) Torsion preview control: acceleration 3 (LSTAC3)	→4.6.9
2799 2800 2801	2386 2387 2388	Torsion preview control: acceleration torsion compensation value K1 (LSTK1) Torsion preview control: acceleration torsion compensation value K2 (LSTK2) Torsion preview control: acceleration torsion compensation value K3 (LSTK3)	→4.6.9
2802 2803	2389 2390	Torsion preview control: torsion delay compensation value KD KD (LSTKD) Torsion preview control: torsion delay compensation value KDN (LSTKDN)	→4.6.9
2804 2805 2806	2391 2392 2393	Torsion preview control: acceleration torsion compensation value K1N (LSTK1N) Torsion preview control: acceleration torsion compensation value K2N (LSTK2N) Torsion preview control: acceleration torsion compensation value K3N (LSTK3N)	→4.6.9
2807	2394	Number of data mask digits	→2.1.4
2808	2395	Feed-forward timing adjustment function (for use when FAD is enabled)	→4.6.5
2815	2402	Torsion preview control: torsion torque compensation coefficient (LSTKT)	→4.6.9
2816	2403	Synchronous axes automatic compensation function : coefficient (K)	→4.18
2817	2404	Synchronous axes automatic compensation function : maximum compensation (sub axis) Synchronous axes automatic compensation function : dead-band width (main axis)	→4.18
2818	2405	Synchronous axes automatic compensation function : filter coefficient	→4.18

6 PARAMETER LIST

6.1 PARAMETERS FOR HRV1 CONTROL

December, 2005

Series 9096
Series 90B0
Series 90B1
Series 90B5 and 90B6

Symbol	FS15*i*	FS16*i*,etc	L1500B1 /4*i*s	L3000B2 /2*i*s	L6000B2 /2*i*s	L9000B2 /2*i*s	L15000C2 /2*i*s	α*i*S300 2000	L3000B2 /4*i*s	L6000B2 /4*i*s	L9000B2 /4*i*s	L15000C2 /3*i*s	L300A1 /4*i*s
	Motor specification		444-B210	445-B110	447-B110	449-B110	456-B110	0292	445-B210	447-B210	449-B210	456-B210	441-B200
	Motor ID No.		90	91	92	93	94	115	120	121	122	123	124
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	01000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000100	00000100	00000000	00000100	00000100	00000100	00000100	00000100
	1955	2011	00000000	00000000	00000000	00000000	00000000	00100000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000100	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2713	2300	10000000	10000000	10000000	10000000	10000000	00000000	10000000	10000000	10000000	10000000	10000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1890	4804	4804	5036	1420	1357	1620	2626	4944	2392	526
PK2	1853	2041	-7180	-14453	-13138	-16000	-5600	-4212	-11180	-10051	-11831	-8448	-2141
PK3	1854	2042	-2647	-2660	-2660	-2660	-2663	-2710	-2660	-2660	-2660	-2657	-2618
PK1V	1855	2043	19	16	16	14	10	114	16	10	16	10	16
PK2V	1856	2044	-260	-214	-214	-195	-131	-1023	-214	-135	-211	-128	-217
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-4371	-5321	-5321	-5849	-8681	3709	-5321	-8463	-5399	-8861	-8755
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	3787	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	0	0	0	0	0	-3850	0	0	0	0	0
PALPH	1870	2058	0	0	0	0	0	-800	0	0	0	0	0
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	4855	7282	7282	5826
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32670	32670	32670	32685	32712	32352	32698	32740	32698	32732	32747
POVC2	1878	2063	1222	1222	1222	1041	703	5196	873	345	873	452	268
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	3626	3626	3626	3087	2086	15494	2590	1024	2590	1340	793
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	0	0	0	0	12288	0	0	0	0	0
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1402	1402	1402	1293	1063	2385	1184	744	1184	852	655
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	15000	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	227	455	911	1481	3104	10931	455	1450	1367	3168	52
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	0	0	16	0	0	0	0	0
DETQLM	1704	2111	0	0	0	0	0	1606	0	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	0	0	0	0	0	0	0	0
MFWKCE	1736	2128	0	0	0	0	0	5500	0	0	0	0	0
MFWKBL	1752	2129	0	0	0	0	0	791	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	1556	0	0	0	0	0
PHDLY2	1757	2134	0	0	0	0	0	20494	0	0	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	45	45	85	135	245	365	85	245	245	365	25

Symbol	FS15*i*	FS16*i*,etc	L600A1 /4*i*s	L900A1 /4*i*s	L6000B2 /4*i*s	L9000B2 /2*i*s	L9000B2 /4*i*s	L15000C2 /2*i*s
	Motor specification		442-B200	443-B200	(160A)	(160A)	(360A)	(360A)
	Motor ID No.		125	126	127	128	129	130
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000100	00000100	00000100
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000110	00001010	00001010
	1708	2014	00000000	00000000	00000000	00000110	00001010	00001010
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000100
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000
	2713	2300	10000000	10000000	10000000	10000000	10000000	10000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	717	390	1751	6198	7416	2130
PK2	1853	2041	-3333	-2009	-6701	-19692	-17747	-8400
PK3	1854	2042	-2618	-2618	-2660	-2660	-2660	-2663
PK1V	1855	2043	9	13	15	12	10	7
PK2V	1856	2044	-122	-179	-202	-158	-141	-87
PK3V	1857	2045	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-9339	-6367	-5642	-7199	-8099	-13022
BLCMP	1860	2048	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0
PVPA	1869	2057	0	0	0	0	0	0
PALPH	1870	2058	0	0	0	0	0	0
PPBAS	1871	2059	0	0	0	0	0	0
TQLIM	1872	2060	6554	7282	7282	5917	4855	4855
EMFLMT	1873	2061	120	120	120	120	120	120
POVC1	1877	2062	32747	32720	32706	32713	32737	32743
POVC2	1878	2063	268	602	777	687	388	313
TGALMLV	1892	2064	4	4	4	4	4	4
POVCLMT	1893	2065	793	1784	2304	2038	1151	927
PK2VAUX	1894	2066	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0
AALPH	1967	2074	0	0	0	0	0	0
OSCTPL	1970	2077	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0
RTCURR	1979	2086	655	983	1117	1050	789	708
TDPLD	1980	2087	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0
TRQCST	1998	2105	104	104	966	1823	2051	4656
LP24PA	1999	2106	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	0	0	0
DETQLM	1704	2111	0	0	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	0	0	0
MFWKCE	1736	2128	0	0	0	0	0	0
MFWKBL	1752	2129	0	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0
PHDLY2	1757	2134	0	0	0	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0
POVCLMT2	1787	2164	0	0	0	0	0	0
MAXCRT	1788	2165	45	45	165	165	365	365

		Motor model	βiS2 4000HV	αiF1 5000	βiS2 4000	βiS2/4000 SVSP40A	αiF2 5000	βiS4 4000	βiS4/4000 SVSP40A	βiS8 3000	βiS8/3000 SVSP40A	αiS2 5000	αiS2 5000HV
		Motor specification	0062	0202	0061	0061	0205	0063	0063	0075	0075	0212	0213
		Motor ID No.	151	152	153	154	155	156	157	158	159	162	163
Symbol	FS15*i*	FS16*i*,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00100000	00000000	00100000	00100000	00100000	00000000	00000000	00000000	00000000	00000000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000100	00000000	00000100	00010000	00000000	00000000	00001110	00000000	00001110	00000000	00000000
	1708	2014	00000100	00000000	00000100	00010000	00000000	00000000	00001110	00000000	00001110	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000010	00000010	00000010	00000010	00000010	00001110	00001110	00001110	00001110	00000010	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	225	672	280	560	680	288	576	450	900	600	420
PK2	1853	2041	−1100	−2294	−1080	−2160	−2247	−960	−1920	−1840	−3680	−1900	−1369
PK3	1854	2042	−2467	−2514	−1112	−1112	−2568	−1144	−1144	−1234	−1234	−2504	−2504
PK1V	1855	2043	78	66	78	39	76	112	56	164	82	39	39
PK2V	1856	2044	−700	−594	−698	−349	−680	−1008	−504	−1476	−738	−350	−351
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235
POA1	1859	2047	−1085	6384	−1089	−2178	5578	−753	−1506	5143	−1029	10853	−1081
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	−30	0	0	−30	−20	0	−30	0	−30	0
PVPA	1869	2057	−10250	0	−10250	−10245	−10256	−7700	−7690	−5144	−5133	−10250	−10254
PALPH	1870	2058	−1000	0	−1000	−500	−3300	−2240	−1120	−2700	−1350	−2000	−2300
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	6554	7282	6554	3277	7282	7282	3641	7282	3641	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32538	32613	32531	32531	32497	32289	32289	32289	32289	32528	32532
POVC2	1878	2063	2879	1933	2963	2963	3390	5988	5988	5994	5994	3005	2953
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	8560	5739	8811	2203	10085	17873	4468	17889	4472	8936	8782
PK2VAUX	1894	2066	−10	0	−10	−5	0	−10	−5	−10	−5	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	20480	0	20480	0	4096	20480	0	16384	0	8192	16384
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1507	1234	1529	764	1636	2178	1089	2780	1390	1540	1526
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	10000	0	15000	7500	12000	0	0	0	0	0	7500
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	119	72	119	238	109	146	292	226	452	117	117
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1050	32	1050	564	32	782	284	1805	794	40	40
DETQLM	1704	2111	11600	7710	11600	11600	6460	7790	7790	7930	7930	7745	7700
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	2345	1188	1172	1172	1276	796	796	1442	1442	1137	1137
MFWKCE	1736	2128	1000	570	3000	6000	855	1000	2000	3500	7000	1000	1250
MFWKBL	1752	2129	2574	3211	2574	2574	3211	3130	3130	1552	1552	3851	3847
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	7188	2571	7188	7188	2565	7691	7691	3852	3852	2565	7688
PHDLY2	1757	2134	8990	12850	8990	8990	12850	8976	8976	8990	8990	12825	12850
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32766	32767	32766	32766	32766	32765	32765	32762	32762	32766	32766
POVC22	1786	2163	19	13	20	20	23	42	42	74	74	20	20
POVCLMT	1787	2164	3617	2425	3723	931	4261	7551	1888	12305	3076	3776	3711
MAXCRT	1788	2165	10	25	25	45	25	25	45	25	45	25	10

Symbol	FS15*i*	FS16*i*,etc	βiS4 4000HV	αiS4 5000	αiS4 5000HV	βiS8 3000HV	βiS12 2000	βiS12 3000HV	αC4 3000*i*	βiS12 3000	αiF4 4000	βiS22 2000	αiF4 4000HV
		Motor model	βiS4 4000HV	αiS4 5000	αiS4 5000HV	βiS8 3000HV	βiS12 2000	βiS12 3000HV	αC4 3000*i*	βiS12 3000	αiF4 4000	βiS22 2000	αiF4 4000HV
		Motor specification	0064	0215	0216	0076	0077	0079	0221	0078	0223	0085	0225
		Motor ID No.	164	165	166	167	169	170	171	172	173	174	175
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00100000	00100000	00000000	00000000	00000000	00000000	00000000	00100000	00000000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001110	00000010	00000010	00001110	00001110	00001110	00001000	00001110	00000010	00001110	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	309	400	280	580	320	361	926	400	659	750	525
PK2	1853	2041	−1092	−1154	−988	−2070	−1958	−1521	−4063	−1550	−2463	−3280	−2056
PK3	1854	2042	−2496	−2553	−2533	−2600	−1246	−2604	−2619	−1243	−2623	−1296	−2619
PK1V	1855	2043	112	64	64	166	230	170	115	170	106	242	113
PK2V	1856	2044	−1010	−574	−574	−1482	−2054	−1524	−1034	−1530	−953	−2172	−1009
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235
POA1	1859	2047	−751	6614	−661	5118	3695	4978	3670	4960	3980	3496	3762
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	−5140	0	0	0	0	0	−30	−20	0	0
PVPA	1869	2057	−7700	−10262	−8978	−5144	−3884	−5140	−5915	−5140	−11789	−3616	0
PALPH	1870	2058	−3000	−3500	−4000	−3500	−4400	−3200	−1500	−2700	−180	−2800	0
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	8010	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32299	32289	32289	32301	32284	32435	32406	32205	32446	32106	32433
POVC2	1878	2063	5865	5994	5994	5842	6045	4164	4529	7041	4029	8275	4184
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	17504	17889	17889	17435	18045	12399	13493	21044	11998	24770	12461
PK2VAUX	1894	2066	−10	0	0	−10	−10	−10	0	−10	0	−10	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	8192	0	12288	12288	8192	20480	12288	16384	8192	12288	12288
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2155	2824	2824	2793	3126	2356	1892	2363	1784	2618	1888
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	8500	0	0	0	0	0	15000	0	15000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	146	127	127	225	315	420	190	418	201	692	190
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	777	24	32	1805	1	1814	1289	1814	32	0	1032
DETQLM	1704	2111	7790	10310	10290	7930	3940	7930	3900	7930	5130	2866	12388
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1592	646	500	2885	1350	2388	2544	1194	1443	2459	2573
MFWKCE	1736	2128	1000	2500	3000	1500	4000	3000	5000	3000	2000	4500	4000
MFWKBL	1752	2129	3339	3847	5122	1552	280	2056	1812	2056	3338	562	3348
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	7686	2563	7692	3848	1832	5133	3855	5133	6670	3089	6670
PHDLY2	1757	2134	8976	12820	12850	8990	8980	8978	8995	8978	8980	8982	8980
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32765	32762	32762	32762	32760	32764	32766	32764	32766	32763	32766
POVC22	1786	2163	41	77	77	75	99	50	31	51	27	64	31
POVCLMT	1787	2164	7395	12702	12702	12424	15559	8836	5701	8891	5069	10913	5676
MAXCRT	1788	2165	10	25	10	10	25	25	25	45	45	45	25

		Motor model	αC8 2000*i*	α*i*F8 3000	β*i*S22 2000HV	α*i*F8 3000HV	β*i*S0.5 6000	β*i*S1 6000	β*i*S8/3000 FS0*i*	α*i*S8 4000	α*i*S8 4000HV	α*i*S12 4000	α*i*S12 4000HV
		Motor specification	0226	0227	0086	0229	0115	0116	0075-Bxx6	0235	0236	0238	0239
		Motor ID No.	176	177	178	179	181	182	183	185	186	188	189
Symbol	FS15*i*	FS16*i*,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00100000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001010	00001010	00001110	00000000	00000010	00000010	00001110	00001010	00001010	00001010	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1096	712	1025	886	141	398	450	544	694	657	783
PK2	1853	2041	-4638	-3187	-4010	-3174	-511	-1137	-1840	-2352	-2700	-2522	-3006
PK3	1854	2042	-2651	-2651	-2665	-2645	-2415	-2388	-1234	-2616	-2636	-2639	-2666
PK1V	1855	2043	150	113	244	113	7	6	164	33	34	52	52
PK2V	1856	2044	-1342	-1009	-2182	-1008	-59	-53	-1476	-294	-306	-466	-470
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	2827	3760	3478	3764	-6462	-7176	5143	-1289	-1240	-815	-808
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	-12850	-12850	-30	0	0	0	-20
PVPA	1869	2057	-3854	-6418	-3616	-6159	0	-11530	-5144	-7691	-7690	-5904	-5904
PALPH	1870	2058	-1236	-3000	-2800	-1261	0	-1000	-2700	-2000	-2000	-2400	-3000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	8010	7282	8010	6918	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32289	32383	32433	32433	32674	32695	32381	32609	32596	32534	32530
POVC2	1878	2063	5994	4807	4185	4184	1178	915	4835	1993	2153	2923	2976
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	17889	14327	12462	12461	3497	2714	14410	5920	6396	8692	8848
PK2VAUX	1894	2066	0	0	-10	0	0	0	-10	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	8192	12288	12288	16384	20480	20480	16384	8192	8192	4096	8192
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2593	1950	2611	1948	1376	1212	2780	1253	1302	1518	1532
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	15000	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	277	369	689	369	42	89	226	562	541	696	690
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1552	786	0	782	30	30	1805	519	519	521	521
DETQLM	1704	2111	3880	5180	2866	0	10290	10290	7930	7780	7268	5170	6159
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	2380	2103	5149	4191	1009	1763	1442	2106	5103	1592	4904
MFWKCE	1736	2128	4500	1500	2500	6000	0	0	3500	4000	4500	3000	2000
MFWKBL	1752	2129	1550	1815	562	1810	0	0	1552	2580	2580	2570	2575
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	3860	5140	3089	0	7690	11560	3852	5652	5150	5135	6174
PHDLY2	1757	2134	8990	8985	8982	0	12820	12880	8990	8990	8990	9000	8990
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32763	32765	32763	32765	32767	32767	32764	32767	32767	32766	32766
POVC22	1786	2163	63	33	64	33	16	12	51	13	14	19	20
POVCLMT	1787	2164	10709	6053	10854	6042	3015	2340	8896	2501	2702	3672	3738
MAXCRT	1788	2165	25	45	25	25	25	25	25	85	45	85	45

Symbol	FS15*i*	FS16*i*,etc	αC12 2000*i*	α*i*F12 3000	β*i*S8/3000 FS0*i*_40A	α*i*F12 3000HV	αC22 2000*i*	α*i*F22 3000	β*i*S12/2000 FS0*i*	α*i*F22 3000HV	αC30 1500*i*	β*i*S22/1500 FS0*i*	α*i*F30 3000
		Motor specification	0241	0243	0075-Bxx6	0245	0246	0247	0077-Bxx6	0249	0251	0084-Bxx6	0253
		Motor ID No.	191	193	194	195	196	197	198	199	201	202	203
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00100000	00100000	00000000	00100000	00000000	00100000	00000000	00100000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00001110	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00001110	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000010	00000000	00001110	00000000	00001010	00000000	00001110	00000000	00001010	00001110	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	3809	1072	900	1044	1755	1458	320	1532	2644	1048	597
PK2	1853	2041	-8197	-3835	-3680	-3677	-6536	-5416	-1958	-5641	-10345	-4337	-2334
PK3	1854	2042	-2679	-2630	-1234	-2679	-2694	-2690	-1246	-2692	-2695	-2659	-2694
PK1V	1855	2043	280	192	82	193	271	198	230	197	166	280	230
PK2V	1856	2044	-2504	-1721	-738	-1727	-2426	-1775	-2054	-1765	-1486	-2507	-2057
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	1516	2204	-1029	2197	1565	2137	3695	2150	2553	3027	1845
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	-5140	0	-20	0	-2590	0	0	0	0	0
PVPA	1869	2057	-1804	-8199	-5133	-8214	-2597	-5136	-3884	-4392	-1545	-2110	-5170
PALPH	1870	2058	-2500	-747	-1350	-2350	-1942	-2800	-4400	-2824	-1300	-4691	-1000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	3641	7282	8010	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32289	32520	32671	32548	32114	32520	32323	32548	32520	32319	32511
POVC2	1878	2063	5994	3101	1214	2755	8171	3101	5566	2755	3101	5617	3215
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	17889	9224	3603	8192	24454	9224	16603	8192	9224	16756	9565
PK2VAUX	1894	2066	0	0	-5	0	0	0	-10	0	0	-10	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	8192	8192	0	12288	8192	8192	8192	8192	8192	8192	8192
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	3020	2085	1390	2092	2911	2131	3126	2118	1655	3012	2306
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	15000	15000	0	15000	0	15000	0	15000	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	350	517	452	516	680	929	315	934	1630	597	1170
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	32	794	774	1548	1291	1	787	2059	1025	1032
DETQLM	1704	2111	2168	0	7930	0	2600	0	3940	0	2148	2248	7735
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	4150	2388	1442	4787	3695	3272	1350	6547	6680	3290	1688
MFWKCE	1736	2128	12000	2000	7000	4000	4000	4500	4000	6000	14000	5500	2500
MFWKBL	1752	2129	1044	2568	1552	2320	1046	1301	280	1808	539	1032	2829
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	5150	0	3852	0	2070	0	1832	0	1054	2580	5140
PHDLY2	1757	2134	8990	0	8990	0	9000	0	8980	0	9000	8990	8995
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	140
POVC21	1785	2162	32761	32765	32767	32765	32761	32765	32763	32765	32766	32763	32764
POVC22	1786	2163	91	38	12	39	83	40	60	40	23	60	48
POVCLMT	1787	2164	14518	6924	2224	6969	13493	7229	10250	7142	4361	10345	8466
MAXCRT	1788	2165	25	85	45	45	45	85	25	45	85	25	165

		Motor model	βiS22/1500 FS0i 40A	βiS2/4000 FS0i	αiF40 3000	αiF40 3000Fan	βiS2/4000 FS0i_40A	βiS4/4000 FS0i	βiS4/4000 FS0i_40A	αiS22 4000	αiS22 4000HV	αiS30 4000	αiS30 4000HV
		Motor specification	0084-Bxx6	0061-Bxx6	0257	0257	0061-Bxx6	0063-Bxx6	0063-Bxx6	0265	0266	0268	0269
		Motor ID No.	205	206	207	208	210	211	212	215	216	218	219
Symbol	FS15i	FS16i,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00100000	00100000	00100000	00100000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000100	00000000	00000000	00010000	00000000	00001110	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000100	00000000	00000000	00010000	00000000	00001110	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001110	00000010	00000010	00000010	00000010	00001110	00001110	00001010	00001010	00001010	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	4342	280	1289	1289	560	288	576	714	709	689	816
PK2	1853	2041	-11170	-1080	-5048	-5048	-2160	-960	-1920	-2904	-2806	-2675	-3277
PK3	1854	2042	-1329	-1112	-2696	-2696	-1112	-1144	-1144	-2674	-1345	-2683	-2696
PK1V	1855	2043	140	78	191	191	39	112	56	69	76	82	82
PK2V	1856	2044	-1254	-698	-1712	-1712	-349	-1008	-504	-616	-685	-733	-738
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	6054	-1089	2216	2216	-2178	-753	-1506	6163	5538	5175	5143
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	-20	0	0	0	0	0
PVPA	1869	2057	-2079	-10250	-2570	-2570	-10245	-7700	-7690	-7689	-7684	-6415	-6415
PALPH	1870	2058	-2342	-1000	-2000	-2000	-500	-2240	-1120	-2000	-1000	-3000	-3000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	3641	6554	7282	7282	3277	7282	3641	7282	7282	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32655	32652	32511	32431	32739	32532	32709	32511	32501	32511	32501
POVC2	1878	2063	1411	1455	3215	4212	364	2945	738	3215	3332	3215	3332
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	4189	4317	9565	12545	1079	8758	2189	9565	9912	9565	9912
PK2VAUX	1894	2066	-10	-10	0	0	-5	-10	-5	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	20480	8192	8192	0	20480	0	4096	8192	4096	4096
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1506	1529	1957	2593	764	2178	1089	1627	1810	1836	1847
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	15000	15000	15000	7500	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1194	119	1839	1839	238	146	292	1216	1093	1470	1460
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	514	1050	1291	1291	564	782	284	519	513	775	775
DETQLM	1704	2111	2248	11600	5140	5140	11600	7790	7790	6224	6194	6450	6430
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	3290	1172	3041	3041	1172	796	796	2041	4264	1871	5117
MFWKCE	1736	2128	11000	3000	2000	2000	6000	1000	2000	2500	2000	4000	3000
MFWKBL	1752	2129	1032	2574	1553	1553	2574	3130	3130	2580	3092	2574	2574
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	2580	7188	3087	3087	7188	7691	7691	5150	5150	5150	5150
PHDLY2	1757	2134	4382	8990	8990	8990	8990	8976	8976	8990	8990	8990	8990
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	120	140	140	120	120	120	140	0	140	0
POVC21	1785	2162	32767	32767	32765	32718	32767	32766	32767	32766	32766	32766	32766
POVC22	1786	2163	14	14	33	629	3	29	7	23	28	29	30
POVCLMT	1787	2164	2586	2665	6099	10707	666	5407	1352	4214	5218	5369	5432
MAXCRT	1788	2165	45	25	165	165	45	25	45	165	85	165	85

		Motor model	α*i*S40 4000	α*i*S40 4000HV	α*i*S50 3000	α*i*S50 3000Fan	α*i*S50 3000HVFan	α*i*S50 3000HV	α*i*S100 2500	α*i*S100 2500HV	α*i*S200 2500	α*i*S200 2500HV	α*i*S300 2000HV
		Motor specification	0272	0273	0275	0275	0276	0276	0285	0286	0288	0289	0293
		Motor ID No.	222	223	224	225	226	227	235	236	238	239	243
Symbol	FS15*i*	FS16*i*,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	01000110	01000110	00000110	00000110	00000110	00000110	01000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00100000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001010	00001010	00001010	00001010	00001010	00001010	00001010	00000000	00001010	00001010	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	748	860	528	528	680	680	874	980	1309	1194	1077
PK2	1853	2041	−3055	−3457	−2088	−2088	−2961	−2961	−4483	−4082	−5199	−5535	−5101
PK3	1854	2042	−2682	−2700	−2690	−2690	−2697	−2697	−2717	−2718	−2719	−2719	−2712
PK1V	1855	2043	92	93	69	69	70	70	91	91	115	115	114
PK2V	1856	2044	−827	−831	−622	−622	−628	−628	−819	−819	−1026	−1026	−1025
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235
POA1	1859	2047	4589	4569	6099	6099	6039	6039	4632	4636	3699	3699	3703
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	31979	31979	31979	31979	21	21	21	21	21
PDDP	1866	2054	1894	1894	3	3	3	3	1894	1894	1894	1894	3787
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	−5648	−5652	−5646	−5646	−5646	−5646	−4368	−3846	−3090	−3088	−3846
PALPH	1870	2058	−3000	−3600	−2000	−2000	−2000	−2000	−1359	−900	−2700	−3000	−900
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32511	32501	32558	32348	32371	32554	32310	32474	32309	32309	32391
POVC2	1878	2063	3215	3332	2627	5245	4967	2680	5728	3672	5734	5734	4714
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	9565	9912	7810	15639	14807	7968	15662	15982	27346	27346	23263
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	4096	4096	4096	4096	0	0	20480	12288	12288	12288	12288
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2073	2083	1439	2037	2057	1454	1960	2033	2712	2712	2483
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	10000	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1701	1693	3312	3312	3279	3279	4589	4423	5973	5973	10871
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	776	769	519	519	519	519	776	1291	1290	1291	1296
DETQLM	1704	2111	5682	5682	6174	6174	6174	6174	3787	0	0	3428	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1853	5230	2046	2046	4861	4861	3520	6952	3518	6729	7634
MFWKCE	1736	2128	4000	4000	6500	6500	2500	2500	6500	2000	4000	4000	5000
MFWKBL	1752	2129	2063	2063	2063	2063	2068	2068	1297	1549	1298	1551	1301
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	5150	5150	5150	5150	5140	5140	2570	0	2068	2575	2574
PHDLY2	1757	2134	8988	8988	8990	8990	9000	9000	8970	0	12820	8984	12814
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	140	0	0	0	0	0	106	140	140	140	140
POVC21	1785	2162	32765	32765	32754	32739	32738	32754	32750	32759	32745	32745	32738
POVC22	1786	2163	38	38	174	365	373	178	223	112	292	292	375
POVCLMT	1787	2164	6846	6908	3300	6608	6736	3366	6581	6752	13952	13952	13952
MAXCRT	1788	2165	165	85	365	365	185	185	365	185	365	185	365

		Motor model	αiS500 2000	αiS500 2000HV	αiS1000 2000HV
		Motor specification	0295	0296	0298
		Motor ID No.	245	246	248
Symbol	FS15*i*	FS16*i*,etc			
	1808	2003	00001000	00001000	00001000
	1809	2004	00000110	01000110	01000110
	1883	2005	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000
	1955	2011	00000000	00000000	00100000
	1956	2012	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000
	1751	2211	00001010	00001010	00000010
	2713	2300	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000
PK1	1852	2040	1943	1713	1053
PK2	1853	2041	−6970	−6505	−3316
PK3	1854	2042	−2711	−2713	−2722
PK1V	1855	2043	134	134	234
PK2V	1856	2044	−1199	−1199	−2096
PK3V	1857	2045	0	0	0
PK4V	1858	2046	−8235	−8235	−8235
POA1	1859	2047	3164	3164	1811
BLCMP	1860	2048	0	0	0
DPFMX	1861	2049	0	0	0
POK1	1862	2050	956	956	956
POK2	1863	2051	510	510	510
RESERV	1864	2052	0	0	0
PPMAX	1865	2053	21	21	21
PDDP	1866	2054	1894	3787	3787
PHYST	1867	2055	319	319	319
EMFCMP	1868	2056	0	0	0
PVPA	1869	2057	−2068	−2070	−3097
PALPH	1870	2058	−2600	−2700	−2000
PPBAS	1871	2059	0	0	0
TQLIM	1872	2060	7282	7282	7282
EMFLMT	1873	2061	0	0	0
POVC1	1877	2062	32309	32309	32309
POVC2	1878	2063	5734	5734	5734
TGALMLV	1892	2064	4	4	4
POVCLMT	1893	2065	27346	27346	27346
PK2VAUX	1894	2066	0	0	0
FILTER	1895	2067	0	0	0
FALPH	1961	2068	0	0	0
VFFLT	1962	2069	0	0	0
ERBLM	1963	2070	0	0	0
PBLCT	1964	2071	0	0	0
SFCCML	1965	2072	0	0	0
PSPTL	1966	2073	0	0	0
AALPH	1967	2074	12288	12288	12288
OSCTPL	1970	2077	0	0	0
PDPCH	1971	2078	0	0	0
PDPCL	1972	2079	0	0	0
DPFEX	1973	2080	0	0	0
DPFZW	1974	2081	0	0	0
BLENDL	1975	2082	0	0	0
MOFCTL	1976	2083	0	0	0
RTCURR	1979	2086	2980	2980	2834
TDPLD	1980	2087	0	0	0
MCNFB	1981	2088	0	0	0
BLBSL	1982	2089	0	0	0
ROBSTL	1983	2090	0	0	0
ACCSPL	1984	2091	0	0	0
ADFF1	1985	2092	0	0	0
VMPK3V	1986	2093	0	0	0
BLCMP2	1987	2094	0	0	0
AHDRTL	1988	2095	0	0	0
RADUSL	1989	2096	0	0	0
SMCNT	1990	2097	0	0	0
DEPVPL	1991	2098	0	0	0
ONEPSL	1992	2099	400	400	400
INPA1	1993	2100	0	0	0
INPA2	1994	2101	0	0	0
DBLIM	1995	2102	0	0	15000
ABVOF	1996	2103	0	0	0
ABTSH	1997	2104	0	0	0
TRQCST	1998	2105	15096	15096	28573
LP24PA	1999	2106	0	0	0
VLGOVR	1700	2107	0	0	0
RESERV	1701	2108	0	0	0
BELLTC	1702	2109	0	0	0
MGSTCM	1703	2110	1296	1293	1296
DETQLM	1704	2111	0	3714	3172
AMRDML	1705	2112	0	0	0
NFILT	1706	2113	0	0	0
NINTCT	1735	2127	4175	8341	8637
MFWKCE	1736	2128	4000	4500	6000
MFWKBL	1752	2129	1041	788	1047
LP2GP	1753	2130	0	0	0
LP4GP	1754	2131	0	0	0
LP6GP	1755	2132	0	0	0
PHDLY1	1756	2133	2069	2324	2580
PHDLY2	1757	2134	8981	8984	8985
DGCSMM	1782	2159	0	0	0
TRQCUP	1783	2160	0	0	0
OVCSTP	1784	2161	140	140	140
POVC21	1785	2162	32745	32745	32745
POVC22	1786	2163	292	292	292
POVCLMT	1787	2164	13952	13952	13952
MAXCRT	1788	2165	365	365	365

6.2 PARAMETERS FOR HRV2 CONTROL

December, 2005

Series 90B0
Series 90B1
Series 90B6 and 90B5
Series 90D0 and 90E0

		Motor model	βiS2 4000HV	αiF1 5000	βiS2 4000	βiS2/4000 SVSP40A	αiF2 5000	βiS4 4000	βiS4/4000 SVSP40A	βiS8 3000	βiS8/3000 SVSP40A	βiS0.2 5000	βiS0.3 5000
		Motor specification	0062	0202	0061	0061	0205	0063	0063	0075	0075	0111	0112
		Motor ID No.	251	252	253	254	255	256	257	258	259	260	261
Symbol	FS15i	FS30,16i,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000100	00000000	00000100	00010000	00000000	00000000	00001110	00000000	00001110	00000000	00000000
	1708	2014	00000100	00000000	00000100	00010000	00000000	00000000	00001110	00000000	00001110	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001110	00001010	00001110	00001110	00001010	00001110	00001110	00001110	00001110	00000010	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	348	620	360	720	760	400	800	650	1160	123	210
PK2	1853	2041	-1676	-3034	-1920	-3840	-3743	-1920	-3840	-3831	-5600	-510	-970
PK3	1854	2042	-1232	-1256	-1237	-1237	-1283	-1253	-1253	-1299	-1299	-1069	-1146
PK1V	1855	2043	78	66	78	39	76	112	56	164	82	4	4
PK2V	1856	2044	-700	-594	-698	-349	-680	-1008	-504	-1476	-738	-36	-33
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-1085	6384	-1089	-2178	5578	-753	-1506	5143	-1029	-10638	-11550
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	-5130	0	0	-10	0	0	-2570	0	0	0
PVPA	1869	2057	-10250	0	-10250	-10245	-12298	-7694	-7687	-5140	-5131	0	0
PALPH	1870	2058	-1000	0	-1000	-500	-1275	-2800	-1400	-3200	-1600	0	0
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	6554	7282	6554	3277	7282	7282	3641	7282	3641	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32538	32613	32531	32531	32497	32289	32289	32289	32289	32725	32725
POVC2	1878	2063	2879	1933	2963	2963	3390	5988	5988	5994	5994	533	533
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	8560	5739	8811	2203	10085	17873	4468	17889	4472	3163	3163
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	20480	20480	16384	0	12288	20480	0	16384	0	20480	20480
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1507	1234	1529	764	1636	2178	1089	2780	1390	1929	1929
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	119	72	119	238	109	146	292	226	452	7	14
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1048	32	1048	815	32	780	532	1807	1045	1	1
DETQLM	1704	2111	11600	10260	11600	11600	10280	7790	7790	7930	7930	7710	7700
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	2345	1188	1172	1172	1276	796	796	1442	1442	379	852
MFWKCE	1736	2128	1000	1667	2500	5000	2000	3000	6000	3500	7000	0	3000
MFWKBL	1752	2129	3358	3858	3358	3358	3862	3392	3392	1298	1298	0	3880
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	7192	7690	7192	7192	7693	8992	8992	3858	3858	7700	7695
PHDLY2	1757	2134	8990	12840	8990	8990	12840	12864	9024	8990	8990	12825	12840
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32766	32767	32766	32766	32766	32765	32765	32762	32762	0	0
POVC22	1786	2163	19	13	20	20	23	42	42	74	74	0	0
POVCLMT	1787	2164	3617	2425	3723	931	4261	7551	1888	12305	3076	0	0
MAXCRT	1788	2165	10	25	25	45	25	25	45	25	45	4	4

Symbol	FS15*i*	FS30,16*i*,etc	α*i*S2 5000	α*i*S2 5000HV	β*i*S4 4000HV	α*i*S4 5000	α*i*S4 5000HV	β*i*S8 3000HV	β*i*S12 2000	β*i*S12 3000HV	αC4 3000*i*	β*i*S12 3000	α*i*F4 4000
		Motor specification	0212	0213	0064	0215	0216	0076	0077	0079	0221	0078	0223
		Motor ID No.	262	263	264	265	266	267	269	270	271	272	273
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001010	00001010	00001110	00001010	00001010	00001110	00001110	00001110	00001010	00001110	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	530	400	331	420	425	605	547	427	1240	402	993
PK2	1853	2041	−2543	−2312	−1560	−1748	−1641	−3028	−3289	−2301	−6415	−2217	−4260
PK3	1854	2042	−1251	−1251	−1246	−1276	−1266	−1300	−1305	−1302	−1309	−1304	−1311
PK1V	1855	2043	39	39	112	64	64	166	230	170	115	170	106
PK2V	1856	2044	−350	−351	−1010	−574	−574	−1482	−2054	−1524	−1034	−1530	−953
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235
POA1	1859	2047	10853	−1081	−751	−661	−661	5118	3695	4978	3670	4960	3980
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	−5130
PVPA	1869	2057	−10250	−10252	−7694	−8974	−10262	−5140	−3884	−5140	−5915	−5140	−11789
PALPH	1870	2058	−2000	−1600	−2800	−3641	−3300	−3200	−4350	−3500	−1500	−3500	−180
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282	8010
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32528	32532	32299	32289	32289	32301	32284	32435	32406	32205	32446
POVC2	1878	2063	3005	2953	5865	5994	5994	5842	6045	4164	4529	7041	4029
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	8936	8782	17504	17889	17889	17435	18045	12399	13493	21044	11998
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	20480	16384	20480	12288	8192	20480	8192	20480	12288	16384	8192
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1540	1526	2155	2824	2824	2793	3126	2356	1892	2363	1784
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	0	0	0	15000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	117	117	146	127	127	225	315	420	190	418	201
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	32	40	780	8	40	1807	1	1814	1289	1814	32
DETQLM	1704	2111	8995	10260	7790	10295	10260	7930	3940	7930	3900	7930	5130
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1137	4548	1592	646	1293	2885	1350	2388	2544	1194	1443
MFWKCE	1736	2128	1000	1250	500	1667	3000	1000	4000	3000	5000	3000	2000
MFWKBL	1752	2129	3851	3847	3339	3847	5122	1298	280	2056	1812	2056	3338
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	7690	7690	8972	7690	7685	3848	3614	5138	3855	5138	6670
PHDLY2	1757	2134	12840	12850	12816	12840	12850	8990	8980	6430	8995	8990	8980
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32766	32766	32765	32762	32762	32762	32760	32764	32766	32764	32766
POVC22	1786	2163	20	20	41	77	77	75	99	50	31	51	27
POVCLMT	1787	2164	3776	3711	7395	12702	12702	12424	15559	8836	5701	8891	5069
MAXCRT	1788	2165	25	10	10	25	10	10	25	25	25	45	45

Symbol	FS15*i*	FS30,16*i*,etc	βiS22	αiF4	αC8	αiF8	βiS22	αiF8	βiS0.4	βiS0.5	βiS1	βiS8/3000	αiS2
		Motor model	2000	4000HV	2000*i*	3000	2000HV	3000HV	5000	6000	6000	FS0*i*	6000
		Motor specification	0085	0225	0226	0227	0086	0229	0114	0115	0116	0075-Bxx67	0218
		Motor ID No.	274	275	276	277	278	279	280	281	282	283	284
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00100000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001110	00001010	00001010	00000000	00001110	00001010	00000010	00001010	00001010	00001110	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1184	570	1276	787	1446	1222	100	138	312	650	552
PK2	1853	2041	-6800	-3578	-6288	-4184	-5822	-5890	-430	-673	-1360	-3831	-2288
PK3	1854	2042	-1331	-1309	-1326	-1325	-1332	-1322	-2463	-1205	-1203	-1299	-1252
PK1V	1855	2043	242	113	150	113	244	113	7	7	6	164	48
PK2V	1856	2044	-2172	-1009	-1342	-1009	-2182	-1008	-61	-59	-53	-1476	-429
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	3496	3762	2827	3760	3478	3764	-6249	-6462	-7176	5143	-884
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	-5130	0	0	0	0	0	-12850	-12850	-12850	-2570	0
PVPA	1869	2057	-3612	0	-3854	-6420	-3612	-6159	0	0	-15420	-5140	-13062
PALPH	1870	2058	-3000	0	-1236	-2000	-3000	-1261	0	0	-1000	-3200	-1000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	8010	7282	8010	5826	7282	7282	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32106	32433	32289	32383	32433	32433	32640	32674	32695	32381	32415
POVC2	1878	2063	8275	4184	5994	4807	4185	4184	1603	1178	915	4835	4413
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	24770	12461	17889	14327	12462	12461	4759	3497	2714	14410	13146
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	16384	12288	8192	8192	8192	12288	20480	20480	20480	16384	20480
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2618	1888	2593	1950	2611	1948	1605	1376	1212	2780	1868
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	15000	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	692	190	277	369	689	369	22	42	89	226	96
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	1032	1552	776	0	782	30	25	1556	1807	1555
DETQLM	1704	2111	2866	0	3880	3870	2866	0	10290	10290	10290	7930	11550
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	2459	2573	2380	2103	5149	4191	400	504	881	1442	1137
MFWKCE	1736	2128	5000	4000	4500	3500	3000	6000	0	0	1500	3500	3000
MFWKBL	1752	2129	562	3348	1550	1815	562	1810	0	0	5135	1298	4112
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	3350	5130	3860	0	3352	5150	7690	7690	15400	3858	7690
PHDLY2	1757	2134	8979	8990	8990	0	8989	8990	12820	12820	12840	8990	7740
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32763	32766	32763	32765	32763	32765	32766	32767	32767	32764	32766
POVC22	1786	2163	64	31	63	33	64	33	22	16	12	51	30
POVCLMT	1787	2164	10913	5676	10709	6053	10854	6042	4104	3015	2340	8896	5554
MAXCRT	1788	2165	45	25	25	45	25	25	25	25	25	25	25

Symbol	FS15*i*	FS30,16*i*,etc	α*i*S8 4000	α*i*S8 4000HV	α*i*S2 6000HV	α*i*S12 4000	α*i*S12 4000HV	α*i*S8 6000	αC12 2000*i*	α*i*S8 6000HV	α*i*F12 3000	β*i*S8/3000 FS0*i*_40A	α*i*F12 3000HV
		Motor specification	0235	0236	0219	0238	0239	0232	0241	0233	0243	0075-Bxx6	0245
		Motor ID No.	285	286	287	288	289	290	291	292	293	294	295
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00100000	00000000	00100000	00000000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001110	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001110	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001010	00001010	00001010	00001010	00001010	00001010	00000010	00001010	00000000	00001110	00000000
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	550	694	497	570	783	460	1875	381	1701	1160	1200
PK2	1853	2041	-3449	-3858	-2371	-3358	-4294	-1760	-9137	-1749	-6391	-5600	-6059
PK3	1854	2042	-1307	-1318	-1249	-1319	-1333	-1305	-1339	-1305	-1315	-1299	-1339
PK1V	1855	2043	33	34	48	52	52	53	280	53	192	82	193
PK2V	1856	2044	-294	-306	-429	-466	-470	-478	-2504	-478	-1721	-738	-1727
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-1289	-1240	-884	-815	-808	-794	1516	-794	2204	-1029	2197
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	-12850	0	-12850	0	0	0
PVPA	1869	2057	-7685	-7685	-13062	-5898	-5898	-16398	-1804	-16398	-8199	-5131	-8203
PALPH	1870	2058	-2000	-2000	-1200	-3000	-3000	-1000	-2500	-1000	-747	-1600	-1178
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	3641	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32609	32596	32416	32534	32530	32520	32289	32548	32520	32671	32548
POVC2	1878	2063	1993	2153	4405	2923	2976	3101	5994	2755	3101	1214	2755
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	5920	6396	13123	8692	8848	9224	17889	8192	9224	3603	8192
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	8192	20480	0	8192	8192	8192	8192	8192	0	12288
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1253	1302	1866	1518	1532	2075	3020	2075	2085	1390	2092
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	15000	0	15000	0	15000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	562	541	96	696	690	346	350	346	517	452	516
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	519	519	1555	521	521	1284	0	1284	32	1045	774
DETQLM	1704	2111	7268	7268	11550	6174	6159	10255	2168	10255	0	7930	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	2106	5103	2302	1592	4904	801	4150	1600	2388	1442	4787
MFWKCE	1736	2128	4000	4500	2200	2000	2000	1000	12000	1400	2000	7000	4000
MFWKBL	1752	2129	2580	2580	4112	2575	2575	5388	1044	5390	2568	1298	2320
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	5150	5150	7690	6174	6174	10250	5150	10260	0	3858	0
PHDLY2	1757	2134	8990	8990	7740	8990	8990	12830	8990	12835	0	8990	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32767	32767	32766	32766	32766	32765	32761	32765	32765	32767	32765
POVC22	1786	2163	13	14	30	19	20	38	91	38	38	12	39
POVCLMT	1787	2164	2501	2702	5544	3672	3738	6857	14518	6857	6924	2224	6969
MAXCRT	1788	2165	85	45	10	85	45	85	25	45	85	45	45

		Motor model	αC22 2000i	αiF22 3000	βiS12/2000 FS0i	αiF22 3000HV	αC30 1500i	βiS22/1500 FS0i	αiF30 3000	βiS22/1500 FS0i_40A	βiS2/4000 FS0i	αiF40 3000	αiF40 3000Fan
		Motor specification	0246	0247	0077-Bxx6	0249	0251	0084-Bxx6	0253	0084-Bxx6	0061-Bxx6	0257	0257
		Motor ID No.	296	297	298	299	301	302	303	305	306	307	308
Symbol	FS15i	FS30,16i,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00100000	00000000	00100000	00000000	00000000	00000000	00000000	00000000	00100000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000100	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000100	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001010	00000000	00001110	00000000	00001010	00001110	00001010	00001110	00001110	00001010	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	2320	1750	547	1919	2238	2171	768	4342	360	1613	1613
PK2	1853	2041	-10593	-6000	-3289	-9132	-13330	-8178	-4492	-16356	-1920	-7446	-7446
PK3	1854	2042	-1347	-1345	-1305	-1346	-1347	-1329	-1347	-1329	-1237	-1348	-1348
PK1V	1855	2043	271	198	230	197	166	280	230	140	78	191	191
PK2V	1856	2044	-2426	-1775	-2054	-1765	-1486	-2507	-2057	-1254	-698	-1712	-1712
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	1565	2137	3695	2150	2553	3027	1845	6054	-1089	2216	2216
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	-20500	0	0	0	0
PVPA	1869	2057	-2597	-5136	-3884	-5136	-1545	-2110	-8465	-2079	-10250	-2570	-2570
PALPH	1870	2058	-1942	-2800	-4350	-2824	-1300	-4691	-1657	-2342	-1000	-2000	-2000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	8010	7282	7282	7282	7282	7282	7282	3641	6554	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32114	32520	32323	32548	32520	32319	32511	32655	32652	32511	32431
POVC2	1878	2063	8171	3101	5566	2755	3101	5617	3215	1411	1455	3215	4212
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	24454	9224	16603	8192	9224	16756	9565	4189	4317	9565	12545
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	4096	12288	8192	8192	8192	8192	4096	0	16384	16384	16384
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2911	2131	3126	2118	1655	3012	2306	1506	1529	1957	2593
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	15000	0	15000	0	0	0	0	0	12000	12000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	680	929	315	934	1630	597	1170	1194	119	1839	1839
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	1548	1291	1	787	2059	1025	1032	514	1048	1291	1291
DETQLM	1704	2111	2600	0	3940	0	2148	2248	7735	2248	11600	5220	5140
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	3695	3272	1350	6547	6680	3290	1688	3290	1172	3041	3041
MFWKCE	1736	2128	4000	4500	4000	6000	14000	5500	2500	11000	2500	6000	2000
MFWKBL	1752	2129	1046	1301	280	1808	539	1032	2829	1032	3358	1560	1553
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	2070	0	3614	0	1054	2580	5140	2580	7192	2590	3085
PHDLY2	1757	2134	9000	0	8980	0	9000	8990	8995	4382	8990	8990	8990
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	140	0	120	140	140
POVC21	1785	2162	32761	32765	32763	32765	32766	32763	32764	32767	32767	32765	32718
POVC22	1786	2163	83	40	60	40	23	60	48	14	14	33	629
POVCLMT	1787	2164	13493	7229	10250	7142	4361	10345	8466	2586	2665	6099	10707
MAXCRT	1788	2165	45	85	25	45	85	25	165	45	25	165	165

		Motor model	β*i*S2/4000 FS0*i*_40A	β*i*S4/4000 FS0*i*	β*i*S4/4000 FS0*i*_40A	α*i*S22 4000	α*i*S22 4000HV	α*i*S30 4000	α*i*S30 4000HV	α*i*S40 4000	α*i*S40 4000HV	α*i*S50 3000	α*i*S50 3000Fan
		Motor specification	0061-Bxx6	0063-Bxx6	0063-Bxx6	0265	0266	0268	0269	0272	0273	0275	0275
		Motor ID No.	310	311	312	315	316	318	319	322	323	324	325
Symbol	FS15*i*	FS30,16*i*,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00010000	00000000	00001110	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00010000	00000000	00001110	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001110	00001110	00001110	00001010	00001010	00001010	00001010	00001010	00001010	00001010	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	720	400	800	581	709	799	816	712	860	547	547
PK2	1853	2041	-3840	-1920	-3840	-3844	-4008	-4447	-4681	-4138	-4938	-3423	-3423
PK3	1854	2042	-1237	-1253	-1253	-1337	-1345	-1317	-1348	-1341	-1350	-1345	-1345
PK1V	1855	2043	39	112	56	69	76	82	82	92	93	69	69
PK2V	1856	2044	-349	-1008	-504	-616	-685	-733	-738	-827	-831	-622	-622
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-2178	-753	-1506	6163	5538	5175	5143	4589	4569	6099	6099
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	31979	31979
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	3	3
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	-10245	-7694	-7687	-7687	-7683	-6412	-6412	-5645	-5648	-5638	-5638
PALPH	1870	2058	-500	-2800	-1400	-2000	-1000	-2300	-2300	-3000	-3000	-1000	-1000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	3277	7282	3641	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32739	32532	32709	32511	32501	32511	32501	32511	32501	32558	32348
POVC2	1878	2063	364	2945	738	3215	3332	3215	3332	3215	3332	2627	5245
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1079	8758	2189	9565	9912	9565	9912	9565	9912	7810	15639
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	20480	0	4096	8192	4096	4096	4096	4096	4096	4096
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	764	2178	1089	1627	1810	1836	1847	2073	2083	1439	2037
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	238	146	292	1216	1093	1470	1460	1701	1693	3312	3312
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	815	780	532	519	513	775	775	776	769	519	519
DETQLM	1704	2111	11600	7790	7790	6224	6194	6450	6430	5682	5682	6174	6174
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1172	796	796	2041	4264	1871	5117	1853	5230	2046	2046
MFWKCE	1736	2128	5000	3000	6000	2500	2000	4000	3000	4000	4000	6500	6500
MFWKBL	1752	2129	3358	3392	3392	2580	3092	2574	2574	2063	2063	2063	2063
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	7192	8992	8992	5150	5150	5150	5150	5150	5150	5150	5150
PHDLY2	1757	2134	8990	12864	9024	8990	8990	8990	8990	8988	8988	8990	8990
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	120	120	120	140	0	140	0	140	0	0	0
POVC21	1785	2162	32767	32766	32767	32766	32766	32766	32766	32765	32765	32754	32739
POVC22	1786	2163	3	29	7	23	28	29	30	38	38	174	365
POVCLMT	1787	2164	666	5407	1352	4214	5218	5369	5432	6846	6908	3300	6608
MAXCRT	1788	2165	45	25	45	165	85	165	85	165	85	365	365

Symbol	FS15*i*	Motor model / FS30,16*i*,etc	α*i*S50 3000HVFan	α*i*S50 3000HV	α*i*S100 2500	α*i*S100 2500HV	α*i*S200 2500	α*i*S200 2500HV	α*i*S2000 2000HV	α*i*S300 2000	α*i*S300 2000HV	α*i*S500 2000	α*i*S500 2000HV
		Motor specification	0276	0276	0285	0286	0288	0289	0290	0292	0293	0295	0296
		Motor ID No.	326	327	335	336	338	339	340	342	343	345	346
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	01000011	01000011	00000011	00000011	00000011	00000011	01000011	00000011	01000011	00000011	01000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00100000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000001	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00001010	00001010	00001010	00000000	00001010	00001010	00011110	00001010	00001010	00001010	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	705	705	1020	1790	1834	2080	643	1659	1327	2660	2255
PK2	1853	2041	−4855	−4855	−7093	−5915	−7805	−8139	−3600	−8045	−7279	−10235	−10049
PK3	1854	2042	−1348	−1348	−1359	−1359	−1360	−1359	−1358	−1354	−1356	−1355	−1356
PK1V	1855	2043	70	70	91	91	115	115	502	114	114	134	134
PK2V	1856	2044	−628	−628	−819	−819	−1026	−1026	−4500	−1025	−1025	−1199	−1199
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235	−8235
POA1	1859	2047	6039	6039	4632	4636	3699	3699	843	3709	3703	3164	3164
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	31979	31979	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	3	3	1894	1894	1894	1894	3787	1894	3787	1894	3787
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	−12825	0	0	0	0
PVPA	1869	2057	−5638	−5638	−4368	−3846	−3090	−3088	−2120	−3081	−3846	−2068	−2070
PALPH	1870	2058	−1000	−1000	−1359	−900	−2700	−3000	−2800	−700	−900	−2600	−2700
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	0	0	0	0
POVC1	1877	2062	32371	32554	32310	32474	32309	32309	32309	32391	32391	32309	32309
POVC2	1878	2063	4967	2680	5728	3672	5734	5734	5734	4714	4714	5734	5734
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	14807	7968	15662	15982	27346	27346	27346	23263	23263	27346	27346
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	0	20480	12288	12288	12288	12288	12288	12288	12288	12288
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2057	1454	1960	2033	2712	2712	2893	2386	2483	2980	2980
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	10000	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	3279	3279	4589	4423	5973	5973	6221	10871	10871	15096	15096
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	519	519	776	1291	1290	1291	2068	1296	1296	1296	1293
DETQLM	1704	2111	6174	6174	3787	0	0	3428	1430	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	4861	4861	3520	6952	3518	6729	3449	3817	7634	4175	8341
MFWKCE	1736	2128	2500	2500	6500	2000	4000	4000	4200	7000	5000	4000	4500
MFWKBL	1752	2129	2068	2068	1297	1549	1298	1551	1060	1301	1298	1041	788
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	5150	5150	2570	0	3092	2575	1297	2574	2574	2069	2324
PHDLY2	1757	2134	8990	8990	8970	0	12826	8984	12828	12814	12814	8981	8984
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	106	140	140	140	140	140	140	140	140
POVC21	1785	2162	32738	32754	32750	32759	32745	32745	32745	32738	32738	32745	32745
POVC22	1786	2163	373	178	223	112	292	292	292	375	375	292	292
POVCLMT	1787	2164	6736	3366	6581	6752	13952	13952	13952	13952	13952	13952	13952
MAXCRT	1788	2165	185	185	365	185	365	185	0	365	365	365	365

		Motor model	αiS1000 2000HV
		Motor specification	0298
		Motor ID No.	348
Symbol	FS15i	FS30,16i,etc	
	1808	2003	00001000
	1809	2004	01000011
	1883	2005	00000000
	1884	2006	00000000
	1951	2007	00000000
	1952	2008	00000000
	1953	2009	00000000
	1954	2010	00000000
	1955	2011	00000000
	1956	2012	00000000
	1707	2013	00000000
	1708	2014	00000000
	1750	2210	00000000
	1751	2211	00001010
	2713	2300	00000000
	2714	2301	00000000
PK1	1852	2040	840
PK2	1853	2041	-5329
PK3	1854	2042	-1361
PK1V	1855	2043	234
PK2V	1856	2044	-2096
PK3V	1857	2045	0
PK4V	1858	2046	-8235
POA1	1859	2047	1811
BLCMP	1860	2048	0
DPFMX	1861	2049	0
POK1	1862	2050	956
POK2	1863	2051	510
RESERV	1864	2052	0
PPMAX	1865	2053	21
PDDP	1866	2054	3787
PHYST	1867	2055	319
EMFCMP	1868	2056	0
PVPA	1869	2057	-2320
PALPH	1870	2058	-2500
PPBAS	1871	2059	0
TQLIM	1872	2060	7282
EMFLMT	1873	2061	0
POVC1	1877	2062	32309
POVC2	1878	2063	5734
TGALMLV	1892	2064	4
POVCLMT	1893	2065	27346
PK2VAUX	1894	2066	0
FILTER	1895	2067	0
FALPH	1961	2068	0
VFFLT	1962	2069	0
ERBLM	1963	2070	0
PBLCT	1964	2071	0
SFCCML	1965	2072	0
PSPTL	1966	2073	0
AALPH	1967	2074	12288
OSCTPL	1970	2077	0
PDPCH	1971	2078	0
PDPCL	1972	2079	0
DPFEX	1973	2080	0
DPFZW	1974	2081	0
BLENDL	1975	2082	0
MOFCTL	1976	2083	0
RTCURR	1979	2086	2834
TDPLD	1980	2087	0
MCNFB	1981	2088	0
BLBSL	1982	2089	0
ROBSTL	1983	2090	0
ACCSPL	1984	2091	0
ADFF1	1985	2092	0
VMPK3V	1986	2093	0
BLCMP2	1987	2094	0
AHDRTL	1988	2095	0
RADUSL	1989	2096	0
SMCNT	1990	2097	0
DEPVPL	1991	2098	0
ONEPSL	1992	2099	400
INPA1	1993	2100	0
INPA2	1994	2101	0
DBLIM	1995	2102	0
ABVOF	1996	2103	0
ABTSH	1997	2104	0
TRQCST	1998	2105	28573
LP24PA	1999	2106	0
VLGOVR	1700	2107	0
RESERV	1701	2108	0
BELLTC	1702	2109	0
MGSTCM	1703	2110	1296
DETQLM	1704	2111	3172
AMRDML	1705	2112	0
NFILT	1706	2113	0
NINTCT	1735	2127	8637
MFWKCE	1736	2128	6000
MFWKBL	1752	2129	1047
LP2GP	1753	2130	0
LP4GP	1754	2131	0
LP6GP	1755	2132	0
PHDLY1	1756	2133	2580
PHDLY2	1757	2134	8985
DGCSMM	1782	2159	0
TRQCUP	1783	2160	0
OVCSTP	1784	2161	140
POVC21	1785	2162	32745
POVC22	1786	2163	292
POVCLMT	1787	2164	13952
MAXCRT	1788	2165	365

		Motor model	L*i*s300A1/4 (200V)	L*i*s600A1/4 (200V)	L*i*s900A1/4 (200V)	L*i*s1500B1/4 (200V)	L*i*s1500B1/4 (400V)	L*i*s3000B2/2 (200V)	L*i*s3000B2/2 (400V)	L*i*s3000B2/4 (200V)	L*i*s4500B2 /2HV(400V)	L*i*s4500B2/2 (200V)	L*i*s4500B2/2 (400V)
		Motor specification	0441-B200	0442-B200	0443-B200	0444-B210	0444-B210	0445-B110	0445-B110	0445-B210	0446-B010	0446-B110	0446-B110
		Motor ID No.	351	353	355	357	358	360	361	362	363	364	365
Symbol	FS15*i*	FS30,16*i*,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00000000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1751	2211	00000000	00000000	00000000	00000000	00001000	00000000	00001000	00000000	00001000	00001000	00001000
	2713	2300	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1968	1868	1594	1512	409	961	602	324	2590	2834	802
PK2	1853	2041	-7138	-6536	-6162	-11488	-2068	-5781	-3127	-4472	-6505	-10862	-4726
PK3	1854	2042	-2618	-2618	-2618	-2647	-2689	-2667	-1330	-2660	-2697	-2696	-2696
PK1V	1855	2043	16	9	13	19	19	14	14	16	11	10	10
PK2V	1856	2044	-217	-122	-179	-260	-260	-194	-194	-214	-149	-131	-131
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-8755	-9339	-6367	-4371	-4371	-5866	-5866	-5321	-7658	-8705	-8705
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	-6400	-6400	-6400	0	0	0	0	0	0	0	0
PVPA	1869	2057	0	0	0	0	0	0	0	0	0	0	0
PALPH	1870	2058	0	0	0	0	0	0	0	0	0	0	0
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	5826	6554	7282	7282	7282	7282	7282	7282	6554	5462	5462
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32704	32704	32705	32698	32698	32711	32711	32698	32714	32707	32707
POVC2	1878	2063	802	802	785	873	873	719	719	873	681	758	758
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	793	793	1784	2590	2590	2131	2131	2590	1549	1199	1199
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	-24576	-8192	28672	0	0	0	20480	0	20480	20480	0
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	655	655	983	1184	1184	1074	1074	1184	915	805	805
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	68	137	137	227	227	502	502	455	884	1005	1005
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	0	0	0	0	0	0	0	0
DETQLM	1704	2111	0	0	0	0	0	0	0	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	0	0	0	0	0	0	0	0
MFWKCE	1736	2128	0	0	0	0	0	0	0	0	0	0	0
MFWKBL	1752	2129	0	0	0	0	0	0	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	0	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	25	45	45	45	45	45	45	85	45	85	85

		Motor model	L*is*6000B2 /2HV(400V)	L*is*6000B2/2 (200V)	L*is*6000B2/2 (400V)	L*is*6000B2/4 (200V)	L*is*7500B2 /2HV(400V)	L*is*7500B2/2 (200V)	L*is*7500B2/2 (400V)	L*is*7500B2/4 (200V)	L*is*9000B2/2 (200V)	L*is*9000B2/2 (400V)	L*is*9000B2/4 (200V)
		Motor specification	0447-B010	0447-B110	0447-B110	0447-B210	0448-B010	0448-B110	0448-B110	0448-B210	0449-B110	0449-B110	0449-B210
		Motor ID No.	367	368	369	370	371	372	373	374	376	377	378
Symbol	FS15*i*	FS30,16*i*,etc											
	1808	2003	00000000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00000000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000110	00000000	00000000	00000000	00000000	00000000	00001000	00001000	00000110	00000010	00001010
	1708	2014	00000110	00000000	00000000	00000000	00000000	00000000	00001000	00001000	00000110	00000010	00001010
	1750	2210	00000100	00000100	00000100	00000000	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1751	2211	00001000	00000000	00001000	00000000	00001000	00001000	00001000	00001000	00000000	00001000	00000000
	2713	2300	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1469	961	766	1401	1742	848	1123	946	1240	834	1483
PK2	1853	2041	-9936	-5255	-4195	-10722	-6205	-5532	-6625	-6400	-7877	-4701	-7099
PK3	1854	2042	-1330	-2660	-2696	-2660	-2697	-2696	-2696	-1331	-2660	-1330	-2660
PK1V	1855	2043	7	13	13	15	9	8	7	8	12	9	10
PK2V	1856	2044	-96	-169	-169	-202	-117	-103	-92	-101	-158	-128	-141
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-11870	-6746	-6746	-5642	-9690	-11014	-12391	-11240	-7199	-8929	-8099
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	-7680	0	0	0	0	-7936	0	-7680	0	-9216	0
PVPA	1869	2057	0	0	0	0	0	0	0	0	0	0	0
PALPH	1870	2058	0	0	0	0	0	0	0	0	0	0	0
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	4369	7282	7282	7282	5462	4551	4046	4046	5917	5259	4855
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32749	32711	32711	32708	32714	32707	32709	32687	32707	32709	32696
POVC2	1878	2063	232	719	719	753	680	765	739	1010	758	737	895
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	688	2131	2131	2233	1075	832	858	799	1199	947	1151
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	20480	0	0	0	20480	-24576	0	20480	0	20480	0
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	610	1074	1074	1184	763	671	671	658	805	716	789
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	1768	1005	1005	911	1768	2010	2261	2051	2010	2261	2051
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	0	0	0	0	0	0	0	0
DETQLM	1704	2111	0	0	0	0	0	0	0	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	0	0	0	0	0	0	0	0
MFWKCE	1736	2128	0	0	0	0	0	0	0	0	0	0	0
MFWKBL	1752	2129	0	0	0	0	0	0	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	0	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	85	85	85	165	85	165	185	365	165	185	365

		Motor model	L*i*s3300C1/2 (200V)	L*i*s3300C1/2 (400V)	L*i*s9000C2/2 (200V)	L*i*s9000C2/2 (400V)	L*i*s11000C2 /2HV(400V)	L*i*s11000C2/2 (200V)	L*i*s11000C2/2 (400V)	L*i*s15000C2 /3HV(400V)	L*i*s15000C2/2 (200V)	L*i*s15000C2/3 (200V)	L*i*s10000C3/2 (200V)
		Motor specification	0451-B110	0451-B110	0454-B110	0454-B110	0455-B010	0455-B110	0455-B110	0456-B010	0456-B110	0456-B210	0457-B110
		Motor ID No.	380	381	384	385	387	388	389	391	392	394	396
Symbol	FS15*i*	FS30,16*i*,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00000000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001010	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001010	00000000	00000000
	1750	2210	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1751	2211	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00000000	00000000	00001000
	2713	2300	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1346	636	587	910	605	431	702	989	1704	478	158
PK2	1853	2041	-6448	-3246	-3839	-4971	-3361	-3377	-4479	-6312	-13440	-3379	-1761
PK3	1854	2042	-2695	-2695	-2696	-2696	-2694	-2695	-2695	-2695	-2663	-2657	-2695
PK1V	1855	2043	9	9	8	7	10	10	9	10	7	10	10
PK2V	1856	2044	-126	-126	-110	-98	-136	-136	-121	-131	-87	-128	-141
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-9048	-9048	-10377	-11674	-8363	-8363	-9409	-8681	-13022	-8861	-8077
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	0	0	0	0	0	0	0	0	0	0	0
PALPH	1870	2058	0	0	0	0	0	0	0	0	0	0	0
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	5462	5462	6372	5663	7282	7282	6877	7282	4855	7282	7282
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32708	32708	32729	32728	32723	32723	32730	32730	32729	32732	32722
POVC2	1878	2063	749	749	489	494	560	560	474	471	483	452	582
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1184	1184	1112	879	1661	1661	1312	1396	621	1340	1719
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	0	-16384	0	-24576	-24576	0	0	0	0	-24576
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	801	801	776	689	948	948	843	869	579	852	964
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	741	741	2087	2348	2087	2087	2348	3104	4656	3168	1865
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	0	0	0	0	0	0	0	0
DETQLM	1704	2111	0	0	0	0	0	0	0	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	0	0	0	0	0	0	0	0
MFWKCE	1736	2128	0	0	0	0	0	0	0	0	0	0	0
MFWKBL	1752	2129	0	0	0	0	0	0	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	0	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	85	85	165	185	85	165	185	185	365	365	165

		Motor model	L*i*s10000C3/2 (400V)	L*i*s17000C3/2 (200V)	L*i*s17000C3/2 (400V)	D*i*S85/400 (200V)	D*i*S85/400 (400V)	D*i*S110/300 (200V)	D*i*S110/300 (400V)	D*i*S260/600 (200V)	D*i*S260/600 (400V)	D*i*S370/300 (200V)	D*i*S370/300 (400V)
		Motor specification	0457-B110	0459-B110	0459-B110	0483-B20x	0483-B20x	0484-B10x	0484-B10x	0484-B31x	0484-B31x	0484-B40x	0484-B40x
		Motor ID No.	397	400	401	423	424	425	426	429	430	431	432
Symbol	FS15*i*	FS30,16*i*,etc											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001000	00001000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001000	00001000	00000000	00000000
	1750	2210	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1751	2211	00000000	00001000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2713	2300	10000000	10000000	10000000	10000100	10000100	10000100	10000100	10000100	10000100	10000100	10000100
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	839	2182	253	344	172	156	78	571	321	478	239
PK2	1853	2041	-4103	-8540	-3693	-2368	-1184	-1045	-523	-4138	-2327	-3338	-1669
PK3	1854	2042	-2695	-2696	-2696	-2491	-2491	-2448	-2448	-2573	-2573	-2515	-2515
PK1V	1855	2043	9	7	7	242	242	420	420	240	213	264	264
PK2V	1856	2044	-125	-99	-99	-2164	-2164	-3763	-3763	-2146	-1907	-2361	-2361
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-9086	-11497	-11497	3897	3897	2241	2241	3931	4422	3572	3572
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	0	0	0	0	0	0	0	0	0	0	0
PALPH	1870	2058	0	0	0	0	0	0	0	0	0	0	0
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	6877	6887	6877	7282	7282	7282	7282	5352	4758	7282	7282
EMFLMT	1873	2061	120	120	120	0	0	0	0	0	0	0	0
POVC1	1877	2062	32720	32711	32711	32683	32683	32682	32682	32722	32731	32705	32705
POVC2	1878	2063	597	709	709	1069	1069	1069	1069	578	457	782	782
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1358	981	981	3172	3172	3173	3173	1714	1354	2322	2322
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	20480	20480	20480	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	857	729	729	1310	1310	1310	1310	963	856	1121	1121
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	2098	4197	4197	1167	1167	1510	1510	4857	5464	6020	6020
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	0	0	0	0	0	0	0	0
DETQLM	1704	2111	0	0	0	0	0	0	0	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	0	0	0	0	0	0	0	0
MFWKCE	1736	2128	0	0	0	0	0	0	0	0	0	0	0
MFWKBL	1752	2129	0	0	0	0	0	0	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	0	0	0	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	185	365	365	45	45	85	85	165	185	85	85

6.3 PARAMETERS FOR HRV1 CONTROL (FOR Series 0*i*-A)

December, 2003

9066 series (Series 0*i*-A)

> **NOTE**
> The parameters listed below cannot be loaded automatically.
> In parameter No. 2020 for entering a motor ID number, enter an appropriate number (15, for example), and perform automatic loading. Then, overwrite these parameters manually.

Symbol	Motor model / Motor specification / Motor ID No / 0*i*M-A	α1 5000*i* 0202	α2 5000*i* 0205	αC4 3000*i* 0221	α4 4000*i* 0223	α4 4000HV*i* 0225	αC8 2000*i* 0226	α8 3000*i* 0227	α8 3000HV*i* 0229	βM0.5 0115	βM1 0116	αC12 2000*i* 0241	α12 3000*i* 0243
	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2011	00000000	00100000	00000000	00100000	00100000	00000000	00000000	00100000	00000000	00000000	00100000	00100000
	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2211	00000010	00000010	00001000	00000010	00000000	00001010	00001010	00000000	00000010	00000010	00000010	00000000
	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	2040	672	680	926	659	525	1096	712	886	141	398	3809	1072
PK2	2041	-2294	-2247	-4063	-2463	-2056	-4638	-3187	-3174	-511	-1137	-8197	-3835
PK3	2042	-2514	-2568	-2619	-2623	-2619	-2651	-2651	-2645	-2415	-2388	-2679	-2630
PK1V	2043	66	76	115	106	113	150	113	113	7	6	280	192
PK2V	2044	-594	-680	-1034	-953	-1009	-1342	-1009	-1008	-59	-53	-2504	-1721
PK3V	2045	0	0	0	0	0	0	0	0	0	0	0	0
PK4V	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	2047	6384	5578	3670	3980	3762	2827	3760	3764	-6462	-7176	1516	2204
BLCMP	2048	0	0	0	0	0	0	0	0	0	0	0	0
DPFMX	2049	0	0	0	0	0	0	0	0	0	0	0	0
POK1	2050	956	956	956	956	956	956	956	956	956	956	956	956
POK2	2051	510	510	510	510	510	510	510	510	510	510	510	510
RESERV	2052	0	0	0	0	0	0	0	0	0	0	0	0
PPMAX	2053	21	21	21	21	21	21	21	21	21	21	21	21
PDDP	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	2055	319	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	2056	0	-20485	0	0	0	0	0	0	-12850	-12850	0	0
PVPA	2057	0	-10256	-5915	-11789	0	-3854	-6418	-6159	0	-11530	-1804	-8199
PALPH	2058	0	-3300	-1500	-180	0	-1236	-3000	-1261	0	-1000	-2500	-747
PPBAS	2059	0	0	0	0	0	0	0	0	0	0	0	0
TQLIM	2060	7282	7282	7282	8010	7282	7282	8010	8010	6918	7282	7282	7282
EMFLMT	2061	0	0	0	0	0	0	0	0	0	0	0	0
POVC1	2062	32692	32635	32590	32610	32591	32434	32579	32579	32674	32695	32317	32552
POVC2	2063	948	1664	2225	1979	2216	4170	2363	2358	1178	915	5644	2702
TGALMLV	2064	4	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	2065	5739	10085	13493	11998	12461	17889	14327	12461	3497	2714	17889	9224
PK2VAUX	2066	0	0	0	0	0	0	0	0	0	0	0	0
FILTER	2067	0	0	0	0	0	0	0	0	0	0	0	0
FALPH	2068	0	0	0	0	0	0	0	0	0	0	0	0
VFFLT	2069	0	0	0	0	0	0	0	0	0	0	0	0
ERBLM	2070	0	0	0	0	0	0	0	0	0	0	0	0
PBLCT	2071	0	0	0	0	0	0	0	0	0	0	0	0
SFCCML	2072	0	0	0	0	0	0	0	0	0	0	0	0
PSPTL	2073	0	0	0	0	0	0	0	0	0	0	0	0
AALPH	2074	0	4096	12288	8192	20480	8192	12288	16384	20480	20480	8192	8192
OSCTPL	2077	0	0	0	0	0	0	0	0	0	0	0	0
PDPCH	2078	0	0	0	0	0	0	0	0	0	0	0	0
PDPCL	2079	0	0	0	0	0	0	0	0	0	0	0	0
DPFEX	2080	0	0	0	0	0	0	0	0	0	0	0	0
DPFZW	2081	0	0	0	0	0	0	0	0	0	0	0	0
BLENDL	2082	0	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	2083	0	0	0	0	0	0	0	0	0	0	0	0
RTCURR	2086	1234	1636	1892	1784	1888	2593	1950	1948	1376	1212	3020	2085
TDPLD	2087	0	0	0	0	0	0	0	0	0	0	0	0
MCNFB	2088	0	0	0	0	0	0	0	0	0	0	0	0
BLBSL	2089	0	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	2090	0	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	2091	0	0	0	0	0	0	0	0	0	0	0	0
ADFF1	2092	0	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	2093	0	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	2094	0	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	2095	0	0	0	0	0	0	0	0	0	0	0	0
RADUSL	2096	0	0	0	0	0	0	0	0	0	0	0	0
SMCNT	2097	0	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	2098	0	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	2099	400	400	400	400	400	400	400	400	400	400	400	400
INPA1	2100	0	0	0	0	0	0	0	0	0	0	0	0
INPA2	2101	0	0	0	0	0	0	0	0	0	0	0	0
DBLIM	2102	0	12000	0	15000	15000	0	0	15000	0	0	15000	15000
ABVOF	2103	0	0	0	0	0	0	0	0	0	0	0	0
ABTSH	2104	0	0	0	0	0	0	0	0	0	0	0	0
TRQCST	2105	72	109	190	201	190	277	369	369	42	89	350	517
LP24PA	2106	0	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	2107	0	0	0	0	0	0	0	0	0	0	0	0
RESERV	2108	0	0	0	0	0	0	0	0	0	0	0	0
BELLTC	2109	0	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	2110	32	32	1289	32	1032	1552	786	782	30	30	0	32
DETQLM	2111	7710	6460	3900	5130	0	3880	5180	0	10290	10290	2168	0
AMRDML	2112	0	0	0	0	0	0	0	0	0	0	0	0
NFILT	2113	0	0	0	0	0	0	0	0	0	0	0	0
NINTCT	2127	1188	1276	2544	1443	2573	2380	2103	4191	1009	1763	4150	2388
MFWKCE	2128	570	855	5000	2000	4000	4500	1500	6000	0	0	12000	2000
MFWKBL	2129	3211	3211	1812	3338	3348	1550	1815	1810	0	0	1044	2568
LP2GP	2130	0	0	0	0	0	0	0	0	0	0	0	0
LP4GP	2131	0	0	0	0	0	0	0	0	0	0	0	0
LP6GP	2132	0	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	2133	2571	2565	3855	6670	0	3860	5140	0	7690	11560	5150	0
PHDLY2	2134	12850	12850	5155	5140	0	5150	5145	0	12820	12880	5150	0
DGCSMM	2159	0	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	2160	0	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	2161	0	0	0	0	0	0	0	0	0	0	0	0
POVC21	2162	0	0	0	0	0	0	0	0	0	0	0	0
POVC22	2163	0	0	0	0	0	0	0	0	0	0	0	0
POVCLMT2	2164	0	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	2165	25	25	25	45	25	25	45	25	25	25	25	85

Symbol	Motor model / Motor specification / Motor ID No / 0*i*M-A	α12 3000HV*i* 0245	αC22 2000*i* 0246	α22 3000*i* 0247	α22 3000HV*i* 0249	αC30 1500*i* 0251	α30 3000*i* 0253	α40 3000*i* 0257	α40 3000*i*Fan 0258
	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2011	00100000	00000000	00100000	00100000	00000000	00000000	00100000	00100000
	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2211	00000000	00001010	00000000	00000000	00001010	00001010	00000010	00000010
	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	2040	1044	1755	1458	1532	2644	485	1047	1047
PK2	2041	-3677	-6536	-5416	-5641	-10345	-1896	-4102	-4102
PK3	2042	-2679	-2694	-2690	-2692	-2695	-2694	-2696	-2696
PK1V	2043	193	271	198	197	166	283	235	235
PK2V	2044	-1727	-2426	-1775	-1765	-1486	-2531	-2107	-2107
PK3V	2045	0	0	0	0	0	0	0	0
PK4V	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	2047	2197	1565	2137	2150	2553	1499	1801	1801
BLCMP	2048	0	0	0	0	0	0	0	0
DPFMX	2049	0	0	0	0	0	0	0	0
POK1	2050	956	956	956	956	956	956	956	956
POK2	2051	510	510	510	510	510	510	510	510
RESERV	2052	0	0	0	0	0	0	0	0
PPMAX	2053	21	21	21	21	21	21	21	21
PDDP	2054	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	2055	319	319	319	319	319	319	319	319
EMFCMP	2056	0	0	0	0	0	0	0	0
PVPA	2057	-8214	-2597	-5136	-4392	-1545	-5181	-2572	-2572
PALPH	2058	-2350	-1942	-2800	-2824	-1300	-1231	-2462	-2462
PPBAS	2059	0	0	0	0	0	0	0	0
TQLIM	2060	7282	8010	7282	7282	7282	7282	7282	7282
EMFLMT	2061	0	0	0	0	0	0	0	0
POVC1	2062	32550	32348	32542	32545	32632	32369	32480	32264
POVC2	2063	2719	5248	2820	2786	1704	4989	3600	6300
TGALMLV	2064	4	4	4	4	4	4	4	4
POVCLMT	2065	8192	24454	9224	8192	9224	14489	14489	19003
PK2VAUX	2066	0	0	0	0	0	0	0	0
FILTER	2067	0	0	0	0	0	0	0	0
FALPH	2068	0	0	0	0	0	0	0	0
VFFLT	2069	0	0	0	0	0	0	0	0
ERBLM	2070	0	0	0	0	0	0	0	0
PBLCT	2071	0	0	0	0	0	0	0	0
SFCCML	2072	0	0	0	0	0	0	0	0
PSPTL	2073	0	0	0	0	0	0	0	0
AALPH	2074	12288	8192	8192	8192	8192	8192	8192	8192
OSCTPL	2077	0	0	0	0	0	0	0	0
PDPCH	2078	0	0	0	0	0	0	0	0
PDPCL	2079	0	0	0	0	0	0	0	0
DPFEX	2080	0	0	0	0	0	0	0	0
DPFZW	2081	0	0	0	0	0	0	0	0
BLENDL	2082	0	0	0	0	0	0	0	0
MOFCTL	2083	0	0	0	0	0	0	0	0
RTCURR	2086	2092	2911	2131	2118	1655	2838	2409	3191
TDPLD	2087	0	0	0	0	0	0	0	0
MCNFB	2088	0	0	0	0	0	0	0	0
BLBSL	2089	0	0	0	0	0	0	0	0
ROBSTL	2090	0	0	0	0	0	0	0	0
ACCSPL	2091	0	0	0	0	0	0	0	0
ADFF1	2092	0	0	0	0	0	0	0	0
VMPK3V	2093	0	0	0	0	0	0	0	0
BLCMP2	2094	0	0	0	0	0	0	0	0
AHDRTL	2095	0	0	0	0	0	0	0	0
RADUSL	2096	0	0	0	0	0	0	0	0
SMCNT	2097	0	0	0	0	0	0	0	0
DEPVPL	2098	0	0	0	0	0	0	0	0
ONEPSL	2099	400	400	400	400	400	400	400	400
INPA1	2100	0	0	0	0	0	0	0	0
INPA2	2101	0	0	0	0	0	0	0	0
DBLIM	2102	15000	0	15000	15000	0	0	15000	15000
ABVOF	2103	0	0	0	0	0	0	0	0
ABTSH	2104	0	0	0	0	0	0	0	0
TRQCST	2105	516	680	929	934	1630	951	1494	1494
LP24PA	2106	0	0	0	0	0	0	0	0
VLGOVR	2107	0	0	0	0	0	0	0	0
RESERV	2108	0	0	0	0	0	0	0	0
BELLTC	2109	0	0	0	0	0	0	0	0
MGSTCM	2110	774	1548	1291	787	2059	1030	1544	1544
DETQLM	2111	0	2600	0	0	2148	7735	5140	5140
AMRDML	2112	0	0	0	0	0	0	0	0
NFILT	2113	0	0	0	0	0	0	0	0
NINTCT	2127	4787	3695	3272	6547	6680	1688	3041	3041
MFWKCE	2128	4000	4000	4500	6000	14000	2031	1625	1625
MFWKBL	2129	2320	1046	1301	1808	539	2829	1553	1553
LP2GP	2130	0	0	0	0	0	0	0	0
LP4GP	2131	0	0	0	0	0	0	0	0
LP6GP	2132	0	0	0	0	0	0	0	0
PHDLY1	2133	0	2070	0	0	1054	5140	3087	3087
PHDLY2	2134	0	5160	0	0	5160	5155	5150	5150
DGCSMM	2159	0	0	0	0	0	0	0	0
TRQCUP	2160	0	0	0	0	0	0	0	0
OVCSTP	2161	0	0	0	0	0	140	140	140
POVC21	2162	0	0	0	0	0	0	0	0
POVC22	2163	0	0	0	0	0	0	0	0
POVCLMT2	2164	0	0	0	0	0	0	0	0
MAXCRT	2165	45	45	85	45	85	135	135	135

APPENDIX

A ANALOG SERVO INTERFACE SETTING PROCEDURE

(1) Overview

Appendix A describes the method of setting parameters required when using the analog servo function with an analog servo interface unit.

> ⚠ **CAUTION**
> 1 For the CNCs that support this function, contact FANUC.
> 2 For analog servo axes, only the feed-forward, backlash compensation, pitch error compensation, and position gain switch functions can be used as digital servo functions.

(2) Series and editions of applicable servo software

(Series 30*i*,31*i*,32*i*)

Series 90D0/J(10) and subsequent editions
Series 90E0/J(10) and subsequent editions

(Series 15*i*-B,16*i*-B,Power Mate *i*)

Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions

(3) Setting parameters

(1) Setting start: Switch on the CNC power from an emergency stop.
(2) Set up the FSSB. Switch the power off and on again.
(3) Initialize the servo parameters. Switch the power off and on again.
(4) Enable the analog servo interface function. Switch the power off and on again. Now setting is completed.

(4) FSSB setting

(a) Connecting the analog servo interface unit requires that the FSSB be set up manually. (The FSSB setting screen cannot be used.)

	#7	#6	#5	#4	#3	#2	#1	#0
1090 (FS15*i*)								FMD
1902 (FS30*i*,16*i*)								

FMD (#0) Specifies the FSSB set mode as follows:
0: Automatic setting mode
<u>1: Manual setting mode ← To be set</u>

(b) Directly enter all parameters listed in the following table. Before doing this, understand the meaning of each parameter sufficiently. For detailed descriptions about parameter setting, refer to the respective CNC Connection Manuals and Parameter Manuals. Analog and digital servo axes can be used together as shown in the reference examples below.

Parameter number			Meaning
FS15*i*	**FS16*i*, PM*i***	**FS30*i***	
1023	1023	1023	Servo axis number for each axis
1093#6, #7	1905#6, #7	1905#6, #7, #1, #2	Selection of interface unit used
1080 to 1089 1120 to 1129	1910 to 1919 1970 to 1979	14340 to 14357 14358 to 14375	Conversion table value for slave number
1094	1936	1936	Connector number for interface unit 1
1095	1937	1937	Connector number for interface unit 2
-	-	1938	Connector number for interface unit 3
-	-	1939	Connector number for interface unit 4
-	-	14376 to 14383	Conversion table value for connector number of interface unit 1
-	-	14384 to 14391	Conversion table value for connector number of interface unit 2
-	-	14392 to 14400	Conversion table value for connector number of interface unit 3
-	-	14401 to 14407	Conversion table value for connector number of interface unit 4
1100 to 1109 1130 to 1139	-	-	Conversion table value for number of slave connected to 1st axis card on additional-axis board
1110 to 1119 1140 to 1149	-	-	Conversion table value for number of slave connected to 2nd axis card on additional-axis board
-	-	14408 to 14425	Conversion table value for slave number on additional-axis board
-	-	14444 to 14451	Conversion table value for connector number of interface unit 1 on additional-axis board
-	-	14452 to 14459	Conversion table value for connector number of interface unit 2 on additional-axis board

NOTE

1 The FSSB settings for the analog servo interface unit are also used for the separate detector interface unit.
(Bits 6, 7, 1, and 2 of parameter No. 1905 or bits 6 and 7 of parameter No. 1093 are used in common.)

2 The slave number of an analog servo axis must be added to behind the last slave number of the units actually connected to the FSSB line. (See the setting examples provided below.)

3 With the FS15*i*, 16*i*, and PM*i*, when an analog servo interface unit is used, HRV3 control (high-speed HRV current control) cannot be used.

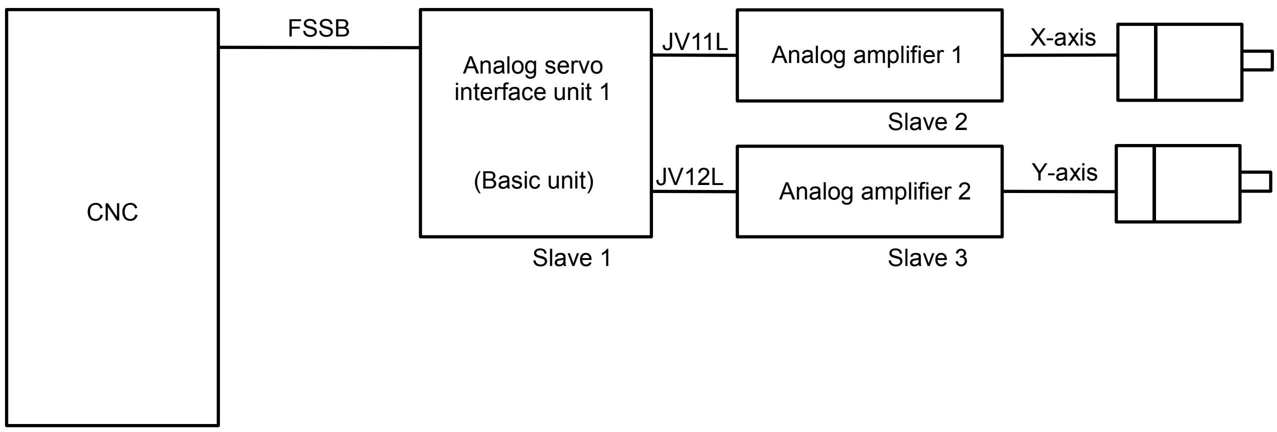
4 With the FS30*i*, up to two interface units (separate detector interface unit and (or) analog servo interface unit) can be connected per FSSB line. Therefore, the first and second interface units are connected to the FSSB1 line, and the third and fourth interface units are connected to the FSSB2 line.
With the FS15*i*, 16*i*, and PMi, up to two units (separate detector interface unit, analog servo interface unit, and (or) FSSB I/O unit) can be connected to the entire FSSB line of one axis card.

(Reference)

FSSB setting example where an analog servo interface unit is used

[Setting example 1: Two analog servo axes]

Let the analog servo interface unit be slave 1. Assume that analog amplifiers are connected behind the analog servo interface unit, and let them be slaves 2 and 3 sequentially.



Parameter No. (FS15*i*)	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089
Parameter No. (FS16*i*, PM*i*)	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Set value	16	0	1	40	40	40	40	40	40	40

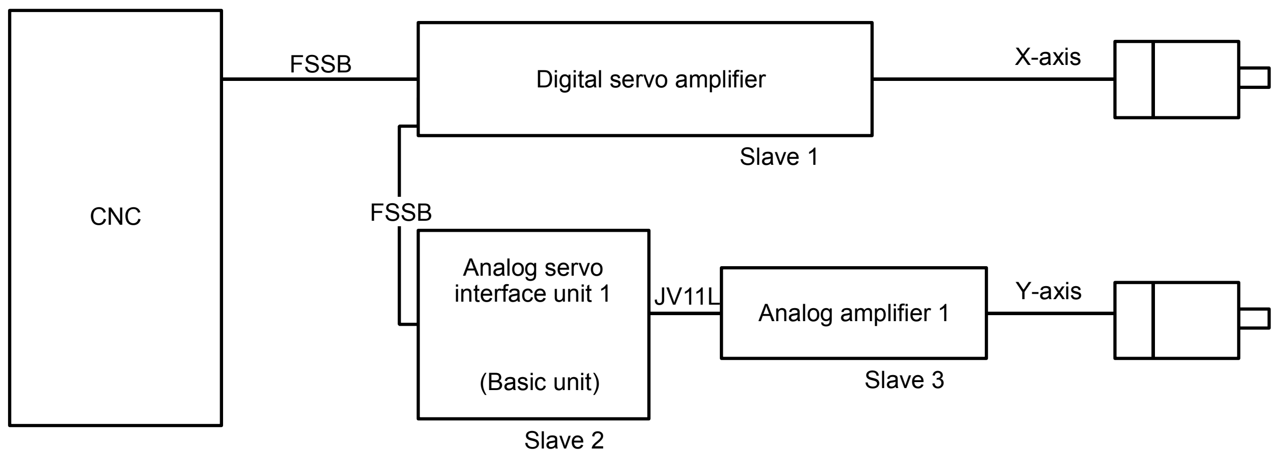
Parameter No. (FS30*i*)	14340	14341	14342	14343 to 14357
Set value	64	0	1	-96

Parameter No. (FS15*i*)	No.1023	No.1093	No.1094	No.1095
Parameter No. (FS16*i*, PM*i*) (FS30*i*)	No.1023	No.1905	No.1936	No.1937
X axis	1	01000000	0	0
Y axis	2	01000000	1	0

Parameter No. (FS30*i*)	14376	14377	14378 to 14407
Set value	0	1	32

[Setting example 2: One digital servo axis + one analog servo axis]

The digital servo amplifier and analog servo interface unit are slaves 1 and 2, as in the sequence in which they are connected to the FSSB. Assuming that the axis connected to the analog servo amplifier is behind the analog servo interface unit, it is slave 3.



Parameter No. (**FS15*i***)	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089
Parameter No. (FS16*i*, PM*i*)	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Set value	0	16	1	40	40	40	40	40	40	40

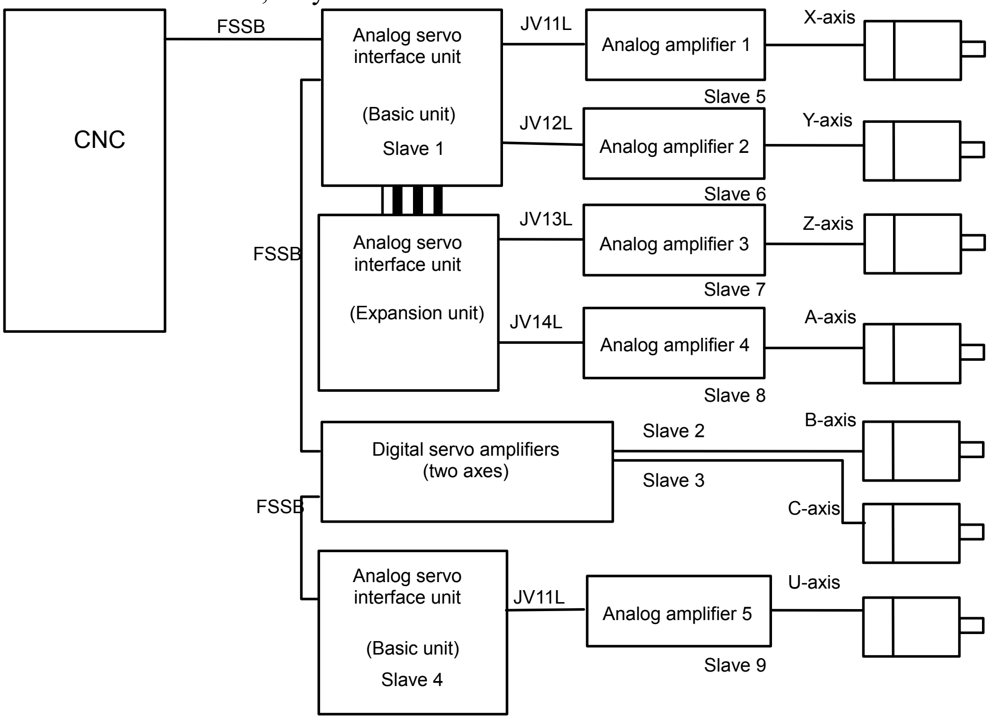
Parameter No. (FS30*i*)	14340	14341	14342	14343 to 14357
Set value	0	64	1	-96

Parameter No. (**FS15*i***)	No.1023	No.1093	No.1094	No.1095
Parameter No. (FS16*i*, PM*i*) (FS30*i*)	No.1023	No.1905	No.1936	No.1937
X axis	1	00000000	0	0
Y axis	2	01000000	0	0

Parameter No. (FS30*i*)	14376	14377 to 14407
Set value	0	32

[Setting example 3: Five analog servo axes + two digital servo axes]

The first analog servo interface unit (including expansion) is slave 1, two digital servo amplifiers are slaves 2 and 3, the second analog servo interface unit is slave 4, as in the sequence in which they are connected to the FSSB. Assuming that the analog amplifiers are connected behind the analog servo interface unit, they are slaves 5 to 9.



Parameter No. (FS15*i*)	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089
Parameter No. (FS16*i*, PM*i*)	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Set value	16	4	5	48	0	1	2	3	6	40

Parameter No. (FS30*i*)	14340	14341	14342	14343	14344	14345	14346	14347	14348	14349 to 14357
Set value	64	4	5	-56	0	1	2	3	6	-96

Parameter No. (FS15*i*)	No.1023	No.1093	No.1094	No.1095
Parameter No. (FS16*i*, PM*i*), (FS30*i*)	No.1023	No.1905	No.1936	No.1937
X axis	1	01000000	0	0
Y axis	2	01000000	1	0
Z axis	3	01000000	2	0
A axis	4	01000000	3	0
B axis	5	00000000	0	0
C axis	6	00000000	0	0
U axis	7	10000000	0	0

Parameter No. (FS30*i*)	14376	14377	14378	14379	14380 to 14383	14384	14385 to 14407
Set value	0	1	2	3	32	6	32

(5) Servo parameter initialization

For axes connected to an analog servo circuit, initialize the servo parameters as listed below.

Parameter number		Name	Set value
FS15*i*	**FS30*i*,16*i*, etc.**		
1804	2000	Initialization bit	00000000
1874	2020	Motor ID number	50 (for HRV1) 252 (for HRV2)
1806	2001	AMR	00000000
1820	1820	CMR	Perform the same initialization as for digital servo according to your machine tool.
1977	2084	FFG (numerator)	
1978	2085	FFG (denominator)	
1879	2022	Direction of movement	111 (counterclockwise) or –111 (clockwise)
1896	1821	Reference counter	Specify the number of pulses per motor revolution (after FFG) in the same manner as for the digital servo circuit.
1876	2023	Number of velocity pulses	Set value = 1536.797 × E where E is the voltage (V) that corresponds to a velocity command of 1000 min^{-1}.
1891	2024	Number of position pulses	Specify the number of pulses per motor revolution (before FFG) in the same manner as for the digital servo circuit.

> **NOTE**
> Although difference in HRV setting is not directly related to analog servo axes, they must be initialized with the same HRV setting by reason of the relationship with the settings of other digital servo axes.
> The Series 30*i* does not support HRV1 control, so it is necessary to perform initialization with the motor ID number (252) for HRV2.

(6) Setting the analog servo function

To enable the analog servo function, set the following parameters for the axes to be connected to an analog servo circuit. (It is also necessary to enable the dummy serial feedback function.)

	#7	#6	#5	#4	#3	#2	#1	#0
1953 (FS15*i*) 2009 (FS30*i*,16*i*)				ANALOG				DMY

DMY (#0) The serial feedback dummy function is:
0: Not used
1: Used ← To be set

ANALOG (#4) The analog servo interface function is:
0: Not used
1: Used ← To be set

1788 (FS15*i*) 2165 (FS30*i*,16*i*)	Maximum amplifier current

Specify 0 for the axis to be connected to an analog servo circuit.

B PARAMETERS SET WITH VALUES IN DETECTION UNITS

If the detection unit is changed with a CMR or flexible feed gear, it is also necessary to change the parameters that are set with values in detection units. This appendix lists these parameters.
For details of these parameters, refer to the respective CNC parameter manuals.

B.1 PARAMETERS FOR Series 15*i*

No.	Description
1718	For vibration damping control : position pulses conversion coefficient
1730	Variable proportional gain function in the stop state : stop judgement level
1827	Effective area (in-position check) for individual axis
1828	Position error limit for individual axis during movement
1829	Position error limit for individual axis at stop
1830	Position error limit for individual axis with servo off
1832	Position error limit for individual axis with feed at stop
1837	Position error limit during rigid tapping movement
1841	Servo error amount within which reference position return is assumed to be possible
1843	Position error limit with torque limit skipped
1844	Grid shift for reference position shift function
1846	Distance for starting second stage compensation in smooth backlash compensation
1847	Distance for ending second stage compensation in smooth backlash compensation
1848	First stage compensation value in smooth backlash compensation
1849	Backlash compensation for individual axis at rapid traverse
1850	Grid shift for individual axis
1851	Backlash compensation for individual axis
1881	Permissible error amount for starting chopping compensation
1896	Mark 1 intervals on linear scale having reference marks
1912	Zero-width synchronization error for each axis
1913	Maximum permissible synchronization error for each axis at rapid traverse
1914	Maximum permissible synchronization error for each axis at stop
1917	Zero-width synchronization error for each axis No.2
1975	Second stage start/end parameter (when the two-stage backlash acceleration function is used)
1994	Overshoot compensation enable level
1996	Unexpected disturbance torque detection pull-back amount
2786	Lifting function against gravity at emergency stop : distance to lift
2795	Torsion preview control: maximum compensation value (LSTCM)
2799	Torsion preview control: acceleration torsion compensation value K1 (LSTK1)
2800	Torsion preview control: acceleration torsion compensation value K2 (LSTK2)
2801	Torsion preview control: acceleration torsion compensation value K3 (LSTK3)
2804	Torsion preview control: acceleration torsion compensation value K1N (LSTK1N)
2805	Torsion preview control: acceleration torsion compensation value K2N (LSTK2N)
2806	Torsion preview control: acceleration torsion compensation value K3N (LSTK3N)
2817	Synchronous axes automatic compensation function : maximum compensation value
5226	Mark 2 intervals on linear scale having reference marks
5227	Distance from origin to reference position on linear scale having reference marks
5423	Pitch error compensation magnification
5428	Pitch error compensation (absolute value) at reference position for movement to reference position in direction opposite to origin return direction
5433	Second cyclic pitch error compensation magnification
5449	Three-dimensional error compensation magnification
5450	Three-dimensional error compensation magnification
5451	Three-dimensional error compensation magnification
5471	Compensation α at compensation point number a for individual axis
5472	Compensation β at compensation point number b for individual axis

No.	Description
5473	Compensation γ at compensation point number c for individual axis
5474	Compensation ε at compensation point number d for individual axis
5504	Compensation point number d for movement axis 1 subjected to straightness compensation
5551	Compensation at compensation point number a for movement axis 1
5552	Compensation at compensation point number b for movement axis 1
5553	Compensation at compensation point number c for movement axis 1
5554	Compensation at compensation point number d for movement axis 1
5561	Compensation at compensation point number a for movement axis 2
5562	Compensation at compensation point number b for movement axis 2
5563	Compensation at compensation point number c for movement axis 2
5564	Compensation at compensation point number d for movement axis 2
5571	Compensation at compensation point number a for movement axis 3
5572	Compensation at compensation point number b for movement axis 3
5573	Compensation at compensation point number c for movement axis 3
5574	Compensation at compensation point number d for movement axis 3
5591	Compensation magnification 1 for movement axis 1 subjected to straightness compensation
5592	Compensation magnification 1 for movement axis 2 subjected to straightness compensation
5593	Compensation magnification 1 for movement axis 3 subjected to straightness compensation
5594	Compensation magnification 1 for movement axis 4 subjected to straightness compensation
5595	Compensation magnification 1 for movement axis 5 subjected to straightness compensation

B.2 PARAMETERS FOR Series 16*i*, 18*i*, AND 21*i*

No.	Description
1821	Reference counter capacity for individual axis
1826	Effective area (in-position check) for individual axis
1827	Effective area (in-position check) for individual axis at cutting feed
1828	Position error limit for individual axis during movement
1829	Position error limit for individual axis at stop
1830	Position error limit for individual axis with servo off
1832	Position error limit for individual axis with feed at stop
1836	Servo error amount within which reference position return is assumed to be possible
1846	Distance for starting second stage compensation in smooth backlash compensation
1847	Distance for ending second stage compensation in smooth backlash compensation
1848	First stage compensation value in smooth backlash compensation
1850	Grid shift/reference position shift for individual axis
1851	Backlash compensation for individual axis
1852	Backlash compensation for individual axis at rapid traverse
1876	Inductosyn 1-pitch interval
1877	Inductosyn shift
1882	Mark 2 intervals on linear scale having reference marks
1883	Distance from origin to reference position on linear scale having reference marks
1884	Distance from origin to reference position on linear scale having reference marks
1885	Permissible cumulative movement value during torque control (PMC axis control)
1886	Position error with torque control canceled (PMC axis control)
2033	For vibration damping control : position pulses conversion coefficient
2082	Second stage start/end parameter (when the two-stage backlash acceleration function is used)
2101	Overshoot compensation enable level
2103	Unexpected disturbance torque detection amount retrace distance
2119	Function for changing the proportional gain in the stop state : stop judgement level
2373	Lifting function against gravity at emergency stop : distance to lift
2382	Torsion preview control: maximum compensation value (LSTCM)
2386	Torsion preview control: acceleration torsion compensation value K1 (LSTK1)
2387	Torsion preview control: acceleration torsion compensation value K2 (LSTK2)
2388	Torsion preview control: acceleration torsion compensation value K3 (LSTK3)
2391	Torsion preview control: acceleration torsion compensation value K1N (LSTK1N)
2392	Torsion preview control: acceleration torsion compensation value K2N (LSTK2N)
2393	Torsion preview control: acceleration torsion compensation value K3N (LSTK3N)
2404	Synchronous axes automatic compensation function : maximum compensation value
3623	Pitch error compensation magnification for individual axis
5300	Rigid tapping effective area (in-position check) for tapping axis
5302	Second-spindle rigid tapping effective area (in-position check) for tapping axis
5304	Third-spindle rigid tapping effective area (in-position check) for tapping axis
5310	Rigid tapping position error limit for tapping axis during movement
5312	Rigid tapping position error limit for tapping axis at stop
5314	Rigid tapping position error limit for tapping axis during movement
5350	Second-spindle rigid tapping position error limit for tapping axis during movement
5352	Second-spindle rigid tapping position error limit for tapping axis at stop
5354	Third-spindle rigid tapping position error limit for tapping axis during movement
5356	Third-spindle rigid tapping position error limit for tapping axis at stop
5761	Compensation at compensation point number a for movement axis 1 (straightness compensation)
5762	Compensation at compensation point number b for movement axis 1 (straightness compensation)
5763	Compensation at compensation point number c for movement axis 1 (straightness compensation)

No.	Description
5764	Compensation at compensation point number d for movement axis 1 (straightness compensation)
5771	Compensation at compensation point number a for movement axis 2 (straightness compensation)
5772	Compensation at compensation point number b for movement axis 2 (straightness compensation)
5773	Compensation at compensation point number c for movement axis 2 (straightness compensation)
5774	Compensation at compensation point number d for movement axis 2 (straightness compensation)
5781	Compensation at compensation point number a for movement axis 3 (straightness compensation)
5782	Compensation at compensation point number b for movement axis 3 (straightness compensation)
5783	Compensation at compensation point number c for movement axis 3 (straightness compensation)
5784	Compensation at compensation point number d for movement axis 3 (straightness compensation)
5871	Compensation α at compensation point number a for individual axis (gradient compensation)
5872	Compensation β at compensation point number b for individual axis (gradient compensation)
5873	Compensation γ at compensation point number c for individual axis (gradient compensation)
5874	Compensation ε at compensation point number d for individual axis (gradient compensation)
8313	Limit to difference in position error between master and slave axes (pair under simplified synchronization control)
8315	Maximum compensation for synchronization (pair under simplified synchronization control)
8316	Difference in reference counter between master and slave axes (pair under simplified synchronization control)
8323	Limit to difference in position error between master and slave axes (more than one pair under simplified synchronization control)
8325	Maximum compensation for synchronization (more than one pair under simplified synchronization control)
8326	Difference in reference counter between master and slave axes (more than one pair under simplified synchronization control)

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B.3 PARAMETERS FOR THE Power Mate *i*

No.	Description
1821	Reference counter capacity for individual axis
1826	Effective area (in-position check) for individual axis
1827	Effective area (in-position check) for individual axis at cutting feed
1828	Position error limit for individual axis during movement
1829	Position error limit for individual axis at stop
1830	Position error limit for individual axis with servo off
1832	Position error limit for individual axis with feed at stop
1836	Servo error amount within which reference position return is assumed to be possible (when ISC is in use)
1850	Grid shift/reference position shift for individual axis
1851	Backlash compensation for individual axis
1852	Backlash compensation for individual axis at rapid traverse
1872*	Servo position error check value
1882	Mark 2 intervals on linear scale having reference marks
1883	Distance from origin to reference position on linear scale having reference marks
1884	Distance from origin to reference position on linear scale having reference marks
1885	Permissible cumulative movement value during torque control (PMC axis control)
1886	Position error with torque control canceled (PMC axis control)
2033	For vibration damping control : position pulses conversion coefficient
2082	Second stage start/end parameter (when the two-stage backlash acceleration function is used)
2101	Overshoot compensation enable level
2103	Unexpected disturbance torque detection amount retrace distance
2119	Function for changing the proportional gain in the stop state : stop judgement level
2404	Synchronous axes automatic compensation function : maximum compensation value
3623	Pitch error compensation magnification for individual axis (H is optional)
5300(D)	Rigid tapping effective area (in-position check) for tapping axis
5310(D)	Rigid tapping position error limit for tapping axis during movement
5312(D)	Rigid tapping position error limit for tapping axis at stop
5314(D)	Rigid tapping position error limit for tapping axis during movement
5761	Compensation at compensation point number a for movement axis 1 (straightness compensation)
5762	Compensation at compensation point number b for movement axis 1 (straightness compensation)
5763	Compensation at compensation point number c for movement axis 1 (straightness compensation)
5764	Compensation at compensation point number d for movement axis 1 (straightness compensation)
5771	Compensation at compensation point number a for movement axis 2 (straightness compensation)
5772	Compensation at compensation point number b for movement axis 2 (straightness compensation)
5773	Compensation at compensation point number c for movement axis 2 (straightness compensation)
5774	Compensation at compensation point number d for movement axis 2 (straightness compensation)
5781	Compensation at compensation point number a for movement axis 3 (straightness compensation)
5782	Compensation at compensation point number b for movement axis 3 (straightness compensation)
5783	Compensation at compensation point number c for movement axis 3 (straightness compensation)
5784	Compensation at compensation point number d for movement axis 3 (straightness compensation)
8313	Limit to difference in position error between master and slave axes (pair under simplified synchronization control)
8315	Maximum compensation for synchronization (pair under simplified synchronization control)
8316	Difference in reference counter between master and slave axes (pair under simplified synchronization control)
8323(H)	Limit to difference in position error between master and slave axes (more than one pair under simplified control)
8325(H)	Maximum compensation for synchronization (more than one pair under simplified synchronization control)
8326(H)	Difference in reference counter between master and slave axes (more than one pair under simplified synchronization control)

The parameter No. indicated with an asterisk (*) is related to a function unique to the Power Mate.
The parameter No. suffixed with "(D)" are related to the functions dedicated to the Power Mate *i*-D.
The parameter No. suffixed with "(H)" are related to the functions dedicated to the Power Mate *i*-H.

B.4 PARAMETERS FOR Series 30*i*, 31*i*, AND 32*i*

No.	Description
1821	Reference counter capacity for individual axis
1826	Effective area (in-position check) for individual axis
1827	Effective area (in-position check) for individual axis at cutting feed
1828	Position error limit for individual axis during movement
1829	Position error limit for individual axis at stop
1830	Position error limit for individual axis with servo off
1832	Position error limit for individual axis with feed at stop
1836	Servo error amount within which reference position return is assumed to be possible
1844	Distance from the point at which deceleration dog is turned off to first grid point when reference position shift of the reference position shift function is set to 0
1846	Distance for starting second stage compensation in smooth backlash compensation
1847	Distance for ending second stage compensation in smooth backlash compensation
1848	First stage compensation value in smooth backlash compensation
1850	Grid shift/reference position shift for individual axis
1851	Backlash compensation for individual axis
1852	Backlash compensation for individual axis at rapid traverse
1876	Inductosyn 1-pitch interval
1877	Inductosyn shift
1882	Mark 2 intervals on linear scale having reference marks
1883	Distance from origin to reference position on linear scale having reference marks
1884	Distance from origin to reference position on linear scale having reference marks
1885	Permissible cumulative movement value during torque control (PMC axis control)
1886	Position error with torque control canceled (PMC axis control)
2033	For vibration damping control : position pulses conversion coefficient
2082	Second stage start/end parameter (when the two-stage backlash acceleration function is used)
2101	Overshoot compensation enable level
2103	Unexpected disturbance torque detection amount retrace distance
2119	Function for changing the proportional gain in the stop state : stop judgment level
2382	Torsion preview control: maximum compensation value (LSTCM)
2373	Lift amount in lifting function against gravity at emergency stop
3623	Pitch error compensation magnification for individual axis
3627	Pitch error compensation value at reference position when movement to reference position is made in the direction opposite to reference position return direction
5300	First-spindle rigid tapping effective area (in-position check) for tapping axis
5302	Second-spindle rigid tapping effective area (in-position check) for tapping axis
5304	Third-spindle rigid tapping effective area (in-position check) for tapping axis
5306	Fourth-spindle rigid tapping effective area (in-position check) for tapping axis
5310	First-spindle rigid tapping position error limit for tapping axis during movement
5312	First-spindle rigid tapping position error limit for tapping axis at stop
5350	Second-spindle rigid tapping position error limit for tapping axis during movement
5352	Second-spindle rigid tapping position error limit for tapping axis at stop
5354	Third-spindle rigid tapping position error limit for tapping axis during movement
5356	Third-spindle rigid tapping position error limit for tapping axis at stop
5358	Fourth-spindle rigid tapping position error limit for tapping axis during movement
5360	Fourth-spindle rigid tapping position error limit for tapping axis at stop
5761	Compensation at compensation point number a for movement axis 1 (straightness compensation)
5762	Compensation at compensation point number b for movement axis 1 (straightness compensation)
5763	Compensation at compensation point number c for movement axis 1 (straightness compensation)
5764	Compensation at compensation point number d for movement axis 1 (straightness compensation)

No.	Description
5771	Compensation at compensation point number a for movement axis 2 (straightness compensation)
5772	Compensation at compensation point number b for movement axis 2 (straightness compensation)
5773	Compensation at compensation point number c for movement axis 2 (straightness compensation)
5774	Compensation at compensation point number d for movement axis 2 (straightness compensation)
5781	Compensation at compensation point number a for movement axis 3 (straightness compensation)
5782	Compensation at compensation point number b for movement axis 3 (straightness compensation)
5783	Compensation at compensation point number c for movement axis 3 (straightness compensation)
5784	Compensation at compensation point number d for movement axis 3 (straightness compensation)
5871	Compensation α at compensation point number a for individual axis (gradient compensation)
5872	Compensation β at compensation point number b for individual axis (gradient compensation)
5873	Compensation γ at compensation point number c for individual axis (gradient compensation)
5874	Compensation ε at compensation point number d for individual axis (gradient compensation)
6287	Position error limit at torque limit skip
7772	Number of pulses from position detector per rotation of EGB master axis (tool axis) [path type]
7773	Number of pulses from position detector per rotation of EGB slave axis (workpiece axis) [path type]
7782	Number of pulses from position detector per rotation of EGB master axis [axis type]
7783	Number of pulses from position detector per rotation of EGB slave axis [axis type]
8181	Synchronous error limit for each axis (axis recomposition)
8323	Limit of position error check in feed axis synchronous control
8326	Difference in reference counter value between master axis and slave axis
8331	Maximum permissible synchronous error in synchronous error excess alarm 1
8332	Maximum permissible synchronous error in synchronous error excess alarm 2
8333	Synchronous error zero width for each axis
8335	Synchronous error zero width 2 for each axis
8377	Permissible error at start of chopping compensation
14010	Maximum permissible movement amount at reference position setup of linear scale with absolute addressing reference marks
14988	Magnification of cycle type second pitch error compensation for each axis

- Setting data for shifting external machine coordinate systems

C FUNCTION-SPECIFIC SERVO PARAMETERS

☆ : Parameters set up automatically or cleared at initialization

Parenthesized parameters : Common parameters that are also used for other functions

Parameter number		Meaning		
FS15*i*	FS30*i*,16*i*,etc.			
[Servo initialization functions]				
1804	2000	Initialization bits		→ 2.1.2
1874	2020	Motor ID number		
1806	2001	AMR		
1820	1820	CMR		
1977 1978	2084 2085	Flexible feed gear (numerator) Flexible feed gear (denominator)		
1879	2022	Move direction		
1876	2023	Number of velocity pulses		
1891	2024	Number of position pulses		
2628	2185	Position pulses conversion coefficient		
1804#0	2000#0	1: Multiplies the number of velocity pulses and position pulses by 10.		
1896	1821	Reference counter capacity		
2622	2179	Reference counter capacity (denominator)		
1875	2021	Load inertia ratio		
–	3111#0	1: Displays the servo setting screen.		
[HRV control]				
1707#0	2013#0	1: Servo HRV3 control	☆	→ 4.2
–	2014#0	1: Servo HRV4 control	☆	
–	2300#0	1: Extended HRV function	☆	
2747	2334	High-speed HRV current control mode: Current loop gain magnification		
2748	2335	High-speed HRV current control mode: Velocity loop gain magnification		
[Vibration suppression functions in the stop state]				
1959#7	2017#7	Velocity loop high cycle management function		→ 4.4.1
1894	2066	250 μs acceleration feedback gain	☆	→ 4.4.2
1958#3	2016#3	Variable proportional gain function in the stop state		→ 4.4.3
1730	2119	Variable proportional gain function in the stop state : stop judgement level		
1747#3	2207#3	1: The velocity loop proportional gain in the stop state is 50%.		
2733	2324	Function for changing the proportional gain in the stop state : arbitrary magnification		
1808#4	2003#4	N pulse suppression function	☆	→ 4.4.4
1992	2099	N pulse suppression level	☆	
1895	2067	TCMD filter coefficient	☆	→ 4.3
1779	2156	Torque command filter coefficient for rapid traverse		→ 4.5.1
[Machine-resonance suppression functions]				
1706	2113	Resonance elimination filter 1 : attenuation center frequency	☆	→ 4.5.2
2620	2177	Resonance elimination filter 1 : attenuation bandwidth		
2772	2359	Resonance elimination filter 1 : damping		
2773	2360	Resonance elimination filter 2 : attenuation center frequency		
2774	2361	Resonance elimination filter 2 : attenuation bandwidth		

☆ : Parameters set up automatically or cleared at initialization
Parenthesized parameters : Common parameters that are also used for other functions

Parameter number		Meaning		
FS15*i*	FS30*i*,16*i*,etc.			
2775	2362	Resonance elimination filter 2 : damping		→ 4.5.2
2776	2363	Resonance elimination filter 3 : attenuation center frequency		
2777	2364	Resonance elimination filter 3 : attenuation bandwidth		
2778	2365	Resonance elimination filter 3 : damping		
2779	2366	Resonance elimination filter 4 : attenuation center frequency		
2780	2367	Resonance elimination filter 4 : attenuation bandwidth		
2781	2368	Resonance elimination filter 4 : damping		
2683#3	2270#3	1: Active resonance elimination filter function (applied with resonance elimination filter 1)		
2765	2352	Detection level (active resonance elimination filter)		
2611#0	2223#0	1: disturbance elimination filter function		→ 4.5.3
2731	2318	Disturbance elimination filter : gain		
2732	2319	Disturbance elimination filter : inertia ratio		
2733	2320	Disturbance elimination filter : gain for inverse model		
2734	2321	Disturbance elimination filter : filter time constant		
2735	2322	Disturbance elimination filter : acceleration feedback limit		
1808#2	2003#2	Observer function	☆	→ 4.5.4
1859	2047	Observer coefficient (POA1)	☆	
1862	2050	Observer coefficient (POK1)	☆	
1863	2051	Observer coefficient (POK2)	☆	
1960#1	2018#1	Disable function for observer in the stop state		
1730	2119	Disable function for observer in the stop state : judgment level for stop state		
1743#2	2203#2	1: Current loop 1/2 PI control function enabled		→ 4.5.5 → 4.3
1742#1 1742#2	2202#1 2202#2	1: Current loop 1/2 PI control function enabled only in cutting feed (Common to the cutting/rapid velocity gain switching function) 1: Current loop 1/2 PI control function is always enabled when the above bit is used.		
2736	2323	Current control PI ratio		
1718	2033	Position feedback pulse count (vibration damping control)		→ 4.5.6
1719	2034	Vibration damping control gain		
1709#7	2019#7	Dual position feedback function (optional function)	☆	→ 4.5.7
1861	2049	Dual position feedback function : maximum amplitude	☆	
1971	2078	Dual position feedback function : conversion coefficient (numerator)	☆	
1972	2079	Dual position feedback function : conversion coefficient (denominator)	☆	
1973	2080	Dual position feedback function : primary delay time constant	☆	
1974	2081	Dual position feedback function : zero zone	☆	
1729	2118	Dual position feedback function : alarm detection level of Semi-Full error (Only this function can be used even if there is no option.)		
1954#5 1954#4	2010#5 2010#4	1: The backlash compensation amount is added to the error counter on the full-closed side. 1: The pitch error compensation amount is added to the error counter on the semi-closed side.		
1746#4	2206#4	1: The backlash compensation amount and pitch amount are added to the error counters on both the full- and semi-closed sides.		
1742#4	2202#4	1: Improvement of judge on zero width		
1956#1	2012#1	Machine speed feedback function	☆	→ 4.5.8
1981	2088	Machine speed feedback gain	☆	

☆ : Parameters set up automatically or cleared at initialization
Parenthesized parameters : Common parameters that are also used for other functions

Parameter number FS15*i*	FS30*i*,16*i*,etc.	Meaning		
[Contour error suppression functions]				
[Feed-forward functions]				
1808#3	2003#3	PI control	☆	→ 4.6.1 to 4.6.3
1883#1	2005#1	Feed-forward function	☆	
1961	2068	Feed-forward coefficient	☆	
1962	2069	Velocity feed-forward coefficient	☆	
1985	2092	Advanced preview feed-forward coefficient	☆	→ 4.6.2
1959#5	2017#5	1: The response of feed-forward is improved when RISC is used.		→ 4.6.3
1740#5	2200#5	1: The response of the position command is improved when RISC is used.		
1800#3	1800#3	Enables feed-forward in rapid traverse.		→ 4.3 → 4.8.3
1988	2095	Feed-forward timing adjustment coefficient		→ 4.6.5
2808	2395	Feed-forward timing adjustment coefficient (for use when FAD is enabled)		
(1742#0)	(2202#0)	Switches the feed-forward coefficient between cutting and rapid traverse. (This parameter is also used for the cutting/rapid traverse-specific fine acc./dec. function.)		→ 4.3 → 4.6.4 → 4.8.3
2602#3	2214#4	Switches the feed-forward coefficient between cutting and rapid traverse. (This function is independent of fine acc./dec..)		
1767	2144	Position feed-forward coefficient for cutting		
1768	2145	Velocity feed-forward coefficient for cutting		
(1985)	(2092)	Position feed-forward coefficient for rapid traverse	☆	
(1962)	(2069)	Velocity feed-forward coefficient for rapid traverse	☆	
[Backlash acceleration functions]				
1808#5	2003#5	Backlash acceleration function	☆	→ 4.6.6
1860	2048	Backlash acceleration amount	☆	
1964	2071	Period during which backlash acceleration remains effective	☆	
(1725)	(2114)	Acceleration amount override		
(2751)	(2338)	Limit of acceleration amount		
(1987)	(2094)	Backlash acceleration amount (for reverse from negative to positive direction)	☆	
(2753)	(2340)	Acceleration amount override (for reverse from negative to positive direction)		
(2754)	(2341)	Limit of acceleration amount (for reverse from negative to positive direction)		
1953#7	2009#7	Backlash acceleration stop	☆	
1975	2082	Timing at which the backlash acceleration is stopped	☆	
1953#6	2009#6	1: Enables the backlash acceleration function during cutting feed only.	☆	
1851	1851	Backlash compensation		→ 4.6.6 to 4.6.7
1884#0	2006#0	1: Does not reflect the backlash compensation in positions.	☆	
1957#6 (1808#5)	2015#6 (2003#5)	Two-stage backlash acceleration function (The backlash acceleration function is also enabled.)	 ☆	→ 4.6.7
(1860)	(2048)	First stage acceleration amount	☆	
1987	2094	First stage acceleration amount from negative direction to positive direction	☆	

☆ : Parameters set up automatically or cleared at initialization
Parenthesized parameters : Common parameters that are also used for other functions

Parameter number FS15*i*	FS30*i*,16*i*,etc.	Meaning		
1760	2137	First stage acceleration override		→ 4.6.7
1975	2082	Second stage start position	☆	
1982	2089	Second stage end scale factor	☆	
1724	2039	Second stage acceleration amount		
1790	2167	Second stage offset		
1725	2114	Second stage acceleration override		
2751	2338	Second stage acceleration amount limit value		
2752	2339	Second stage acceleration amount (for turn-over from negative direction to positive direction)		
2753	2340	Second stage acceleration amount override (for turn-over from negative direction to positive direction)		
2754	2341	Second stage acceleration amount limit value (for turn-over from negative direction to positive direction)		
1960#2	2018#2	The format of the second stage acceleration override is changed.		
1953#6	2009#6	1: Enables backlash acceleration only during cutting feed.	☆	
2611#7	2223#7	1: When bit 3 of parameter No. 1800 = 1, the backlash acceleration function is enabled only for cutting feed.		
(1980)	(2087)	Torque offset	☆	
(2603#1)	(2215#1)	Torque offset canceling when an emergency stop is released		
1883#7 (1808#5)	2005#7 (2003#5)	Static friction compensation function (The backlash acceleration function is also enabled.)	☆ ☆	→ 4.6.8
(1964)	(2071)	Compensation count	☆	
1965	2072	Static friction compensation	☆	
1966	2073	Stop state judgement parameter	☆	
(1953#7)	(2009#7)	Stop of static friction compensation	☆	
1990	2097	Parameter for stopping static friction compensation	☆	
[Torsion preview control]				
2795	2382	Torsion preview control: maximum compensation value (LSTCM) (Setting maximum compensation value enables torsion preview control.)		→ 4.6.9
2796	2383	Torsion preview control: acceleration 1 (LSTAC1)		
2797	2384	Torsion preview control: acceleration 2 (LSTAC2)		
2798	2385	Torsion preview control: acceleration 3 (LSTAC3)		
2799	2386	Torsion preview control: acceleration torsion compensation value K1 (LSTK1)		
2800	2387	Torsion preview control: acceleration torsion compensation value K2 (LSTK2)		
2801	2388	Torsion preview control: acceleration torsion compensation value K3 (LSTK3)		
2802	2389	Torsion preview control: torsion delay compensation value KD (LSTKD)		
2803	2390	Torsion preview control: torsion delay compensation value KDN (LSTKDN)		
2804	2391	Torsion preview control: acceleration torsion compensation value K1N (LSTK1N)		
2805	2392	Torsion preview control: acceleration torsion compensation value K2N (LSTK2N)		
2806	2393	Torsion preview control: acceleration torsion compensation value K3N (LSTK3N)		

☆ : Parameters set up automatically or cleared at initialization
Parenthesized parameters : Common parameters that are also used for other functions

Parameter number FS15*i*	FS30*i*,16*i*,etc.	Meaning		
2815	2402	Torsion preview control: torsion torque compensation coefficient (LSTKT)		→ 4.6.9
[Overshoot compensation functions]				
1808#6	2003#6	Overshoot compensation function	☆	→ 4.7
1857	2045	Velocity loop incomplete integral gain (PK3V)	☆	
1970	2077	Overshoot compensation counter	☆	
1994	2101	Overshoot compensation enable level	☆	
1742#3	2202#3	Overshoot compensation type 2		
[High-speed positioning functions]				
1957#0	2015#0	Position gain switch function		→ 4.8.1
1714	2029	Limit speed for enabling position gain switching		
1744#1	2204#1	1: Increases the increment system for the effective switch velocity to 10 times.		
1957#0 1744#5	2015#0 2204#5	Position gain switch function type 2		
1957#1	2015#1	Low-speed integration function		→ 4.8.2
1714	2029	Limit speed for disabling low-speed integration at acceleration		
1716	2030	Limit speed for enabling low-speed integration at deceleration		
(1744#1)	(2204#1)	1: Increases the increment system for the switch velocity to 10 times.		
1951#6	2007#6	Fine acc./dec. (FAD) function	☆	→ 4.8.3
1749#2	2209#2	0: FAD bell-shaped, 1: FAD linear type		
(1985)	(2092)	Position feed-forward coefficient (This parameter is also used for look-ahead control.)		
1742#0	2202#0	Cutting/rapid traverse-specific fine acc./dec. function		→ 4.3 → 4.8.3
1800#3	1800#3	Enables feed-forward in rapid traverse.		
1702	2109	Fine acc./dec. time constant		
1766	2143	Fine acc./dec. time constant 2		
(1767)	(2144)	Position feed-forward coefficient for cutting		
(1768)	(2145)	Velocity feed-forward coefficient for cutting		
(1985)	(2092)	Position feed-forward coefficient for rapid traverse	☆	
(1962)	(2069)	Velocity feed-forward coefficient for rapid traverse	☆	
1749#3	2209#3	1: Synchronization is established in the rigid tapping mode when FAD is specified.		→ 4.8.3
[Serial feedback dummy functions]				
1953#0	2009#0	Dummy serial feedback function	☆	→ 4.9
1800#1	1800#1	1: Ignores the V-READY ON alarm.		
1745#2	2205#2	Separate detector-based dummy feedback function		
[Brake control functions]				
1883#6	2005#6	Brake control function	☆	→ 4.10
1976	2083	Brake control timer	☆	
2686#7	2273#7	Torque limit setting function during brake control		
2788	2375	Torque limit magnification during brake control		
[Stop distance reduction functions]				
1959#0	2017#0	Emergency stop distance reduction function type 1 (VCMD0)		→ 4.11.1
1744#7	2204#7	Emergency stop distance reduction function type 2 (return)		→ 4.11.2
2786 2787	2373 2374	Lifting function against gravity at emergency stop : distance to lift Lifting function against gravity at emergency stop : lifting time		→ 4.11.3

☆ : Parameters set up automatically or cleared at initialization
Parenthesized parameters : Common parameters that are also used for other functions

Parameter number FS15*i*	FS30*i*,16*i*,etc.	Meaning		
1745#4 1745#5	2205#4 2205#5	Separate detector hardware disconnection stop distance reduction function For axes under synchronization control, this bit is also set.		→ 4.11.4
2600#7	2212#7	OVL and OVC alarm stop distance reduction function		→ 4.11.5
[Unexpected disturbance torque detection functions] (Optional functions)				
1958#0	2016#0	Unexpected disturbance torque detection function		→ 4.12
1740#5	2200#5	Improvement in the accuracy of an estimated disturbance load		
2716	2302	Improvement in the accuracy of an estimated disturbance load (A Q-phase current phase lag is compensated for.)	☆	
1980	2087	Torque offset	☆	
1727	2116	Dynamic friction compensation value	☆	
2758	2345	Dynamic friction compensation value in the stop state		
2759	2346	Dynamic friction compensation limit value		
1997	2104	Unexpected disturbance torque detection alarm level		
1996	2103	Retrace distance	☆	
1740#3	2200#3	Cutting/traverse unexpected disturbance torque detection switching function	☆	
2603#7	2215#7	Cutting/traverse unexpected disturbance torque detection switching function type-2		
(1997)	(2104)	Unexpected disturbance torque detection alarm level for cutting		
1765	2142	Unexpected disturbance torque detection alarm level for rapid traverse	☆	
2684#2	2271#2	2-axes simultaneous retract function at unexpected disturbance torque detection		
2603#1	2215#1	Torque offset canceling when an emergency stop is released		
[Linear motor functions]				
1954#2	2010#2	Linear motor control function	☆	→ 4.14
1705	2112	AMR conversion coefficient 1	☆	
1761	2138	AMR conversion coefficient 2		
1762	2139	AMR offset		
2683#0	2270#0	AMR offset setting range expansion from -60 degrees to +60 degrees		
(2628)	(2185)	Position pulse conversion coefficient		
1740#6	2200#6	The velocity loop proportional gain format is changed.		
1750#2	2210#2	Current gain internally 4 times function	☆	
1753 1754 1755	2130 2131 2132	Smoothing compensation performed twice per pole pair Smoothing compensation performed four times per pole pair Smoothing compensation performed six times per pole pair	☆	
2782 2783 2784	2369 2370 2371	Smoothing compensation performed twice per pole pair (negative direction) Smoothing compensation performed four times per pole pair (negative direction) Smoothing compensation performed six times per pole pair (negative direction)		
1743#6	2203#6	Linear motor quadruple smoothing compensation		
2713#7	2300#7	1: Determines overheat via PMC.	☆	
[Synchronous built-in servo motor functions]				
1954#2	2300#2	Synchronous built-in servo motor control	☆	→ 4.15
1806	2001	AMR		
2608#0	2220#0	Non-binary detector		
1705	2112	AMR conversion coefficient 1	☆	

☆ : Parameters set up automatically or cleared at initialization
Parenthesized parameters : Common parameters that are also used for other functions

Parameter number		Meaning		
FS15*i*	FS30*i*,16*i*,etc.			
1761	2138	AMR conversion coefficient 2		
1762	2139	AMR offset		
2601#7	2213#7	Pole position detection function (optional)		
2616#3	2228#3	Motor saliency 0: Lq>Ld, 1: Lq<Ld		
2617#0	2229#0	1: AMR offset is used.		
2617#3	2229#3	0: After pole detection, an abnormal movement is monitored.		
2617#4	2229#4	0: Automatic selection mode (minute operation mode + stop mode) 1: Minute operation mode		
2625 2641 2642	2182 2198 2199	Current A for pole detection Current B for pole detection Current C for pole detection		→ 4.15
2681	2268	Allowable travel distance magnification/stop speed decision value		
2790 2791	2377 2378	Smoothing compensation performed 1.5 times per pole pair Smoothing compensation performed 1.5 times per pole pair (negative direction)		
2793 2794	2380 2381	Smoothing compensation performed three times per pole pair Smoothing compensation performed three times per pole pair (negative direction)		
2713#7	2300#7	1: Oveaheat is checked via the PMC.	☆	
[Torque control functions]				
1951#7	2007#7	Torque control type 1	☆	
1743#4	2203#4	Torque control type 2		→ 4.16
1998	2105	Torque constant	☆	
[Tandem disturbance elimination control] (Optional functions)				
1709#1	2019#1	Enables tandem disturbance elimination control.		
1952#2	2008#2	Enables the velocity feedback average function. (Set this parameter for the main axis only.)		
1721	2036	Tandem disturbance elimination control proportional gain (Set this parameter for the main axis only.)		
1721	2036	Tandem disturbance elimination control phase compensation coefficient (Set this parameter for the sub-axis only.)		→ 4.17
2738	2325	Tandem disturbance elimination control integral gain (Set this parameter for the main axis only.)		
2738	2325	Tandem disturbance elimination control phase compensation coefficient (Set this parameter for the sub-axis only.)		
2746	2333	Tandem disturbance elimination control incomplete integral time constant (Set this parameter for the main axis only.)		
[Synchronous axes automatic compensation function]				
2688#3	2275#3	Enables synchronous axes automatic compensation. (Set this parameter for the sub-axis.)		
2816	2403	Synchronous axes automatic compensation: coefficient (K) (sub-axis)		→ 4.18
2817	2404	Synchronous axes automatic compensation: maximum compensation value (sub-axis), dead-band width (main-axis)		
2818	2405	Synchronous axes automatic compensation : filter coefficient (sub-axis)		
[Tandem control functions] (Optional functions)				
1817#6	1817#6	Tandem control function (main- and sub-axes)		
–	1010	Number of CNC controlled axes		→ 4.19
1021	–	Parallel-axis name (main axis: 77, sub-axis: 83)		
1980	2087	Preload value		→ 4.19.1

☆ : Parameters set up automatically or cleared at initialization
Parenthesized parameters : Common parameters that are also used for other functions

Parameter number FS15*i*	FS30*i*,16*i*,etc.	Meaning		
1952#7	2008#7	Damping compensation function	☆	→ 4.19.2
1721	2036	Damping compensation gain (main axis) and damping compensation phase (sub-axis)		
1952#2	2008#2	Velocity feedback average function	☆	→ 4.19.3
1951#1	2007#1	Servo alarm two-axis monitor function	☆	→ 4.19.4
1960#7	2018#7	Motor feedback sharing function (sub-axis)		→ 4.19.5
1940#1	2200#1	Full-closed loop feedback sharing function (sub-axis)		→ 4.19.6
[Servo check board functions]				
1956#5 1956#4	2012#5 2012#4	VCMD output magnification 00: 1, 01: 16, 10: 16^2, 11: 16^3	☆	→ Appendix I
1957#5	2015#5	1: Outputs an estimated load to the check board. (The estimated load is output to the torque command channel.)		→ 4.6.7, 4.12
1743#5	2203#5	1: Enables the four-times torque command output. (Small-torque command output can be measured.)		→ 4.14, Appendix I
1726	2115	For internal data output: Must be kept at 0. The output of the SPEED signal (number of revolutions) is disabled. (Series 9096)		
1774	2151	Internal data output: Always specify 0. (Series 90B0)		→ 4.14
1775	2152	Internal data output: Always specify 0. (Series 90B0)		
1776	2153	Internal data output: Always specify 0. (Series 90B0)		
1746#7	2206#7	1: Performs high-speed data output to the check board (Series 90B0).		→ Appendix I
2613#1	2225#1	1: TCMD signal check board output 1/2 (Series 90B0)		
2613#2	2225#2	1: SPEED signal check board output 1/2 (7500 min^{-1}/5 V) (Series 90B0)		
2208#3	-	1: Arbitrary data screen is displayed.		→ 4.14
-	DGN353 DGN354	DGN for internal data display DGN for internal data display		
[Related to simplified frequency characteristics measurement]				
2683#7	2270#7	1: Starts disturbance input.		→ Appendix H
2683#6	2270#6	1: Inputs disturbance for both of an odd-numbered axis and even-numbered axis simultaneously. (Used for synchronous axes or tandem axes)		
2683#5	2270#5	1: The input waveform of disturbance input is a square wave. (Usually, select 0: Sine wave.)		
2739	2326	Disturbance input gain		
2740	2327	Disturbance input start frequency		
2741	2328	Disturbance input end frequency		
2742	2329	Number of disturbance input measurement points		

D PARAMETERS RELATED TO HIGH-SPEED AND HIGH PRECISION OPERATIONS

The *i* series CNCs are provided with some functions for high-speed and high precision operations. This appendix lists parameters categorized by model and function and their standard setting values so as to make it easy to tune the functions.
Appendix D consists of the following two items:

(1) CNC model-specific information
This section lists high-speed and high precision functions and parameters related to them for individual CNC models.
The parameter tables in this section contain standard setting values.

(2) Servo parameters
This section lists servo parameters common to all CNC models and standard setting values for them.

NOTE

1 Use the standard setting values included in the parameter tables as reference data for initialization. If a parameter needs tuning based on the machine type, determine a final setting for the parameter according to the characteristic of the machine and how to use it.
To reduce machining time, change parameters from standard settings to speed priority I to speed priority II while checking the operation status. (The settings for speed priority II can reduce much more machining time than the settings for speed priority I.)

2 For the specifications of CNC models and detailed explanations about their functions, refer to the respective CNC manuals.

3 In the following table, the circle indicates that the item is supported, the triangle indicates partial support, and the cross indicates non-support.

D.1 MODEL-SPECIFIC INFORMATION

D.1.1 Series 15*i*-MB

[Functions related to high-speed and high precision operations]

High-speed high precision functions	Look-ahead acc./dec. before interpolation	Fine HPCC
Series 15*i*-MB	○	○
Acc./dec. before interpolation		
– Type	Linear/Bell-shaped	Linear/Bell-shaped/ Smooth bell-shaped
– Time constant setting for individual axes	○	○
Velocity control		
– Automatic corner deceleration	○	○
– Arc radius-based velocity control	○	○
– Acceleration-based velocity control	×	○
– Cutting load-based velocity control	×	○
– Jerk control	×	○
– Optimum torque acc./dec.	○	○
Other functions		
– Nano interpolation	○	○
– 5-axis machining function	○	○
– Smooth interpolation	○	○
– NURBS	○	○
– Nano smoothing	○	○
Additional hardware	None	None

[Parameters]

Use the standard setting values included in the parameter tables as reference data for initialization. If a parameter needs tuning based on the machine type, determine a final setting for the parameter according to the characteristic of the machine and how to use it.

- Standard settings (precision priority)
  When there is vibration or significant impact, or when machining is to be performed more precisely, make settings based on the standard settings.
- Cutting time-first setting
  To reduce machining time, make settings for speed priority I then for speed priority II in stages. The settings for speed priority II can reduce much more machining time than the settings for speed priority I.

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1478	400.0	500.0	1000.0	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
1635	24	16	16	Time constant (msec) for acc./dec. after interpolation
1656	64	48	32	Time constant (msec) for bell-shaped acc./dec. before interpolation (portion with the time fixed)
1660	700.0	2000.0	4000.0	Acceleration of linear-/bell-shaped acc./dec. before interpolation (portion with the acceleration fixed) (Acceleration is specified in mm/sec^2 units for individual axes.)
1663	525.0	1500.0	3000.0	Allowable acceleration (mm/sec^2) during acceleration-dependent deceleration (HPCC mode) (Acceleration is specified in mm/sec^2 for individual axes.)
1665	525.0	1500.0	3000.0	Allowable acceleration (mm/sec^2) at arc interpolation during acceleration-dependent deceleration (non-HPCC mode) (Acceleration is specified in mm/sec^2 for individual axes.)

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1483	100.0	Lower speed limit to acceleration-dependent deceleration (HPCC mode) (mm/min)
1491	100.0	Lower speed limit to deceleration acceleration-dependent (non-HPCC mode) (mm/min)
1517#6	0	Speed difference- or acceleration-dependent deceleration type 0: Compatible with the 15B (by making the most of allowable speed difference and acceleration for each axis) 1: Fixed speed regardless of the direction of movement as long as the same contour is involved.
1600#4	0	0: Linear- or bell-shaped acc./dec. after interpolation enabled (Note 1) 1: Exponential acc./dec. after interpolation enabled
1603#6	1/0	When using the function for changing the time constant of bell-shaped acc./dec. before interpolation, set 1.
1473	mm / inch 10000.0/3937.0	Reference speed in the function for changing the time constant of bell-shaped acc./dec. before interpolation (mm/min / inch/min)
2401#6	0	Setting this parameter to 1 enables look-ahead acc./dec. before interpolation and multibuffer when the power is switched on and in the cleared state. Fine HPCC is also enabled if available. If it is reset to 0, it is turned on with the G05.1Q1 command.
7565#7	0	Setting this parameter to 1 causes a specified speed to be ignored and assumes that a speed set in parameter No. 7567 is specified
7567	0	Specified clamp value in the fine HPCC mode (mm/min (input unit)) If the parameter setting is 0, no clamp takes place except for the maximum cutting speed specified in parameter No. 1422.
7565#4	0/1	Set this parameter to 1 if the cutting load-based deceleration function is to be enabled. (This parameter is used if the mechanical rigidity of the Z-axis is low.)
7697#1	0/1	When using the slant type for override by cutting load, set 1. (Note 2)
7698	80	Override of area 1 in deceleration by cutting load (This setting is unnecessary if bit 4 of parameter No. 7565 is set to 0 or bit 1 of parameter No. 7697 is set to 0.) (%) (Note 2)
7591	80	Region 2 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 7565 = 0)

Parameter No.	Standard setting value	Description
7592	70	Region 3 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 7565 = 0)
7593	60	Region 4 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 7565 = 0)
8495#0	0/1	When using smooth velocity control as velocity control by acceleration, set 1. (Note 2)

NOTE
1 To perform bell-shaped acc./dec. after cutting feed interpolation, the option for bell-shaped acc./dec. after cutting feed interpolation is required.
2 Only fine HPCC can be used.

D.1.2 Series 16*i*/18*i*/21*i*/0*i*/0*i* Mate-MB, 0*i*/0*i* Mate-MC/20*i*-FB

[Functions related to high-speed and high precision operations]

High-speed and high precision function	Advanced preview control (APC)	AI advanced preview control (AI-APC)	AI contour control (AICC)	AI nano contour control (AI nano CC)	High precision contour control (HPCC)	AI high precision contour control (AI-HPCC)	AI nano high precision contour control (AI nano HPCC)
Series 0*i* Mate M-C	×	○	×	×	×	×	×
Series 0*i*-MC	×	○	○	×	×	×	×
Series20*i*-FB	○	×	○	×	×	×	×
Series 0*i* Mate-MB	×	○	×	×	×	×	×
Series 0*i*-MB	×	○	○	×	×	×	×
Series21*i*-MB	○	○	○	○	×	×	×
Series18*i*-MB	○	×	○	○	○	○	○
Series16*i*-MB	○	×	○	○	○	○	○
Acc./dec. before interpolation							
Type	Linear	Linear/ Bell-shaped	Linear/ Bell-shaped/ Smooth bell-shaped	Linear/ Bell-shaped/ Smooth bell-shaped	Linear/ Bell-shaped	Linear/ Bell-shaped/ Smooth bell-shaped	Linear/ Bell-shaped/ Smooth bell-shaped
Time constant setting for individual axes	×	×	×	×	×	○	○
Velocity control							
Automatic corner deceleration	○	○	○	○	○	○	○
Arc radius-based velocity control	○	○	○	○	○	○	○
Acceleration-based velocity control	×	○	○	○	○	○	○
Cutting load-based velocity control	×	×	×	×	○	○	○
Jerk control (Note 1)	×	×	△	△	×	○	○
Optimum torque acc./dec.	×	×	×	×	×	○	○
Other functions							
Nano interpolation	×	×	×	○	×	×	○
5-axis machining function	×	×	×	×	×	○	○
Smooth interpolation	×	×	×	×	○	○	○
NURBS	×	×	×	×	○	○	○
Nano smoothing	×	×	×	×	×	○	○
Additional hardware	None	None	None	None	RISC board is necessary.		

NOTE

1 Jerk control can be used in the Series 16*i*-MB/18*i*-MB.

[Parameters]

Described below are the parameters that must be specified for individual high-speed and high precision cutting machines separately. Use the standard setting values included in the parameter tables as reference data for initialization. If a parameter needs tuning based on the machine type, determine a final setting for the parameter according to the characteristic of the machine and how to use it.

- Standard settings (precision priority)
  When there is vibration or significant impact, or when machining is to be performed more precisely, make settings based on the standard settings.
- Cutting time-first setting
  To reduce machining time, make settings for speed priority I then for speed priority II in stages. The settings for speed priority II can reduce much more machining time than the settings for speed priority I.

NOTE

1. Performing bell-shaped acc./dec. after interpolation requires the look-ahead bell-shaped acc./dec. after interpolation option.
2. Performing linear-shaped acc./dec. after cutting feed interpolation requires the linear-shaped acc./dec. after cutting feed interpolation option.
3. Performing bell-shaped acc./dec. after cutting feed interpolation requires the bell-shaped acc./dec. after cutting feed interpolation option.
4. Performing bell-shaped acc./dec. in rapid-traverse requires the bell-shaped acc./dec. in rapid-traverse option.

(1) Advanced preview control

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1432	-	-	-	Maximum cutting feedrate (mm/min) for individual axes
1620	-	-	-	Time constant (msec) for linear-shaped acc./dec. in rapid-traverse for individual axes
1621	-	-	-	Time constant T2 (msec) for bell-shaped acc./dec. in rapid-traverse for individual axes
1730	3060	5150	7275	Feedrate upper limit (mm/min) for arc radius R
1731	5000	5000	5000	Arc radius R (1 μm) for arc radius-based feedrate upper limit
1732	100	100	100	Arc radius-based feedrate clamp lower speed limit (mm/min)
1768	24	16	16	Time constant (msec) for acc./dec. after cutting feed interpolation
1770	10000	10000	10000	Maximum cutting feedrate (mm/min) during acc./dec. before interpolation
1771	240	80	40	Time (msec) allowed before a maximum cutting feedrate during acc./dec. before interpolation is reached
1783	400	500	1000	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
1784	-	-	-	Speed (mm/min) at occurrence of overtravel alarm To be specified according to the overrun distance at overtravel

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1602#0	1	The type of linear-shaped acc./dec. before interpolation is B.
1602#4	1	Automatic deceleration at corners is under speed difference-dependent control
1602#6,#3	#6,#3	
	1,0	Acc./dec. after interpolation is of a linear type (to be specified when FAD is used)
	1,1	Acc./dec. after interpolation is of a bell-shaped type (to be specified when FAD is not used)
1802#7	0/1	To be set to 1 if the CMR setting is 2 or greater (parameter No. 1820 setting is 4 or greater).
3403#0	1	To be set to the standard setting value.

(2) AI advanced preview control

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1432	-	-	-	Maximum cutting feedrate (mm/min) for individual axes
1620	-	-	-	Time constant (msec) for linear-shaped acc./dec. in rapid-traverse for individual axes
1621	-	-	-	Time constant T2 (msec) for bell-shaped acc./dec. in rapid-traverse for individual axes
1730	3060	5150	7275	Feedrate upper limit (mm/min) for arc radius R
1731	5000	5000	5000	Arc radius R (1 μm) for arc radius-based feedrate upper limit
1732	100	100	100	Arc radius-based feedrate clamp lower speed limit (mm/min)
1768	24	16	16	Time constant (msec) for acc./dec. after cutting feed interpolation
1770	10000	10000	10000	Maximum cutting feedrate (mm/min) during acc./dec. before interpolation
1771	240	80	40	Time (msec) allowed before a maximum cutting feedrate during acc./dec. before interpolation is reached
1772	64	48	32	Time constant of bell-shaped acc./dec. before interpolation (for constant-time part) (msec)
1783	400	500	1000	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
1784	-	-	-	Speed (mm/min) at occurrence of overtravel alarm To be specified according to the overrun distance at overtravel
1785	320	112	56	Parameter (msec) for determining an allowable acceleration in determining acceleration-dependent speed. The parameter is to be set with the time allowed before a maximum cutting feedrate (1432) is reached. A maximum cutting feedrate of 10000 mm/min is used as the standard setting value.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1602#6,#3	#6,#3	
	1,0	Acc./dec. after interpolation is of a linear type (to be specified when FAD is used)
	1,1	Acc./dec. after interpolation is of a bell-shaped type (to be specified when FAD is not used)
1603#7	1	Acc./dec. before interpolation is of bell-shaped type. (0: Linear-shaped acc./dec. before interpolation)
1802#7	0/1	To be set to 1 if the CMR setting is 2 or greater (parameter No. 1820 setting is 4 or greater).

(3) AI contour control

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1432	-	-	-	Maximum cutting feedrate (mm/min) for individual axes
1620	-	-	-	Time constant (msec) for linear-shaped acc./dec. in rapid-traverse for individual axes
1621	-	-	-	Time constant T2 (msec) for bell-shaped acc./dec. in rapid-traverse for individual axes
1730	3060	5150	7275	Feedrate upper limit (mm/min) for arc radius R
1731	5000	5000	5000	Arc radius R (1 μm) for arc radius-based feedrate upper limit
1732	100	100	100	Arc radius-based feedrate clamp lower speed limit (mm/min)
1768	24	16	16	Time constant (msec) for acc./dec. after cutting feed interpolation
1770	10000	10000	10000	Maximum cutting feedrate (mm/min) during acc./dec. before interpolation
1771	240	80	40	Time (msec) allowed before a maximum cutting feedrate during acc./dec. before interpolation is reached
1772	64	48	32	Time constant (msec) for bell-shaped acc./dec. before interpolation (portion with the time fixed)
1783	400	500	1000	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
1784	-	-	-	Speed (mm/min) at occurrence of overtravel alarm To be specified according to the overrun distance at overtravel
1785	320	112	56	Parameter (msec) for determining an allowable acceleration in determining acceleration-dependent speed. The parameter is to be set with the time allowed before a maximum cutting feedrate (1432) is reached. A maximum cutting feedrate of 10000 mm/min is used as the standard setting value.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1602#6,#3	#6,#3	
	1,0	Acc./dec. after interpolation is of a linear type (if bell-shaped acc./dec. before interpolation is used)
	1,1	Acc./dec. after interpolation is of a bell-shaped type (if linear-shaped acc./dec. before interpolation is used)
1603#7	1	Acc./dec. before interpolation is of a bell-shaped type (0: Linear-shaped acc./dec. before interpolation)
1802#7	0/1	To be set to 1 if the CMR setting is 2 or greater (parameter No. 1820 setting is 4 or greater).
7050#5	1	To be set to the standard setting value.
7050#6	0	To be set to the standard setting value.
7052#0	0/1	To be set to 1 for the PMC and Cs axes.
7055#3	1/0	To be set to 1 if a function of changing the time constant for bell-shaped acc./dec. before interpolation is to be used.
7058	0	To be set to standard value.
7066	mm / inch 10000/3937	Reference speed (mm/min / inch/min) for a function of changing the time constant for bell-shaped acc./dec. before interpolation

(4) AI nano contour control

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1432	-	-	-	Maximum cutting feedrate (mm/min) for individual axes
1620	-	-	-	Time constant (msec) for linear-shaped acc./dec. in rapid-traverse for individual axes
1621	-	-	-	Time constant T2 (msec) for bell-shaped acc./dec. in rapid-traverse for individual axes
1730	3060	5150	7275	Feedrate upper limit (mm/min) for arc radius R
1731	5000	5000	5000	Arc radius R (1 μm) for arc radius-based feedrate upper limit
1732	100	100	100	Arc radius-based feedrate clamp lower speed limit (mm/min)
1768	24	16	16	Time constant (msec) for acc./dec. after cutting feed interpolation
1770	10000	10000	10000	Maximum cutting feedrate (mm/min) during acc./dec. before interpolation
1771	240	80	40	Time (msec) allowed before a maximum cutting feedrate during acc./dec. before interpolation is reached
1772	64	48	32	Time constant (msec) for bell-shaped acc./dec. before interpolation (portion with the time fixed)
1783	400	500	1000	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
1784	-	-	-	Speed (mm/min) at occurrence of overtravel alarm To be specified according to the overrun distance at overtravel
1785	320	112	56	Parameter (msec) for determining an allowable acceleration in determining acceleration-dependent speed. The parameter is to be set with the time allowed before a maximum cutting feedrate (1432) is reached. A maximum cutting feedrate of 10000 mm/min is used as the standard setting value.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1602#6,#3	#6,#3	
	1,0	Acc./dec. after interpolation is of a linear type (if bell-shaped acc./dec. before interpolation is used)
	1,1	Acc./dec. after interpolation is of a bell-shaped type (if linear-shaped acc./dec. before interpolation is used)
1603#7	1	Acc./dec. before interpolation is of a bell-shaped type (0: Linear-shaped acc./dec. before interpolation)
1802#7	0/1	To be set to 1 if the CMR setting is 2 or greater (parameter No. 1820 setting is 4 or greater).
7052#0	0/1	To be set to 1 for the PMC and Cs axes.
7053#0	0	AI nano contour control (1: AI contour control is enabled.)
7055#3	1/0	To be set to 1 if a function of changing the time constant for bell-shaped acc./dec. before interpolation is to be used.
7058	0	To be set to standard value.
7066	mm / inch 10000/3937	Reference speed (mm/min / inch/min) for a function of changing the time constant for bell-shaped acc./dec. before interpolation

(5) High-precision contour control

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1432	-	-	-	Maximum cutting feedrate (mm/min) for individual axes
1620	-	-	-	Time constant (msec) for linear-shaped acc./dec. in rapid-traverse for individual axes
1621	-	-	-	Time constant T2 (msec) for bell-shaped acc./dec. in rapid-traverse for individual axes
1768	24	16	16	Time constant (msec) for acc./dec. after cutting feed interpolation
8400	10000	10000	10000	Maximum cutting feedrate (mm/min) during acc./dec. before interpolation
8401	240	80	40	Time (msec) allowed before a maximum cutting feedrate during acc./dec. before interpolation is reached
8410	400	500	1000	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
8416	64	48	32	Time constant (msec) for bell-shaped acc./dec. before interpolation (portion with the time fixed)
8470	320	112	56	Parameter (msec) for determining an allowable acceleration in determining acceleration-dependent speed. The parameter is to be set with the time allowed before a maximum cutting feedrate (1432) is reached. A maximum cutting feedrate of 10000 mm/min is used as the standard setting value.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1602#6,#3	#6,#3	
	1,0	Acc./dec. after interpolation is of a linear type (if bell-shaped acc./dec. before interpolation is used)
	1,1	Acc./dec. after interpolation is of a bell-shaped type (if linear-shaped acc./dec. before interpolation is used)
1802#7	0/1	To be set to 1 if the CMR setting is 2 or greater (parameter No. 1820 setting is 4 or greater).
7510	-	Largest of controlled-axis numbers for which high precision contour control is performed
8402#7,#1, 1603#3	1,1 1	Acc./dec. before interpolation is of a bell-shaped type (with the acceleration change fixed)
8402#4	0	To be set to the standard setting value.
8402#5	1	To be set to the standard setting value.
8403#7,#1, 8404#1,#0	1,1 1,1	No alarm is raised on an M, S, T, B, or rapid traverse command. Rapid traverse is processed on the RISC side.
8420	180	Number of blocks to be looked ahead (0: 120 blocks)
8451#0	1	To be set to the standard setting value.
8451#4	0/1	Set this parameter to 1 if cutting load-dependent override is to be used. (This parameter is used if the mechanical rigidity of the Z-axis is low.)
8456	80	Region 2 override (%) for the cutting load-based deceleration function (needn’t be specified if bit 4 of parameter No. 8451 = 0)
8457	70	Region 3 override (%) for the cutting load-based deceleration function) (needn’t be specified if bit 4 of parameter No. 8451 = 0)

Parameter No.	Standard setting value	Description
8458	60	Region 4 override (%) for the cutting load-based deceleration function) (needn't be specified if bit 4 of parameter No. 8451 = 0)
8459#0	0	To be set to the standard setting value.
8459#1	1	To be set to the standard setting value.
8475#2	1	Automatic deceleration at corners is enabled.
8475#3	1	Acceleration-dependent determination of speed during arc interpolation is enabled.
8480#4	0/1	To be set to 1 if the software series on the RISC side is B435. Otherwise, to be reset to 0.
8480#5	0	To be set to the standard setting value.
8480#6	0	To be set to the standard setting value.
8485#0	1/0	Scaling/coordinate system rotation in high precision contour control mode is enabled/disabled. (An option is necessary.)
8485#1	1/0	A canned cycle in high precision contour control mode is enabled/disabled. (An option is necessary.)
8485#2	1/0	A helical interpolation in high precision contour control mode is enabled/disabled. (An option is necessary.)
8485#4	1/0	A involute interpolation in high precision contour control mode is enabled/disabled. (An option is necessary.)
8485#5	1/0	A smooth interpolation in high precision contour control mode is enabled/disabled. (An option is necessary.)

(6) AI high precision contour control, AI nano high precision contour control

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1432	-	-	-	Maximum cutting feedrate (mm/min) for individual axes
1620	-	-	-	Time constant (msec) for linear-shaped acc./dec. in rapid-traverse for individual axes
1621	-	-	-	Time constant T2 (msec) for bell-shaped acc./dec. in rapid-traverse for individual axes
1768	24	16	16	Time constant (msec) for acc./dec. after cutting feed interpolation
8400	10000	10000	10000	Maximum cutting feedrate (mm/min) during acc./dec. before interpolation
19510	240	80	40	Time (msec) allowed before a maximum cutting feedrate is reached for an individual axis during acc./dec. before interpolation. If this parameter is 0, a setting in parameter No. 8401 is used.
8410	400	500	1000	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
8416	64	48	32	Time constant (msec) for bell-shaped acc./dec. before interpolation (portion with the time fixed)
8470	320	112	56	Parameter (msec) for determining an allowable acceleration in determining acceleration-dependent speed. The parameter is to be set with the time allowed before a maximum cutting feedrate (1432) is reached. A maximum cutting feedrate of 10000 mm/min is used as the standard setting value.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1602#6,#3	#6,#3	
	1,0	Acc./dec. after interpolation is of a linear type (if bell-shaped acc./dec. before interpolation is used)
	1,1	Acc./dec. after interpolation is of a bell-shaped type (if linear-shaped acc./dec. before interpolation is used)
1802#7	0/1	To be set to 1 if the CMR setting is 2 or greater (parameter No. 1820 setting is 4 or greater).
7510	-	Largest of controlled-axis numbers for which high precision contour control is performed
8402#7,#1	1,1	Acc./dec. before interpolation is of a bell-shaped type (with the acceleration change fixed)
8403#1	1	No alarm is raised on an M, S, T, B, or rapid traverse command.
8451#4	0/1	Set this parameter to 1 if cutting load-dependent override is to be used. (This parameter is used if the mechanical rigidity of the Z-axis is low.)
19516	80	Region 1 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 8451 = 0)
8456	80	Region 2 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 8451 = 0)
8457	70	Region 3 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 8451 = 0)
8458	60	Region 4 override (%) for the cutting load-based deceleration function) (needn't be specified if bit 4 of parameter No. 8451 = 0)
8480#4	0	To be set to the standard setting value.

Parameter No.	Standard setting value	Description
8480#5	0	To be set to the standard setting value.
8480#6	0	To be set to the standard setting value.
19501#6	1/0	To be set to 1 if a function of changing the time constant for bell-shaped acc./dec. before interpolation is to be used.
19504#0	1	Bell-shaped rapid traverse acc./dec. is used.
19520	mm / inch 10000/3937	Reference speed (mm/min / inch/min) for a function of changing the time constant for bell-shaped acc./dec. before interpolation
19600#0	0/1	Scaling is performed on the CNC side or, as 5-axis control mode, on the RISC side. (An option is necessary.)
19600#1	0/1	Programmable mirror image is performed on the CNC side or, as 5-axis control mode, on the RISC side. (An option is necessary.)
19600#2	0/1	Rotary dynamic fixture offset is performed on the CNC side or, as 5-axis control mode, on the RISC side. (An option is necessary.)
19600#3	0/1	Coordinate rotation is performed on the CNC side or, as 5-axis control mode, on the RISC side. (An option is necessary.)
19600#4	0/1	Three-dimensional coordinate conversion is performed on the CNC side or, as 5-axis control mode, on the RISC side. (An option is necessary.)
19600#5	0/1	Cutter compensation C is performed on the CNC side or, as 5-axis control mode, on the RISC side. (An option is necessary.)

D.1.3 Series 30*i*/31*i*/32*i*-A, 31*i*-A5

[Functions related to high-speed and high precision operations]

High-speed and high precision function		AI contour control I	AI contour control II (Note 1)	AI contour control II + High-speed processing (Note 2)
Series30*i*-A		○	○	○
Series31*i*-A/A5		○	○	○
Series32*i*-A		○	○	×
Acc./dec. before interpolation				
	Type	Linear/ Bell-shaped	Linear/ Bell-shaped/ Smooth bell-shaped	Linear/ Bell-shaped/ Smooth bell-shaped
	Acceleration setting for each axis	○	○	○
Velocity control				
	Velocity control by speed difference among axes	○	○	○
	Velocity control by acceleration in circular interpolation	○	○	○
	Acceleration-based velocity control	○	○	○
	Cutting load-based velocity control	×	○	○
	Jerk control	×	○	○
	Optimum torque acc./dec.	○	○	○
Other functions				
	Nano interpolation	○	○	○
	5-axis machining functions (Note 3)	○	○	○
	Smooth interpolation (Note 4)	○	○	○
	NURBS (Note 4)	○	○	○
	Nano smoothing (Note 4)	○	○	○

NOTE

1. In FS30*i* systems controlling more than four paths and more than 20 axes, this function cannot be used.
2. In FS30*i* and FS31*i* systems controlling more than two paths and more than 12 axes, this function cannot be used.
3. These functions can be used with the FS30*i*-A and FS31*i*-A5 only.
4. These functions cannot be used with the FS32*i*.

[Parameters]

Described below are the parameters that must be specified for individual high-speed and high precision cutting machines separately.
Use the standard setting values included in the parameter tables as reference data for initialization. If a parameter needs tuning based on the machine type, determine a final setting for the parameter according to the characteristic of the machine and how to use it.

- Standard settings (precision priority)
  When there is vibration or significant impact, or when machining is to be performed more precisely, make settings based on the standard settings.
- Cutting time-first setting
  To reduce machining time, make settings for speed priority I then for speed priority II in stages. The settings for speed priority II can reduce much more machining time than the settings for speed priority I.

(1) AI high precision contour control, AI nano high precision contour control

- Parameters that need tuning based on the machine type

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
1432	-	-	-	Maximum cutting feedrate (mm/min) for individual axes
1620	-	-	-	Time constant (msec) for linear-shaped acc./dec. in rapid-traverse for individual axes
1621	-	-	-	Time constant T2 (msec) for bell-shaped acc./dec. in rapid-traverse for individual axes
1769	24	16	16	Time constant (msec) for acc./dec. after cutting feed interpolation
1660	700.0	2000.0	4000.0	Acceleration in acc./dec. before interpolation (for constant-acceleration part) (Acceleration is specified in mm/sec^2 for individual axes.)
1772	64	48	32	Time constant of bell-shaped acc./dec. before interpolation (msec) (for constant-acceleration part)
1783	400.0	500.0	1000.0	Allowable speed difference (mm/min) in acceleration-dependent on speed difference at corners
1737	525.0	1500.0	3000.0	Permissible acceleration in deceleration by acceleration (Acceleration is specified in mm/sec^2 for individual axes.)
1735	525.0	1500.0	3000.0	Permissible acceleration in deceleration by acceleration in circular interpolation (Acceleration is specified in mm/sec^2 for individual axes.)

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No.	Standard setting value	Description
1602#6,#3	#6,#3	
	1,0	Acc./dec. after interpolation is of a linear type
	1,1	Acc./dec. after interpolation is of a bell-shaped type (Note 1)
7055#3	1/0	To be set to 1 if a function of changing the time constant for bell-shaped acc./dec. before interpolation is to be used.
7066	mm / inch 10000.0/3937.0	Reference speed (mm/min / inch/min) for a function of changing the time constant for bell-shaped acc./dec. before interpolation
19503#0	0/1	When using smooth velocity control as velocity control by acceleration, set 1. (Note 2)
8451#4	0/1	Set this parameter to 1 if cutting load-dependent override is to be used. (This parameter is used if the mechanical rigidity of the Z-axis is low.) (Note 2)
19515#1	0/1	When using the slant type for override by cutting load, set 1. (Note 2)
19516	80	Region 1 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 8451 or bit 1 of parameter No. 19515 = 0) (Note 2)
8456	80	Region 2 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 8451 = 0) (Note 2)
8457	70	Region 3 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 8451 = 0) (Note 2)
8458	60	Region 4 override (%) for the cutting load-based deceleration function (needn't be specified if bit 4 of parameter No. 8451 = 0) (Note 2)

NOTE

1 To perform bell-shaped acc./dec. after cutting feed interpolation, the option for bell-shaped acc./dec. after cutting feed interpolation is required.

2 These functions cannot be used with AI contour control I.

D.2 SERVO PARAMETERS RELATED TO HIGH-SPEED AND HIGH PRECISION OPERATIONS

Described below are the servo parameters that need setting and tuning for high-speed and high precision operations.
To specify parameters, follow this procedure.

1. First specify one of items (1) to (3) about fixed parameters that are dependent on the CNC model and mode to be used.
2. Specify item (4) about parameters to be tuned in common to all CNC models and modes. (See Chapters 3 and 4 of this parameter manual for explanations about how to tune the parameters and detailed descriptions of the related functions.)
3. If you want to use SERVO HRV control, specify item (5).

(1) When HRV2 and fine ACC./Dec. is used (Series 16*i*/18*i*/21*i*/20*i*/0*i*)

- Using advanced preview control in the Series 16*i*/18*i*/21*i*
- Using AI advanced preview control in the Series 21*i*/20*i*/0*i* (servo software Series 90B0)

For the above cases, make the following settings for using HRV2 control and fine acc./dec.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No. FS16*i*, etc.	Standard setting value	Description
2003#3	1	Enables PI control function
2003#5	1	Enables backlash acceleration
2004	0X000011 (Note 1)	HRV2 current control
2005#1	1	Enables feed-forward
2006#4	1	Uses the latest feedback data for velocity feedback.
2007#6	1	Enables FAD (Fine acc./dec.)
2015#6	1	Enables stage-2 backlash acceleration.
2016#3	1	Enables variable proportional gain in the stop state
2017#7	1	Enables velocity loop high cycle management function
2018#2	1	Changes the second override format for stage-2 backlash acceleration.
2040	Standard parameter for HRV2 (Note 2)	Current integral gain
2041	Standard parameter for HRV2 (Note 2)	Current proportional gain
2092	10000	Advanced preview (position) feed-forward coefficient
2119	2 (detection unit of 1 μm) 20 (detection unit of 0.1μm)	For variable proportional gain function in the stop state : judgment level for stop state (specified in detection units)
2146	50	Stage-2 backlash acceleration end timer
2202#1	1	Cutting/rapid traverse velocity loop gain variable
2209#2	1	Enables FAD of linear type.

NOTE

1 Keep the bit indicated with X (bit 6) at the standard setting.

2 For motors not supporting the HRV2 standard parameters, change the parameter settings to the settings for HRV2 according to the instructions described in Section G.4.

- Parameters whose settings must be changed according to the size of the machine but needn't tuning once set up

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
2109	24	16	16	FAD time constant

(2) When HRV2 is used, but fine acc./dec. is not (Series 30*i*/31*i*/32*i*/15*i*/16*i*/18*i*/21*i*/0*i*)

When using AI contour control I, AI contour control II, look-ahead acc./dec. before interpolation, Fine HPCC, AI nano high precision contour control, AI high precision contour control, AI nano contour control, AI contour control, or high precision contour control, make the following settings.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No. FS30*i*,16*i*, etc. FS15*i*	Standard setting value	Description
2003#3 1808#3	1	Enables PI control function
2003#5 1808#5	1	Enables backlash acceleration
2004 1809	0X000011 (Note 1)	HRV2 current control
2005#1 1883#1	1	Enables feed-forward
2006#4 1884#4	1	Uses the latest feedback data for velocity feedback.
2015#6 1957#6	1	Enables two-stage backlash acceleration
2016#3 1958#3	1	Enables variable proportional gain in the stop state
2017#7 1959#7	1	Enables velocity loop high cycle management function
2018#2 1960#2	1	Changes the second override format for stage-2 backlash acceleration.
2040 1852	Standard parameter for HRV2 (Note 2)	Current integral gain
2041 1853	Standard parameter for HRV2 (Note 2)	Current proportional gain
2092 1985	10000	Advanced preview (position) feed-forward coefficient
2119 1730	2 (detection unit of 1 μm) 20 (detection unit of 0.1 μm)	For variable proportional gain function in the stop state : judgment level for stop state (specified in detection units)
2146 1769	50	Stage-2 backlash acceleration end timer
2202#1 1742#1	1	Cutting/rapid traverse velocity loop gain variable

NOTE
1. Keep the bit indicated with X (bit 6) at the standard setting.
2. For motors not supporting the HRV2 standard parameters, change the parameter settings to the settings for HRV2 according to the instructions described in Section G.4.

(3) When using HRV1 and FAD (Series 21*i*/0*i*)

To use AI advanced preview control in the Series 21*i*/0*i* (servo software Series 9096), make the following settings for using HRV1 control and fine acc./dec.

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No. FS21*i*	Standard setting value	Description
2003#3	1	Enables PI control function
2003#5	1	Enables backlash acceleration
2004	Standard parameter for HRV1	HRV1 current control
2005#1	1	Enables feed-forward
2006#4	1	Uses the latest feedback data for velocity feedback.
2007#6	1	Enables FAD (Fine acc./dec.)
2015#6	1	Enables two-stage backlash acceleration
2016#3	1	Enables variable proportional gain in the stop state
2017#7	1	Enables velocity loop high cycle management function
2018#2	1	Changes the second override format for stage-2 backlash acceleration.
2040	Standard parameter for HRV1	Current integral gain
2041	Standard parameter for HRV1	Current proportional gain
2092	10000	Advanced preview (position) feed-forward coefficient
2119	2 (detection unit of 1 μm) 20 (detection unit of 0.1μm)	For variable proportional gain function in the stop state : judgment level for stop state (specified in detection units)
2146	50	Stage-2 backlash acceleration end timer
2202#1	1	Cutting/rapid traverse velocity loop gain variable
2209#2	1	Enables FAD of linear type.

- Parameters whose settings must be changed according to the size of the machine but needn't tuning once set up

Parameter No.	Standard setting value			Description
	Standard setting	Speed priority I	Speed priority II	
2109	24	16	16	FAD time constant

(4) Parameters common to all CNC models (requiring tuning)

- Parameters requiring tuning for finding optimum values

Parameter No. FS30*i* ,16*i*, etc. FS15*i*	Setting at tuning start	Description	Items to be referenced in tuning
2021 1875	300	Load inertia ratio (velocity gain) * When the cutting/rapid velocity gain switching function is used, this parameter is applied to rapid traverse.	While checking vibration at stop, abnormal sound during low-speed movement, vibration during high-speed rotation, and so on, find the vibration limit, and set about 70% of the limit. → See 3.3.1(6)
2107 1700	150	Cutting load inertia ratio override (in % units) * When the cutting/rapid velocity gain switching function is used, the gain magnified by this parameter setting is applied to cutting.	While checking vibration at stop, abnormal sound during low-speed movement, vibration during high-speed rotation, and so on, find the vibration limit, and set about 70% of the limit. → See 3.3.1(6) and 4.3.
1825	Standard: 3000 Speed priority I: 5000 Speed priority II: 10000	Position gain	After determining the velocity loop gain, find the upper limit of the range in which hunting (low frequency vibration) does not occur. → See 3.3.1(6).
2069 1962	Standard: 50 When nano interpolation is used, see Note 2. 200	Velocity feed-forward coefficient	Make adjustment while observing the shape of rounded corners. → See 3.3.1(11).
2047 1859	Standard parameter	Observer parameter	Make adjustment while observing estimated disturbance value on the check board. → See 4.12.1.
2087 1980	0	Torque offset	Make adjustment while measuring positive and negative torque commands at a constant low feedrate.
2048 1860	30	Stage-1 acceleration amount for 2-stage backlash acceleration	Make adjustment while observing the quadrant protrusion size. → See 4.6.7.
2039 1724	100	2nd-stage acceleration amount	Make adjustment while observing the quadrant protrusion size.
2082 1975	10	Stage-2 start distance (detection unit)	Make adjustment while observing the quadrant protrusion size.
2089 1982	50	Stage-2 end distance (set with a ratio to the start distance specified in 10% units)	Make adjustment while observing the quadrant protrusion size.
2114 1725	10	Stage-2 override	Make adjustment while observing the quadrant protrusion size.

NOTE
1 There is the following relationship between the load inertia ratio and velocity loop gain (%).
Velocity loop gain (%) = (1 + load inertia ratio/256) × 100
2 The phrase "using nano interpolation" means using AI contour control I, AI contour control II, Fine HPCC, look-ahead acc./dec. before interpolation, AI nano high precision contour control, or AI nano contour control.

(5) Parameters common to all CNC models (parameters needed to use HRV3)

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No. FS30*i* ,16*i*, etc. FS15*i*	Standard setting value	Description
2004 1809	0X000011 (Note 1)	HRV2 current control (in a mode other than high-speed HRV control)
2013#0 1707#0	1	In the G05.4Q1 command, high-speed HRV control (HRV3 current control)
2202#1 1742#1	1	Cutting/rapid velocity loop gain switching function
2040 1852	Standard parameter for HRV2 (Note 2)	Current integral gain
2041 1853	Standard parameter for HRV2 (Note 2)	Current proportional gain
2334 2747	150	Current loop gain magnification for high-speed HRV current control

NOTE
1. Keep the bit indicated with X (bit 6) at the standard setting.
2. For motors not supporting the HRV2 standard parameters, change the parameter settings to the settings for HRV2 according to the instructions described in Section G.4.

- Parameters that need tuning

Parameter No. FS30*i* ,16*i*, etc. FS15*i*	Setting	Description	Items to be referenced in tuning
2107 1700	150	Cutting load inertia ratio override (in % units)	While checking vibration at stop, abnormal sound during low-speed movement, vibration during high-speed rotation, and so on, find the vibration limit, and set about 70% of the limit.
2335 2748	200	Cutting load inertia ratio override (in % units) when high-speed HRV current control is in use	While checking vibration at stop, abnormal sound during low-speed movement, vibration during high-speed rotation, and so on, find the vibration limit, and set about 70% of the limit.

(6) Parameters for Series 30*i* and 31*i* (parameters needed to use HRV4)

- Parameters that do not usually need tuning so often and can be left at fixed values

Parameter No. FS30*i*	Standard setting value	Description
2004	0X000011 (Note 1)	HRV3 current control (in a mode other than high-speed HRV control)
2014#0	1	In the G05.4Q1 command, high-speed HRV control (HRV4 current control)
2300#0	1	Extended HRV function
2202#1	1	Cutting/rapid velocity loop gain switching function
2040	Standard parameter for HRV2	Current integral gain
2041	Standard parameter for HRV2	Current proportional gain
2334	150	Current loop gain magnification for high-speed HRV current control

NOTE
1 Keep the bit indicated with X (bit 6) at the standard setting.

- Parameters that need tuning

Parameter No. FS30*i*, etc.	Setting	Description	Items to be referenced in tuning
2107	150	Cutting load inertia ratio override (in % units)	While checking vibration at stop, abnormal sound during low-speed movement, vibration during high-speed rotation, and so on, find the vibration limit, and set about 70% of the limit.
2335	200	Cutting load inertia ratio override (in % units) when high-speed HRV current control is in use	While checking vibration at stop, abnormal sound during low-speed movement, vibration during high-speed rotation, and so on, find the vibration limit, and set about 70% of the limit.

E VELOCITY LIMIT VALUES IN SERVO SOFTWARE

(1) Overview

The feed axis velocity is subject to the feedrate limits that depend on the internal processing of the system itself and that of the servo software. These velocity limit values on the feed axis are explained below.

> **NOTE**
> The permissible speeds listed below do not take detector hardware limitations into account. For the maximum permissible speed of a detector itself, refer to the specifications of the detector.

(2) Velocity feedback (rotation speed) limit

The following limits apply to the rotation speed of motors according to the type of motor speed detector.

Detector type	Resolution	Allowable rotation speed
αi Pulsecoder	2^{20}, 2^{24}pulse/rev	7500min^{-1}
HEIDENHAIN RCN220	2^{20}pulse/rev	7500min^{-1}
HEIDENHAIN RCN223, 723	2^{23}pulse/rev	937min^{-1} (HRV1,2) 1875min^{-1} (HRV3) 3750min^{-1} (HRV4)
HEIDENHAIN RCN727	2^{27}pulse/rev	

Even if any of the above detectors is used as a position detector, the same speed limits as those given above apply as the speed limits on the detector.

* Limit values related to linear motors
If a linear motor is used, its speed detector is a linear scale. So, a velocity rather than a rotation speed is involved, but the same limits as stated above are applied.

Detector type	Resolution	Allowable speed
HEIDENHAIN LS486 (incremental) with high-resolution serial output circuit	20/512 μm/pulse	300m/min
Sony BS75A (incremental) with high-resolution serial output circuit	0.1379/512 μm/pulse	4.2m/min (HRV1,2) 8.4m/min (HRV3) 17m/min (HRV4)
HEIDENHAIN LC191F (absolute)	0.1 μm/pulse	786m/min
HEIDENHAIN LC491F (absolute)	0.05 μm/pulse	393m/min

(3) Position feedback (axis feedrate) limits

The following feedrate limits may be applied according to each of the functions because of a weight on data that is handled in detection units within the servo software.

- When ordinary position control is exercised

(Series 15*i*-B, 16*i*-B, 18*i*-B, 21*i*-B, 20*i*-B, 0*i*-B/C, 0*i* Mate-B/C, Power Mate *i*)

<table>
<tr><th colspan="3">Function used</th><th colspan="2">Allowable feedrate</th></tr>
<tr><th>Hi-speed and high precision function</th><th>Feed-forward</th><th>Fine acc./dec.</th><th>Detection unit of 1 μm</th><th>Detection unit of 0.1 μm</th></tr>
<tr><td>None</td><td>None</td><td>None</td><td rowspan="6">IS-B : 240m/min
IS-C : 100m/min</td><td>IS-B : 196m/min
IS-C : 100m/min</td></tr>
<tr><td>None</td><td>Performed (conventional type)</td><td>None</td><td>24m/min (*1)</td></tr>
<tr><td>None</td><td>Not performed/ performed (conventional type)</td><td>Performed</td><td rowspan="3">98m/min</td></tr>
<tr><td>Advanced preview control</td><td>Performed (advanced preview type)</td><td>Not performed/ performed</td></tr>
<tr><td>AI contour control
High precision contour control</td><td>Performed (advanced preview type)</td><td>Automatically switched off</td></tr>
<tr><td>AI nano contour control
AI high precision contour control
AI nano high precision contour control</td><td>Performed (advanced preview type)</td><td>Automatically switched off</td><td>98m/min (*2)</td></tr>
<tr><td>Fine HPCC</td><td>Performed (advanced preview type)</td><td>Automatically switched off</td><td>IS-B : 999m/min
IS-C : 100m/min</td><td>IS-B : 196m/min
IS-C : 100m/min</td></tr>
<tr><td>Electric gear box</td><td>Performed (conventional type)</td><td>None</td><td>IS-B : 240m/min
IS-C : 100m/min</td><td>24m/min (*1)</td></tr>
</table>

- When speed control based on a PMC axis is exercised using a position command

(Series 15*i*-B, 16*i*-B, 18*i*-B, 21*i*-B, 20*i*-B, 0*i*-B/C, 0*i* Mate-B/C, Power Mate *i*)

<table>
<tr><th rowspan="2">Function used</th><th colspan="2">Allowable feedrate</th></tr>
<tr><th>Detection unit of 1/1000 deg</th><th>Detection unit of 1/10000 deg</th></tr>
<tr><td>PMC-axis-based speed control (position command)</td><td>5461min^{-1}</td><td>546min^{-1}</td></tr>
</table>

- When ordinary position control is exercised

(Series 30*i*,31*i*,32*i*)

<table>
<tr><th colspan="2">Function used</th><th colspan="4">Allowable feedrate</th></tr>
<tr><th>Hi-speed and high precision function</th><th>Feed-forward</th><th>Detection unit of 1 μm</th><th>Detection unit of 0.1 μm</th><th>Detection unit of 0.01 μm</th><th>Detection unit of 0.001 μm</th></tr>
<tr><td>None</td><td>Not performed/ performed (advanced preview type)</td><td rowspan="2">IS-B:999m/min
IS-C:100m/min</td><td rowspan="2">IS-B:999m/min
IS-C:100m/min</td><td rowspan="2">IS-D:10m/min
→100m/min(*3)</td><td rowspan="2">IS-E:1m/min
→100m/min(*3)</td></tr>
<tr><td>AI contour control I
AI contour control II</td><td>Not performed/ performed (advanced preview type)</td></tr>
<tr><td>Electric gear box</td><td>Performed (conventional type)</td><td>IS-B:240m/min
IS-C:100m/min</td><td>24m/min (*1)</td><td>2.4m/min
→100m/min(*3)</td><td>0.24m/min
→100m/min(*3)</td></tr>
</table>

- When rotary tool control based on a servo motor is used

(Series 30*i*,31*i*,32*i*)

Function used	Allowable feedrate			
Rotary tool control based on a servo motor	Detection unit of 1/1000 deg	Detection unit of 1/10000 deg	Detection unit of 1/100000 deg	Detection unit of 1/1000000 deg
Performed (No.1408#3=0)	IS-B:2777min^{-1} IS-C: 277min^{-1}	IS-B:2777min^{-1} IS-C: 277min^{-1}	IS-D:27min^{-1}	IS-E:2min^{-1}
Performed (No.1408#3=1)	IS-B:27777min^{-1} IS-C: 2777min^{-1}	IS-B:27777min^{-1} IS-C: 2777min^{-1}	IS-D:277min^{-1}	IS-E:27min^{-1}

* In the table, the values enclosed in a box are the limits due to the internal processing of the servo software. For the limits due to the internal processing of the servo software, if CMR is increased to decrease the detection unit, the permissible feedrate decreases in proportion to the detection unit. (Reducing the detection unit from 0.1 μm to 0.05 μm causes the permissible feedrate to be halved.)

* If a semi-closed system (rotary or linear motor) where a detector with a high resolution is used, using also nano interpolation enables these functions to be used for position control at the highest limit to the detector resolution even if the detection unit is not subdivided.

* If you are using these functions with a larger detection unit because of feedrate limits placed by the detection units stated above, velocity feedback data that can seriously affect velocity loop control is used for control at the highest limit to the detector resolution.

(*1) If conventional feed-forward is used, the permissible feedrate is decreased.
To avoid this, take one of the following actions:
- Disable feed-forward when not using the high precision function.
- Use fine acc./dec. at the same time.

(*2) For AI nano contour control, AI high precision contour control, and AI nano high precision contour control, the limit is 98 m/min on the NC and 196 m/min on the servo software. If CMR is increased to further decrease the detection unit, the feedrate limit on the NC is invariable, but the feedrate limit on the servo software decreases in proportion to the detection unit. If the detection unit is decreased, therefore, the feedrate limit will be the smaller one.

Detection unit	Limit on the NC	Limit on the servo software
0.1μm	98m/min	196m/min
0.05μm	98m/min	98m/min
0.02μm	98m/min	39m/min
0.01μm	98m/min	19.6m/min

(*3) With the servo software and system software indicated below, the allowable feedrate value applicable when an increment system is selected from IS-D and IS-E is extended. A feedrate of up to 100 m/min can be specified with the increment system IS-D or IS-E by using matching servo software and system software and setting the following parameters:

- Series and editions of applicable servo software
  (Series 30*i*,31*i*,32*i*)
  Series 90D0/J(10) and subsequent editions
  Series 90E0/J(10) and subsequent editions
- Series and editions of applicable system software
  Series 30*i*-A:
    Series G002, G012, and G022/04.0 and subsequent editions
  Series 31i-A:
    Series G101, G111/04.0 and subsequent editions
  Series 31i-A5:
    Series G121, G131/04.0 and subsequent editions
  Series 32i-A:
    Series G201/04.0 and subsequent editions (IS-E is not supported.)
- Parameter setting method
  To extend the feedrate with the increment system IS-D or IS-E, both of parameter No. 1013 and No. 2282 must be set to 1. (The increment systems IS-D and IS-E are optional functions.)

	#7	#6	#5	#4	#3	#2	#1	#0
1013（FS30*i*）	**IESP**							

IESP(#7) When the increment system IS-D or IS-E is used, the function that can set a value range wider than the conventionally allowed one for speed and acceleration parameters is:
0: Not used.
1: Used.
With an axis for which this parameter is set, a value range wider than the conventionally allowed one can be set for parameters to be set in speed and acceleration units when the increment system IS-D or IS-E is selected.
Moreover, a movement can be made at a parameter-set speed.
The number of fractional digits displayed on the parameter input screen for an axis with this parameter set is also modified. When IS-D is used, the number of fractional digits is reduced by 1 from the conventional number of fractional digits. When IS-E is used, the number of fractional digits is reduced by 2 from the conventional number of fractional digits.

NOTE
When this parameter has been modified, the power must be turned off before operation is continued.

	#7	#6	#5	#4	#3	#2	#1	#0
2282 (FS30*i*)					**ISE64**			

ISE64(#3) The speed limit on feed-forward (bit 1 (FEED) of parameter No. 2005 = 1) is:

0: Applied as conventionally done.

1: Extended.

When feed-forward is enabled, the speed limit on an axis for which this parameter is set is extended if the increment system is IS-D or IS-E.

F SERVO FUNCTIONS

Servo software series / Name of function	9096	90B0	90B6 90B5	90B1	90D0	90E0	Reference items in this manual
[Servo initial setting]							
Flexible feed gear function	A	A	A	A	A	A	2.1
Position feedback pulses conversion coefficient	-	A	A	A	A	A	2.1.8 Supplementary 3
Supporting a fraction in reference counter setting	-	A	A	A	A	A	2.1.3
Supporting serial-type separate detectors	-	A	A	A	A	A	2.1.4
Supporting high-resolution serial output circuits H and C	-	Q	A	A	A	A	2.1.4
Supporting linear motor position detection circuits H and C	-	Q	A	A	A	A	4.14.1
Improving the reference counter when the RCN723 or RCN223 is used	-	Q	A	A	A	A	2.1.4
Supporting analog input separate detector interface unit	-	-	-	-	J	J	2.1.5
Supporting CZ*i* sensor (serial separate detector)	-	A	A	A	A	A	2.1.6
Supporting CZ*i* sensor (synchronous built-in servo motor)	-	-	-	-	A	A	2.1.6
Supporting PWM distribution module (PDM)	-	-	-	A	-	-	2.1.7
Illegal parameter setting alarm detail output	A	A	A	A	A	A	2.1.8
Automatic format change for position gain	-	A	A	A	A	A	2.1.8 Supplementary 5
Expanding the position gain setting range	A	A	A	A	A	A	2.1.8 Supplementary 5
[Servo functions]							
SERVO HRV control	A	A	A	A	-	-	4.1
SERVO HRV2 control	-	A	A	A	A	A	4.1.1
SERVO HRV3 control (high-speed HRV current control)	-	A	A	A	A	A	4.2.1
SERVO HRV4 control (high-speed HRV current control)	-	-	-	-	A	-	4.2.2
Cutting/rapid velocity loop gain switching function	A	A	A	A	A	A	4.3
1/2 PI is always enabled for cutting/rapid velocity gain	-	A	A	A	A	A	4.3
Upper limit to cutting/rapid velocity loop gain loop of 400%	-	A	A	A	A	A	4.3
Velocity loop high cycle management function	A	A	A	A	A	A	4.4.1
Supporting the tandem velocity loop high cycle management function	-	A	A	A	A	A	4.4.1, 4.18.9
Acceleration feedback function	A	A	A	A	A	A	4.4.2
Variable proportional gain function in the stop state	A	A	A	A	A	A	4.4.3
Variable proportional gain function in the stop state : supporting 50%	A	A	A	A	A	A	4.4.3
Variable proportional gain function in the stop state : supporting arbitrary magnification	-	A	A	A	A	A	4.4.3
Addition of N pulses suppression function	A	A	A	A	A	A	4.4.4
TCMD filter	A	A	A	A	A	A	4.5.1
TCMD filter (cutting/rapid)	A	A	A	A	A	A	4.5.1
Resonance elimination filter : stage 1	-	A	A	A	A	A	4.5.2
Resonance elimination filter : stage 4	-	J	A	A	A	A	4.5.2
Active resonance elimination filter	-	P	A	A	A	A	4.5.2
Disturbance elimination filter	-	A	A	A	A	A	4.5.3
Observer function	A	A	A	A	A	A	4.5.4
Observer function (with the disable function for observer in the stop state added)	A	A	A	A	A	A	4.5.4
Current loop 1/2 PI control function	A	A	A	A	A	A	4.5.5

Name of function \ Servo software series	9 0 9 6	9 0 B 0	9 0 B 6 / 9 0 B 5	9 0 B 1	9 0 D 0	9 0 E 0	Reference items in this manual
Current loop 1/2 PI control function always enabled	A	A	A	A	A	A	4.5.5
Current loop PI control function current control PI ratio variable	-	A	A	A	A	A	4.5.5
Vibration damping control function	A	A	A	A	A	A	4.5.6
Dual position feedback function	A	A	A	A	A	A	4.5.7
Machine speed feedback function	A	A	A	A	A	A	4.5.8
Machine speed feedback function (normalization)	A	A	A	A	A	A	4.5.8
Feed-forward function	A	A	A	A	A	A	4.6.1
Advanced preview feed-forward function	A	A	A	A	A	A	4.6.2
RISC feed-forward function	A	A	A	A	-	-	4.6.3
Feed-forward timing adjustment	A	A	A	A	A	A	4.6.5
Feed-forward timing adjustment (for supporting FAD)	-	J	A	A	-	-	4.6.5
Cutting/rapid feed-forward switching function	-	B	A	A	A	A	3.4, 4.6.4
Backlash acceleration function	A	A	A	A	A	A	4.6.6
Supporting backlash acceleration override function	-	W	A	A	J	J	4.6.6
Backlash acceleration stop function	A	A	A	A	A	A	4.6.6
2-stage backlash acceleration function	A	A	A	A	A	A	4.6.7
2-stage backlash acceleration function : second stage acceleration limit	-	J	A	A	A	A	4.6.7
2-stage backlash acceleration function : second stage acceleration direction-specific setting	-	J	A	A	A	A	4.6.7
Two-stage backlash acceleration function: second stage acceleration (type 2)	-	X	A	A	A	A	4.6.7
Backlash acceleration function : enabled only for cutting	A	A	A	A	A	A	4.6.7
Backlash acceleration function : improvement on "enabled only for cutting"	-	C	A	A	A	A	4.6.7
Static friction compensation function	A	A	A	A	A	A	4.6.8
Torsion preview control	-	W	A	A	-	-	4.6.9
Overshoot compensation function	A	A	A	A	A	A	4.7
Overshoot compensation function type 2	A	A	A	A	A	A	4.7
Position gain switching function	A	A	A	A	A	A	4.8.1
position gain switching function type 2	A	A	A	A	A	A	4.8.1
Expanding the velocity setting range for high-speed positioning function	A	A	A	A	A	A	4.8.1
Low-speed integral function	A	A	A	A	A	A	4.8.2
Fine acc./dec. function	A	A	A	A	-	-	4.8.3
Cutting/rapid fine acc./dec. switching function	A	A	A	A	-	-	3.4, 4.8.3
Synchronization in rigid tapping mode when the FAD function is used	A	A	A	A	-	-	4.8.3
Serial feedback dummy function	-	A	A	A	A	A	4.9.1
Dummy function for separate detector	-	A	A	A	A	A	4.9.1
Brake control function	A	A	A	A	A	A	4.10
Quick stop type 1 at emergency stop	A	A	A	A	A	A	4.11.1
Quick stop type 2 at emergency stop	A	A	A	A	A	A	4.11.2
Lifting function against gravity at emergency stop	-	P	A	A	A	A	4.11.3
Quick stop function for hardware disconnection of separate detector	A	A	A	A	A	A	4.11.4
Quick stop function at the OVC and OVL alarm	A	A	A	A	A	A	4.11.5
Unexpected disturbance torque detection function	A	A	A	A	A	A	4.12.1
Improvement on dynamic friction compensation for estimated disturbance	-	E	A	A	A	A	4.12.1
2-axes simultaneous retract function related to unexpected disturbance torque detection	-	E	A	A	A	A	4.12.1

Name of function \ Servo software series	90 96	90 B0	90 B6 / 90 B5	90 B1	90 D0	90 E0	Reference items in this manual
Cutting/rapid unexpected disturbance torque detection switching function	A	A	A	A	A	A	4.12.2
Current offset acquisition at an emergency stop	A	A	A	A	A	A	4.13
Supporting linear motors	A	A	A	A	A	A	4.14.1
Expanding the AMR offset setting range for linear motors	-	C	A	A	A	A	4.14.1
Current gain internally 4 times function	-	A	A	A	A	A	4.14.1
Function of changing the velocity loop proportional gain format	A	A	A	A	A	A	4.14.1
Linear motor smoothing compensation	A	A	A	A	A	A	4.14.2
Linear motor smoothing compensation : supporting direction-specific operations	-	N	A	A	A	A	4.14.2
Torque control function type 1	A	A	A	A	A	A	4.16
Torque control function type 2	A	A	A	A	A	A	4.16
Tandem disturbance elimination control function	-	A	A	A	A	A	4.17
Synchronous axes automatic compensation function	-	V	A	A	-	-	4.18
Synchronous axes automatic compensation function (dead-band width)	-	-	-	A	-	-	4.18
Tandem disturbance elimination control function	A	A	A	A	A	A	4.19
Tandem control function (preload function)	A	A	A	A	A	A	4.19.1
Tandem control function (damping compensation function)	A	A	A	A	A	A	4.19.2
Tandem control function (velocity feedback average function)	A	A	A	A	A	A	4.19.3
Tandem control function (servo alarm 2-axes simultaneous monitor)	A	A	A	A	A	A	4.19.4
Servo alarm 2-axes simultaneous monitor : supporting VRDY OFF invalidation	-	C	A	A	A	A	4.19.4
Tandem control function (motor feedback sharing function)	A	A	A	A	A	A	4.19.5
Tandem control function (full-preload function)	A	A	A	A	A	A	4.19.6
Tandem control function (position feedback switching)	A	A	A	A	A	A	4.19.7
Velocity loop integrator copy function	-	N	A	A	A	A	4.19.9
Supporting SERVO GUIDE	A	F	A	A	C	C	4.20
Supporting SERVO GUIDE and tuning navigator	-	T	A	A	C	C	4.20
Disturbance input function (frequency characteristic measurement)	-	A	A	A	-	-	Appendix H
High-speed data output to the check board	-	A	A	A	-	-	Appendix I
[CNC functions]							
Changing the check board output magnification for TCMD and SPEED signals	-	N	A	A	-	-	Appendix I
Supporting PMC-based velocity loop gain override	A	A	A	A	A	A	
Supporting the EGB function	-	A	A	A	A	A	
Supporting the high-speed response function	-	A	A	A	A	A	
Supporting nano interpolation	-	A	A	A	A	A	

G PARAMETERS FOR α AND OTHER SERIES

The motor ID numbers necessary to automatically set parameters for the α series, β series, and conventional linear motors are explained below.
Search for the motor ID number of the motor used, based on the motor model and the drawing number (4-digit number in the middle of A06B-****-B***).

> **NOTE**
> The motor ID numbers for consecutive (odd and even) servo controlled axis numbers must be for one of servo HRV1, servo HRV2, or servo HRV3.

G.1 MOTOR ID NUMBERS OF α SERIES MOTORS

α series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
α1/3000	0371	61	A	A
α2/2000	0372	46	A	A
α2/3000	0373	62	A	A
α3/3000	0123	15	A	A
α6/2000	0127	16	A	A
α6/3000	0128	17	A	A
α12/2000	0142	18	A	A
α12/3000	0143	19	A	A
α22/1500	0146	27	A	A
α22/2000	0147	20	A	A
α22/3000	0148	21	A	A
α30/1200	0151	28	A	A
α30/2000	0152	22	A	A
α30/3000	0153	23	A	A
α40/2000	0157	30	A	A
α40/2000FAN	0158	29	A	A
α65/2000	0331	39	A	A
α100/2000	0332	40	A	A
α150/2000	0333	41	A	A
α300/1200	0135	113	A	A
α300/2000	0137	115	A	A
α400/1200	0136	114	A	A
α400/2000	0138	116	A	A
α1000/2000	0131	117	S	S

The motor ID numbers are for servo HRV1.

αM series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
α/3000	0376	98	A	A
αM2.5/3000	0377	99	A	A
αM3/3000	0161	24	A	A
αM6/3000	0162	25	A	A
αM9/3000	0163	26	A	A
αM22/3000	0165	100	A	A
αM30/3000	0166	101	A	A
αM40/3000	0169	110	A	A
αM40/3000FAN	0170	108 (360-A driving) 109 (240-A driving)	A A	A A

The motor ID numbers are for servo HRV1.

αL series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
αL3/3000	0561	68	A	A
αL6/3000	0562	69	A	A
αL9/3000	0564	70	A	A
αL25/3000	0571	59	A	A
αL50/2000	0572	60	A	A

The motor ID numbers are for servo HRV1.

αC series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
α/2000	0121	7	A	A
αC6/2000	0126	8	A	A
αC12/2000	0141	9	A	A
αC22/1500	0145	10	A	A

The motor ID numbers are for servo HRV1.

αHV series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
α3/3000HV	0171	1	A	A
α6/3000HV	0172	2	A	A
α12/3000HV	0176	3	A	A
α22/3000HV	0177	4 (40-A driving) 102 (60-A driving)	A	A
α30/3000HV	0178	5 (40-A driving) 103 (60-A driving)	A	A
α40/3000HV	0179	118	A	A

The motor ID numbers are for servo HRV1.

αMHV series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
αM6/3000HV	0182	104	A	A
αM9/3000HV	0183	105	A	A
αM22/3000HV	0185	106	A	A
αM30/3000HV	0186	107	A	A
αM40/3000HV	0189	119	A	A

The motor ID numbers are for servo HRV1.

G.2 MOTOR ID NUMBERS OF β SERIES MOTORS

β series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
β0.5/3000	0113	14 (20-A driving)	N	D
β1/3000	0031	11 (20-A driving)	N	D
β2/3000	0032	12 (20-A driving)	N	D
β3/3000	0033	33	A	A
β6/2000	0034	34	A	A

The motor ID numbers are for servo HRV1.

βM series servo motor

Motor model	Motor specification	Motor ID No.	90B0	9096
βM0.2/4000	0111	* (260)	N	*
βM0.3/4000	0112	* (261)	N	*
βM0.4/4000	0114	* (280)	N	*
βM0.5/4000	0115	181(281)	N	D
βM1/4000	0116	182(282)	N	D

The motor ID numbers not enclosed in parentheses are for servo HRV1, and the motor ID numbers enclosed in parentheses are for servo HRV2 and HRV3.

* For βM0.2, βM0.3, and βM0.4, HRV1 control cannot be used. It cannot, therefore, be used in Series 9096.

(Reference)

In the parameter table in item 4, two motor ID numbers are assigned to the same β series servo motor. One of them is the parameter for driving the motor with an α/β series servo amplifier (12A). Use caution not to use the wrong type number.

Motor model	α servo amplifier drive		α*i* servo amplifier drive	
	Maximum amplifier current [A]	Motor ID No.	Maximum amplifier current [A]	Motor ID No.
β0.5/3000	12	13	20	14
β1/3000	12	35	20	11
β2/3000	12	36	20	12

G.3 MOTOR ID NUMBERS OF CONVENTIONAL LINEAR MOTORS

Linear motor

Motor model	Motor specification	Motor ID No.	90B0	9096
300D/4	0421	124	A	A
600D/4	0422	125	A	A
900D/4	0423	126	A	A
1500A/4	0410	90	A	A
3000B/2	0411	91	A	A
3000B/4	0411-B811	120	A	A
6000B/2	0412	92	A	A
6000B/4	0412-B811	127 (160-A driving)	R	D
9000B/2	0413	128 (160-A driving)	N	D
9000B/4	0413-B811	129 (360-A driving)	Q	D
15000C/2	0414	130 (360-A driving)	Q	D
15000C/3	0414-B811	123	A	A

The motor ID numbers are for servo HRV1. Loading is possible with the servo software of the series and edition listed above or subsequent editions.

(Reference)

In the parameter table in item 4, two motor ID numbers are assigned to the same linear motor. One of them is the parameter for driving the motor with an α series servo amplifier (130A or 240A). Use caution not to use the wrong type number.

Motor model	α servo amplifier drive		α*i* servo amplifier drive	
	Maximum amplifier current [A]	Motor ID No.	Maximum amplifier current [A]	Motor ID No.
6000B/4	240	121	160	127
9000B/2	130	93	160	128
9000B/4	240	122	360	129
15000C/2	240	94	360	130

G.4 PARAMETERS FOR SERVO HRV2 CONTROL

By converting parameter settings as shown below, servo HRV1 control parameters can be changed to parameters for servo HRV2 control.

> **NOTE**
> This section explains the conversion method to be applied when only servo HRV1 control parameters are provided. For motors for which servo HRV2 control parameters are provided, use these servo HRV2 control parameters.

<1> To set the current control period to 125 μs, set the following:

Parameter		#7	#6	#5	#4	#3	#2	#1	#0
1809 (FS15*i*) / 2004 (FS30*i*, 16*i*)	Conventional setting	DLY1	DLY0	TIB1	DLY2	TRW1	TRW0	TIB0	TIA0
		0	X	0	0	0	1	1	0
	When servo HRV2 control is used	DLY1	DLY0	TIB1	DLY2	TRW1	TRW0	TIB0	TIA0
		0	X	0	0	0	0	1	1

The standard setting at the bit marked by X (bit 6) must be left unchanged.

<2> Changing the current loop gain (integral)

1852 (FS15*i*) / 2040 (FS30*i*, 16*i*)	Current integral gain

Set a value obtained by multiplying the standard parameter value by 0.8.

<3> Changing the current loop gain (proportional)

1853 (FS15*i*) / 2041 (FS30*i*, 16*i*)	Current proportional gain

Set a value obtained by multiplying the standard parameter value by 1.6.

G.5 HRV1 CONTROL PARAMETERS FOR α SERIES, β SERIES, AND CONVENTIONAL LINEAR MOTORS

The HRV1 control parameters for the α series, β series, and conventional linear motors are given in the table below.
9096 series
90B0 series

	Motor model		α3HV	α6HV	α12HV	α22HV	α30HV	αC3	αC6	αC12	αC22	β1/3	β2/3
	Motor specification		0171	0172	0176	0177 (40A)	0178 (40A)	0121	0126	0141	0145	0031 (20A)	0032 (20A)
	Motor ID No.		1	2	3	4	5	7	8	9	10	11	12
Symbol	FS15*i*	FS16*i*,etc.											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	01000110	01000110	01000110	01000110	01000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	01000100	01000100	01000100	01000100	01000100	01000100	01000100	01000000	01000000	01000000	01000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00100000	00100000	00100000	00100000	00100000	00100000	00000000	00000000	00000000	00000000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001100	00001100
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00001100	00001100
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	687	828	730	800	1100	1600	1800	3000	2330	598	1173
PK2	1853	2041	-2510	-3129	-3038	-3190	-3886	-5059	-6105	-9750	-6831	-1882	-4002
PK3	1854	2042	-2617	-2638	-2638	-2694	-2663	-2608	-2641	-2687	-2694	-2564	-2596
PK1V	1855	2043	107	127	188	271	293	107	127	251	271	61	37
PK2V	1856	2044	-955	-1141	-1683	-2426	-2625	-955	-1140	-2245	-2426	-550	-667
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	3972	3326	2254	1564	1446	3974	3329	1690	1564	-690	5692
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	3787	3787	3787	3787	3787	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	2500	4000	-12840	3500	4000	3046	4381	4000	4000	2500	3300
PVPA	1869	2057	2200	-7692	-6925	-6671	-4113	-6405	-3858	-3094	-3872	2100	-10246
PALPH	1870	2058	70	-1920	-2832	-3000	-3400	-250	-2500	-4000	-2800	43	-960
PPBAS	1871	2059	5	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	4369	4369
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32686	32637	32568	32370	32359	32686	32637	32412	32370	32605	32522
POVC2	1878	2063	1031	1639	2505	4981	5110	1030	1636	4446	4981	2034	3077
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	3059	4866	7445	14847	15235	3056	4858	13245	14847	2014	3051
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	8192	16288	16288	12192	16288	11192	8192	8192	0	0
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1287	1623	2008	2836	2872	1286	1622	2678	2836	1044	1285
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	5145	5145	5170	10250	15370	12800	17920	17920	12800	80	2786
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	15000	15000	15000	15000	15000	15000	0	0	0	0	7200
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	205	325	527	684	921	205	326	395	684	86	139
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	2568	0	16	2592	2576	16	24	16	24	1536	1536
DETQLM	1704	2111	6244	3870	5140	3915	3147	0	5220	0	2660	7784	7740
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1700	300	3420	700	900	2729	3326	4520	3298	0	0
MFWKCE	1736	2128	3333	4286	2000	2667	3636	4000	6500	6000	7000	0	5000
MFWKBL	1752	2129	2578	2076	2581	2574	1813	1048	1047	785	1042	0	4128
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	0	0	0	5140
PHDLY2	1757	2134	0	0	0	0	0	0	0	0	0	0	7720
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	25	25	45	45	45	25	25	25	45	25	25

Symbol		Motor model / Motor specification / Motor ID No.	β0.5/3 0113 (12A) 13	β0.5/3 0113 (20A) 14	α3/3 0123 15	α6/2 0127 16	α6/3 0128 17	α12/2 0142 18	α12/3 0143 19	α22/2 0147 20	α22/3 0148 21	α30/2 0152 22	α30/3 0153 23
Symbol	FS15*i*	FS16*i*,etc.											
	1808	2003	00001000	00001000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	01000100	01000100	01000100	01000000	01000100	01000100	01000100	01000100	01000100	01000100	01000100
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00100000	00100000	00100000	00100000	00100000	00000000	00100000	00100000	00100000	00000000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00001100	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00001100	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000010	00000010	00000010	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	220	367	1183	2054	754	3121	1324	1975	881	3173	1175
PK2	1853	2041	-540	-900	-2941	-4194	-2363	-4953	-3671	-4041	-2759	-5522	-3088
PK3	1854	2042	-2556	-2556	-3052	-3052	-2633	-3052	-3052	-3052	-3052	-3052	-3052
PK1V	1855	2043	9	5	87	99	91	188	165	203	214	144	240
PK2V	1856	2044	-79	-48	-781	-887	-818	-1683	-1474	-1821	-1921	-1293	-2153
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-4789	-7981	4858	4279	4639	2254	2574	2084	1976	2935	1763
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	1200	1200	2000	3500	-12820	-6440	-12840	4000	-12820	-12840	4500
PVPA	1869	2057	2000	2000	-7690	-6415	-3845	-5135	-7690	-3590	-8970	-3097	-5130
PALPH	1870	2058	77	46	-800	-1600	-650	-1500	-1500	-2000	-1226	-1120	-2500
PPBAS	1871	2059	5	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	7282	4369	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32585	32570	32713	32689	32698	32568	32614	32543	32518	32668	32493
POVC2	1878	2063	2288	2470	690	991	877	2505	1922	2811	3128	1245	3443
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	6797	2447	2045	2940	2601	7445	5709	8358	9305	3695	10245
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	17384	0	3000	8192	0	10192	18384	18384	14288	14288	9192
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1918	1151	1052	1261	1187	2008	1758	2127	2245	1414	2355
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	5160	5160	0	10265	30	12800	5145	7680	2585	10240	5145
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	15000	9000	15000	15000	15000	0	15000	15000	15000	0	15000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	29	49	251	419	454	527	601	911	864	1870	1123
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	32	32	32	0	16	0	24	20	0
DETQLM	1704	2111	7790	7790	6214	3960	5170	5220	0	3468	5170	4040	3890
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	400	400	2047	2729	1706	4037	2615	2956	1663	4989	2000
MFWKCE	1736	2128	0	0	1500	5000	1000	5000	2000	6000	2000	6000	6000
MFWKBL	1752	2129	0	0	1812	1556	2076	1045	1551	1300	2571	1044	2581
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	3880	0	3880	5160
PHDLY2	1757	2134	0	0	0	0	0	0	0	12820	0	12820	12840
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	12	25	40	40	80	45	85	85	135	135	135

Symbol	Motor model		αM3	αM6	αM9	α22/1.5	α30/1.2	α40/FAN	α40/2	β3/3	β6/2	β1/3	β2/3
	Motor specification		0161	0162	0163	0146	0151	0158	0157	0033	0034	0031 (12A)	0032 (12A)
	Motor ID No.		24	25	26	27	28	29	30	33	34	35	36
Symbol	FS15*i*	FS16*i*,etc											
	1808	2003	00001000	00001000	00001000	00000000	00000000	00000000	00000000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	01000100	01000100	01000100	01000000	01000000	01000100	01000100	01000000	01000000	01000000	01000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00100000	00100000	00000000	00000000	00000000	00100000	00100000	00100000	00100000	00000000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000010	00000000	00000000	00000010	00000010	00000010	00000010	00000000	00000010
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	538	950	748	2330	5060	1649	1649	629	990	359	704
PK2	1853	2041	-1652	-2582	-2402	-6381	-9923	-5395	-5395	-2093	-3544	-1129	-2401
PK3	1854	2042	-3052	-3052	-2632	-2694	-2705	-2700	-2700	-2622	-2632	-2564	-2596
PK1V	1855	2043	53	38	61	271	147	201	201	144	144	102	62
PK2V	1856	2044	-471	-328	-550	-2426	-1313	-1801	-1801	-2587	-2587	-916	-1111
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-806	-1156	-690	1564	2891	2107	2107	1467	1467	4141	3415
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	2500	3500	3000	4000	8000	-12820	-12820	3000	3200	2500	3300
PVPA	1869	2057	2400	-3590	-6407	-3872	-2078	-3855	-3855	-10250	-6420	2100	-10250
PALPH	1870	2058	70	-1440	-1600	-2800	-1800	-2400	-2400	-1600	-1600	71	-1600
PPBAS	1871	2059	5	5	5	5	5	5	5	5	5	5	5
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32697	32727	32692	32370	32665	32361	32579	32456	32456	32617	32540
POVC2	1878	2063	886	516	955	4981	1283	5090	2358	3897	3897	1884	2850
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	2627	1529	2832	14847	3809	15175	7007	11600	11600	5594	8474
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	3000	31672	12288	12288	12288	14288	14288	0	0	0	0
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1193	910	1238	2836	1436	2867	1948	2506	2506	1740	2142
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	25	5145	0	12800	12800	12800	12800	-1476	30	80	-2786
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	15000	15000	0	0	0	15000	15000	15000	12000	0	12000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	221	581	653	684	1842	1756	1756	107	215	51	83
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	24	24	32	24	28	20	20	0	0	0	0
DETQLM	1704	2111	5220	5220	5220	2660	0	3920	3920	2640	3890	7784	7740
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	1990	2729	853	3298	7846	3326	3326	0	0	0	0
MFWKCE	1736	2128	2000	2500	2000	7000	9500	7000	7000	0	5000	0	3000
MFWKBL	1752	2129	2588	1298	2570	1042	788	1300	1300	0	2064	0	4128
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	5140	0	0	20	20	6164	2573	0	5140
PHDLY2	1757	2134	0	0	12840	0	0	12840	12840	12840	12850	0	12840
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	40	80	85	47	85	135	135	25	25	12	12

Symbol	FS15*i*	FS16*i*,etc.	α65/2	α100/2	α150/2	α2/2	αL25	αL50	α1/3	α2/3	αL3	αL6	αL9
Motor model			α65/2	α100/2	α150/2	α2/2	αL25	αL50	α1/3	α2/3	αL3	αL6	αL9
Motor specification			0331	0332	0333	0372	0571	0572	0371	0373	0561	0562	0564
Motor ID No.			39	40	41	46	59	60	61	62	68	69	70
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	01000110	01000110	01000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00010000	00010000	00010000	00000000	00000000	00000000	01000100	01000100	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000	00000010	00000110	00000000	00000000	00000000
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	790	1578	1574	1170	574	700	390	530	757	855	737
PK2	1853	2041	-3473	-4761	-4809	-2289	-2254	-2000	-1053	-1653	-3394	-3610	-2588
PK3	1854	2042	-2714	-2714	-2718	-2485	-2700	-2701	-2480	-2490	-2652	-2676	-2673
PK1V	1855	2043	121	102	120	91	92	116	111	128	18	17	35
PK2V	1856	2044	-1085	-916	-1072	-812	-825	-1035	-997	-1146	-158	-155	-309
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	3498	4141	3541	4674	4599	3666	3806	3311	-2395	-2455	-1227
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	3787	3787	3787	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	4444	4884	6668	2147	4500	4800	2800	2520	2000	2000	1240
PVPA	1869	2057	-4617	-4617	-3849	-7690	-7692	-6430	2330	-6156	0	0	-10249
PALPH	1870	2058	-1620	-1620	-1890	-1000	-2200	-3300	57	-1200	0	0	-800
PPBAS	1871	2059	20	20	20	0	5	5	5	5	5	5	5
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	120	120	120	120	120	120	120	120	120	120	120
POVC1	1877	2062	32482	32529	32332	32627	32476	32214	32623	32519	32693	32696	32607
POVC2	1878	2063	3569	2987	5452	1766	3644	6929	1811	3112	940	894	2010
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	10622	8881	16262	5245	10844	20705	5377	9256	2787	2653	5970
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	1100	1100	1100	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	28672	20480	20480	0	24576	0	1680	8194	16384	28672	20480
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2398	2193	2968	1685	2423	3349	1706	2239	1228	1198	1798
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	50	0	50	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	2438	4103	4548	104	928	1343	51	74	219	450	450
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	12	0	0	0	20	24	0	0	64	64	16
DETQLM	1704	2111	2148	0	0	6194	50	0	7715	7780	2650	2620	5160
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	4800	0	2402	785	2300	2000	2500	2500
MFWKCE	1736	2128	3600	4800	3500	2500	2000	4000	0	3000	0	0	2500
MFWKBL	1752	2129	1551	1294	1033	1806	2567	2321	0	3088	0	0	2586
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	7710	7710	0	0	0
PHDLY2	1757	2134	0	0	0	0	0	0	12830	12830	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	245	365	365	12	135	135	12	12	40	85	85

	Motor model		1500A	3000B	6000B	9000B	15000C	αM2	αM2.5	αM22	αM30	α22/3HV	α30/3HV
	Motor specification		0410 Linear	0411 Linear	0412 Linear	0413 Linear	0414 Linear	0376	0377	0165	0166	0177	0178
	Motor ID No.		90	91	92	93 (130A)	94 (240A)	98	99	100	101	102 (60A)	103 (60A)
Symbol	FS15*i*	FS16*i*,etc.											
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	01000100	01000100
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000100	00000100	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000	00100000	00100000	00100000	00100000	00100000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000100	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000010	00000000	00000000
	2713	2300	10000000	10000000	10000000	10000000	10000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1890	4804	4804	5036	1420	600	400	555	736	1050	1100
PK2	1853	2041	-7180	-14453	-13138	-16000	-5600	-1957	-1154	-2698	-2623	-3811	-4300
PK3	1854	2042	-2647	-2660	-2660	-2660	-2663	-2476	-2547	-2686	-2696	-2694	-2663
PK1V	1855	2043	19	16	16	14	10	31	56	97	128	181	195
PK2V	1856	2044	-260	-214	-214	-195	-131	-274	-500	-867	-1142	-1618	-1750
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-4371	-5321	-5321	-5849	-8681	-1383	-759	4378	3322	2346	2168
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	0	0	0	0	0	-9230	-8722	-7695	-3870	-6412	-3856
PALPH	1870	2058	0	0	0	0	0	-1400	-1800	-2700	-2240	-2240	-3000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282	7282
EMFLMT	1873	2061	120	120	120	120	120	0	0	0	0	0	0
POVC1	1877	2062	32670	32670	32670	32685	32712	32685	32645	32587	32567	32590	32586
POVC2	1878	2063	1222	1222	1222	1041	703	1041	1535	2260	2514	2221	2279
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	3626	3626	3626	3087	2086	3089	4556	6714	7473	6599	6771
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	0	0	0	0	0	20480	8192	12288	8192	20480	12288
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	1402	1402	1402	1293	1063	1293	1730	1907	2012	1890	1915
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0	15000	15000	15000	15000	15000	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	227	455	911	1481	3104	139	143	943	1341	1026	1381
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	0	0	2600	2584	40	24	2584	2592
DETQLM	1704	2111	0	0	0	0	0	6440	7780	5220	5220	5145	4658
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	0	0	0	0	1322	625	1802	1756	4200	5885
MFWKCE	1736	2128	0	0	0	0	0	2000	2500	0	3000	2778	4000
MFWKBL	1752	2129	0	0	0	0	0	2578	3847	0	2577	1554	1287
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	0	2590	0	0
PHDLY2	1757	2134	0	0	0	0	0	0	0	0	12815	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	45	45	85	135	245	25	25	135	135	60	60

	Motor model		α M6HV	α M9HV	α M22HV	α M30HV	α	α	α	α 300/1.2	α 400/1.2	α 300/2	α 400/2
	Motor specification		0182	0183	0185	0186	0170	0170	0169	0135	0136	0137	0138
	Motor ID No.		104	105	106	107	108	109	110	113	114	115	116
Symbol	FS15*i*	FS16*i*,etc.					(360A)	(240A)	(130A)				
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	01000110	01000110	00000110	01000110	01000110	01000110	01000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00100000	00100000	00100000	00100000	00100000	00100000	00000000	00100000	00100000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2713	2300	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	783	542	430	648	1046	968	822	1715	2910	1357	1593
PK2	1853	2041	-2832	-2277	-2470	-2532	-4459	-3716	-2254	-5809	-7671	-4212	-5395
PK3	1854	2042	-2607	-2640	-2682	-2692	-2664	-2664	-2664	-2711	-2712	-2710	-2711
PK1V	1855	2043	37	66	94	161	43	65	119	116	112	114	113
PK2V	1856	2044	-329	-595	-845	-1444	-386	-579	-1069	-1035	-1003	-1023	-1016
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-1154	6373	4490	2628	-983	-656	3551	3668	3782	3709	3736
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	3787	3787	1894	3787	3787	3787	3787
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	-7690	-6408	-5135	-6422	-3852	-3858	-3873	-2323	-1822	-3850	-2838
PALPH	1870	2058	-1800	-1800	-2000	-3226	-1800	-2700	-4950	-2000	-4000	-800	-2000
PPBAS	1871	2059	0	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	7282	7282	7282	7282	7282	7282	7282	8010	8010	7282	7282
EMFLMT	1873	2061	0	0	0	0	0	0	0	120	120	120	120
POVC1	1877	2062	32725	32678	32596	32447	32613	32420	32279	32343	32366	32352	32356
POVC2	1878	2063	538	1119	2149	4009	1937	4345	6107	5312	5020	5196	5145
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	1596	3321	6385	11935	5752	12943	18231	15843	14964	15494	15339
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	28672	12288	24576	0	20480	20480	0	16384	12288	12288	12288
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	929	1341	1859	2542	1453	2180	2302	2412	2344	2385	2373
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	0	15000	15000	15000	15000	15000	15000	15000	0	15000	15000
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	580	603	967	1061	4330	2887	1563	10808	14575	10931	14398
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	40	40	40	24	0	0	1	16	16	16	24
DETQLM	1704	2111	0	5220	3940	5220	0	0	4174	0	0	1606	1636
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	5572	853	4051	2388	5116	3411	1848	0	0	0	0
MFWKCE	1736	2128	0	0	0	1000	2000	5000	2000	7500	5000	5500	6500
MFWKBL	1752	2129	0	0	0	3221	1287	1551	2051	787	272	791	784
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	0	0	0	0	0	0	1556	1550
PHDLY2	1757	2134	0	0	0	0	0	0	0	0	0	20494	20494
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	0	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	0	0	0	0	0	0	0	0	0	0	0
POVCLMT	1787	2164	0	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	45	45	65	65	365	245	135	245	245	365	365

Symbol	FS15*i*	FS16*i*,etc.											
	Motor model		α1000/2	α40HV	αM40HV	3000B/4N	6000B/4N	9000B/4N	15000C/3N	300D/4	600D/4	900D/4	6000B/4N
	Motor specification		0131	0179	0189	0411-B811 Linear	0412-B811 Linear	0413-B811 Linear	0414-B811 Linear	0421 Linear	0422 Linear	0423 Linear	0412-B811 Linear
	Motor ID No.		117	118	119	120	121 (240A)	122 (240A)	123	124	125	126	127 (160A)
	1808	2003	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000	00001000
	1809	2004	01000110	01000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	01000100	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
	1955	2011	00100000	00100000	00100000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
	2713	2300	00000000	00000000	00000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000
	2714	2301	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	1170	715	600	1620	2626	4944	2392	526	717	390	1751
PK2	1853	2041	-3684	-3141	-2020	-11180	-10051	-11831	-8448	-2141	-3333	-2009	-6701
PK3	1854	2042	-2722	-2699	-2680	-2660	-2660	-2660	-2657	-2618	-2618	-2618	-2660
PK1V	1855	2043	234	230	120	16	10	16	10	16	9	13	15
PK2V	1856	2044	-2100	-2061	-1077	-214	-135	-211	-128	-217	-122	-179	-202
PK3V	1857	2045	0	0	0	0	0	0	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	1807	1841	3522	-5321	-8463	-5399	-8861	-8755	-9339	-6367	-5642
BLCMP	1860	2048	0	0	0	0	0	0	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0	0	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956	956	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510	510	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0	0	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21	21	21	21	21	21	21
PDDP	1866	2054	3787	3787	1894	1894	1894	1894	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319	319	319	319	319	319	319
EMFCMP	1868	2056	19379	0	0	0	0	0	0	0	0	0	0
PVPA	1869	2057	-3097	-6429	-3859	0	0	0	0	0	0	0	0
PALPH	1870	2058	-2000	-1529	-3186	0	0	0	0	0	0	0	0
PPBAS	1871	2059	5	0	0	0	0	0	0	0	0	0	0
TQLIM	1872	2060	6473	7282	7282	7282	4855	7282	7282	5826	6554	7282	7282
EMFLMT	1873	2061	120	120	0	120	120	120	120	120	120	120	120
POVC1	1877	2062	31823	32518	32368	32698	32740	32698	32732	32747	32747	32720	32706
POVC2	1878	2063	7334	3119	4997	873	345	873	452	268	268	602	777
TGALMLV	1892	2064	4	4	4	4	4	4	4	4	4	4	4
POVCLMT	1893	2065	27745	9277	14897	2590	1024	2590	1340	793	793	1784	2304
PK2VAUX	1894	2066	0	0	0	0	0	0	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0	0	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0	0	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0	0	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0	0	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0	0	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0	0	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0	0	0	0	0	0	0
AALPH	1967	2074	16384	0	0	0	0	0	0	0	0	0	0
OSCTPL	1970	2077	0	0	0	0	0	0	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0	0	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0	0	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0	0	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0	0	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0	0	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0	0	0	0	0	0	0
RTCURR	1979	2086	2838	2241	2339	1184	744	1184	852	655	655	983	1117
TDPLD	1980	2087	0	0	0	0	0	0	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0	0	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0	0	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0	0	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0	0	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0	0	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0	0	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0	0	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0	0	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0	0	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0	0	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0	0	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400	400	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0	0	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0	0	0	0	0	0	0
DBLIM	1995	2102	15000	15000	15000	0	0	0	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0	0	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0	0	0	0	0	0	0
TRQCST	1998	2105	28519	1534	1538	455	1450	1367	3168	52	104	104	966
LP24PA	1999	2106	0	0	0	0	0	0	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0	0	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0	0	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0	0	0	0	0	0	0
MGSTCM	1703	2110	2334	24	0	0	0	0	0	0	0	0	0
DETQLM	1704	2111	2607	5722	5160	0	0	0	0	0	0	0	0
AMRDML	1705	2112	0	0	0	0	0	0	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0	0	0	0	0	0	0
NINTCT	1735	2127	0	4054	2047	0	0	0	0	0	0	0	0
MFWKCE	1736	2128	6500	2000	2000	0	0	0	0	0	0	0	0
MFWKBL	1752	2129	1042	3075	3584	0	0	0	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0	0	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0	0	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0	0	0	0	0	0	0
PHDLY1	1756	2133	2581	0	5135	0	0	0	0	0	0	0	0
PHDLY2	1757	2134	15381	0	12820	0	0	0	0	0	0	0	0
DGCSMM	1782	2159	0	0	0	0	0	0	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0	0	0	0	0	0	0
OVCSTP	1784	2161	140	0	0	0	0	0	0	0	0	0	0
POVC21	1785	2162	32667	0	0	0	0	0	0	0	0	0	0
POVC22	1786	2163	1264	0	0	0	0	0	0	0	0	0	0
POVCLMT2	1787	2164	21831	0	0	0	0	0	0	0	0	0	0
MAXCRT	1788	2165	365	85	85	85	245	245	365	25	45	45	165

	Motor model		9000B	9000B/4N	15000C	βM0.5	BM1
	Motor specification		0413 Linear	0413-B811 Linear	0414 Linear	0115	0116
	Motor ID No.		128 (160A)	129 (360A)	130 (360A)	181	182
Symbol	FS15*i*	FS16*i*,etc.					
	1808	2003	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000110	00000110	00000110	00000110	00000110
	1883	2005	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000100	00000100	00000100	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000110	00001010	00001010	00000000	00000000
	1708	2014	00000110	00001010	00001010	00000000	00000000
	1750	2210	00000000	00000000	00000100	00000000	00000000
	1751	2211	00000000	00000000	00000000	00000010	00000010
	2713	2300	10000000	10000000	10000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	6198	7416	2130	141	398
PK2	1853	2041	-19692	-17747	-8400	-511	-1137
PK3	1854	2042	-2660	-2660	-2663	-2415	-2388
PK1V	1855	2043	12	10	7	7	6
PK2V	1856	2044	-158	-141	-87	-59	-53
PK3V	1857	2045	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-7199	-8099	-13022	-6462	-7176
BLCMP	1860	2048	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319
EMFCMP	1868	2056	0	0	0	-12850	-12850
PVPA	1869	2057	0	0	0	0	-11530
PALPH	1870	2058	0	0	0	0	-1000
PPBAS	1871	2059	0	0	0	0	0
TQLIM	1872	2060	5917	4855	4855	6918	7282
EMFLMT	1873	2061	120	120	120	0	0
POVC1	1877	2062	32713	32737	32743	32674	32695
POVC2	1878	2063	687	388	313	1178	915
TGALMLV	1892	2064	4	4	4	4	4
POVCLMT	1893	2065	2038	1151	927	3497	2714
PK2VAUX	1894	2066	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0
AALPH	1967	2074	0	0	0	20480	20480
OSCTPL	1970	2077	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0
RTCURR	1979	2086	1050	789	708	1376	1212
TDPLD	1980	2087	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0
TRQCST	1998	2105	1823	2051	4656	42	89
LP24PA	1999	2106	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0
MGSTCM	1703	2110	0	0	0	30	30
DETQLM	1704	2111	0	0	0	10290	10290
AMRDML	1705	2112	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0
NINTCT	1735	2127	0	0	0	1009	1763
MFWKCE	1736	2128	0	0	0	0	0
MFWKBL	1752	2129	0	0	0	0	0
LP2GP	1753	2130	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0
PHDLY1	1756	2133	0	0	0	7690	11560
PHDLY2	1757	2134	0	0	0	12820	12880
DGCSMM	1782	2159	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0
POVC21	1785	2162	0	0	0	32767	32767
POVC22	1786	2163	0	0	0	16	12
POVCLMT2	1787	2164	0	0	0	3015	2340
MAXCRT	1788	2165	165	365	365	25	25

G.6 HRV2 CONTROL PARAMETERS FOR βM SERIES MOTORS

December, 2002

The HRV2 control parameters for the βM series motors are given in the table below.
90B0 series

> **NOTE**
> The parameters cannot be used with Series 9096.

Symbol	FS15*i*	FS16*i*,etc.	βM0.2	βM0.3	βM0.4	βM0.5	βM1
		Motor specification	0111	0112	0114	0115	0116
		Motor ID No.	260	261	280	281	282
	1808	2003	00001000	00001000	00001000	00001000	00001000
	1809	2004	00000011	00000011	00000011	00000011	00000011
	1883	2005	00000000	00000000	00000000	00000000	00000000
	1884	2006	00000000	00000000	00000000	00000000	00000000
	1951	2007	00000000	00000000	00000000	00000000	00000000
	1952	2008	00000000	00000000	00000000	00000000	00000000
	1953	2009	00000000	00000000	00000000	00000000	00000000
	1954	2010	00000000	00000000	00000000	00000000	00000000
	1955	2011	00000000	00000000	00000000	00000000	00000000
	1956	2012	00000000	00000000	00000000	00000000	00000000
	1707	2013	00000000	00000000	00000000	00000000	00000000
	1708	2014	00000000	00000000	00000000	00000000	00000000
	1750	2210	00000000	00000000	00000000	00000000	00000000
	1751	2211	00000010	00000010	00000010	00001010	00001010
	2713	2300	00000000	00000000	00000000	00000000	00000000
	2714	2301	00000000	00000000	00000000	00000000	00000000
PK1	1852	2040	123	210	100	138	312
PK2	1853	2041	-510	-970	-430	-673	-1360
PK3	1854	2042	-1069	-1146	-2463	-1205	-1203
PK1V	1855	2043	4	4	7	7	6
PK2V	1856	2044	-36	-33	-61	-59	-53
PK3V	1857	2045	0	0	0	0	0
PK4V	1858	2046	-8235	-8235	-8235	-8235	-8235
POA1	1859	2047	-10638	-11550	-6249	-6462	-7176
BLCMP	1860	2048	0	0	0	0	0
DPFMX	1861	2049	0	0	0	0	0
POK1	1862	2050	956	956	956	956	956
POK2	1863	2051	510	510	510	510	510
RESERV	1864	2052	0	0	0	0	0
PPMAX	1865	2053	21	21	21	21	21
PDDP	1866	2054	1894	1894	1894	1894	1894
PHYST	1867	2055	319	319	319	319	319
EMFCMP	1868	2056	0	0	-12850	-12850	-12850
PVPA	1869	2057	0	0	0	0	-15420
PALPH	1870	2058	0	0	0	0	-1000
PPBAS	1871	2059	0	0	0	0	0
TQLIM	1872	2060	7282	7282	5826	7282	7282
EMFLMT	1873	2061	0	0	0	0	0
POVC1	1877	2062	32725	32725	32640	32674	32695
POVC2	1878	2063	533	533	1603	1178	915
TGALMLV	1892	2064	4	4	4	4	4
POVCLMT	1893	2065	3163	3163	4759	3497	2714
PK2VAUX	1894	2066	0	0	0	0	0
FILTER	1895	2067	0	0	0	0	0
FALPH	1961	2068	0	0	0	0	0
VFFLT	1962	2069	0	0	0	0	0
ERBLM	1963	2070	0	0	0	0	0
PBLCT	1964	2071	0	0	0	0	0
SFCCML	1965	2072	0	0	0	0	0
PSPTL	1966	2073	0	0	0	0	0
AALPH	1967	2074	20480	20480	20480	20480	20480
OSCTPL	1970	2077	0	0	0	0	0
PDPCH	1971	2078	0	0	0	0	0
PDPCL	1972	2079	0	0	0	0	0
DPFEX	1973	2080	0	0	0	0	0
DPFZW	1974	2081	0	0	0	0	0
BLENDL	1975	2082	0	0	0	0	0
MOFCTL	1976	2083	0	0	0	0	0
RTCURR	1979	2086	1929	1929	1605	1376	1212
TDPLD	1980	2087	0	0	0	0	0
MCNFB	1981	2088	0	0	0	0	0
BLBSL	1982	2089	0	0	0	0	0
ROBSTL	1983	2090	0	0	0	0	0
ACCSPL	1984	2091	0	0	0	0	0
ADFF1	1985	2092	0	0	0	0	0
VMPK3V	1986	2093	0	0	0	0	0
BLCMP2	1987	2094	0	0	0	0	0
AHDRTL	1988	2095	0	0	0	0	0
RADUSL	1989	2096	0	0	0	0	0
SMCNT	1990	2097	0	0	0	0	0
DEPVPL	1991	2098	0	0	0	0	0
ONEPSL	1992	2099	400	400	400	400	400
INPA1	1993	2100	0	0	0	0	0
INPA2	1994	2101	0	0	0	0	0
DBLIM	1995	2102	0	0	0	0	0
ABVOF	1996	2103	0	0	0	0	0
ABTSH	1997	2104	0	0	0	0	0
TRQCST	1998	2105	7	14	22	42	89
LP24PA	1999	2106	0	0	0	0	0
VLGOVR	1700	2107	0	0	0	0	0
RESERV	1701	2108	0	0	0	0	0
BELLTC	1702	2109	0	0	0	0	0
MGSTCM	1703	2110	1	1	30	25	1556
DETQLM	1704	2111	7710	7700	10290	10290	10290
AMRDML	1705	2112	0	0	0	0	0
NFILT	1706	2113	0	0	0	0	0
NINTCT	1735	2127	379	852	400	504	881
MFWKCE	1736	2128	0	3000	0	0	1500
MFWKBL	1752	2129	0	3880	0	0	5135
LP2GP	1753	2130	0	0	0	0	0
LP4GP	1754	2131	0	0	0	0	0
LP6GP	1755	2132	0	0	0	0	0
PHDLY1	1756	2133	7700	7695	7690	7690	15400
PHDLY2	1757	2134	12825	12840	12820	12820	12840
DGCSMM	1782	2159	0	0	0	0	0
TRQCUP	1783	2160	0	0	0	0	0
OVCSTP	1784	2161	0	0	0	0	0
POVC21	1785	2162	0	0	32766	32767	32767
POVC22	1786	2163	0	0	22	16	12
POVCLMT2	1787	2164	0	0	4104	3015	2340
MAXCRT	1788	2165	4	4	25	25	25

H DETAILS OF HIGH-SPEED AND HIGH-PRECISION ADJUSTMENT

(1) Overview

Appendix H explains in detail the adjustment procedure described in Section 3.3, "ADJUSTING PARAMETERS FOR HIGH-SPEED AND HIGH-PRECISION MACHINING".

(2) 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 the 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, acc./dec. 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 SERVO GUIDE or SD. G08P1 and G08P0 in the program are G codes for starting and ending the advanced preview control mode in Series 16*i* and so on, respectively. For a mode to be used, select the corresponding G codes from Table H (a).

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

Table H (a) Codes for starting and ending each mode

	Start	End
FS16*i*, 18*i*, 21*i* + Advanced preview control	G08P1	G08P0
FS16*i* + High-precision contour control FS16*i* + AI high-precision contour control FS16*i* + AI nano high-precision contour control FS15*i* + Fine HPCC	G05P10000	G05P0
FS30*i* + AI contour control I FS30*i* + AI contour control II FS16*i* + AI contour control FS16*i* + AI nano-contour control FS15*i* + Fine HPCC FS21*i* + AI advanced preview control	G05.1Q1	G05.1Q0

In Fig. H (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. H (b), the arc radius reduction can be reduced to nearly 0.

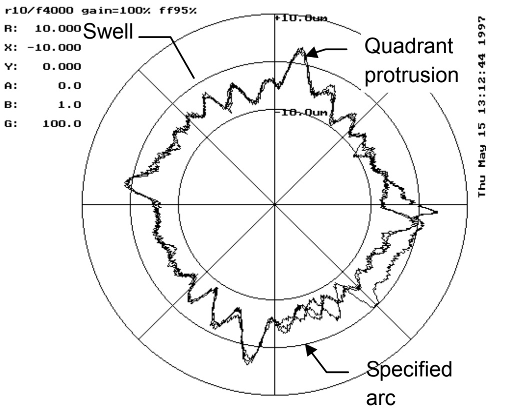


Fig. H (a) Feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 95%
FAD time constant: 24 ms (linear type)

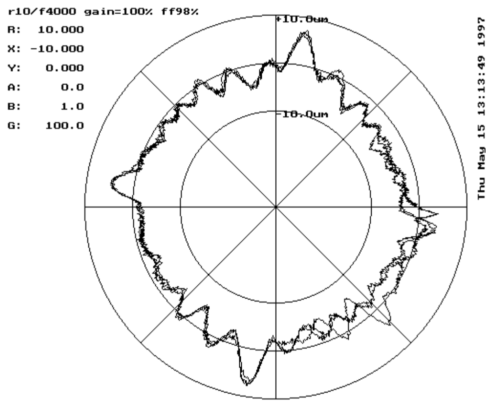


Fig. H (b) Feed-forward adjustment
Velocity loop gain: 100%
<u>Advanced preview feed-forward coefficient: 98%</u>
FAD time constant: 24 ms (linear type)

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. H (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 acc./dec.) to reduce the quadrant protrusions and improve the roundness (Fig. H (d)).

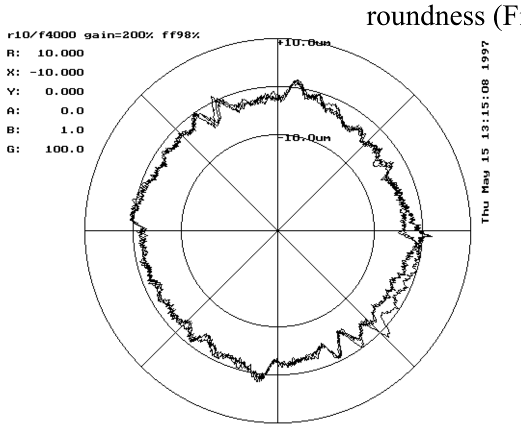


Fig. H (c) Effect of velocity loop gain
<u>Velocity loop gain: 200%</u>
Advanced preview feed-forward coefficient: 98%
FAD time constant: 24 ms (linear type)

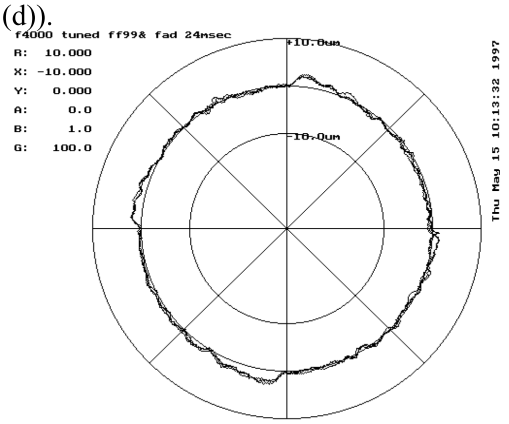


Fig. H (d) Effect of velocity loop gain
<u>Velocity loop gain: 300%</u>
<u>Advanced preview feed-forward coefficient: 99%</u>
FAD time constant: 24 ms (linear type)

(3) 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]

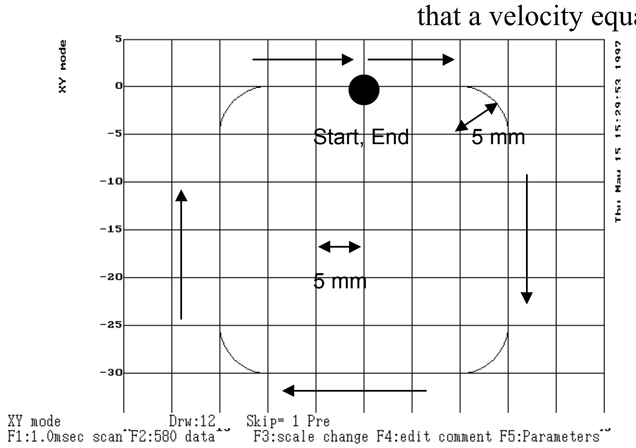
The formula below is applicable. In actual adjustment, however, make an adjustment starting with a velocity feed-forward coefficient of 100.

(Velocity feed-forward coefficient) =

100 × (Motor rotor inertia + load inertia) / 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.)




```
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;
```

Fig. H (e) Programmed figure

When the actual path is measured in a mode for displaying a reference path, the actual path and reference path are plotted at the same time as shown below:

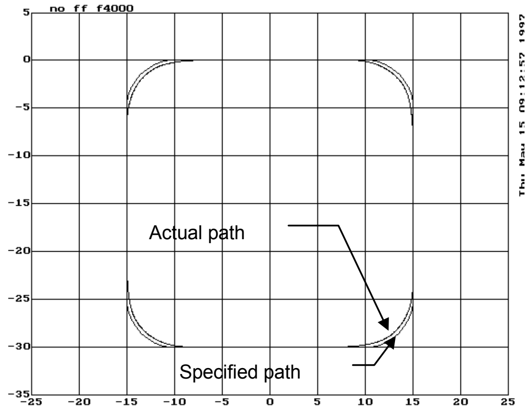


Fig. H (f) Specified path and actual path

When advanced preview feed-forward is disabled, a figure error of hundreds μm occurs as shown in Fig. H (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. H (g), a display magnification of 100 is set.

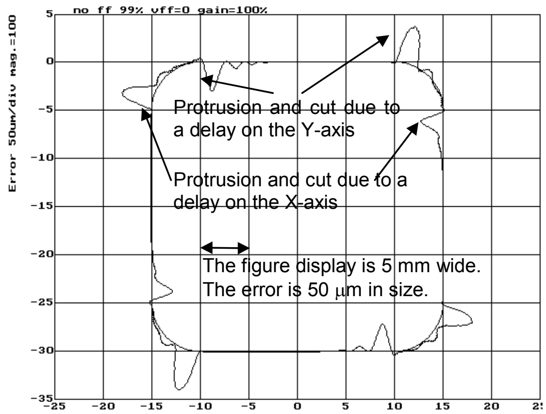


Fig. H (g) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: 0%

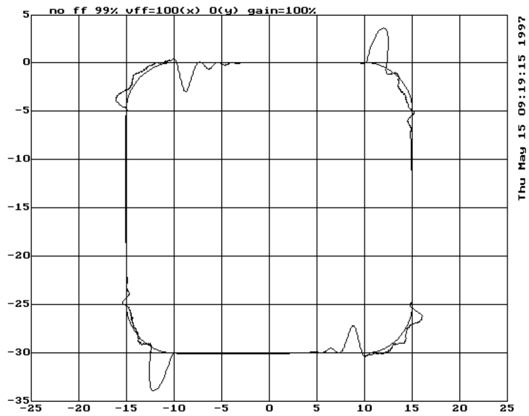


Fig. H (h) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X100%

In Fig. H (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. H (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. H (i), excessively large velocity feed-forward coefficients are specified, so that the protrusions shown in Fig. H (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. H (i). Fig. H (j) shows the result of adjustment to the optimum values. Fig. H (k) enlarges the errors only for display.

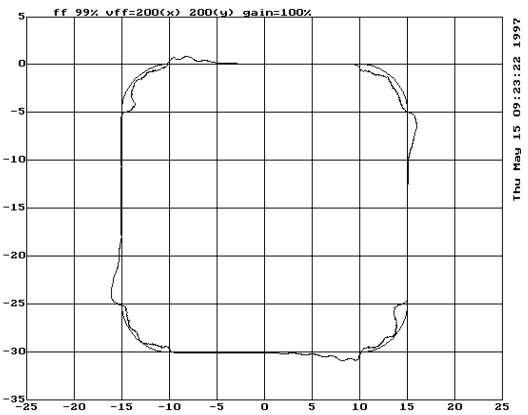


Fig. H (i) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X200%, Y200%

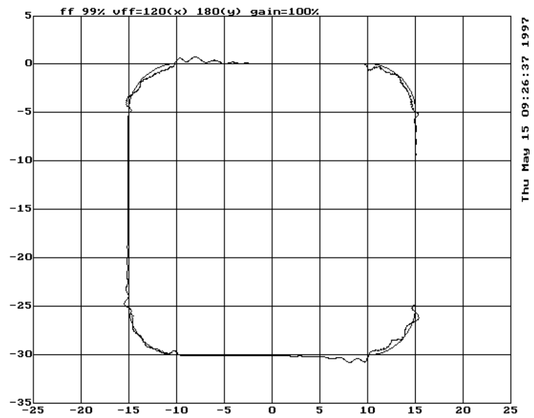


Fig. H (j) Velocity feed-forward adjustment
Velocity loop gain: 100%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X120%, Y180%

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 Item H (4).

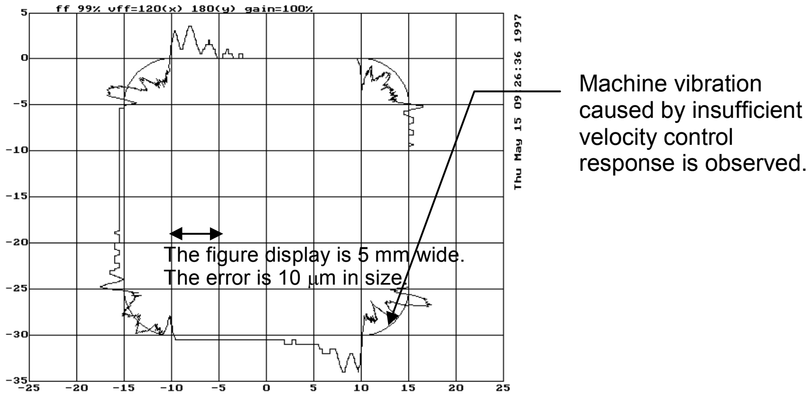


Fig. H (k) Velocity feed-forward adjustment

Swells in the arc areas can be reduced by increasing the velocity loop gain (Fig. H (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 Item H (6).

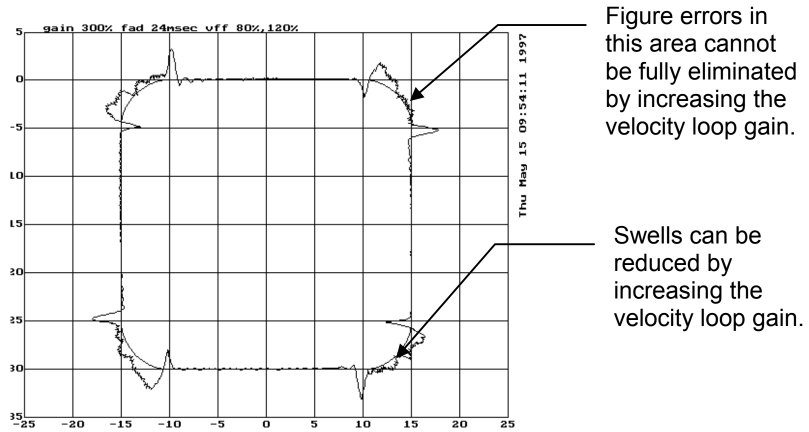


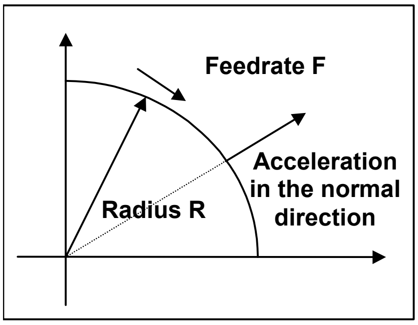
Fig. H (l) Velocity feed-forward adjustment
Velocity loop gain: 300%
Advanced preview feed-forward coefficient: 99%
FAD time constant: 24 ms (linear type)
Velocity feed-forward: X120%, Y180%

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

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

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

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

$4000/60/889\times1000 = 75$ 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. H (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. H (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. H (n), but the machining time has increased by 200 msec.

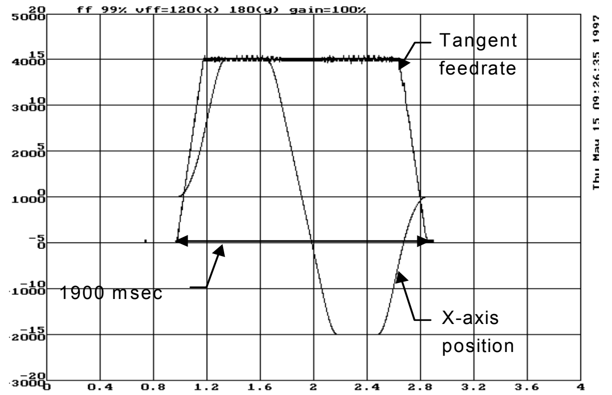


Fig. H (m) When the arc radius based feedrate clamp function is not used

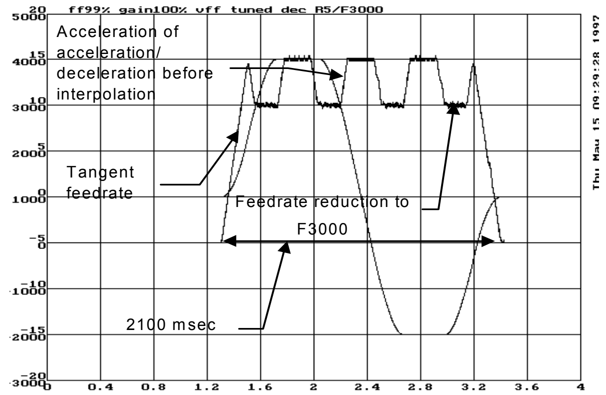


Fig. H (n) When the arc radius based feedrate clamp function is used

[Guideline for adjustment value setting]

Empirically, the values below are adequate. For the parameter numbers, refer to the parameter manual of each CNC.
Standard: F3060 for R5 (527 mm/sec^2)
Speed priority I: F5150 for R5 (1473 mm/sec^2)
Speed priority II: F7275 for R5 (2940 mm/sec^2)

[Actual adjustment]

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

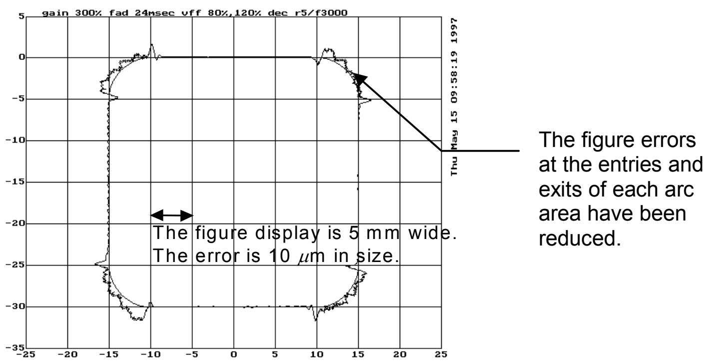


Fig. H (o) Arc radius based feedrate clamping

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

[Purpose of adjustment]

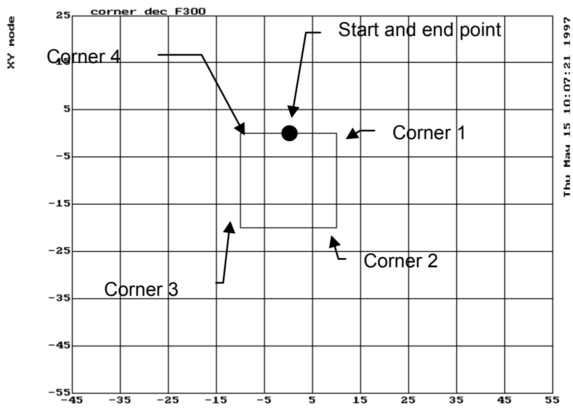
In the program shown in Fig. H (p), the feedrate along each axis changes to a great extent at each block joint. With a high-precision high-speed system, the CNC reads programmed figures beforehand. If the feedrate along each axis changes at a block joint, such a system can decrease the feedrate by a parameter-specified allowable feedrate difference to reduce a shock and figure error at the block joint. Acc./dec. is performed based on the time constant for acc./dec. 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.
Standard: F400 for R5
Speed priority I: F500 for R5
Speed priority II: F1000 for R5

[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. H (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. H (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. H (q) where a reduced corner feedrate of F1000 is set, an overshoot of 10 μm or more has occurred. In Fig. H (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 acc./dec. before interpolation may be too large. In such a case, set a longer time for acc./dec. before interpolation. (In this case, a longer machining time results.)
Fig. H (s) shows the feedrate along the X-axis and Y-axis (corner 1) when the corner deceleration function is used.

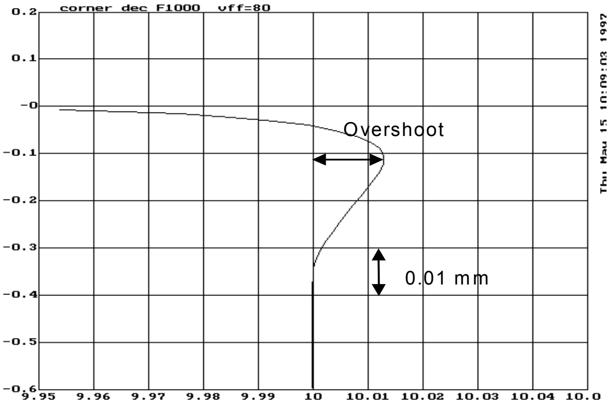


Fig. H (q) Reduced corner feedrate F1000

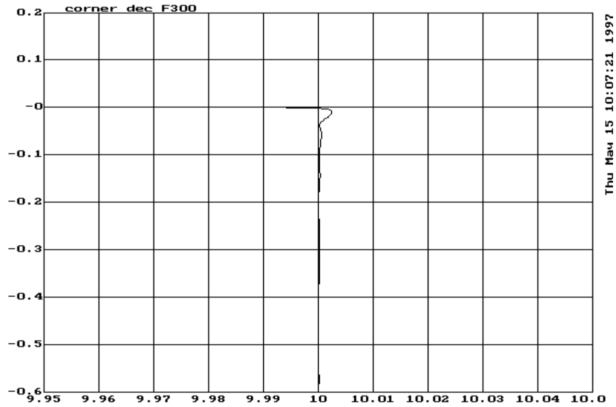


Fig. H (r) Reduced corner feedrate F300

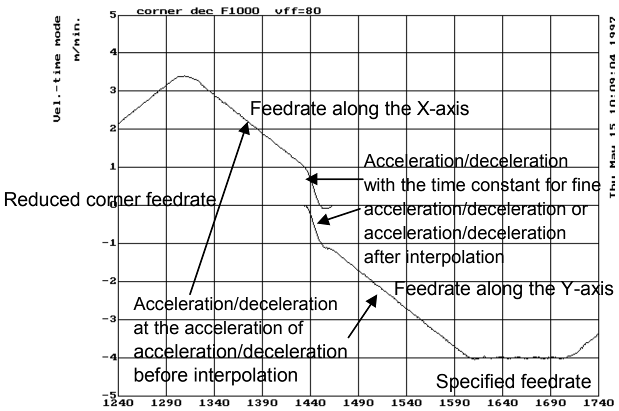


Fig. H (s) Time and feedrate relationship for reduced corner feedrate F1000

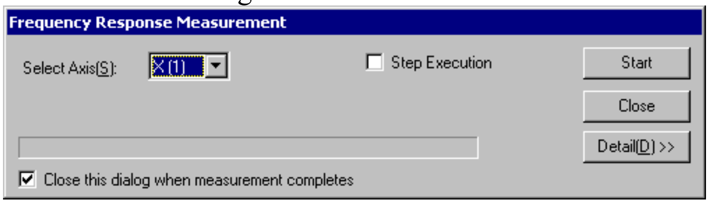
(6) Frequency characteristic measurement method

(a) Using SERVO GUIDE

To measure the frequency characteristic, follow this procedure.

> **NOTE**
> 1 Basically, no CNC parameter setting is required.

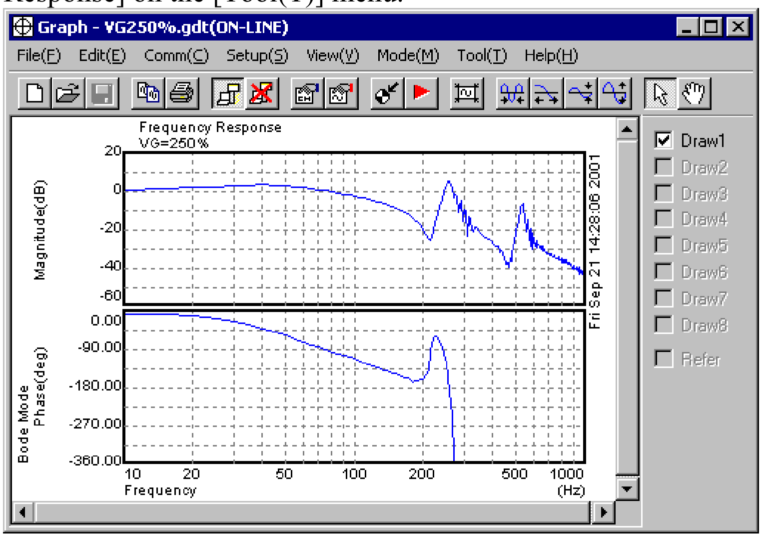
1 On the graph window menu, select [Tool(T)] → [Frequency Response] → [Measure...] to display the "Frequency measurement" dialog box.



2 Select an axis on which you want to measure frequency characteristics, and click the [Start] button. The axis is automatically vibrated, and frequency characteristics (board line chart) are displayed.

3 Click the [Detail] button. It becomes possible to specify options. Make option settings as required.

4 To re-draw, select [Draw Bode diagram] from [Frequency Response] on the [Tool(T)] menu.

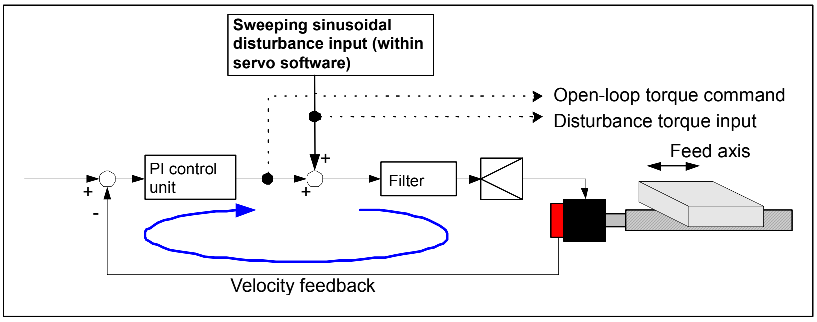


(b) When SERVO GUIDE is not used

Using the disturbance input function enables you to get frequency characteristics.

Disturbance input function

The disturbance input function is a function that lets you apply vibration to axes by entering sinusoidal disturbance wave as a torque command. With this function, you can get the frequency characteristics of the velocity loop of the system (including machine sections).



Series and editions of applicable servo software

(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B0/A(01) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

Parameter setting method

<1> Specify the following parameters.

	#7	#6	#5	#4	#3	#2	#1	#0
2683 (FS15*i*) / 2270 (FS30*i*, 16*i*)	DSTIN	DSTTAN	DSTWAV					

DSTIN(#7) DISTURBANCE INPUT
0 : Stop
1 : Start (a change of 0 → 1 triggers disturbance input.)

DSTTAN(#6) A disturbance input type is specified as follows:
0 : Input for only one axis
1 : Input for both L and M axes (for synchronous and tandem axes, setting is to be made only for the L axis.)

DSTWAV(#5) The input waveform of disturbance input is:
0: Sine wave. (Usually, select the sine wave.) .
1: Square wave.

2739 (FS15*i*) / 2326 (FS30*i*, 16*i*)	**Disturbance input gain**

[Default value] 0

[Valid data range] 0 to 7282 (to be set in Tcmd units; a value of 7282 corresponds to an amplifier maximum current.)
Usually, specify 500 to apply vibration to the machine so that it will sound lightly.

2740 (FS15*i*) / 2327 (FS30*i*, 16*i*)	**Disturbance input function start frequency (Hz)**

[Valid data range] 1 to 2000

[Recommended value] 10

2741 (FS15*i*) / 2328 (FS30*i*, 16*i*)	**Disturbance input end frequency**

[Default value] 200

[Valid data range] 1 to 2000 (Unit : Hz)

2742 (FS15*i*) / 2329 (FS30*i*, 16*i*)	**Number of disturbance input measurement points**

[Default value] 3

[Valid data range] SWEPT SINE MODE 1 to 32767
Continuous sine mode Less than 0
Usually, specify 0 or greater to make the machine vibrate in swept sine mode.

<2> Cautions

- Turn off the functions that work only when the machine is at a halt, such as the variable proportional gain function in the stop state and the overshoot compensation function.
- When measuring cutting characteristics, pay attention to which function type, cutting or rapid traverse, is in use.
- Decrease the position gain to about 1000.

<3> How to use

The default disturbance input setting is the swept sine mode.
When the rising edge of the disturbance input bit is detected, application of vibration is started. Vibration is automatically stopped when sine sweeping from the start frequency to the end frequency is completed. A reset or an emergency stop makes the machine stop operating. After the emergency stop is released, turning the function bit off and on again restarts disturbance input.

- Example of setting
  No2326 = 500 → gain = 500
  No2327 = 0 → start frequency = 10 Hz
  No2328 = 0 → end frequency = 200 Hz
  No2329 = 0 → repetition = 3 times

<4> Setting for outputting input/output data to the check board
Make the following settings so that the disturbance input frequency and current command can be observed on the check board.

1726 (FS15*i*) 2115 (FS30*i*, 16*i*)	**Shift amount**

[Setting value] 4

1774 (FS15*i*) 2151 (FS30*i*, 16*i*)	**Disturbance input frequency**

[Setting value] 2629 for the L axis and 2757 for the M axis
2108 for the L axis and 2236 for the M axis (for the Series 90B3 and 90B7)

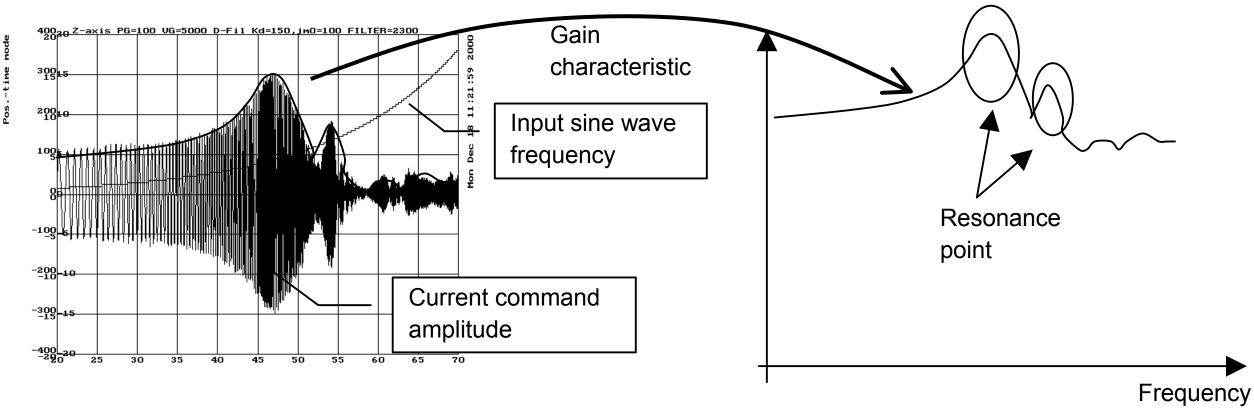
1775 (FS15*i*) 2152 (FS30*i*, 16*i*)	**Shift amount**

[Setting value] 2

1776 (FS15*i*) 2153 (FS30*i*, 16*i*)	**Current command**

[Setting value] 268 for the L axis and 396 for the M axis
2372 for the L axis and 2500 for the M axis (for the Series 90B3 and 90B7)

<5> SD software setting
On the F9 screen of the SD software, specify data conversion for each channel. Select 2:Tcmd. Specify 7282 for the current command channel and 1820 for the disturbance input frequency channel. For channel data settings on the check board, the disturbance input frequency and the current command are set, respectively, to 5 (for a DIP switch, 12) and 6 (for a DIP switch, 13).
Entering a trigger at the same time as the start of disturbance input collects the data shown below.



The envelope of the current command amplitude indicates the gain characteristic of the velocity loop.

(7) Adjustment of backlash acceleration

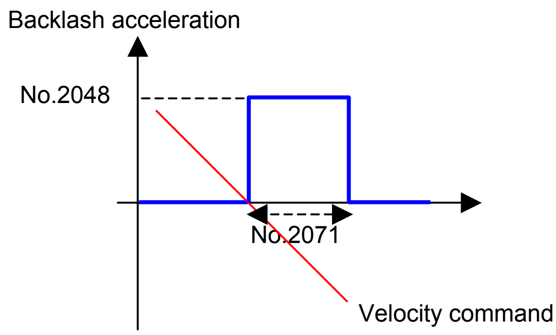
NOTE

The examples given below show the adjustment of backlash acceleration in the Series 30*i* and 16*i*. Even with other CNCs, the adjustment procedure is the same. When using the Series 15*i*, however, replace parameter Nos. according to the table given below.

(a) Backlash acceleration function

A simple figure as shown below is formed by the compensation value of backlash acceleration. The acceleration compensation value is added to the velocity command to help inversion of the velocity integral gain when the motor is reversed. This effect can reduce the path error in the reverse operation.

(Standard backlash acceleration)



Basically, the above two parameters are considered. Parameter No. 2071 is the backlash acceleration time, and its recommended value is 20. Normally, this value need not be adjusted. Parameter No. 2048 is the backlash acceleration amount. In the initial adjustment stage, set 100 in this parameter. Adjust this value while observing the arc figure.

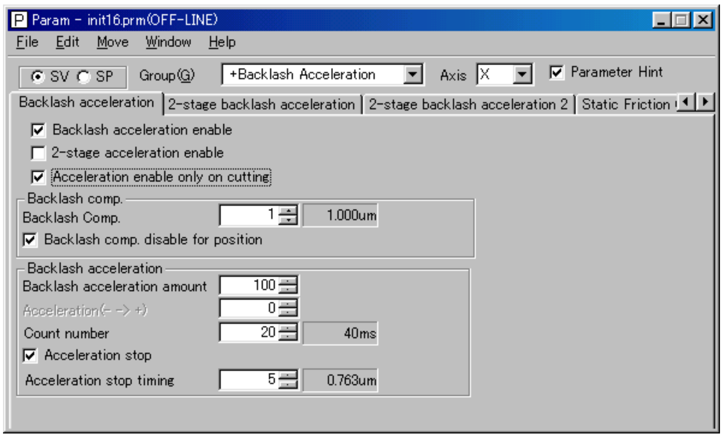
(b) Setting initial parameters for backlash acceleration

Before starting backlash acceleration adjustment, set the following initial parameters:

[Basic parameters for backlash acceleration]

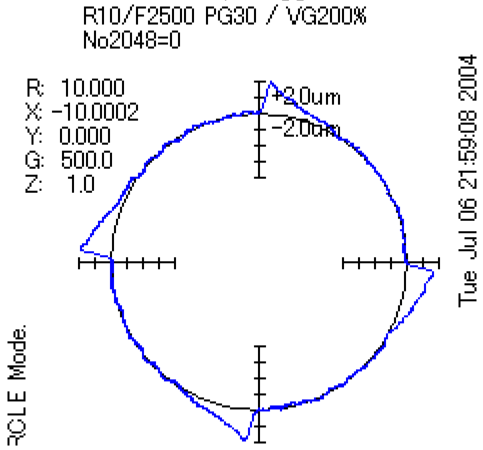
Parameter No.		Recommended value	Description
15*i*	30*i*,16*i*,etc.		
1851	1851	1 or greater	Backlash compensation
1808#5	2003 #5	1	Enables backlash acceleration function
1884#0	2006 #0	0/1	0: Semi-closed loop, 1: Full-closed loop
1953#7	2009 #7	1	Stop of backlash acceleration
2611#7	2223 #7	1	Enables backlash acceleration during cutting only.
1957#6	2015 #6	0	Disables the 2-stage backlash acceleration function.
1860	2048	100	Backlash acceleration amount
1975	2082	5 (1μm detection) 50 (0.1μm detection)	Backlash acceleration stop distance (in detection unit)
1964	2071	20	Backlash acceleration time

These parameters can be set in the parameter window of SERVO GUIDE.

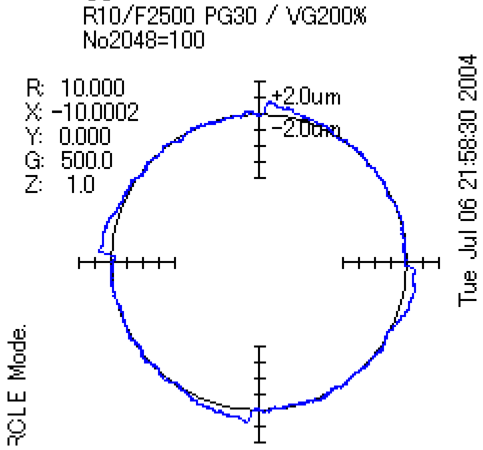


(c) Adjusting backlash acceleration

The following figure shows an arc figure before servo adjustment. Quadrant protrusions of about 4 μm appear on the X- and Y-axes.

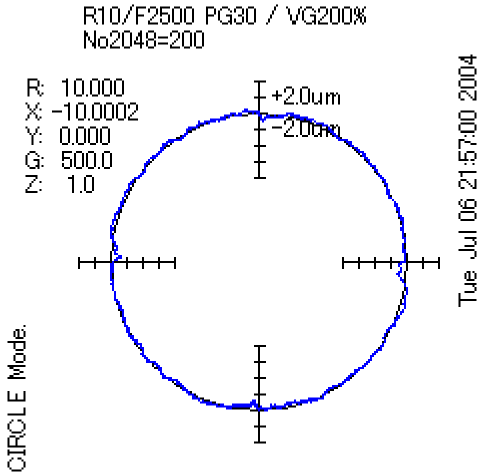


The figure below shows the result of a backlash acceleration adjustment made according to the parameter settings in item (b). By setting recommended values for backlash acceleration, quadrant protrusions can be suppressed.



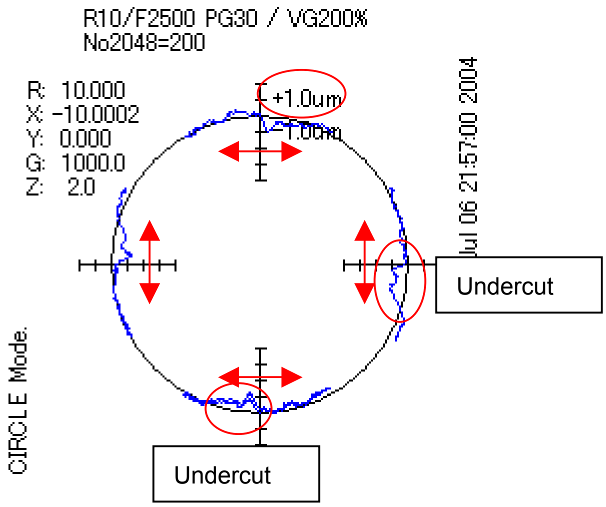
(c)-1 Determining the end of adjustment

First, it is necessary to understand when the backlash acceleration adjustment is ended. The figure below shows the result of an adjustment made by setting parameter No. 2048 to 200. An undercut occurs at the reverse points. Undercuts damage the surface of the machined workpiece, so they must be avoided. Therefore, it is necessary to end the adjustment of parameter No. 2048 just when no undercut occurs.



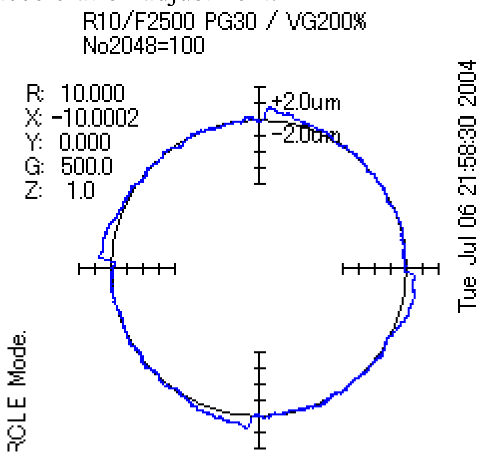
By enlarging the positional deviation at a reverse point, the generation of an undercut can be determined easily. Pressing z widens the figure while pressing Z shrinks the width. Pressing u decreases one grid size while pressing d increases the grid size.

When z and u are pressed, a figure as shown below is obtained:



(c)-2 Effect of gain adjustment

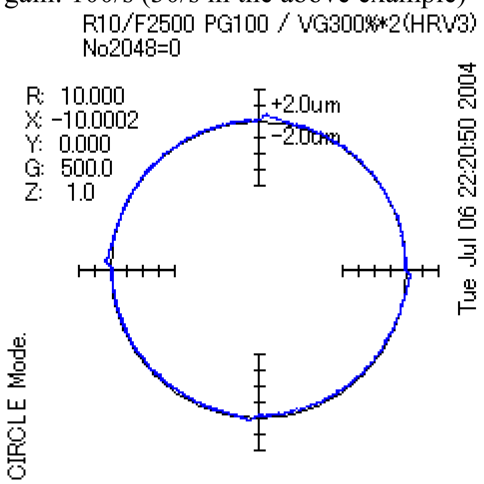
According to the description in item (c)-3 - (1), the final value of parameter No. 2048 must be determined to be 100. However, small protrusions are still left at the reverse points. This is because the gain adjustment is insufficient in this example. The power to suppress the position gain and velocity loop gain protrusions is strong and stable. Therefore, it is necessary to make gain adjustments thoroughly before the backlash acceleration adjustment.



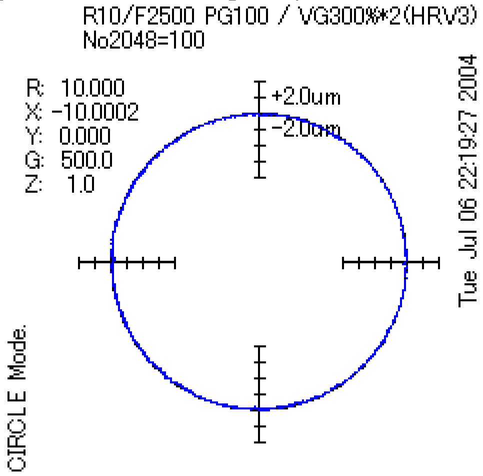
The figure shown below is the result of the gain adjustment, where backlash acceleration is not used. Even when backlash acceleration is not used, protrusions are almost eliminated. Therefore, the importance of gain adjustment can be understood.

(Adjustment items)

- Application of high-speed HRV current control
- Velocity loop gain: 600% (200% in the above example)
- Position gain: 100/s (30/s in the above example)



After a thorough gain adjustment, backlash acceleration can be adjusted easily. The figure shown below is the result obtained after the initial parameters of backlash acceleration listed in item (c)-3 - (2) are set. Thanks to the effect of the gain adjustment and a little backlash acceleration, protrusions are completely eliminated.

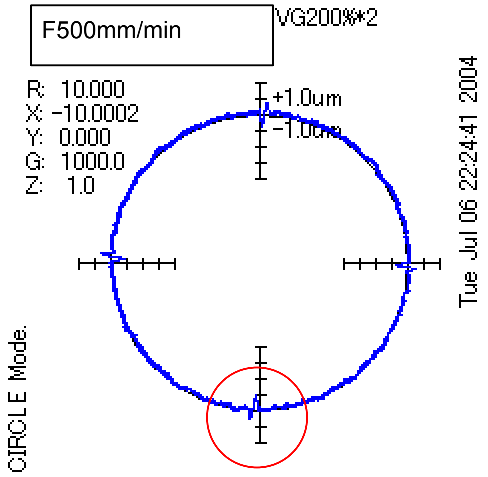


As indicated by this figure, the most important item to eliminate quadrant protrusions is gain adjustment. If gain adjustment is made successfully, backlash acceleration can be adjusted easily. Therefore, backlash acceleration does not play the leading role for suppressing quadrant protrusions.

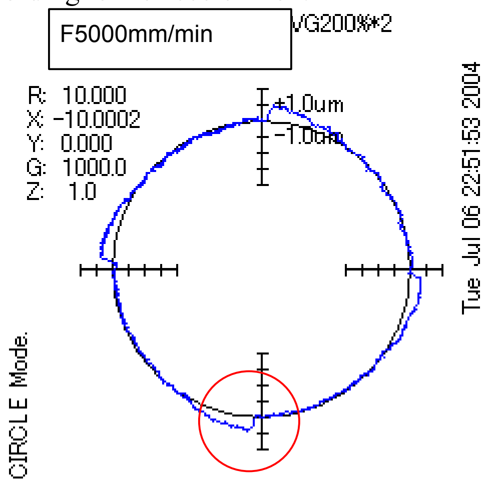
(c)-3 Override function

The two figures shown below indicate the difference by feedrate. In this example, the same acceleration amount (parameter No. 2048 is set to 100) is used, but the results are completely reversed. This example shows that a low feedrate requires a small backlash acceleration amount and that a high feedrate requires a large acceleration amount. This means that the backlash acceleration amount must be changed according to the feedrate.

An actually optimum acceleration amount is almost proportional to the acceleration. Therefore, an override function is required to change the acceleration amount according to the acceleration.



For F500 mm/min, 100 set in parameter No. 2048 is too large.



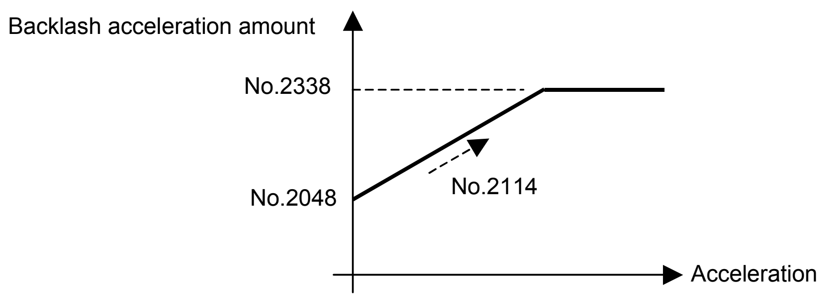
For F5000 mm/min, 100 set in parameter No. 2048 is too small.

* In this chapter, PG is assumed to be 50, and VG is assumed to be 400%.

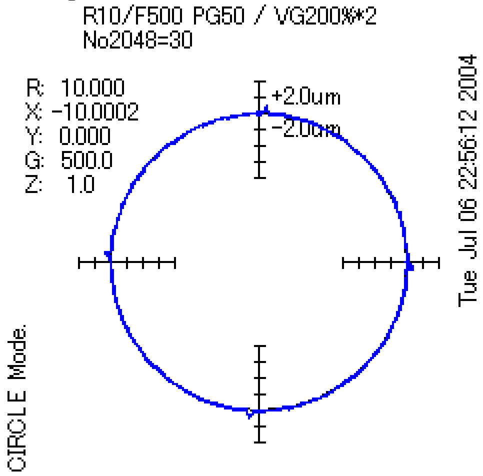
The override function has two parameters. Parameter No. 2114 specifies an override coefficient, and parameter No. 2338 specifies a limit. These parameters may be adjusted easily if steps (1) through (3) explained below are followed.

[Parameters for the override function]

Parameter No.		Standard value	Description
15*i*	**30*i*,16*i*,etc.**		
1860	2048	100	Backlash acceleration amount
1725	2114	0	Backlash acceleration override coefficient
2751	2338	0	acklash acceleration limit

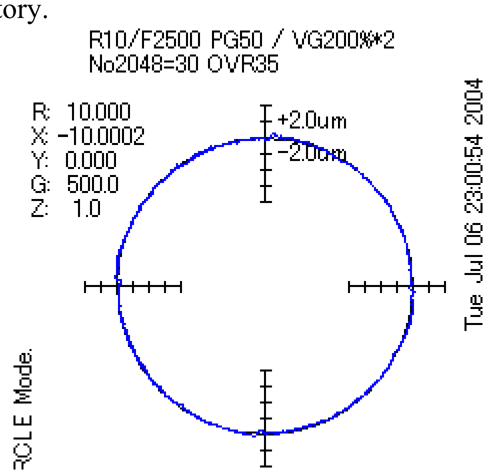


(1) Determining parameter No. 2048
To determine parameter No. 2048, an adjustment must be made at low feedrate. This example assumes a feedrate of F500 mm/min and a radius of 10 mm. Adjust an optimum value at a low feedrate, and set it in parameter No. 2048. The figure below shows the result of setting 30 in parameter No. 2048. Here, this value is set in parameter No. 2048.

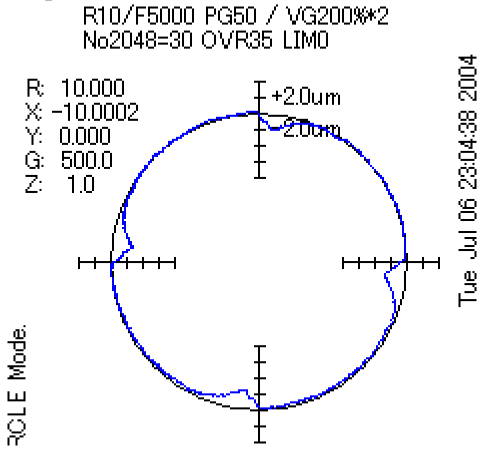


(2) Determining parameter No. 2114
Parameter No. 2114 must be set after the adjustment of parameter No. 2048. About a half of the maximum cutting feedrate is used to determine the value to be set in parameter No. 2114. In this example, F2500 mm/min is used. By increasing the value in parameter No. 2114, determine an optimum value that does not cause undercuts. Increasing the value in parameter No. 2114 increases the actual acceleration amount.

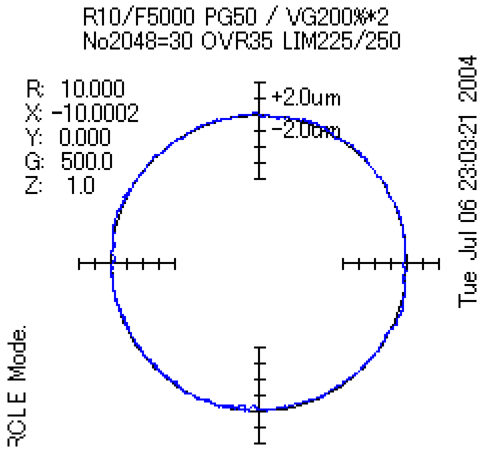
The following figure shows the result of the adjustment of parameter No. 2114. Quadrant protrusions can be suppressed satisfactory.



(3) Determining parameter No. 2338
Finally, set parameter No.2338. With an override coefficient determined using a middle feedrate, a large acceleration amount is output when the feedrate is set to a high feedrate. For this reason, the acceleration amount must be limited for high feedrate. In this example, F5000 mm/min is used.



The following shows the result of the adjustment of parameter No. 2338 at high speed. Quadrant protrusions are suppressed well.



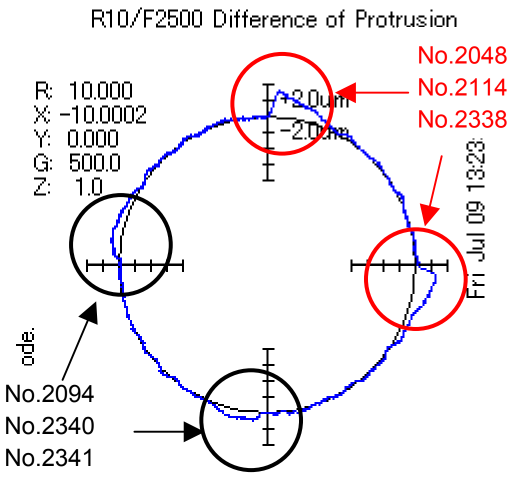
(d) Acceleration amount for each direction

There may be difference in size between the right and left quadrant protrusions or between the top and bottom quadrant protrusions. In such a case, an acceleration amount must be set separately.

If parameter No. 2094 is not 0, parameter No. 2094 is used for the left and bottom reverse points. Parameter No. 2340 is used as the override coefficient for parameter No. 2094, and parameter No. 2341 is used as the limit for parameter No. 2094.

[Parameters of acceleration amount for each direction]

Parameter No.		Standard value	Description
15*i*	30*i*,16*i*,etc.		
1860	2048	50	Backlash acceleration amount
1725	2114	0	Backlash acceleration override coefficient
2751	2338	0	Backlash acceleration limit
1987	2094	0	Backlash acceleration amount (- to +)
2753	2340	0	Backlash acceleration override coefficient (- to +)
2754	2341	0	Backlash acceleration limit (- to +)



(e) Disabling backlash acceleration after stop

The optimum acceleration amount after a long stop may slightly be different from that at the time of adjustment using an arc. This phenomenon is due to the difference in friction, backlash, and machine torsion in the stopped state. The figure given below shows the bad effect of backlash acceleration, where a 3-µm overshoot is generated at the time of 10-µm step movement. As a solution to this problem, the following servo software can disable backlash acceleration after a stop:

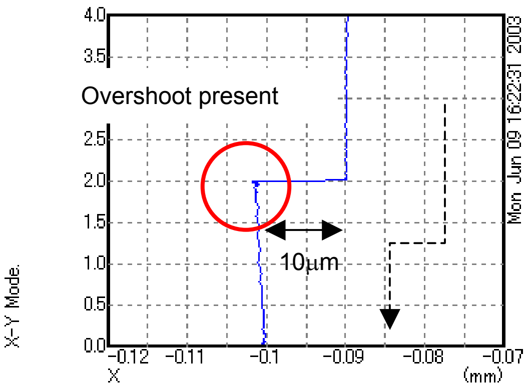
Series and editions of applicable servo software
(Series 15*i*-B,16*i*-B,18*i*-B,21*i*-B,0*i*-B,0*i* Mate-B,Power Mate *i*)
Series 90B0/W(23) and subsequent editions
Series 90B1/A(01) and subsequent editions
Series 90B6/A(01) and subsequent editions
(Series 0*i*-C,0*i* Mate-C,20*i*-B)
Series 90B5/A(01) and subsequent editions

[Parameters for the function for disabling backlash acceleration after a stop]

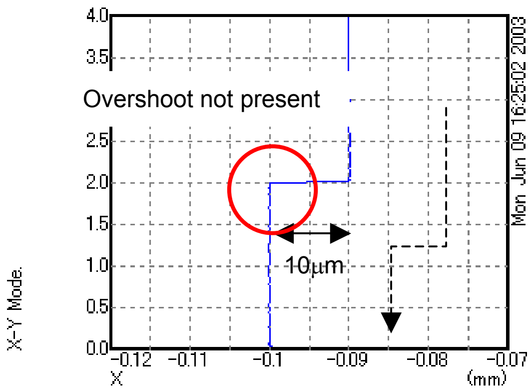
Parameter No.		Standard value	Description
15*i*	**30*i*,16*i*,etc.**		
1883#7	2005#7	1	Static friction compensation function
2696#7	2283#7	1	Function for disabling backlash acceleration after a stop
1966	2073	5	Judgment parameter for stop state (ITP)
1964	2071	0	Static friction compensation function enable time
1965	2072	0	Static friction compensation value

(*) This function uses the parameters for the static friction compensation function.

When this function is disabled



When this function is enabled



I SERVO CHECK BOARD OPERATING PROCEDURE

(1) Overview

The servo check board enables digital control values used in a digital servo section to be observed from the outside. The digital control values can be observed in either analog or digital form. Analog outputs can be observed directly with an oscilloscope, and digital outputs can be observed with a personal computer.

(2) Servo check board configuration

The following table lists the signals that can be observed with the servo check board, and the number of supported axes.

Table I (a) Servo check board specification

Name	Specification	Output interface	Number of supported axes	Number of output channels	
A	A06B-6057-H630	Analog and digital	8	4 (optional)	
B	A06B-6057-H620	Digital only	4	4 (optional)	(*)
C	A06B-6057-H602	Analog only	2	8 (fixed)	(*)

* Servo check board A (one-piece analog/digital type) is upward-compatible, that is, can be replaced, with digital check board B and analog check board C.

The method for connecting the servo check board with a CNC varies with the type of the CNC.
The method may also vary with the name of a connectable terminal.
The following table lists the ordering information for adapters and cables required to connect the check board.

Table I (b) Adapters and cables required to connect the servo check board to each CNC

CNC	Required adapters and cables	Ordering information
Series 16*i*, 18*i*, 21*i*, 0*i*	Dedicated *i*-B adapter board + dedicated *i*-B cable	A02B-0281-K822
	Straight cable	A06B-6050-K872
Series 15*i*, Power Mate *i*	Adapter board + dedicated *i* series cable	A02B-0236-K822
	Straight cable	A06B-6050-K872

NOTE
With the Series 30*i*, 31*i*, and 32*i*, the check board cannot be connected.

(3) Servo check board connection

> ⚠ **CAUTION**
> When connecting the servo check board to an NC, keep the NC power supply switched off. When the servo check board is directly connected not via an adapter board, the circuitry of both of the CNC and check board can be damaged.

(a) Connection between check board A (one-piece analog/digital type) and each CNC

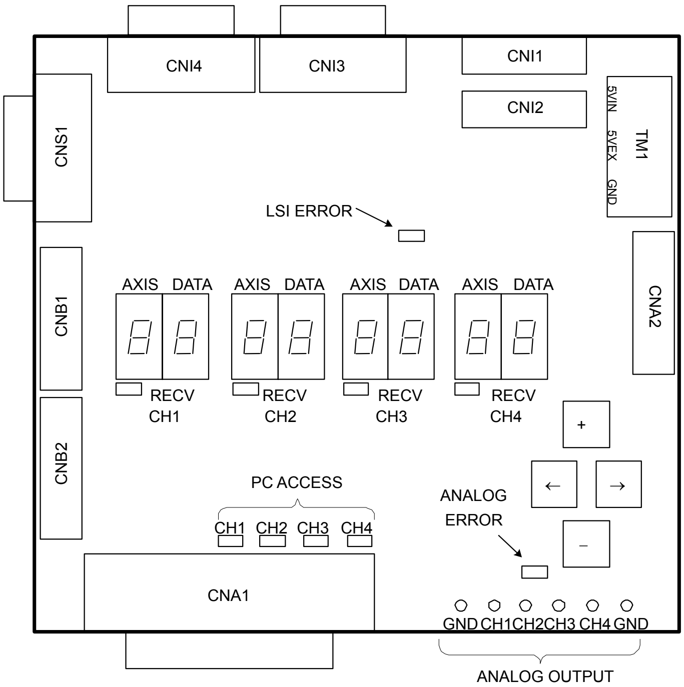
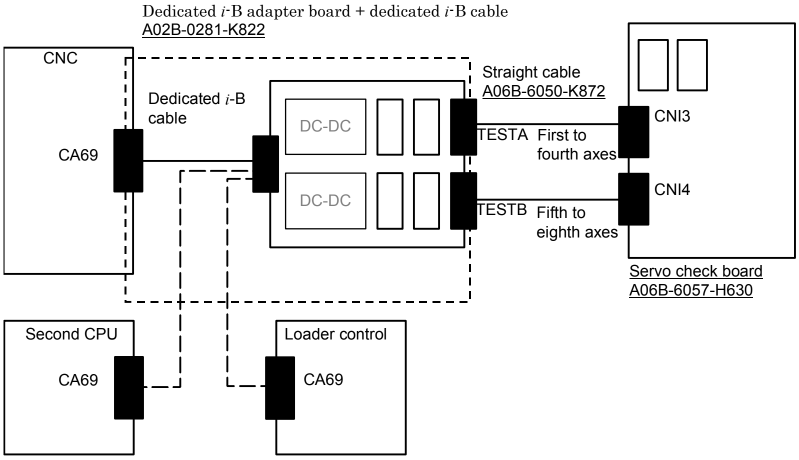


Fig. I (a) Connector layout on servo check board A (A06B-6057-H630)

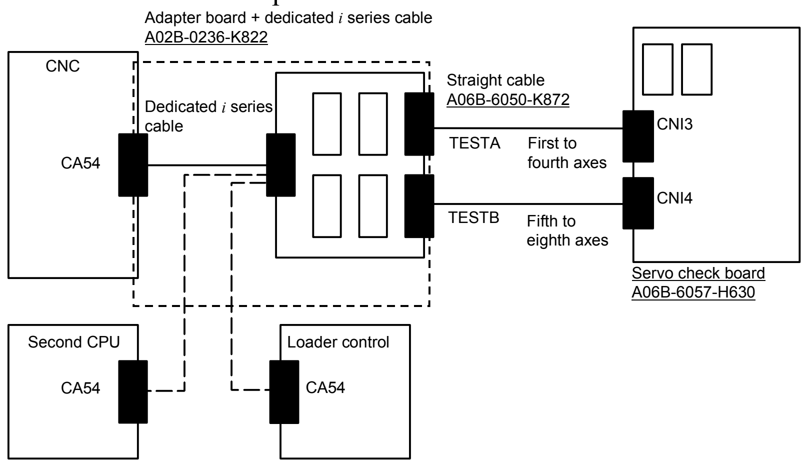
Series 16*i*, 18*i*, 21*i*, 0*i*

* A dedicated *i*-B cable is used to connect the CA69 connector of the CNC with the adapter.



Series 15*i*, Power Mate *i*

* A dedicated cable is used to connect the CA54 connector of the CNC with the adapter.



(b) Connection between servo check board B (interface board supporting automatic adjustment) and each CNC

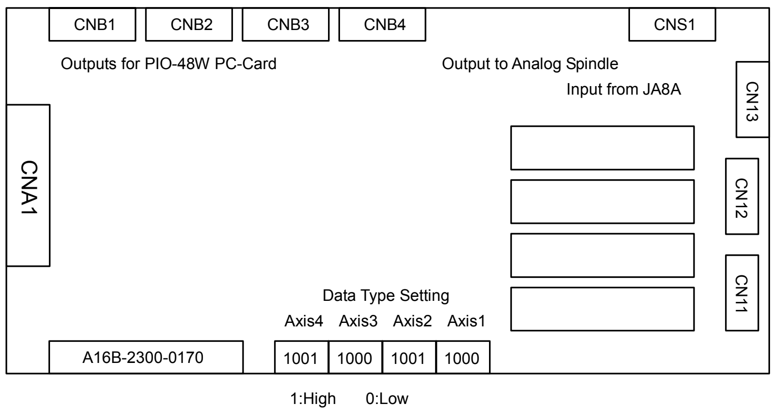
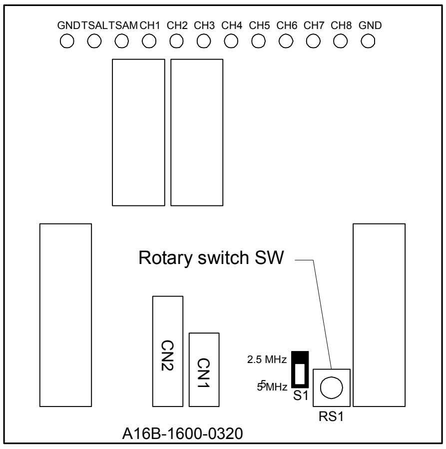


Fig. I (b) Connector layout on servo check board B (A06B-6057-H620)

* The connection method for servo check board C is the same as for servo check board A

  A straight cable is used to connect the dedicated adapter board with the check board, and TESTA or TESTB of the dedicated adapter board is connected to CBI3 on the check board. In this case, the data of axes 1 to 4 and the data of axes 5 to 8 cannot be observed at the same time.

(c) Connection between servo check board C (analog check board) and each CNC



NOTE
Install a jumper pin on the 5 MHz side at S1 (clock) on the check board.

Do not use check pins TSAL and TSAM.

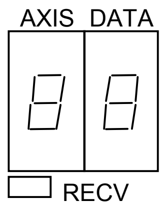
Fig. I (c) Connector layout on servo check board C (A06B-6057-H602)

* The connection method for servo check board B is the same as for servo check board A
A reverse-insertion protection cable is used to connect the dedicated adapter board with the check board, and one of TEST0 through TEST3 of the dedicated adapter board is connected to the connector CN2 on the check board.

(4) Selecting signals for observation

(a) Servo check board A (one-piece analog/digital type)
On servo check board A, a pair of two 7-segment LED digits is used to select the axis and data type for signals to be observed.
Set the AXIS digit with the axis number (1 to 8) set in parameter No. 1023.
Also set the DATA digit with the type of data to be observed (the table below).
Data is not output for an axis unless the RECV LED lights for that axis.

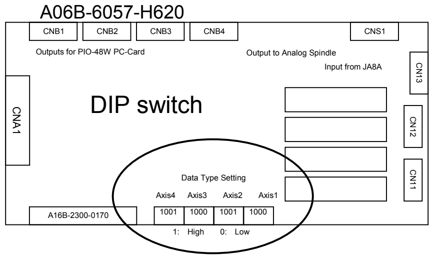
DATA	Data type
0	Velocity command (VCMD)
1	Torque command (TCMD) or estimated load torque
2	Speed (SPEED)
4	Position (POS)
5	Automatic adjustment data
6	Automatic adjustment data 2
7	Servo-spindle synchronization error (updated every 8 ms)



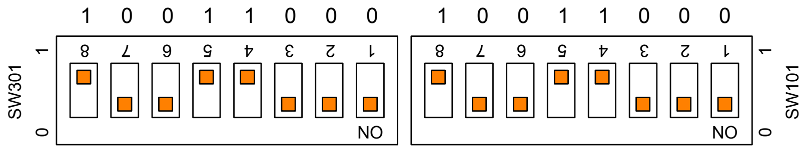
* DATA7 is output only when the CNC is the Power Mate *i*.

(b) Servo check board B (digital type)
Set the DIP switches as explained below.

Set DIP switches 1 and 0 according to the directions printed on the printed-circuit board.



Example of setting with the DIP switches on your side as shown at the right.



Data for the third and fourth axis is selected.

Data for the first and second axis is selected.

NOTE
The terms "L axis" and "M axis" refer to an axis assigned an odd number specified in parameter No. 1023 and an axis assigned an even number that follows directly that odd number, respectively.

Data type	L axis				M axis				
Velocity command (VCMD)							O		1
	O	O	O	O	O	O		O	0
Torque command/ estimated load				O			O	O	1
	O	O	O		O	O			0
Speed (SPEED)		O				O		O	1
	O		O	O	O		O		0

Data type	L axis				M axis				
Position (POS)	O				O			O	1
		O	O	O		O	O		0
Adjustment	O		O		O		O	O	1
		O		O		O			0
Adjustment 2	O	O			O	O		O	1
			O	O			O		0

(c) Servo check board C (analog type)
Output data is permanently assigned to each check pin as listed below.
The rotary switch on the printed-circuit board is kept at 0 for usual use.

* The terms "L axis" and "M axis" refer to an axis assigned an odd number specified in parameter No. 1023 and an axis assigned an even number that follows directly that odd number, respectively.

<table>
<tr><th colspan="2"></th><th colspan="8">Check pin</th></tr>
<tr><th colspan="2"></th><th>CH1</th><th>CH2</th><th>CH3</th><th>CH4</th><th>CH5</th><th>CH6</th><th>CH7</th><th>CH8</th></tr>
<tr><td rowspan="3">Rotary switch</td><td>0</td><td rowspan="3">L axis VCMD</td><td rowspan="3">L axis TCMD</td><td rowspan="3">M axis VCMD</td><td rowspan="3">M axis TCMD</td><td>L axis SPEED</td><td>M axis SPEED</td><td>-</td><td>-</td></tr>
<tr><td>1</td><td>L axis POS</td><td>M axis POS</td><td>L axis adjust-ment</td><td>M axis adjust-ment</td></tr>
<tr><td>2</td><td>L axis adjust-ment 2</td><td>M axis adjust-ment 2</td><td>-</td><td>-</td></tr>
</table>

(5) VCMD signal

When the feed-forward function is not used, the VCMD signal conveys a velocity command.
With this signal, it is possible to measure very slight vibration in the motor and its motion irregularity.
When the feed-forward function is used, the VCMD signal represents a positional deviation rather than a velocity command. So the signal can be used to measure vibration in the motor and irregularity in the feed distance of the tool driven by the motor.
The signal conversion type for the VCMD signal can be switched using parameters.
This switching is used, if the signal waveform is hard to observe because of the VCMD signal being reciprocating within ±5 V.

	#7	#6	#5	#4	#3	#2	#1	#0
No. 1956 (FS15*i*) No. 2012 (FS16*i*)			VCM2	VCM1				

Parameters for rotary motor

VCM2	VCM1	Specified rotation speed/5 V
0	0	0.9155 min^{-1}
0	1	14 min^{-1}
1	0	234 min^{-1}
1	1	3750 min^{-1}

Parameters for linear motor **(Incremental type : P=signal pitch[μm])**
(Absolute type : P= resolution [μm] × 512)

VCM2	VCM1	Specified velocity/5 V
0	0	0.00375 × P m/min
0	1	0.006 × P m/min
1	0	0.96 × P m/min
1	1	15.36 × P m/min

Using an oscilloscope to see the movement of the entire signal in DC mode, then its magnified image in AC mode enables you to check very slight vibration in the motor and its motion irregularity.

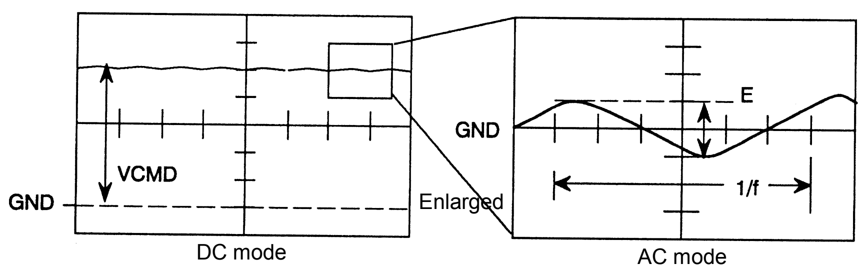


Fig. I (d) Waveform of the VCMD signal

The following table lists the number of positional deviation pulses for a VCMD voltage of 5 V.

Table I (c) Number of positional deviation pulses for a VCMD voltage of 5 V for semi-closed loop

VCM2	VCM1	Number of positional deviation pulses for a VCMD voltage of 5 V
0	0	15,258 × FFG/Kp
0	1	244,133 × FFG/Kp
1	0	3,906,133 × FFG/Kp
1	1	62,498,133 × FFG/Kp

Kp: Position gain (s^{-1})
FFG: Flexible feed gear (numerator/denominator)

Table I (d) Number of positional deviation pulses for a VCMD voltage of 5 V for full-closed loop

VCM2	VCM1	Number of positional deviation pulses for a VCMD voltage of 5 V
0	0	0.0153 × (number of positional feedback occurrences per motor revolution)/Kp
0	1	0.2441 × (number of positional feedback occurrences per motor revolution)/Kp
1	0	3.96061 × (number of positional feedback occurrences per motor revolution)/Kp
1	1	62.5 × (number of positional feedback occurrences per motor revolution)/Kp

Kp: Position gain (s^{-1})

Table I (e) Number of positional deviation pulses for a VCMD voltage of 5 V when a linear motor is in use

VCM2	VCM1	Number of positional deviation pulses for a VCMD voltage of 5 V
0	0	32,000×FFG/Kp
0	1	512,000×FFG/Kp
1	0	8,192,000×FFG/Kp
1	1	131,072,000×FFG/Kp

Kp: Position gain (s^{-1})
FFG: Flexible feed gear (numerator/denominator)
(Example)

Assume the following conditions:
Position gain = 30 (s^{-1}), semi-closed loop, detection unit of 1 μm/pulse, flexible feed gear = 1/100,
VCM2 = 0, VCM1 = 1 (VCMD waveform signal calculation parameters)
If a waveform with E = 0.3 V and I/f = 20 ms is observed:

Number of positional deviation pulses for a VCMD voltage of 5 V = 244133/100/30 = 81 pulses

Table vibration = 81 × 0.3/5 = 4.88 μm
Vibration frequency = 50 Hz

(6) TCMD signal

The TCMD signal conveys a torque command for the motor.
When a motor is running at high speed, its actual currents (IR and IS) may differ from the rating because of back electromotive force.
The output voltage of the signal becomes 4.44 V at maximum current. A higher signal voltage may be observed in a motor in which the actual current limit function is enabled, however.

Table I (f) TCMD waveform conversion

Maximum current	Ap/V	Applicable servo motor
4Ap	0.9	β*i*S0.2/5000, β*i*S0.3/5000
10Ap	2.3	α*i*S2/5000HV, α*i*S2/6000HV, α*i*S4/5000HV, β*i*S2/4000HV, β*i*S4/4000HV, β*i*S8/3000HV
20Ap	4.5	α*i*S2/5000, α*i*S2/6000, α*i*S4/5000, α*i*F1/5000, α*i*F2/5000, α*i*F4/4000HV, α*i*F8/3000HV, αC4/3000*i*, αC8/2000*i*, αC12/2000*i*, β*i*S0.4/5000, β*i*S0.5/5000, β*i*S0.5/6000, β*i*S1/5000, β*i*S1/6000, β*i*S2/4000, β*i*S4/4000, β*i*S8/3000, β*i*S12/3000HV, β*i*S22/2000HV, L*i*S300A1/4, L*i*S1500B1/4(400V)
40Ap	9	α*i*F4/4000, α*i*F8/3000, α*i*S8/4000HV, α*i*S8/6000HV, α*i*S12/4000HV, α*i*F12/3000HV, α*i*F22/3000HV, αC22/2000*i*, β*i*S2/4000(40A-driven), β*i*S4/4000(40A-driven), β*i*S8/3000(40A-driven), β*i*S12/3000, β*i*S22/2000, L*i*S600A1/4, L*i*S900A1/4, L*i*S1500B1/4, L*i*S3000B2/2 , L*i*S4500B2/2HV
80Ap	18	α*i*S8/4000, α*i*S8/6000, α*i*S12/4000, α*i*F12/3000, α*i*F22/3000, α*i*S22/4000HV, α*i*S30/4000HV, α*i*S40/4000HV, αC30/1500*i*, L*i*S3000B2/4, L*i*S4500B2/2, L*i*S6000B2/2, L*i*S6000B2/2HV, L*i*S7500B2/2HV, L*i*S3300C1/2, L*i*S11000C2/2HV
160Ap	36	α*i*S22/4000, α*i*S30/4000, α*i*S40/4000, α*i*F30/3000, α*i*F40/3000, α*i*F40/3000 FAN, L*i*S6000B2/4, L*i*S7500B2/2, L*i*S9000B2/2, L*i*S9000C2/2, L*i*S11000C2/2, L*i*S10000C3/2
180Ap	41	α*i*S50/3000HV, α*i*S50/3000HV FAN, α*i*S100/2500HV, α*i*S200/2500HV, L*i*S7500B2/2(400V), L*i*S9000B2/2(400V), L*i*S9000C2/2(400V), L*i*S11000C2/2(400V), L*i*S15000C2/3HV, L*i*S10000C3/2(400V)
360Ap	82	α*i*S50/3000, α*i*S50/3000FAN, α*i*S100/2500, α*i*S200/2500, α*i*S300/2000, α*i*S500/2000, α*i*S300/2000HV, α*i*S500/2000HV, α*i*S1000/2000HV, L*i*S7500B2/4, L*i*S9000B2/4, L*i*S15000C2/2, L*i*S15000C2/3, L*i*S17000C3/2
1440Ap	328	α*i*S2000/2000HV

* Effective current (RMS) = TCMD signal output (Ap) × 0.71

(7) SPEED signal

The SPEED signal conveys the rotation speed of the motor.

Signal conversion	3750 min^{-1}/5 V

Linear motor (Incremental : P= signal pitch[μm])
(Absolute : P= resolution [μm] × 512)

Signal conversion	15.36 × P (m/min)/5 V

When the SPEED signal is latched at 5 V, check whether the following parameter is set with a value.

No. 1726 (FS15*i*)	Must be kept at 0.
No. 2115 (FS16*i*)	

* Setting this parameter with a value other than 0 disables the SPEED signal output.

(8) Changing the check board output magnification for the TCMD and SPEED signals

Conventionally, the measured waveforms of the TCMD signal (torque command) and SPEED signal (actual feedrate) were folded at 5 V in some cases and difficult to read if the torque command value is large or the actual feedrate exceeds 3750 min^{-1}, because the ranges of these signals were fixed when output to the check board. An improvement was made so that the output ranges of measured waveforms can be changed according to parameter settings.

Series and editions of applicable servo software
- Series 90B0/N(14) and subsequent editions
- Series 90B1/A(01) and subsequent editions
- Series 90B6/A(01) and subsequent editions
- Series 90B5/A(01) and subsequent editions

	#7	#6	#5	#4	#3	#2	#1	#0
No. 2613 (FS15*i*)						TSA05	TCMD05	
No. 2225 (FS16*i*)								

TCMD05(#1) The voltage of the TCMD signal output to the check board is:
0 : Unchanged (default)
1 : Halved
* The actual output voltage is affected by the following function bit (TCMD4X).

TSA05(#2) The voltage of the SPEED signal output to the check board is:
0 : Unchanged (3750 min^{-1}/5 V) (default)
1 : Halved (7500 min^{-1}/5 V)

Conventionally, there has been the following function bit (TCMD4X) for multiplying the output voltage weight of TCMD by 4. This bit can be used along with the newly added function bit (TCMD05).

	#7	#6	#5	#4	#3	#2	#1	#0
No. 1743 (FS15*i*)			TCMD4X					
No. 2203 (FS16*i*)								

TCMD4X(#5) The voltage of the TCMD signal output to the check board is:
0 : Unchanged (default)
1 : Multiplied by 4

Using these function bits changes the output ranges of the TCMD and SPEED signals as listed in Table I (g) and Table I (h).

- TCMD signal output range

Table I (g) TCMD signal conversion (improved)

TCMD4X	TCMD05	TCMD value/4.4 V	Remark
0	1	Amplifier maximum current × 2 (A)	
0	0	Amplifier maximum current (A)	Conventional mode
1	1	Amplifier maximum current/2 (A)	
1	0	Amplifier maximum current/4 (A)	× 4 mode

Example:

Relationships between the output voltage and TCMD value [A] when an 80-A amplifier is used

TCMD4X	TCMD05	TCMD value/4.4 V
0	1	160 [A]
0	0	80 [A]
1	1	40 [A]
1	0	20 [A]

- SPEED signal output range

Table I (h) SPEED signal conversion (improved)

TSA05	Actual feedrate per 5 V Rotary motor	Actual feedrate per 5 V Linear motor	Remark
0	3750 [min^{-1}]	15.36 × P [min^{-1}]	Conventional mode
1	7500 [min^{-1}]	30.72 × P [min^{-1}]	

* Letter P in the linear motor column has a different meaning depending on the type of the scale.

- When the FANUC high-resolution serial conversion circuit is used
  (Incremental scale) → $\boxed{\text{P = signal pitch[μm]}}$

- When a scale that matches the FANUC serial interface is used.
  (Absolute scale) → $\boxed{\text{P = resolution [μm] × 512}}$

(9) Acquiring signals using a personal computer

Servo check boards A and B, listed in Table I (a), have a digital output interface. Using the servo adjustment software (SD) enables them to collect servo data such as position and speed through the interface into a personal computer.

(a) Connection between a servo check board and a personal computer (IBM PC/AT compatible)
Connect servo check board connector CNA1 to the printer port of a personal computer. The printer port must support bidirectional communication mode. (Measurement is impossible in ECP mode.)
Windows® does not support the servo adjustment software (SD). Use it in full-screen mode or MS-DOS mode.

(b) Basic operating instructions

<1> Enter "SD INIT" at a DOS prompt. The software starts with all its states initialized, and its main screen appears (if the name of the software's executable file is "SD.EXE").
The main screen lets you measure and view data.
Entering "CTRL + letter" switches the drawing mode. Select a drawing mode suitable for the data to be observed. (Pressing the ? key displays a list of the available drawing modes.)
Drawing mode examples:
CTRL + X: XY mode (XY display)
CTRL + T: XTYT mode (time axis display)

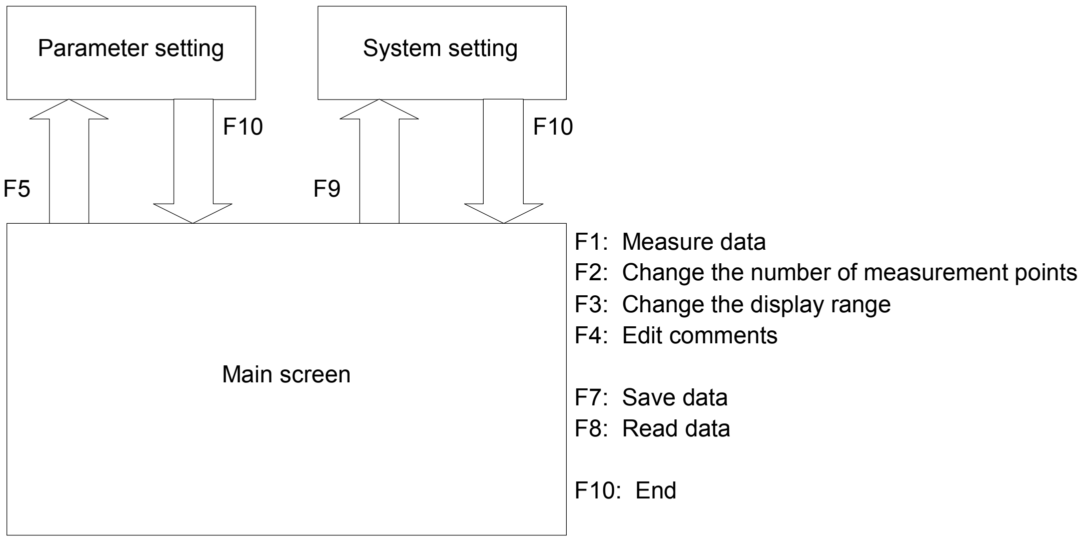


Fig. I (e) Servo adjustment software basic configuration and key manipulation

<2> To change the type of data to be measured and the unit of conversion for it, press the F9 key on the main screen to display the system setting screen.

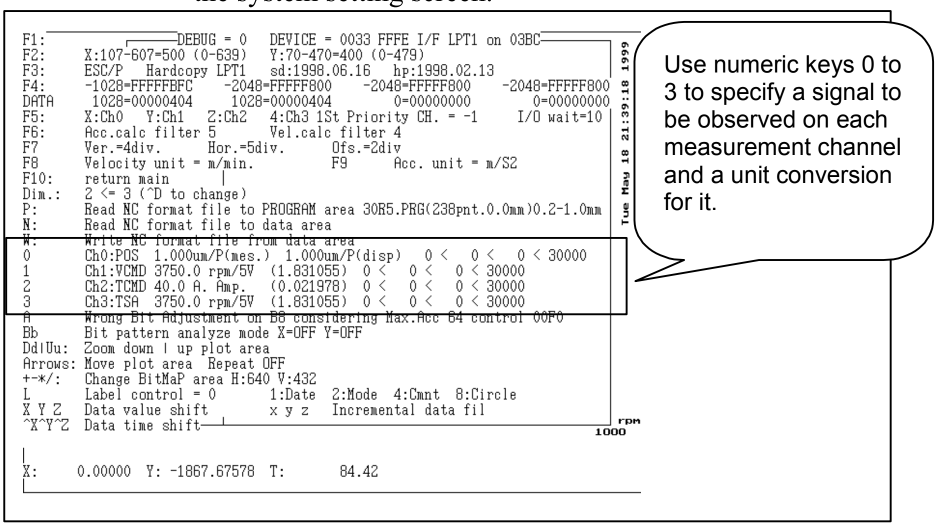


Fig. I (f) System setting screen

Data output on CH1 to CH4 of the check board corresponds to channels 0 to 3 on the SD software. To change the setting, press numeric key 0 to 3. Select a data type (0: position, 1: velocity command, 2: torque command, 3: rotation speed) from the display at the bottom of the screen, then specify the unit of conversion for the data.
Conversion values (except for position data) can be set up according to descriptions in (5) to (8).

Table I (i) Meaning of measurement data conversion values and example setting

Type	Display at the bottom of the screen	Meaning of conversion values	Example	Input value
POS	1 pulse = X?	Detection unit (in mm units)	1 μm	0.001
VCMD	5 V = X min^{-1}?	What min^{-1} corresponds to VCMD of 5 V?	VCM2 = 1 VCM1 = 1	3750 (Note)
TCMD	X Ap. Amp.?	Maximum amplifier current (A)	40 A	40
SPEED (number of revolutions)	5 V = X min^{-1}?	What min^{-1} corresponds to SPEED of 5 V?	-	Constantly 3750 (rotary motor)

NOTE
To observe the VCMD signal as the number of positional deviation pulses, input conversion values listed in Tables I (c) to (e).

To exit the system setting screen, press the F10 key.

<3> To specify measurement intervals, press the F5 key to display the parameter setting screen.
Pressing numeric keys 1, 2, 5, and 0 can change the setting. Usually select 1 ms.

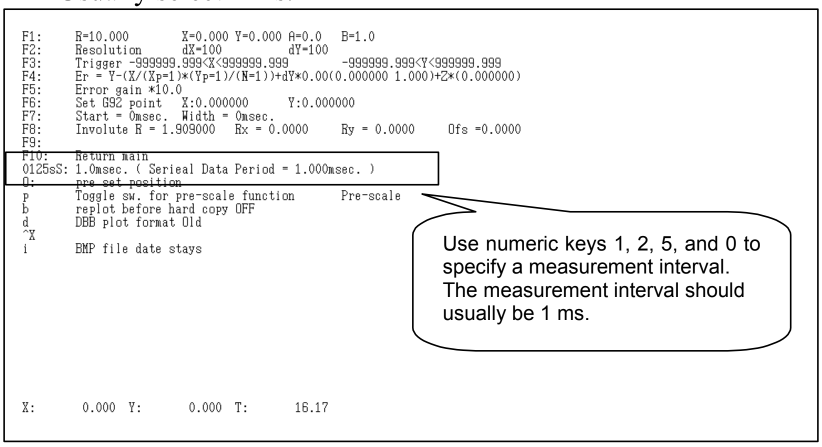


Fig. I (g) Parameter setting screen

To return to the main screen after parameter setting, press the F10 key.

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Revision Record

FANUC AC SERVO MOTOR α*i*/β*i* series, LINEAR MOTOR L*i*S series, SYNCHRONOUS BUILT-IN SERVO MOTOR D*i*S series PARAMETER MANUAL (B-65270EN)

Edition	Date	Contents	Edition	Date	Contents
05	May., 2005	• Applied to Series30*i*/31*i*/32*i* • Addition of HRV4 control • Total revision of chapter of Parameter Adjustment • Addition of functions added after issue of Edition 04 • Correction of errors			
04	Oct., 2003	• Addition of the SERVO MOTOR β*i*s series • Addition of functions added after issue of Edition 03 • Correction of errors			
03	Mar., 2003	• Addition of the SERVO MOTOR α*i*s series • Addition of item for SERVO GUIDE(Ver 2.00) • Addition of functions added after issue of Edition 02 • Correction of errors			
02	Sep., 2002	• Addition of the parameter tables for αHV*i* • Addition of item for SERVO GUIDE • Addition of functions added after issue of Edition 01 • Correction of errors			
01	May, 2001	———	06	Feb., 2006	• Model name change • Addition of the D*i*S series motor • Addition of functions added after issue of Edition 05 • Correction of errors