YASKAWA

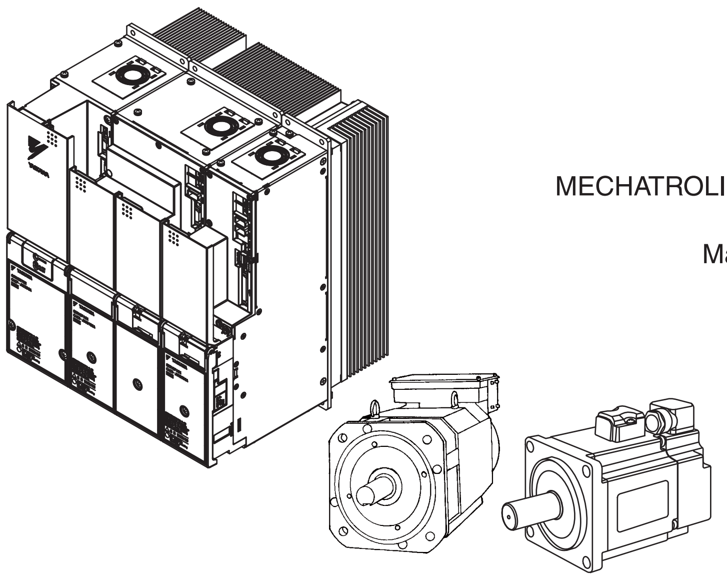
AC Servo Drives

Σ-V-SD Series

USER'S MANUAL

For Application Development in Servo Systems

UAK□J-□□C□□ Spindle motor
SGMGV-□□□8□□□ Servomotor
CACP-JU□□□3□ Power regeneration converter
CACR-JU□□□□2□ SERVOPACK



MANUAL NO. SIEP S800000 87B

About this Manual

This manual contains information that is required to design servo system applications.

Keep this manual in a location where it can be accessed for reference whenever required.

The following four manuals are also required in addition to this manual to design servo system applications.

- MECHATROLINK-III Communication ASIC JL-100/JL-101 Hardware User's Manual (Manual No.: MMA TDEP 019A)
- MECHATROLINK-III Protocol User's Manual (Manual No.: MMA TDEP 020A)
- MECHATROLINK-III Command Specifications for Standard Servo Profile (Manual No.: MMA TDEP 021A)
- MECHATROLINK-III Communication ASIC JL-100/JL-101 (C1 Master) Access Driver (Manual No.: MMA TDEP 024A)

The above four manuals are available from the MECHATROLINK Members Association.
To obtain these manuals, register as a member of the MECHATROLINK Members Society on the following website.
URL: http://www.mechatrolink.org/

Also refer to the manuals that are listed on the following page for additional information as required.

■ Description of Technical Terms

The following table gives the meanings of terms that are used in this manual.

Term	Meaning
Spindle Motor	Σ-V-SD Series UAKAJ and UAKBJ motor
Servomotor	Σ-V-SD Series SGMGV servomotor
Power Regeneration Converter	Σ-V-SD Series CACP-JU converter
SERVOPACK	Σ-V-SD Series CACR-JU servo amplifier
SERVOPACK for One Axis	A SERVOPACK that can control one motor
SERVOPACK for Two Axes	A SERVOPACK that can control two motors
Σ-V-SD Driver	A power regeneration converter and a SERVOPACK
Servo Drive	A set including a servomotor (or a spindle motor) and a Σ-V-SD driver
Servo System	A complete system that consists of a servo drive, a host controller, and peripheral devices
Servo ON	The power to the motor ON
Servo OFF	The power to the motor OFF
Base Block (BB)	The power supply to motor is turned OFF by shutting off the base current to the power transistor in the current amplifier.
Servo Lock	A state in which the motor is stopped and is in position loop with a position reference of 0.
DC-bus Voltage	The main circuit DC voltage (between P and N terminals) in a power regeneration converter and a SERVOPACK

■ Important Information

The following icon is used to indicate information that requires special attention.

IMPORTANT

- Indicates important information that must be memorized, as well as precautions, such as alarm displays, that do not involve potential damage to equipment.

■ Notation Used in this Manual

• Notation for Reverse Signals

The names of reverse signals (ones that are valid when low) are written with a forward slash (/) before the signal name.

Notation Example

$\overline{\text{BK}}$ is written as /BK.

• Notation for Parameters

The notation depends on whether the parameter requires a value setting (parameter for numeric settings) or requires the selection of a function (parameter for selecting functions).

•Parameters for Numeric Settings

These are the control methods to which the parameter applies.
[Speed] : Speed control [Position] : Position control [Torque] : Torque control

Pn406	Emergency Stop Torque		Speed Position Torque		
	Setting Range	Setting Unit	Factory Setting	When Enabled	Classification
	0 to 800%	1%	800%	Immediately	Setup

Parameter number

This is the setting range for the parameter.

This is the minimum unit (set value increment) that you can set for the parameter.

This is the default setting of the parameter.

This is when any changes made to the parameter become effective.

This is the parameter classification.

•Parameters for Selecting Functions

Parameter		Meaning	When Enabled	Classification
Pn002	n.□0□□ [Factory Setting]	The absolute encoder is used as an absolute encoder.	After restart	Setup
	n.□1□□	The absolute encoder is used as an incremental encoder.		

Parameter number

The notation "n.□□□□" indicates a parameter for selecting a function.
Each □ indicates the set value for the corresponding digit.
The notation in this example means that the third digit is set to a value of 1.

This section explains of selected function.

■ Manuals Related to the Σ-V-SD Series

Refer to the following manuals as required for your application.

Manual Name	Selecting Models and Peripheral Devices	Studying Specifications and Ratings	Designing the System	Performing Panel Installation and Wiring	Performing Trial Operation	Performing Trial Operation and Servo Adjustment	Performing Maintenance and Inspections
Σ-V-SD Series Safety Precautions (TOMP C710829 04)	✓			✓			✓
AC Servomotor Safety Precautions (TOBP C2300200 00)				✓			✓
Σ-V-SD Series User's Manual (SIEP S800000 78)	✓	✓			✓	✓	✓
Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands (SIEP S800000 76)			✓				

■ Precautions

This manual contains generic information. Some of it may not apply to your individual application requirements. When you design a host controller, use this manual to help you design the software and construct the CNC system.
Yaskawa is not responsible for any unexpected operations, malfunctions, damages, or losses of opportunity related to the customer's system (including equipment, workpieces, tools, etc.) resulting from the contents of this manual.
The customer must perform all required functional and quality checks for any system that is designed based on the contents of this manual.

■ Safety Information

The following conventions are used to indicate safety precautions in this manual. Information marked as shown below is important for safety. Always read this information and heed the precautions that are provided.

WARNING	Indicates precautions that, if not heeded, could possibly result in loss of life or serious injury.
CAUTION	Indicates precautions that, if not heeded, could result in relatively serious or minor injury, or property damage. In some situations, the precautions indicated could have serious consequences if not heeded.
PROHIBITED	Indicates prohibited actions that must not be performed. For example, this symbol would be used to indicate that fire is prohibited:
MANDATORY	Indicates compulsory actions that must be performed. For example, this symbol would be used to indicate that grounding is compulsory:

Safety Precautions

The following precautions are for storage, transportation, installation, wiring, operation, maintenance, inspections, and disposal. These precautions are important and must be observed.

⚠ WARNING

- Never touch any rotating parts of the motor while the motor is running.
  There is a risk of injury.
- Before starting operation with a machine connected, make sure that an emergency stop can be applied at any time.
  There is a risk of injury or equipment damage.
- Never touch the inside of the power regeneration converter or the inside of the SERVOPACK.
  There is a risk of electric shock.
- Always keep the power supply terminal cover attached while power is being supplied.
  There is a risk of electric shock.
- Do not touch terminals before the main-circuit capacitor has had time to discharge after the power supply has been turned OFF. A high voltage may still remain in the power regeneration converter and SERVOPACK.
  There is a risk of electric shock due to the residual voltage.
- Do not touch any terminals while the CHARGE indicator is lit.
  There is a risk of electric shock due to the residual voltage.
- Do not touch terminals before the main-circuit capacitor has had time to discharge after a withstand voltage test.
  There is a risk of electric shock due to the residual voltage.
- Perform trial operation according to the procedures and instructions in the user's manuals for the products.
  Operating mistakes while the motor and machine are connected may damage the machine or even cause accidents resulting in injury or death.
- The output range of multi-turn data in the absolute detection system of the Σ-V-SD driver is different from that for conventional systems (15-bit encoder or 12-bit encoder). In particular, if you set up a Σ-series infinite length positioning system with a Σ-V-SD-series, be sure to make the system modification.
- The multi-turn limit value must be changed only for special applications.
  Changing it inappropriately or unintentionally can be dangerous.
- If the Multi-turn Limit Disagreement alarm occurs, check the setting of the Pn205 parameter in the SERVOPACK and make sure that it is correct.
  If the multi-turn limit value setting is implemented while an incorrect value is set in Pn205, an incorrect value will be set in the encoder. The alarm will disappear even if an incorrect value is set, but incorrect positions will be detected, resulting in a dangerous situation where the machine will move to unexpected positions.
- Do not remove the top front cover, cables, connector, or options while power is being supplied.
  There is a risk of electric shock.
- Do not damage, pull on, apply excessive force to, place heavy objects on, or pinch the cables.
  There is a risk of electric shock, operational failure, or fire.
- Do not attempt to modify the products in any way.
  There is a risk of injury, equipment damage, or fire.
- Provide an appropriate stopping device on the machine itself to ensure safety.
  The holding brake on a motor with a brake is not a sufficient stopping device to ensure safety.
  There is a risk of injury.
- Do not approach the machine after a momentary interruption to the power supply. When power is restored, operation may restart suddenly. Provide safety measures in advance to ensure human safety when operation restarts.
  There is a risk of injury.

⚠ WARNING

- Always connect the power regeneration converter and SERVOPACK ground terminals ⏚ to grounding poles. (Connect to 100 Ω or less ground resistance for a power regeneration converter or SERVOPACK with a 200-V input power supply, or to 10 Ω or less ground resistance for a power regeneration converter or SERVOPACK with a 400-V input power supply.)
  There is a risk of electric shock or fire.
- Do not allow installation, disassembly, or repairs to be performed by anyone other than specified personnel.
  There is a risk of electric shock or injury.
- System that use Hard Wire Base Block function must be designed according to the contents of this manual and only by engineers that have full knowledge of the related safety standards.
  There is a risk of injury or equipment damage

■ Storage and Transportation

⚠ CAUTION

- Do not store or install the products in any of the following locations.
  There is a risk of fire, electric shock, or equipment damage.
  - Locations that are subject to direct sunlight
  - Locations that are subject to temperatures that exceed the specified storage or installation temperature conditions
  - Locations that are subject to humidity that exceeds the specified storage or installation conditions
  - Locations that are subject to condensation as the result of rapid changes in temperature
  - Locations that are subject to corrosive or flammable gases
  - Locations that are subject to excessive dust, dirt, salt, or metallic powder
  - Locations that are subject to water, oil, or chemicals
  - Locations that are subject to shock or vibration
- Do not hold a motor by the cable, motor shaft, or encoder while moving it.
  There is a risk of injury or malfunction.
- Do not hold the power regeneration converter or SERVOPACK by the front cover or terminal cover while moving it.
  This may cause the cover to break and the power regeneration converter or SERVOPACK to fall to the ground.
- Do not place any load on a packing box that exceeds the limit that is specified on the box.
  There is a risk of injury or malfunction.
- If disinfectants or insecticides must be used to treat packing materials such as wooden frames, pallets, or plywood, the packing materials must be treated before the product is packaged, and methods other than fumigation must be used.
  Example of proper treatment: Heat treatment, where materials are kiln-dried to a core temperature of 56°C for 30 minutes or longer.
  If the electronic products, which include stand-alone products and products installed in machines, are packed with fumigated wooden materials, the electric components may be greatly damaged by the gases or fumes resulting from the fumigation process.
  In particular, disinfectants containing halogen, which includes chlorine, fluorine, bromine, or iodine, can contribute to the erosion of the capacitors.

■ Installation

⚠ CAUTION

- Never use the products in locations that are subject to water, corrosive atmospheres, or flammable gas, or near combustible objects.
  There is a risk of electric shock or fire.
- Do not step on the products or place heavy objects on the products.
  There is a risk of injury or malfunction.
- Do not cover the inlet or outlet ports. Do not allow foreign objects to enter the products.
  There is a risk of internal element deterioration, malfunction, or fire.
- Always mount the products in the specified orientations.
  Otherwise, failures may occur.
- Provide the specified clearances between the power regeneration converter and the inside surfaces of the control panel and between the SERVOPACK and the inside surfaces of the control panel, and keep both the converter and the SERVOPACK sufficiently separated from all other devices.
  There is a risk of fire or malfunction of the power regeneration converter or SERVOPACK.
- Do not subject the products to strong impacts.
  Otherwise, failures may occur.

■ Wiring

⚠ CAUTION

- Check the wiring to confirm that it has been performed correctly.
  There is a risk of motor runaway, injury, or malfunction.
- Do not bundle the main circuit and the I/O signal cables/encoder cables together or run them through the same duct. Keep the main circuit cable and I/O signal cables at least 30 cm away from each other.
  Malfunction may result if these cables are too close to each other.
- The maximum wiring length is 3 m for I/O signal cables, 20 m for motor main circuit cables or encoder cables, and 10 m for control power supply cables (+24 V, 0 V).
- Provide sufficient shielding when using the products in the following locations.
  - Locations that are subject to noise, such as from static electricity
  - Locations that are subject to strong electromagnetic or magnetic fields
  - Locations that are subject to radiation
  - Locations that are near power lines

  There is a risk of equipment damage.
- Wiring and inspections must be performed by qualified engineers only.
- Do not connect a commercial power supply to the U, V, or W motor connection terminals.
  There is a risk of injury or fire.
- Firmly connect the power supply terminals and motor connection terminals.
  There is a risk of fire.
- Do not touch terminals before the main-circuit capacitor has had time to discharge after the power supply has been turned OFF. A high voltage may still remain in the power regeneration converter and SERVOPACK.
  First make sure that the CHARGE indicator is not lit and that the DC bus voltage (between P and N) is correct by using a tester or other device before performing wiring or starting inspections.
- Observe the following precautions when wiring the main circuit terminal block.
  - Do not turn ON the power supply to the servo drive until all wiring, including the main circuit terminals, has been completed.
  - If the main circuit terminals have a connector, remove the connector from the SERVOPACK before you perform wiring.
  - Only insert one wire into each wire insertion slot on the terminal block or connector.
  - When inserting wires, be sure not to short-circuit the exposed portion of the core wire on adjacent wires.
- Always use the specified power supply voltage.
  There is a risk of fire or malfunction of the power regeneration converter or SERVOPACK.
- Make sure that the polarity is correct (P (+), N (-)).
  Incorrect polarity may cause rupture or damage.
- In places with poor power supply conditions, take all steps necessary to ensure that the input power is supplied within the specified voltage range.
  There is a risk of equipment damage.
- Install breakers and other safety measures to provide protection against shorts in external wiring.
  There is a risk of fire.
- Use a 24-VDC control power supply with double insulation or reinforced insulation. Make sure that the output holding time is 100 ms or longer.
- Use shielded twisted-pair cables or shielded multicore twisted-pair cables for I/O signal and encoder cables.
- When connecting the battery, connect the polarity correctly.
  There is a risk of damaging the battery, power regeneration converter, SERVOPACK, or servomotor and a risk of explosion.
- Mount a battery into the power regeneration converter.
  It is dangerous to install batteries on the encoder cable, because there is a risk of creating a loop circuit between the batteries.

■ Operation

⚠ CAUTION

- Use only the specified combinations of motors and SERVOPACKs.
  There is a risk of fire or malfunction.
- To avoid unexpected accidents, perform trial operation with the motor only (i.e., do not connect the motor axis to the machine).
  There is a risk of injury.
- Check to make sure that the holding brake works properly during trial operation. Also check to ensure the safety of the system in response to disconnected signal lines and other problems.
- Before starting operation with a machine connected, change the settings to match the parameters of the machine.
  Machine runaway or malfunction could occur if operation is started before these settings are made.
- Do not frequently turn the power supply ON and OFF.
  The Σ-V-SD driver contains a capacitor in the power supply. When the power supply is turned ON, a large amount of charging current will flow. Therefore, if the power supply is turned OFF and ON too frequently, it can deteriorate the elements (capacitors and fuses) in the main circuits of the power regeneration converter and SERVOPACK, which in turn can lead to malfunctions.
- The forced stop function for forward and reverse overtravel is disabled when the jogging and origin search operations are executed from the SigmaWin for Σ-V-SD (MT).
- Check to make sure that the motor parameters in the SERVOPACK match those for the spindle motor if a SERVOPACK is used to drive a spindle motor.
  There is a risk of injury, fire, or equipment damage.
- If you use a servomotor with a vertical shaft, you must install a safety device to prevent the workpiece from falling when an alarm or overtravel occurs. Also make sure the drive is set to stop in the zero clamp state when overtravel occurs.
  The workpiece may fall if overtravel occurs.
- Do not touch the power regeneration converter heat sink, SERVOPACK heat sink, or motor while the power is ON or immediately after the power supply is turned OFF.
  There is a risk of burns.
- Do not make extreme adjustments or changes to settings, which could result in unstable operation.
  There is a risk of injury or equipment damage.
- When an alarm occurs, resolve the problem and confirm the safety of the machine before clearing the alarm state and resuming operation.
  There is a risk of equipment damage, fire, or injury.
- Do not use the holding brake on a servomotor for braking.
  There is a risk of malfunction.
- You cannot use the Pn001 SERVOPACK parameter to set the stopping method of the servomotor when the main circuit power supply or the control power supply is turned OFF during operation without turning OFF the servo.
- Do not establish communications with the host controller when operating the SigmaWin for Σ-V-SD (MT).
  This may cause an alarm or warning to occur, all processes to stop, and the system to stop. Communications with the host controller are allowed while running SigmaWin for Σ-V-SD (MT) only for following functions.
  Functions That Require Communications during Operation
  - Advanced autotuning by reference
  - One-parameter tuning
  - Anti-resonance control adjustment function

  Functions for Which You Can Use Communications during Operation
  - Parameter editing (excluding parameter initialization)
  - Monitoring
  - Alarm displays (excluding resetting alarms and clearing the alarm history)
  - Data tracing
- Dynamic braking is an auxiliary function for an emergency stop. Dynamic braking is not intended to stop the motor. The motor may enter a free-run state due to a malfunction. For protection, install stopping equipment to ensure safety at the machine if an error occurs.
- Do not use the servo drive under a load moment of inertia that exceeds the maximum allowable value.
  There is a risk of damage or malfunction of the resistors or power elements in the SERVOPACK.

■ Maintenance and Inspections

⚠ CAUTION

- Do not attempt to disassemble the power regeneration converter or the SERVOPACK.
  There is a risk of electric shock or injury.
- Do not attempt to change the wiring while power is being supplied.
  There is a risk of electric shock or injury.
- After you replace the SERVOPACK, restart operation only after you transfer the parameters from the old SERVOPACK to the new SERVOPACK.
  There is a risk of equipment damage.

■ Disposal Precautions

⚠ CAUTION

- Correctly discard the product as stipulated by regional, local, and municipal laws and regulations. Be sure to include these contents in all labelling and warning notifications on the final product as necessary.

■ General Precautions

Observe the following general precautions to ensure safe application.

- The products shown in illustrations in this manual are sometimes shown without covers or protective guards. Always replace the covers are protective guards as specified first, and then operate the products according to the manual.
- The drawings presented in this manual are typical examples and may not match the products that you received.
- If the manual must be ordered due to loss or damage, inform your nearest Yaskawa representative or one of the offices listed on the back of this manual.

Warranty

(1) Details of Warranty

■ Warranty Period

The warranty period for a product that was purchased (hereinafter called “delivered product”) is one year from the time of delivery to the location specified by the customer or 18 months from the time of shipment from the Yaskawa factory, whichever is sooner.

■ Warranty Scope

Yaskawa shall replace or repair a defective product free of charge if a defect attributable to Yaskawa occurs during the warranty period above.
This warranty does not cover defects caused by the delivered product reaching the end of its service life and replacement of parts that require replacement or that have a limited service life.

This warranty does not cover failures that result from any of the following causes.

1. Improper handling, abuse, or use in unsuitable conditions or in environments not described in product catalogs or manuals, or in any separately agreed-upon specifications
2. Causes not attributable to the delivered product itself
3. Modifications or repairs not performed by Yaskawa
4. Use of the delivered product in a manner in which it was not originally intended
5. Causes that were not foreseeable with the scientific and technological understanding at the time of shipment from Yaskawa
6. Events for which Yaskawa is not responsible, such as natural or human-made disasters

(2) Limitations of Liability

1. Yaskawa shall in no event be responsible for any damage or loss of opportunity to the customer that arises due to failure of a delivered product.
2. Yaskawa shall not be responsible for any programs (including parameter settings) or the results of program execution of the programs provided by the user or by a third party for use with programmable Yaskawa products.
3. The information described in product catalogs or manuals is provided for the purpose of the customer purchasing the appropriate product for the intended application. The use thereof does not guarantee that there are no infringements of intellectual property rights or other proprietary rights of Yaskawa or third parties, nor does it construe a license.
4. Yaskawa shall not be responsible for any damage arising from infringements of intellectual property rights or other proprietary rights of third parties as a result of using the information described in catalogs or manuals.

(3) Suitability for Use

1. It is the customer’s responsibility to confirm conformity with any standards, codes, or regulations that apply if the Yaskawa product is used in combination with any other products.
2. The customer must confirm that the Yaskawa product is suitable for the systems, machines, and equipment used by the customer.
3. Consult with Yaskawa to determine whether use in the following applications is acceptable. If use in the application is acceptable, use the product with extra allowance in ratings and specifications, and provide safety measures to minimize hazards in the event of failure.
   - Outdoor use, use involving potential chemical contamination or electric interference, or use in conditions or environments not described in product catalogs or manuals
   - Nuclear energy control systems, combustion systems, railroad systems, aviation systems, vehicle systems, medical equipment, amusement machines, and installations subject to separate industry or government regulations
   - Systems, machines, and equipment that may present a risk to life or property
   - Systems that require a high degree of reliability, such as systems that supply gas, water, or electricity, or systems that operate continuously 24 hours a day

• Other systems that require a similar high degree of safety

4. Never use a product for an application involving serious risk to life or property without first ensuring that the system is designed to secure the required level of safety with risk warnings and redundancy, and that the Yaskawa product is properly rated and installed.
5. The circuit examples and other application examples described in product catalogs and manuals are for reference. Check the functionality and safety of the actual devices and equipment to be used before using the product.
6. Read and understand all use prohibitions and precautions, and operate the Yaskawa product correctly to prevent accidental harm to third parties.

(4) Specifications Change

The names, specifications, appearance, and accessories of products in product catalogs and manuals may be changed at any time based on improvements and other reasons. The next editions of the revised catalogs or manuals will be published with updated code numbers. Consult with your Yaskawa representative to confirm the actual specifications before purchasing a product.

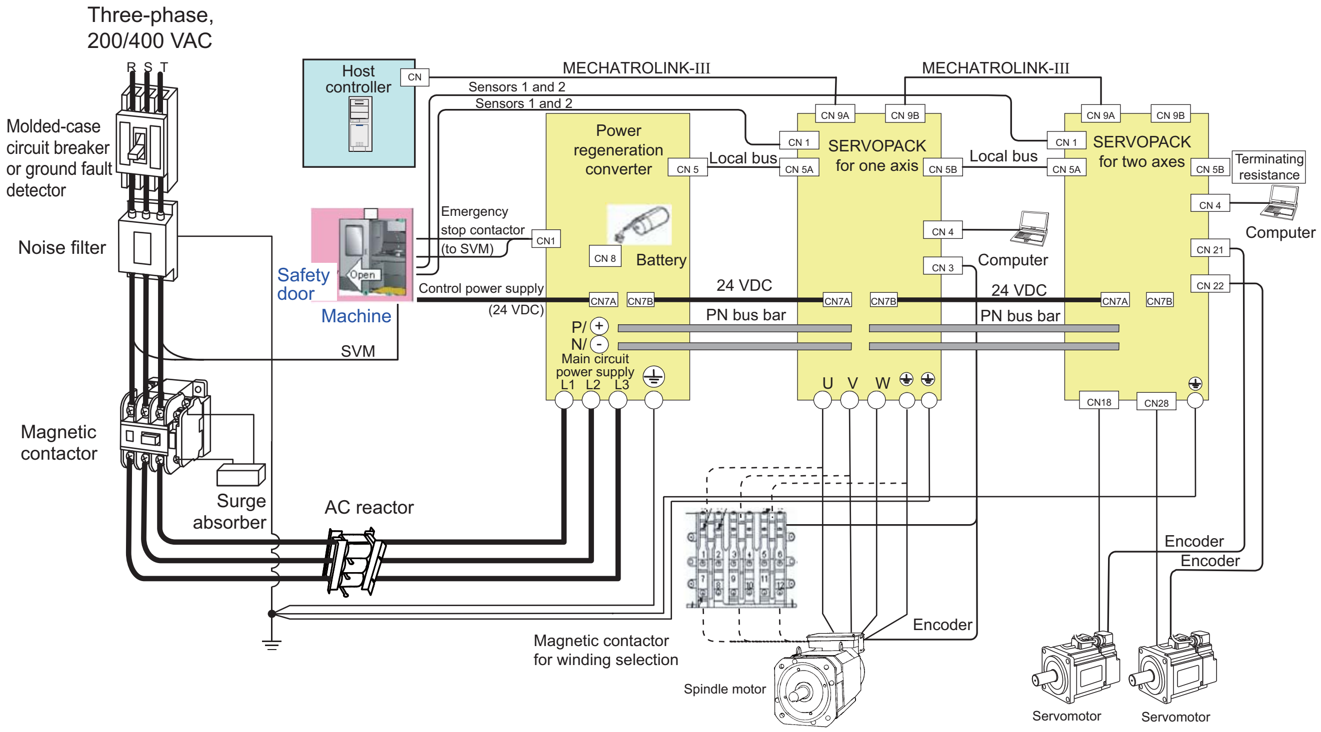
Contents

1

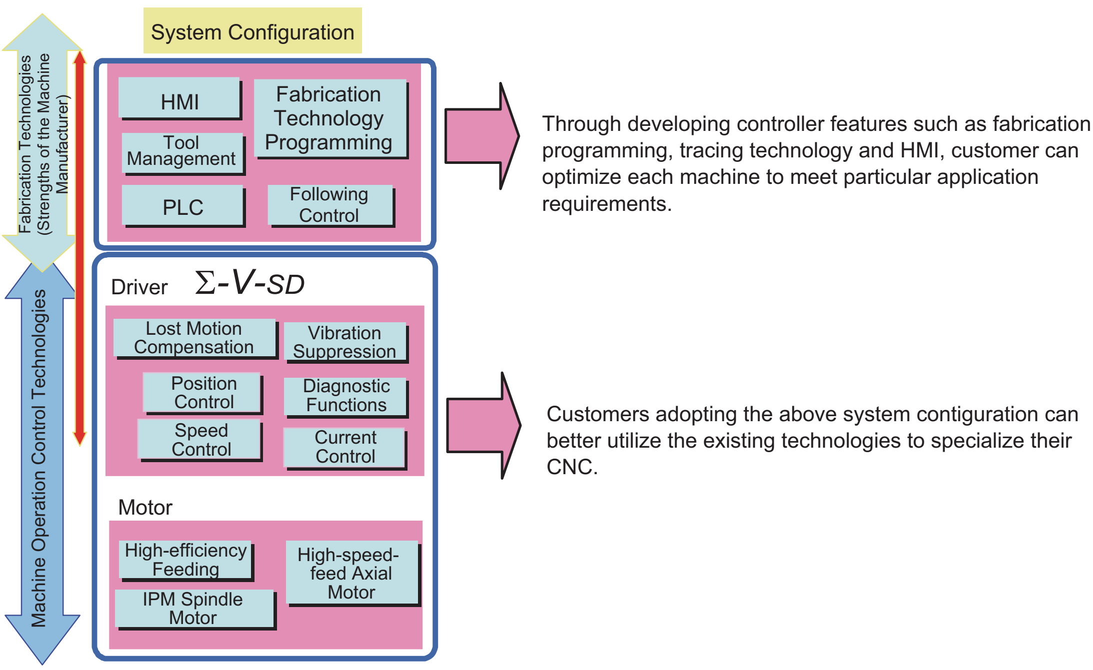
Application Overview

This chapter provides an overview of product applications.

The following diagram shows a system configuration that uses a servo drive.

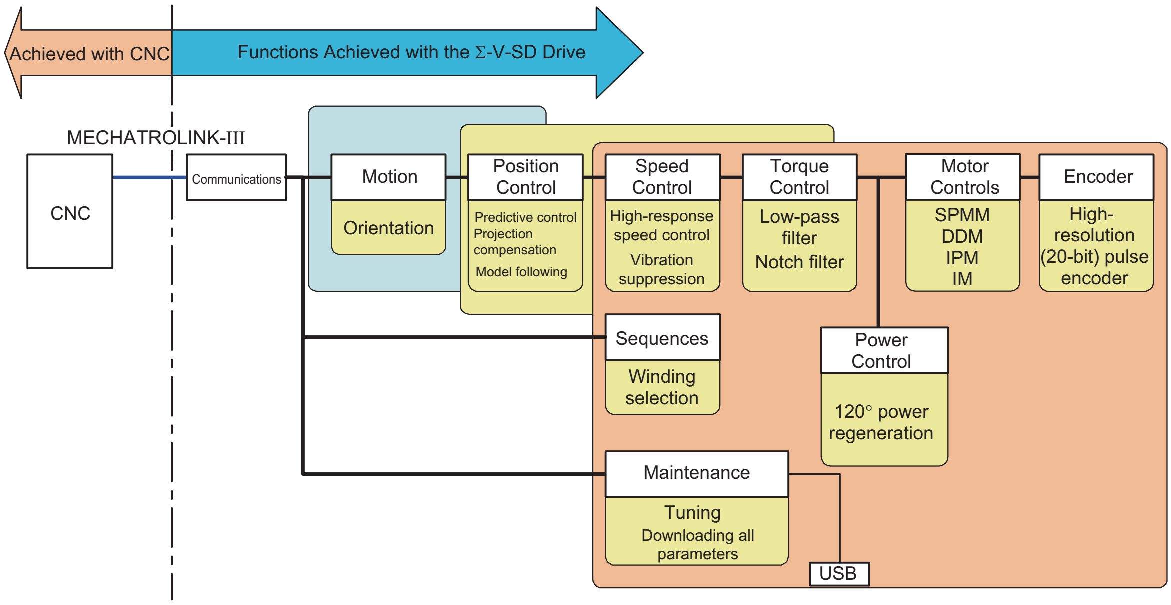


You can set up the optimal system for machine tools by using a Σ-V-SD driver together with a host controller (CNC). An overview of the roles of the Σ-V-SD driver and the host controller is given in the following figure.



Customers adopting the above system configuration can better utilize the existing technologies to specialize their CNC.

The following figure shows the functions of the servo drive.



2

MECHATROLINK-III Communications

This chapter describes MECHATROLINK-III communications.

2.1 MECHATROLINK-III and Communications Settings

The Σ-V-SD drivers were developed for machine tools. MECHATROLINK-III servo profile commands are used to interface the servo drive and the host controller.
The host controller implements the ASIC (JL-100/JL-101) for MECHATROLINK-III communications and is connected to the CPU by a bus connection.
When the host controller is used to control the servo, processing for the host controller is performed in real time.
While there are many compatible real-time operating systems, an ASIC access driver for MECHATROLINK-III communications is installed and the servo is controlled through access functions.
Refer to the *MECHATROLINK-III Communication ASIC JL-100/JL-101 (C1 Master) Access Driver* (Manual No.: MMA TDEP 024A) for details on access functions.

2.1.1 MECHATROLINK-III Initial Settings

You can download the master (C1) access drivers for the MECHATROLINK-III communications ASIC to install in the host controller from the following website.
URL: http://www.mechatrolink.org/

You can also download sample application examples for the master (C1) from the above website.
Follow the C source files and the instructions from this website to install the drivers on the host controller.
The data bus width (BWDT) between the CPU and communications ASIC and the endian configuration (ENDIAN) must also be set on the host controller.
Set the BWDT and ENDIAN pin connections on the communications ASIC and the access driver settings correctly.
Refer to the *MECHATROLINK-III Communication ASIC JL-100/JL-101 Hardware User's Manual* (Manual No.: MMA TDEP 019A) for details on BWDT and ENDIAN pin connection settings.
The following two access drivers for communications ASIC for master (C1) are available depending on the endian.

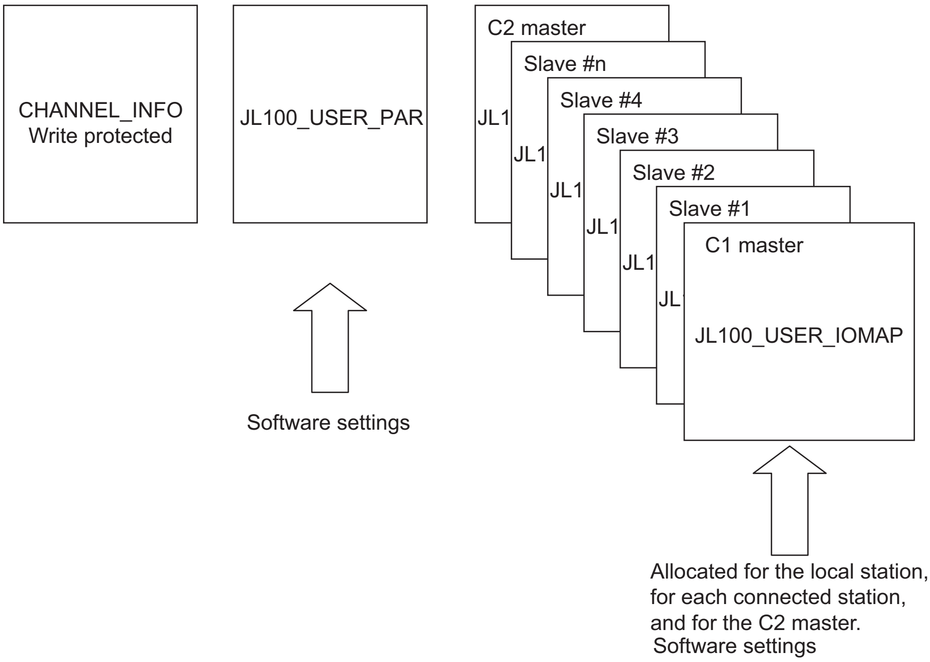
- M-III_driver_mst_16 bit_big_ver.1.20: For big endian, 16-bit bus connection
- M-III_driver_mst_ver.1.20: For little endian, 16-bit bus connection; little endian, 32-bit bus connection; or big endian, 32-bit bus connection

Install the header files according to the endian type of your system.
Refer to the *MECHATROLINK-III Communication ASIC JL-100/JL-101 (C1 Master) Access Driver* (Manual No.: MMA TDEP 024A) for details on the access drivers.

2.1.2 Communications Settings for the Master Station

You must set the values in the JL100_USER_PAR and JL100_USER_IOMAP data structures in the access driver at the master station.

To configure the system environment settings, set the JL100_USER_PAR and JL100_USER_IOMAP data structures in the communications ASIC.



(1) JL100_USER_PAR Structure (Communications Parameter Settings)

This section describes the JL100_USER_PAR data structure.

Member Name	Description	Setting Example	Remarks
mod	Communications mode setting	JL100_MOD_TYPE_C1MST | JL100_MOD_INT_FR	Master mode, hardware synchronization
ma0	Local station address	1	Master station (fixed)
ma_max	Maximum number of connected slaves	5	As an example, the following five axes are set: X, Y, Z, M, and SP.
t_mcyc	Transmission cycle (10 ns)	100000	1 [ms]
intoffset	Interrupt delay time (10 ns)	70000	700 [µs]
c2_dly	C2 master send start time (10 ns)	99500	Transmission cycle - 500 (10 ns)
prot_sel	Communications protocol selection	0	Cyclic communications
max_rtry	Maximum retry times	1	1 retry
pkt_sz	Data length sent in one message frame	64	64 bytes
wdt	WDT setting for host monitoring	1000	8 [ms] (1 = 8 [µs])
dly_cnt	Number of times to measure transmission delay	1	1 time

(2) JL100_USER_IOMAP Structure (Communications Conditions Settings)

This section describes the JL100_USER_IOMAP data structure.

Member Name	Description	Setting Example	Remarks
axis_adr	Station address	0001 hex 0002 hex 0003 hex 0004 hex 0104 hex	For C1 master For C2 master For slave First axis of a SERVOPACK for two axes Second axis of a SERVOPACK for two axes
t_rsp	Response monitoring time (10 ns)	10000	0.1 [ms]
cd_len	Command data length	48	Bytes
rd_len	Response data length	48	Bytes
cmdbuff_offset	Command buffer offset address	–	–
rspbuff_offset	Response buffer offset address	–	–

Refer to *4 How to Use Access Drivers* in the *MECHATROLINK-III Communication ASIC JL-100/JL-101 (C1 Master) Access Driver* (Manual No.: MMA TDEP 024A) for details on the JL100_USER_PAR and JL100_USER_IOMAP data structures.

2.2 Initializing Communications

The communication settings are used to call the access driver functions and initialize communications.

Using the *mst_init()* sample programming that is included with the access drivers as an example, perform the following items when you create a new program.

- Initialize the communications ASIC.
- Check the operation of the communications ASIC (a read/write check of the memory area).
- Detect the slave stations.
- Set the transmission cycle.
- Measure the delay in data sent over the network.
- Check the communications mode and change to cyclic communications mode.

Refer to *5.2.1 Communications Initialization Processing* in the *MECHATROLINK-III Communication ASIC JL-100/JL-101 (C1 Master) Access Drivers (*Manual No.: MMA TDEP 024A) for details on the processes for initializing communications.

2.3 Cyclic Communications Interrupt Processing

When the communications ASIC has been initialized, cyclic communications start between the master (host controller) and slaves (SERVOPACKs). Refer to *5.2.2 Cyclic Communications Processing* in the *MECHATROLINK-III Communication ASIC JL-100/JL-101 (C1 Master) Access Drivers* (Manual No.: MMA TDEP 024A) for details on cyclic communications.

When cyclic communications start, the INT1 synchronized interrupt signal for cyclic communications is output from the master and slave ASICs after the interrupt delay time (INToffset) from the transmission cycle synchronization (SYNC) frame.
During interrupt processing, response data is read from the slave and processing related to that response data (analysis of the response data and creation of command data to send to the slave) and user application processing are performed after the communications ASIC's communications buffer is switched.
The results of processing are written to the communication ASIC's communications buffer as command data.
The command data must be written before the next INT1 synchronized interrupt signal for cyclic communications is input.
For synchronized interrupt processing, refer to the *mst_exchange_sync()* sample programming that is included with the access drivers as an example and perform the following items.

- Confirm the communications ASIC status.
- Process switching the response data buffer and command data buffer.
- Confirm the response data reception status.
- Process the received response data (for all axes).
- Create the command data (for all axes).
- Write the command data (for all axes).

2.4 Operation Sequence

The operation sequence is the procedure for operating the servo drive through commands sent from the host controller.
When cyclic communications start, the operation sequence is executed to operate the machine.
The operation sequence depends on whether the SERVOPACK parameters are managed by the host controller or by the SERVOPACK.
Refer to *5.1 Operation Sequence for Managing Parameters Using a Controller* and *5.2 Operation Sequence for Managing Parameters Using a SERVOPACK* in the *Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on operation sequences.

IMPORTANT

A motor parameter file must be written to the SERVOPACK for the spindle motor, but with the following operation sequence, the motor parameter file is not written.

To write the motor parameter file, use either the SigmaWin for Σ-V-SD (MT) or the drive parameter upload/download function (refer to *8.2 SERVOPACK Parameter Uploading/ Downloading Functions*.

2.4.1 Operation Sequence When Parameters Are Managed by the Host Controller

Parameters are transferred to the SERVOPACK from the host controller after the power supply is turned ON. Therefore, if parameters are changed at the host controller or if the SERVOPACK is replaced, the parameters do not need to be set again.

The operation sequence when parameters are managed by the host controller is given below.

Step	Operation	Commands Used
1	Turn ON the control and main circuit power supplies.	–
2	Confirm that the SERVOPACK initialization has been completed (i.e., confirm that SVCMD_STAT.M_RDY = 1).	NOP
3	Disconnect the previous communications connection.	DISCONNECT
4	Establish a communications connection and start counting WDT.	CONNECT
5	Read the device ID and other information.	ID_RD or MEM_RD
6	Read the device settings (e.g., parameters).	SVPRM_RD
7	Set the parameters required for the device.	SVPRM_WR
8	Enable the parameters that were set (setup).	CONFIG
9	Turn ON the power supply to the encoder and obtain the position data.	SENS_ON
10	Turn ON the servo.	SV_ON
11	Start operation.	INTERPOLATE, VELCTRL, etc.
12	Turn OFF the servo.	SV_OFF
13	Disconnect communications.	DISCONNECT
14	Turn OFF the control and main circuit power supplies.	–

Note: If the communications connection is disconnected properly, step 3 is not required.
If the communications connection is not disconnected properly, send the DISCONNECT command for at least two communications cycles before you establish a connection again, and then send the CONNECT command in step 4.

2.4.2 Operation Sequence When Parameters Are Managed by the SERVOPACK

The normal operation sequence is performed after the parameters that are required for the machine setup are set in the SERVOPACK’s non-volatile memory.

(1) Setup Operation Sequence

The setup operation sequence is performed at the first run of the machine.

Step	Operation	Commands Used
1	Turn ON the control and main circuit power supplies.	–
2	Confirm that the SERVOPACK initialization has been completed (i.e., confirm that SVCMD_STAT.M_RDY = 1).	NOP
3	Disconnect the previous communications connection.	DISCONNECT
4	Establish a communications connection and start counting WDT.	CONNECT
5	Read the device ID and other information.	ID_RD or MEM_RD
6	Read the device settings (e.g., parameters).	SVPRM_RD
7	Set the parameters required for the device. (Select the non-volatile memory area for the servo parameter write mode.)	SVPRM_WR
8	Disconnect communications.	DISCONNECT
9	Turn OFF the control and main circuit power supplies.	–

Note: If you use the SigmaWin for Σ-V-SD (MT) to setup the parameters, connect the SigmaWin for Σ-V-SD (MT) to the SERVOPACK after step 1 and set the parameters.
If you use the SigmaWin for Σ-V-SD (MT) to write the parameters, the data is written to the SERVOPACK’s non-volatile memory.

(2) Operation Sequence during Normal Operation

The operation sequence during normal operation is performed when a machine that was previously set up is operating normally.

Step	Operation	Commands Used
1	Turn ON the control and main circuit power supplies.	–
2	Confirm that the SERVOPACK initialization has been completed. (Confirm that SVCMD_STAT.M_RDY = 1.)	NOP
3	Disconnect the previous communications connection.	DISCONNECT
4	Establish a communications connection and start counting WDT.	CONNECT
5	Read the device ID and other information.	ID_RD or MEM_RD
6	Read the device settings (e.g., parameters).	SVPRM_RD
7	Turn ON the power supply to the encoder and obtain the position data.	SENS_ON
8	Turn ON the servo.	SV_ON
9	Start operation.	INTERPOLATE, VELCTRL, etc.
10	Turn OFF the servo.	SV_OFF
11	Disconnect communications.	DISCONNECT
12	Turn OFF the control and main circuit power supplies.	–

Note: If the communications connection is disconnected properly, step 3 is not required. If the communications connection is not disconnected properly, send the DISCONNECT command for at least two communications cycles before you establish a connection again, and then send the CONNECT command in step 4.

2.4.3 Detailed Description of Commands Used in the Operation Sequence

This section describes the commands that are used during the operation sequence.

(1) DISCONNECT Command

■ Disconnecting the Previous Communications Connection

This process is not required if the operation sequence is being executed correctly.
If the host controller is reset while the SERVOPACK's control power is turned ON, the SERVOPACK will generate a communications error alarm and maintain the connection. To return to the normal state, clear the alarm status and disconnect communications so that a communications connection can be established again.
Send the DISCONNECT command to enable connecting communications again.
Send the DISCONNECT command during step 3 of the operation sequence.

■ Disconnecting a Communications Connection

When execution of the Servo OFF Command (SV_OFF: 32 hex) has been completed, send the Disconnection Command (DISCONNECT: 0F hex) to stop MECHATROLINK communications. Then, turn OFF the main circuit power supply in this state.

(2) CONNECT Command

Send the Establish Connection Command (CONNECT: 0E hex) to establish a communications connection. The command parameters are as follows: VER, COM_MOD, COM_TIM, and PROFILE_TYPE. Set these parameters as required for the system.

Settings Example
VER = 30 hex: Standard servo profile
COM_MOD = 82 hex: Synchronized communications, single-phase communications, and sub-commands enabled (48-byte specification for servo)
COM_TIM = 1: Generally set a 1:1 ratio between the transmission cycle and communications cycle
PROFILE_TYPE = 10 hex: Standard profile

If synchronized communications is enabled by the COM_MOD setting, use application software to detect watchdog data errors during transmission cycle interrupts (INT1 signal interrupts).
Watchdog processing must be performed during transmission cycle interrupt processing.

Refer to *1.2.2 Watchdog Data (WDT/RWDT)* in the *MECHATROLINK-III Command Specifications for Standard Servo Profile* (Manual No.: MMA TDEP 021A) and *2.2.2 Watchdog Data (WDT/RWDT)* in the *Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on watchdog processing.

(3) CONFIG Command

This command sets the device based on the parameters that have been written.
The CONFIG command enables the parameters that are set in the SERVOPACK.
The parameter for this command is CONFIG_MOD. Set this parameter as required for the system.

Example
CONFIG_MOD = 0 hex: Recalculate parameters and perform setup.

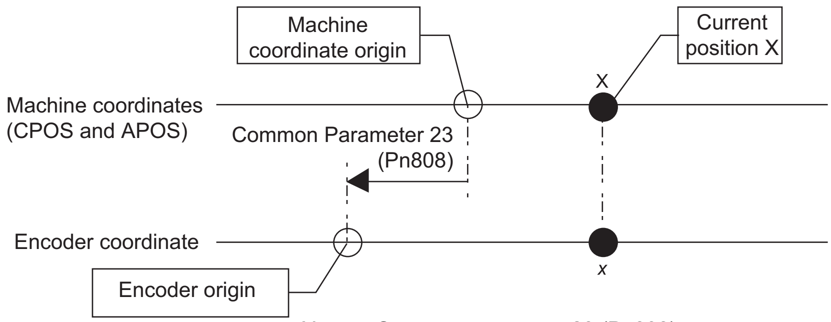
Note: If CONFIG_MOD is set to 2, all parameters in the SERVOPACK will be reset to their factory settings.

(4) SENS_ON Command

This command turns ON the power supply to the motor's encoder and obtains the position data.
Confirm that RCMD is SENS_ON (23 hex) and CMD_STAT.CMDRDY is 1 to confirm that execution of the SENS_ON command has been completed.
Confirm that SVCMD_STAT.POS_RDY is 1 to confirm that the position data was successfully obtained.
If SVCMD_STAT.POS_RDY is 0, the position data was not obtained correctly.
Output an error signal as an alarm from the host controller.

The spindle motor uses an incremental encoder, so the position is 0 when the power supply is turned ON. Servomotors use absolute encoders, so the SENS_ON command must be used to read the position data from the absolute encoder and set the machine coordinate system in the SERVOPACK. In this case, the machine coordinates are set based on the position detected by the absolute encoder and the offset of the absolute encoder origin (i.e., the offset value between the encoder coordinates and the machine coordinates as set in the SERVOPACK parameters).
The relationships between the machine coordinates (CPOS and APOS), the encoder coordinates, and the absolute encoder origin offset are shown in the following figure.

CPOS: Command position
APOS: Feedback position



X = x + Common parameter 23 (Pn808)
Common parameter 23 (Pn808): Absolute Encoder Origin Offset

Parameter	Setting Range	Setting Unit	Factory Setting	When Enabled	Classification
Pn808	-1073741823 to 1073741823	Reference units	0	Immediately	Setup

(5) SV_ON Command

This command turns ON the power to the motor.
When the control power and main circuit power supply are turned ON, SVCMD_STAT.PON changes to 1.
When the SENS_ON command is sent, SVCMD_STAT.POS_RDY changes to 1 and the position can be read from the SERVOPACK correctly.
When PON and POS_RDY change to 1, the motor is ready to receive power and SVCMD_STAT.M_RDY changes to 1.
Confirm that SVCMD_STAT.M_RDY is 1 and then send the SV_ON command from the host controller.

If SVCMD_STAT.M_RDY is 0, one of the following may have occurred.

- An alarm occurred (COM_ALM is 8 hex or higher, or D_ALM is 1).
- SVCMD_STAT.PON is 0 (the main circuit power supply is OFF).
- An absolute encoder is used and execution of the SENS_ON command has not completed.
- SVCMD_IO.ESPT is 1 (the HWBB signal is OFF).
- The SERVOPACK parameters have been initialized.

(6) Starting Operation

After the servo is turned ON, you can send commands to operate the motor.
To operate the motor for a feed or spindle axis, refer to *Chapter 4 Feed Axis Operation* or *Chapter 5 Spindle Axis Operation*.

(7) SV_OFF Command

This command turns OFF the power to the motor.
When you turn OFF the power to the machine, stop the motors for all axes and send the SV_OFF command.
If the SV_OFF command is sent while the motor is still turning, all axes other than the spindle axis will be stopped with the dynamic brake (DB).
If the power supply is turned ON and OFF or the motor is started and stopped by turning the servo ON when a position reference is input from the host controller, the dynamic brake circuit will operate frequently. This can cause the elements in the SERVOPACK to deteriorate. Send commands from the host controller to start and stop the servomotor.

3

Machine-specific Settings

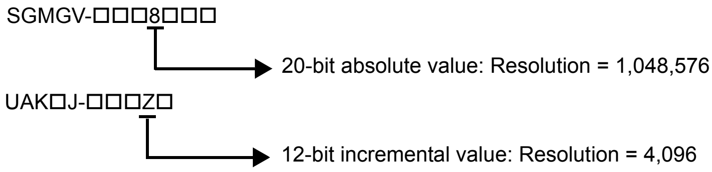
This chapter describes Σ-V-SD driver settings for different machines.
Refer to *8.2 Basic Functions Settings* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on Σ-V-SD driver settings.

3.1 Reference Unit

The Σ-V-SD driver uses MECHATROLINK-III communications to send commands to and receive feedback data from the host controller.
The SERVOPACK performs servo control in pulse units (i.e., at the encoder resolution), so commands from the host controller are also in pulses.

■ Encoder Resolution

The encoder resolution depends on the motor.



3.2 Electronic Gear

The Σ-V-SD driver does not provide an electronic gear.
Set the electronic gear that is required for the load configuration of each axis at the host controller.
Commands that are sent to the SERVOPACK are in pulse units.
Send the commands for the feed axis and spindle axis at the encoder resolution per motor revolution.

3.3 Axis Type

Motor and encoder settings must be made for each axis that is controlled by the Σ-V-SD driver.

> **IMPORTANT**
> Make the following settings so that the Σ-V-SD driver can identify the axis configuration.
> • Spindle Motor Parameter Settings
> • Motor Type, Application Selection, and Winding Selection Settings
> • Encoder Type Setting
> Incorrect settings may result in spindle motor or servomotor failure to operate or incorrect operation.

(1) Spindle Motor Parameter Settings

The motor parameters for the spindle motor must be written to the SERVOPACK.
The motor parameters are provided as an electronic file from Yaskawa.
Use either of the following two methods to write the motor parameters to the SERVOPACK.

- Use the SigmaWin for Σ-V-SD (MT) Engineering Tool to write the parameters to the SERVOPACK.
- Write the parameters to the SERVOPACK from the host controller.

Refer to *8.2 SERVOPACK Parameter Uploading/Downloading Functions* for details on how to write the parameters to the SERVOPACK.

(2) Motor Type, Application Selection, and Winding Selection Settings

Parameter			Meaning	Model
No.	Name	Set Value		
Pn01E.0	Motor Type Setting and Application Selection	n.□□□0 (factory setting)	Servomotor	SGMGV-□□□□□
		n.□□□1	SPM-type spindle motor	–
		n.□□□2	Induction-type servomotor	–
		n.□□□3	Spindle motor	UAK□J-□□□□□
		n.□□□4	IPM-type servomotor	–
		n.□□□5	IPM-type spindle motor	–
Pn01E.1	Winding Selection	n.□□0□ (factory setting)	None	–
		n.□□1□	Mechanical winding selection	UAKBJ-□□□□□

(3) Encoder Type Setting

Parameter			Meaning	Model
No.	Name	Set Value		
Pn01F.0	Encoder Type	n.□□□0 (factory setting)	Serial encoder (servomotor)	SGMGV-□□□□□
		n.□□□1	Pulse encoder (spindle motor)	UAK□J-□□□□□
		n.□□□2	Serial encoder (spindle motor)	–

3.4 Acceleration/Deceleration Filters

SERVOPACKs come with two different acceleration/deceleration filters for position references. These filters apply an acceleration/deceleration filter to the position references for each axis. The same filter and same time constant must be used for all axes that are being used for interpolation control.
However, the acceleration/deceleration filters for position references in the SERVOPACK are used when the communications cycle for MECHATROLINK-III communications is long. Apply acceleration/deceleration filters for axis movement references at the host controller (acceleration/deceleration before interpolation, acceleration/deceleration after interpolation, etc.).
If synchronized control is required between the spindle axis and feed axis (for tapping, threading, etc.), the same position reference filter must be used for both axes.

Refer to *Chapter 4 Feed Axis Operation* for details on the operation of a feed axis.
Refer to *Chapter 5 Spindle Axis Operation* for details on the operation of a spindle axis.

4

Feed Axis Operation

This chapter describes the operation of a feed axis.

4.1 High-speed Feeding and Cutting Operations

Feed axis operations include G00 (high-speed feeding) and a series of cutting operation such as G01 (linear interpolation feeding operation).

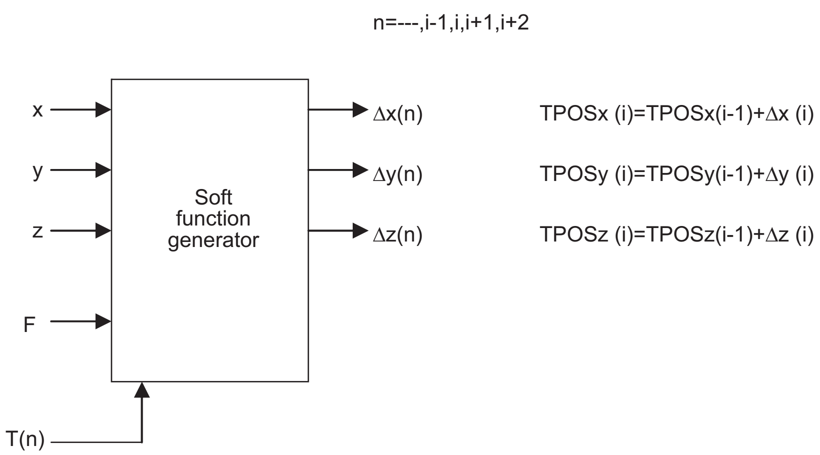
Position references are given for high-speed feeding and cutting operations with the INTERPOLATE (34 hex) command from the host controller.

4.1.1 How to Use the INTERPOLATE (34 Hex) Command

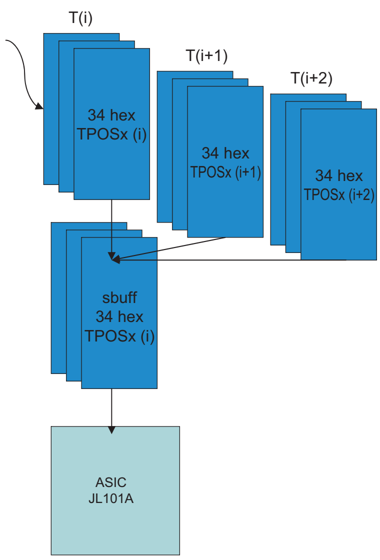
This command moves the axis by giving a target position (TPOS) reference each communications cycle. Manual operations that are related to axis movement, such as jogging, stepping, handle pulse generator operation, homing, and automatic operation (memory operation), are performed with the INTERPOLATE (34 hex) command.
Refer to *2.3 Cyclic Communications Interrupt Processing* for details on the IINTERPOLATE (34 hex) command

(1) How to Create a Movement Reference

You can move the axes by finding the positions of the axes with linear, circular, or another software function generator on the host controller and sending an INTERPOLATE (34 hex) command every communications cycle.



An interrupt signal is generated by the MECHATROLINK-III Communications ASIC (JL-100 or JL-101) each communications cycle.
The host controller receives the MECHATROLINK-III data during interrupt processing and determines the TPOSx based on the Δx(n) that is calculated by the function generator. This TPOSx value is then used as the target position for the INTERPOLATE (34 hex) command.



The following tables give the details of the INTERPOLATE (34 hex) command.

Field	Description
CMD	Ox34
CMD_CTRL	–
SVCMD_CTRL	–
SVCMD_IO	–
TPOS	Target Position The reference unit is set in common parameters 43 and 44.
VFF	Speed Feedforward The speed unit is set in common parameters 41 and 42. Normally, reference units/s is selected.
TFF	Torque Feedforward The torque unit is set in common parameters 47 and 48. Normally, the percent of the rated torque is selected.
TLIM	Torque Limit The torque unit is set in common parameters 47 and 48. Normally, FFFF FFFF hex (i.e., no torque limit) is set.

Usable Phase		3
Processing Time		Within the communications cycle
Byte	INTERPOLATE	
	Command	Response
0	34 hex	34 hex
1	WDT	RWDT
2	CMD_CTRL	CMD_STAT
3		
4	SVCMD_CTRL	SVCMD_STAT
5		
6		
7		
8	SVCMD_IO	SVCMD_IO
9		
10		
11		
12	TPOS	CPRM_SEL_MON1
13		
14		
15		
16	VFF	CPRM_SEL_MON2
17		
18		
19		
20	TFF	MONITOR1
21		
22		
23		
24	Reserved	MONITOR2
25		
26		
27		
28	TLIM	MONITOR3
29		
30		
31		

Note 1. The target position is the reference that is used to drive the actual servomotor.
The combination of the acceleration/deceleration profile, backlash offset, and pitch error correction from the host controller is sent to the SERVOPACK as the target position (TPOS).
2. The speed feedforward (VFF) is set by changing the unit from Δ reference target value/communications cycle to reference units/s.
3. Set the following control functions as needed.
• SVCMD_CTRL.ACCFIL (Acceleration/Deceleration Filter)
• SVCMD_CTRL_LTREQ (Latch Request)
• SVCMD_IO.GSEL (Gain Select)

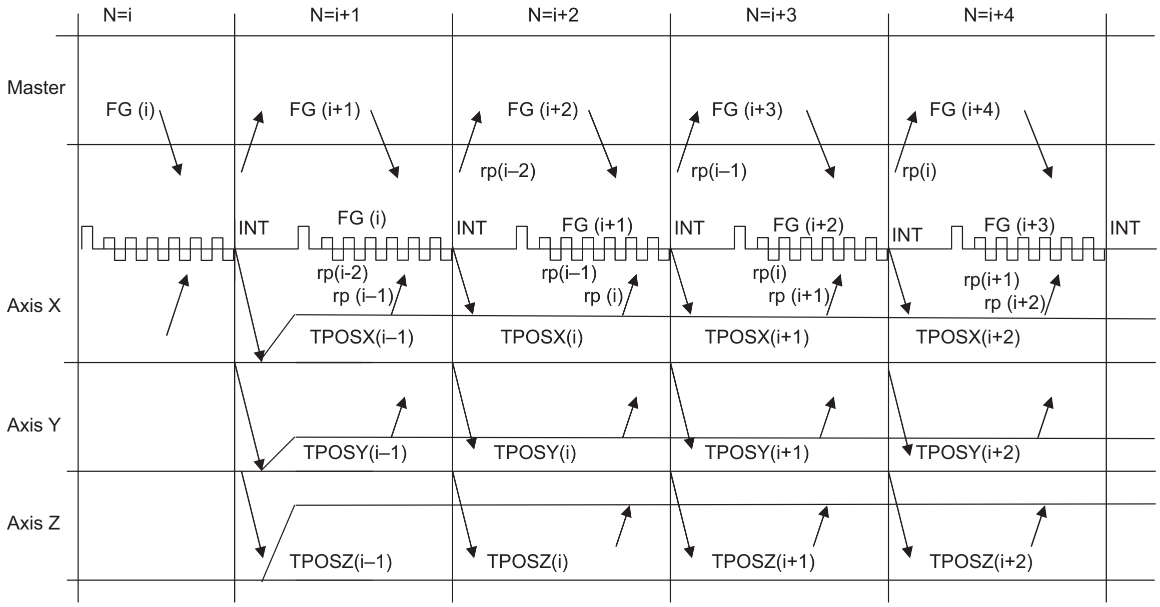
Refer to *2.7.15 Motion Command Data Setting Method* and *4.1 Units* in the *Σ-V-SD AC Servo Drives Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on units and bit commands.

(2) Synchronization

When an INTERPOLATE (34 hex) command is sent to the SERVOPACK from the host controller, the SERVOPACK synchronizes on the MECHATROLINK-III communications, receives the command, and returns a feedback response.

To obtain the current value, the backlash offset and pitch error correction are subtracted from the feedback position (APOS).

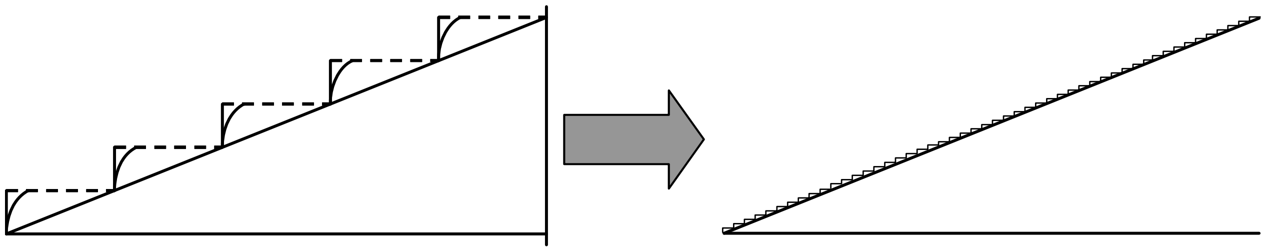
The SYNC signal that is output from the MECHATROLINK-III Communications ASIC is offset by the INToffset time to produce the interrupt signal (INT1) that serves as the interrupt signal for each SERVOPACK.
Each axis uses the interrupt signal (INT1) to start operation at the same time, so all axes are completely synchronized.
The axis operations for each SERVOPACK are based on an interrupt that is offset by the INToffset time from SYNC signal offset, so all axis operations are also completely synchronized.



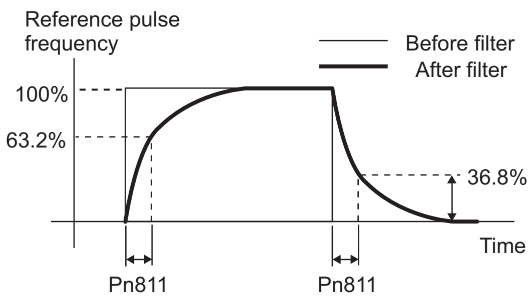
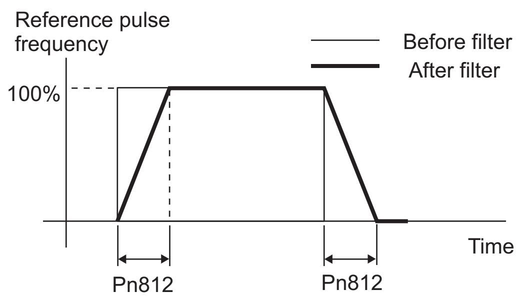
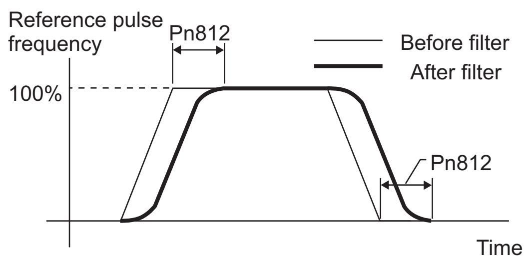
The target position (TPOS) for each axis is the reference that is used to operate the actual servomotor.
The acceleration/deceleration profile, backlash offset, and pitch error correction are performed by the host controller and the combination of those items is sent to the SERVOPACK as the target position (TPOS).

4.1.2 Acceleration/Deceleration Filters

For the INTERPOLATE (34 hex) command, the position reference is updated from the host controller each MECHATROLINK-III communications cycle. However, from the SERVOPACK, the update cycle of the position reference depends on the communications cycle.
If the communications cycle is short (e.g., 250 µs), the position reference is updated quickly, which results in smooth motor operation.
If the communications cycle is set to 1 ms or longer, the position reference update interval is longer and the motor may not operate smoothly.
In this case, you can apply an acceleration/deceleration filter to the position reference to make the motor operate smoothly.
With a Σ-V-SD driver, you can set the SVCMD_CTRL.ACCFIL in the MECHATROLINK-III INTERPOLATE (34 hex) command to enable or disable filters and set different filter types. For machine tool feed axis operations, a moving average filter is used for the position reference filter from the SERVOPACK.



Before filter (reference every 2 ms) After filter (with moving average filter)

Acceleration/Deceleration Filter	Moving Average Filter
	
	

Set SVCMD_CTRL.ACCFIL to 2 (moving average position reference filter) for the INTERPOLATE (34 hex) command.
If the bit field for SVCMD_CTRL (ACCFIL) is set to 1, set the filter time constant in SERVOPACK parameter Pn811.
If the bit field for SVCMD_CTRL (ACCFIL) is set to 2, set the filter time constant in SERVOPACK parameter Pn812.

(1) Position Reference Filter Selection

Bits	Name	Function	Setting Range	
4 and 5	ACCFIL	Position Reference Filter Selection	0	No position reference filter
			1	Exponential position reference filter
			2	Moving average position reference filter
			3	Reserved.

(2) Parameters Related to Position Reference Filters

No.	Name	Unit	Setting Range	Factory Setting	When Enabled
Pn811	Exponential Function Acceleration/ Deceleration Time Constant (when ACCFIL is set to 1)	0.1 ms	0 to 5100	0	Immediately
Pn812	Moving Average Time (when ACCFIL is set to 2)	0.1 ms	0 to 5100	0	Immediately

Note: The value is updated after pulse distribution is completed (DEN = 1) and positioning is completed (SVCMD_IO.PSET = 1).

4.1.3 Gain Selection (G-SEL)

Feed axis operations include high-speed feeding (G00), cutting (G01, G02, etc.), jogging, and handle pulse generator feeding. You can select the control function and gain bank required for each of these movements.

■ Terminology: Gain Bank

A gain bank is a group of control parameters. This enables you to select a gain bank and control functions for different operation modes.

(1) Control Functions

For machine tools, high-speed feeding positioning operations (G00) and cutting operations (G01) are performed. High-speed feeding and cutting operations each have their own set of control functions.
The SERVOPACK can select the control functions that are suitable for each of these operations.

Operation Mode	Required Operation	Control Functions That Are Used
Cutting operations (G01, G02, etc.)	High-precision cutting	Predictive control and quadrant projection compensation
High-speed feeding operation (G00)	Machine vibration suppression	Model following and velocity feedforward

Set parameters Pn070.0, Pn070.1, and Pn071.0 to enable or disable the control functions.
Select the axis operation modes and gain banks with the SVCMD_IO.GSEL parameter to the INTERPOLATE (34 hex) command.

(2) Gain Banks

A gain bank is a group of four gain parameters for a particular axis operation.
The following combinations of gain banks and control functions are used depending on the feed axis operation.
Select the correct operation mode from the host controller for either high-speed feeding (including jogging, stepping, and handle pulse generator operations) or cutting operations.

■ Gain Banks

<table>
<tr><th rowspan="4">Axis Operation</th><th colspan="4">SVCMD_IO(CMD)</th><th colspan="3" rowspan="2">Control Functions</th></tr>
<tr><th colspan="4">G-SEL</th></tr>
<tr><th>Bit 11</th><th>Bit 10</th><th>Bit 9</th><th>Bit 8</th><th>Pn070.0</th><th>Pn070.1</th><th>Pn071.0</th></tr>
<tr><th colspan="2">Operation Mode</th><th colspan="2">Gain Bank</th><th>Predictive Control</th><th>Quadrant Projection Compensation</th><th>Internal Speed Feedforward Control and Model Following Control</th></tr>
<tr><td>Cutting operation</td><td colspan="2">0</td><td colspan="2">Gain bank 0 (fixed)</td><td>0 or 1</td><td>0 or 1</td><td>–</td></tr>
<tr><td>High-speed feeding operation</td><td colspan="2">1</td><td colspan="2">Gain bank 1 (fixed)</td><td>–</td><td>–</td><td>0, 1, or 2</td></tr>
<tr><td>Spindle axis operation</td><td colspan="2">2</td><td colspan="2">Select from gain banks 0 through 3</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>Reserved.</td><td colspan="2">3</td><td colspan="2">Gain bank 3 (fixed)</td><td>–</td><td>–</td><td>–</td></tr>
</table>

■ Related Parameters

Parameter	Name	Digit	Function
Pn070	Function at Cutting Feed	0	Predictive Control: 0 = disabled, 1 = enabled
		1	Quadrant Projection Compensation: 0 = disabled, 1 = enabled
Pn071	Function for Fast-forward	0	None
		1	Internal speed feedforward
		2	Model following

■ Gain Bank and Parameter Combinations

Gain Parameter	Gain Bank			
	0	1	2	3
Speed loop gain	Pn100	Pn104	Pn12B	Pn12E
Speed loop integral time constant	Pn101	Pn105	Pn12C	Pn12F
Position loop gain	Pn102	Pn106	Pn12D	Pn130
Torque reference filter	Pn401	Pn412	Pn413	Pn414

The gain parameters are selected based on the feed axis operation that is used (interpolation, high-speed feeding, tap, etc.). Adjust the gain based on the feed axis operation that is used.

Example

- Cutting Operation
  For cutting operations, set SVCMD_IO.G-SEL to 0 ((bit 11, bit 10, bit 9, bit 8) = (0, 0, 0, 0)) to select gain bank 0.
  Set Pn070.0 to 1 to enable predictive control. Set Pn070.1 to 1 to enable quadrant projection compensation.
- High-speed Feeding Operation
  For high-speed feeding operations, set SVCMD_IO.G-SEL to 5 ((bit 11, bit 10, bit 9, bit 8) = (0, 1, 0, 1)) to select gain bank 1.
  Set Pn071.0 to 1 to enable internal speed feedforward. Set Pn071.0 to 2 to enable model following control.
- Spindle Axis Operation
  For spindle axis operations, set SVCMD_IO.G-SEL to 10 ((bit 11, bit 10, bit 9, bit 8) = (1, 0, 1, 0)) to select gain bank 2.

■ Synchronized Operation of Feed and Spindle Axes

In operations such as tapping, where the feed and spindle axes must be synchronized, you must match the position loop gain for each of the axes. Failure to do so will result in increased synchronization error, which will affect the operation.
If the gains for cutting operations (gain bank 0) are too large, you may not be able to set the same gains for the spindle axis (doing so may result in vibration, for example). Design the system so gain bank 2 or 3 can be selected for the feeding axis motion that needs to be synchronized with the spindle axis.

4.2 Manual Operation

Machine tools have manual operations such as jogging, stepping, and handle pulse generator operation.
Basically, only one axis can be moved at a time during manual operation. Positioning operations are the same as for high-speed feeding operations.
Position references are given as high-speed feeding operations for each axis.

4.3 The Roles of Main Commands and Subcommands

When feed axis operations are performed, you may need to check SERVOPACK alarms or change SERVOPACK parameters during axis movement.
In particular, when you check SERVOPACK alarms or change parameters during the execution of the INTERPOLATE (34 hex) command, the interpolation operation reference (position reference) may be interrupted, and make it impossible to achieve the required speed.
This can result in damage to the cutting surface during cutting operations.
To solve this problem, you can execute the Read Alarm or Warning subcommand (ALM_RD: 05 hex) in parallel with the MECHATROLINK-III INTERPOLATE main command to check SERVOPACK alarms.

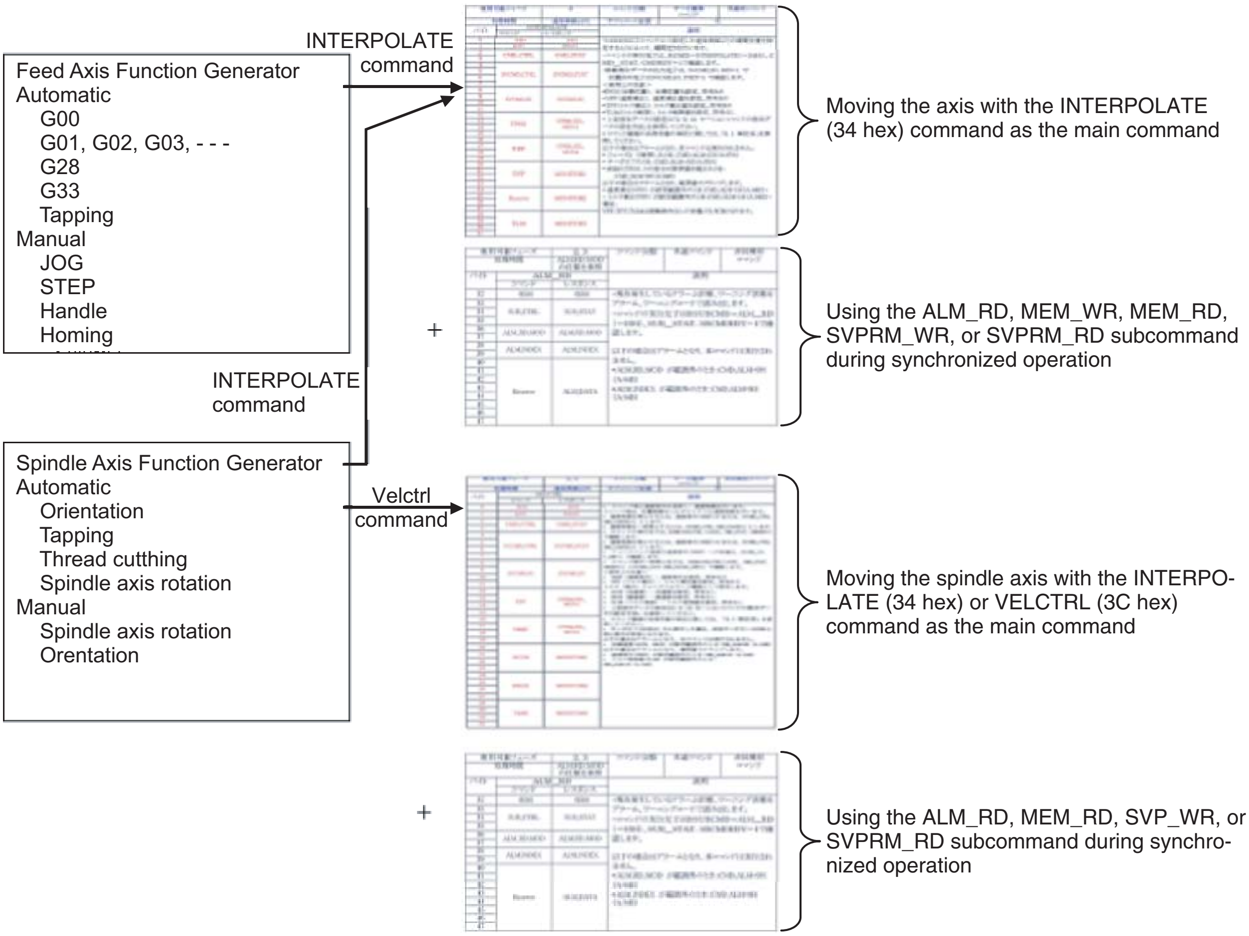
Operation	Main Command	Subcommand
Axis movement during normal operation	INTERPOLATE	SMON
Axis movement when an alarm or warning has occurred	INTERPOLATE	ALM_RD
Axis movement when changing a parameter	INTERPOLATE	SVPRM_WR
Stopping axis when changing a parameter	INTERPOLATE	SVPRM_WR

The following table shows the possible combinations of main commands and subcommands.

			Subcommand					
			NOP (00 hex)	ALM_RD (05 hex)	MEM_RD (1D hex)	MEM_WR (1E hex)	SVPRM_RD (40 hex)	SVPRM_WR (41 hex)
Main Command	Common Commands	NOP (00 hex)	○	○	○	○	○	○
		ID_RD (03 hex)	○	○	○	○	○	○
		CONFIG (04 hex)	○	×	×	×	×	×
		ALM_RD (05 hex)	○	×	×	×	×	×
		ALM_CLR (06 hex)	○	×	×	×	×	×
		SYNC_SET (0D hex)	○	×	×	×	×	×
		CONNECT (0E hex)	○	×	×	×	×	×
		DISCONNECT (0F hex)	○	×	×	×	×	×
		MEM_RD (1D hex)	○	×	×	×	×	×
		MEM_WR (1E hex)	○	×	×	×	×	×
	Servo Commands	POS_SET (20 hex)	○	×	×	×	×	×
		SENS_ON (23 hex)	○	×	×	×	×	×
		SENS_OFF (24 hex)	○	×	×	×	×	×
		SMON (30 hex)	○	○	○	○	○	○
		SV_ON (31 hex)	○	○	○	○	○	○
		SV_OFF (32 hex)	○	○	○	○	○	○
		INTERPOLATE (34 hex)	○	○	○	○	○	○
		POSING (35 hex)	○	○	○	○	○	○
		FEED (36 hex)	○	○	○	○	○	○
		VELCTRL (3C hex)	○	○	○	○	○	○
		TRQCTRL (3D hex)	○	○	○	○	○	○
		SVPRM_RD (40 hex)	○	×	×	×	×	×
		SVPRM_WR (41 hex)	○	×	×	×	×	×

○: Can be used together.
×: Cannot be used together.

Execute the INTERPOLATE (34 hex) command as the main command to move the feed axis, and read alarms or warnings or change parameters with a subcommand (ALM_RD, MEM_RD, MEM_WR, SVPRM_RD, or SVPRM_WR).



4.3.1 Using Subcommands to Check Alarms or Warnings

If a SERVOPACK alarm occurs during movement of a feed axis, CMD_STAT.D_ALM will change to 1.
If a SERVOPACK warning occurs, CMD_STAT.D_WAR will change to 1.
Use the ALM_RD (05 hex) subcommand to determine what SERVOPACK alarm or warning occurred.
Refer to *7.1 Alarm and Warning Processing* for details on how to check alarms and warnings and how to handle them when they occur.

4.3.2 Using Subcommands to Change Parameters

You can select different gain banks for different axis operations on the SERVOPACK with up to four different banks of gain settings.
However, in some cases, four gain banks is not enough for a particular machine configuration or set of operations, or you may need to change the SERVOPACK parameters based on the machine specifications.
In these cases, you can use the Write Servo Parameter command (SVPRM_WR: 41 hex) to change the parameters, even during axis movement.

■ About the Write Servo Parameter Command (SVPRM_WR: 41 Hex)

To change parameters, use the SVPRM_WR (41 hex) command. Specify the number of the parameter to change, the data size, the write mode, and the data you want to write, and then execute the SVPRM_WR (41 hex) command.
There are two write modes: One for the RAM area (data is lost when the power supply is turned OFF) and one for the non-volatile memory area (data is retained even when the power supply is turned OFF).
However, the non-volatile memory area has a write limit of approximately 10,000 writes.
Generally, any gain-related settings are written to RAM, while any settings related to the load configuration are written to the non-volatile memory area.

Refer to *3.4.8 Write Servo Parameter Subcommand (SVPRM_WR: 41H)* in the *Σ-V-SD AC Servo Drives Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on the SVPRM_WR (41 hex) command.

Example: Changing the Speed Loop Gain Parameter (Pn104) in Gain Bank 1

Gain Setting Parameter	Gain Bank			
	Gain 0	Gain 1	Gain 2	Gain 3
Speed loop gain	Pn100	Pn104	Pn12B	Pn12E
Speed loop integral time constant	Pn101	Pn105	Pn12C	Pn12F
Position loop gain	Pn102	Pn106	Pn12D	Pn130
Torque reference filter	Pn401	Pn412	Pn413	Pn414

Specification Method
SUBCMD SVCMD_WR = 41 hex
NO = 104: Speed Loop Gain Pn104
SIZE = 2: 2 bytes
MODE = 10 hex: Write to RAM
PARAMETER =□□□□: Data to write

When RSUBCMD is SVPRM_WR (41 hex) and SUB_STAT.SUBCMDRDY is 1 in the response data, the parameter has been written successfully. The time required to write the parameter depends on the operating status of the SERVOPACK, but on average, approximately 4 ms is required.

4.4 Latching

The latch function saves the position of the machine when a latch signal is input while there is a latch request. Latch operations are required to determine the position for a machine operation, such as homing for a feed axis, setting the orientation of a spindle axis, or setting the reference point for threading with a lathe. The skip function is used to automatically measure workpieces and tools. When the skip function is used, the position is saved by specifying a latch signal selection. Then, all remaining movement is cancelled and the next step is executed.
The SERVOPACK contains functions to perform these latch operations, and they can be used together with the INTERPOLATE (34 hex) command for axis movement.
Use the SVCMD_CTRL bit field in the INTERPOLATE (34 hex) command for latch requests and latch signal selection.
Touch probes or other such equipment use one of the external input signals 1 through 3 of SERVOPACK external input signals (CN1). Select the external input signal that has been connected.

4.4.1 SVCMD_CTRL Bit Field (Latch Operations)

Bit 8	LT_REQ1	Latch Request 1	0	None	Rising edge
			1	Request for latch	
	Description: Requests a latch through phase C or an external input signal.				
Bit 9	LT_REQ2	Latch Request 2	0	None	Rising edge
			1	Request for latch	
	Description: Requests a latch through phase C or an external input signal.				
Bits 10 and 11	LT_SEL1	Latch Signal Selection 1	0	Phase C	Rising edge
			1	External input signal 1	
			2	External input signal 2	
			3	External input signal 3	
	Description: Selects phase C of LT_REQ1 or an external input signal. Set this bit to a different value than LT_SEL2. If LT_SEL1 is changed while LT_REQ1 is 1, the LT_SEL1 selection for when LT_REQ1 is 1 will be continued.				
Bits 12 and 13	LT_SEL2	Latch Signal Selection 2	0	Phase C	Rising edge
			1	External input signal 1	
			2	External input signal 2	
			3	External input signal 3	
	Description: Selects phase C of LT_REQ2 or an external input signal. Set this bit to a different value than LT_SEL1. If LT_SEL2 is changed while LT_REQ2 is 1, the LT_SEL2 selection for when LT_REQ2 is 1 will be continued.				

Note: Refer to *7.2.5 I/O Signals* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on external input signals.

4.4.2 SVCMD_STAT Bit Field (Latch Operations)

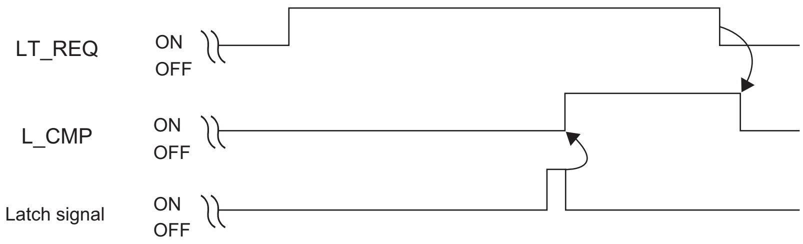
The following SVCMD_STAT.L_CMP1 and SVCMD_STAT.L_CMP2 bits indicate the completion of a latch operation.

Bit 8	L_CMP1	Latch Completion 1	0	Latch is not completed.
			1	Latch is completed.
	Description: This status is used to determine the completion of a latch operation for LT_REQ1. L_CMP1 remains 1 until LT_REQ1 changes to 0.			
Bit 9	L_CMP2	Latch Completion 2	0	Latch is not completed.
			1	Latch is completed.
	Description: This status is used to determine the completion of a latch operation for LT_REQ2. L_CMP2 remains 1 until LT_REQ2 changes to 0.			

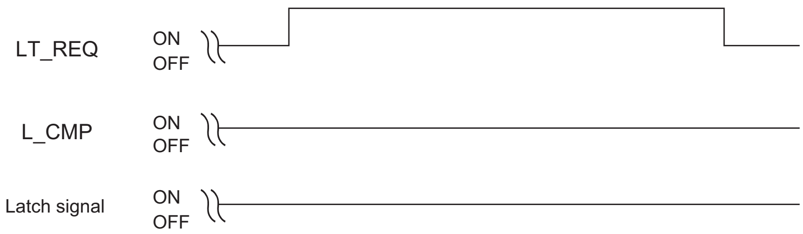
4.4.3 Latch Operation Sequence

Type/Operation	Latch Operation
Latching	The latch operation begins when LT_REQ1 or LT_REQ2 changes to 1. The latch operation ends on the specified latch signal input.
Monitoring latching	L_CMP1 and L_CMP2 are used to determine if the latch operation has finished.
Canceling latching	The latch operation is cancelled when LT_REQ1 or LT_REQ2 changes to 0.
Latch position monitoring	Use SVCMD_CTRL.SEL_MON1 through SVCMD_CTRL.SEL_MON3 to read the latch position LPOS1 or LPOS2.

(1) Normal Latch Operation



(2) Latch Operation When Latching Is Not Completed



To read the latch position, set one of the monitor selection codes SVCMD_CTRL.SEL_MON1 through SVC-MD_CTRL.SEL_MON3 to the latch position monitor LPOS1 or LPOS2. Then, check to make sure that the latch operation is finished (i.e., that SVCMD_STAT.L_CMP1 or SVCMD_STAT.L_CMP2 is 1) and then read the latch position (LPOS1 or LPOS2) from the specified monitor.
Refer to *4.2 Monitor Data* in the *Σ-V-SD AC Servo Drives Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on monitor selection.

(3) SVCMD_CTRL Bit Fields (Monitor Selection Fields)

Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
SEL_MON2				SEL_MON1			

Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
Reserved (0).				SEL_MON3			

4.5 Absolute Position Detection

An absolute position detection system can be constructed with a host controller when a servomotor with an absolute encoder is used. An absolute position detection system eliminates the need for homing after the power supply is turned ON, but the following must be set up to use such a system.

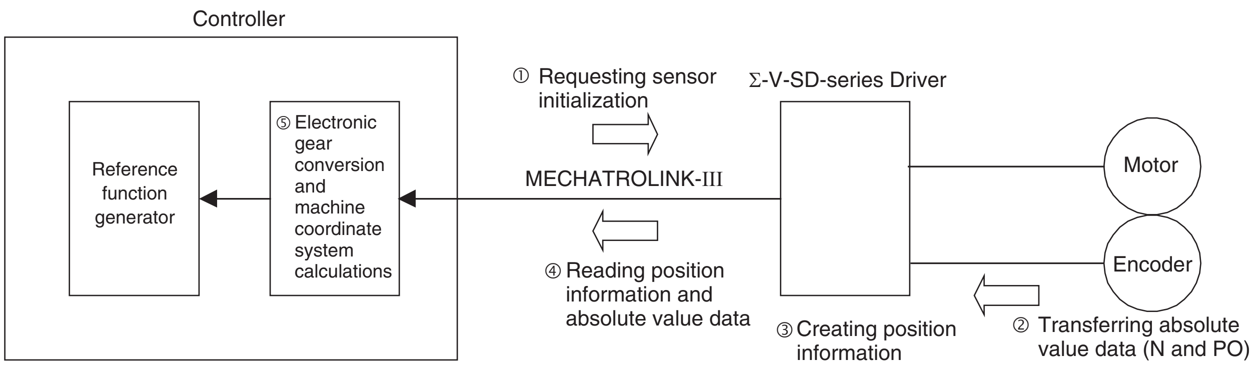
- Initialization of the absolute encoder
- Machine coordinate system settings and sequence execution
- Reading the position of the absolute encoder after the power supply is turned ON and setting the machine coordinate system

■ Terminology: Absolute Encoder

There are two types of servomotor encoders. An incremental encoder detects a position by calculating the difference from home position. An absolute encoder detects the absolute position relative to a reference position.
The absolute encoder uses a battery connected to the battery terminals of the power regeneration converter to maintain the absolute value data at all times, even when the power supply is turned OFF. It also updates the absolute value data if the position changes while the power supply is OFF.
The absolute encoder consists of a detector that is used to detect the absolute position within one rotation and a counter that is used to count the number of rotations.

4.5.1 Overview of Absolute Position Detection

To read the absolute value data from the absolute encoder to the host controller, turn ON the host controller and the SERVOPACK at the same time or turn ON the SERVOPACK first.
The following diagram shows an overview of absolute position detection.



①Requesting Sensor Initialization

The host controller sends a request to the SERVOPACK to initialize the sensor when MECHATROLINK-III communications are established.

②Transferring Absolute Value Data (N.PO)

The SERVOPACK obtains the multi-turn data (N) and the initial incremental pulses (PO) when the sensor initialization request is received.

③Creating Position Information

The SERVOPACK creates the position data according to the multiturn data and initial incremental pulses.

④Reading Position Information and Absolute Value Data

The host controller reads the position data or absolute value data from the SERVOPACK.

⑤Electronic Gear Conversion

The host controller calculates the absolute value from the read information, performs the electric gear conversion, and sets the machine coordinate system. The machine coordinate system origin offset must be set in the SERVOPACK or at the host controller in advance.
For details, refer to *4.5.6 Origin Offset*.

This allows an absolute position detection system to detect the absolute position of the machine immediately after the power supply is turned ON so that machine operation can be started immediately.

■ Terminology: Absolute Value Data

The absolute value data that is stored in an absolute encoder is the number of turns from the absolute base position (multiturn data: N).
The initial incremental pulse (PO) is a pulse that represents the transition from the phase C position at the point when the absolute encoder is initialized.
When the absolute encoder is reset, only the number of rotations from the absolute reference position (multiturn data: N) is cleared. The initial incremental pulse (PO) is not changed.

■ Additional Information: Absolute Position Calculations

The absolute position is calculated according to the following formula:

Absolute position (P) = N × RP + PO

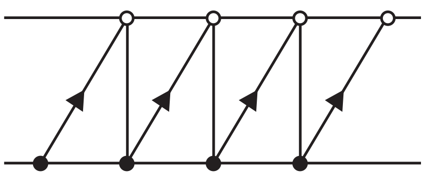
The conditions for the above formula are as follows:

- PO: Number of initial incremental pulses
- N: Number of rotations from the absolute reference position (multiturn data)
- RP: Number of feedback pulses per motor rotation

4.5.2 Finite-length/Infinite-length Axes and Absolute Position Detection Settings

There are two types of axes: infinite-length axes, which reset the current machine coordinate system position to a specified value every rotation, and finite-length axes, which do not reset the current position.
Use finite-length axes to perform operations within a defined area or range.
Use an infinite-length axis for rotary tables and other operations that require the current machine coordinate system value to be reset to 0 every rotation.
To manage positions for an infinite-length axis, the current position must be reset at regular intervals. This must be implemented on the host controller.

For an infinite-length axis, reset the mechanical position, reference position, and current value at a regular interval when the position reaches the reset position set for the axis (POSMAX). This is primarily effective for axes such as those used for a rotary table. Implement this functionality on the host controller to use an axis as an infinite-length axis.



To manage the position of an infinite-length axis, first the pulse position and encoder position are always stored as paired information in the battery backup memory of the host controller. This data is used as the power OFF pulse position and the power OFF encoder position when the power supply is turned ON again.
The following formula is used to find the pulse position from the relative encoder position.

Pulse position = Power OFF pulse position + (Encoder position - Power OFF encoder position)*
*The portion in parentheses ( ) represents the travel distance (relative encoder position) while the power supply is OFF.

■ Terminology: Encoder Position

The encoder position is the absolute encoder position information (Multiturn data × Number of encoder pulses per encoder rotation + Initial incremental pulses + Incremental pulses moved since turning ON the power) and corresponds to the machine coordinate system position (APOS).

■ Terminology: Pulse Position

The pulse position is the position information managed by the host controller converted into pulses.

To use an absolute encoder for absolute position detection, you must set the correct host controller settings and SERVOPACK parameters. The setting methods for the position detection and coordinate system settings depend on whether a finite-length or an infinite-length axis is used.
For details on absolute position detection, refer to *4.5.3 Procedure for Setting Up the Absolute Position Detection System*.

4.5.3 Procedure for Setting Up the Absolute Position Detection System

This section describes the procedure for setting up the absolute position detection system.

■ Absolute Position Detection System Startup Flowchart

Use the following procedure to start the absolute position detection system.

1	Connecting and Checking Devices Check to confirm that the absolute encoder backup battery (BA000518) is connected to the power regeneration converter and that the servomotor has an absolute encoder (SGMGV-□□□8□□□).
	↓
2	Initializing the Absolute Encoder Set the absolute encoder to its default values. (Refer to *4.5.4 Initializing the Absolute Encoder.*)
	↓
3	Related Parameter Settings Set all parameters related to the host controller and SERVOPACK absolute position detection. The settings depend on whether a finite-length or an infinite-length axis is used.
	↓
4	Origin Settings Perform homing to set the absolute origin (i.e., the machine coordinate system origin). The setting procedure depends on whether a finite-length or an infinite-length axis is used.

To ensure that the absolute position detection system operates correctly, refer to the following section and perform steps 2 through 4, above, correctly.

Always perform the startup procedure for the absolute position detection system in the following situations.

- When starting the absolute position detection system for the first time
- After replacing the servomotor
- When an absolute encoder-related alarm occurs

4.5.4 Initializing the Absolute Encoder

It is necessary to initialize the absolute encoder in the following cases.

- The first time the machine is started
- When an encoder backup alarm (A.810) occurs
- When an encoder checksum alarm (A.820) occurs
- To reset the multiturn data for the absolute encoder to 0

Perform an absolute encoder reset from the SigmaWin for Σ-V-SD (MT) to initialize the absolute encoder.
You can also use the Write Memory command (MEM_WR: 1E hex) from the host controller.

(1) Initialization Procedure

Refer to *8.5.4 Absolute Encoder Setup* in *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on how to reset an absolute encoder with the SigmaWin for Σ-V-SD (MT).

Use the following procedure to initialize an absolute encoder with the Write Memory command (MEM_WR: 1E hex) from the host controller.
After initialization, always turn the power supply to the SERVOPACK OFF and ON again.

1. Make sure that the servo is OFF for an axis before you initialize the absolute encoder.

If the servo is ON, use the Servo OFF command (SV_OFF: 32 hex) to turn OFF the servo.

2. Execute the MEM_WR (1E hex) command as the MECHATROLINK-III main command or subcommand.

Command = MEM_WR (1E hex)
Address = 80004000 hex
Mode/Data_Type = 12 hex
Size = 0001 hex
Data = 1008 hex (Request code: 1008 hex is the absolute encoder reset operation.)
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.
If an error occurs, perform step 5 and end the adjustment operation.

3. Send the following data and begin preparations for execution.

Command = MEM_WR
Address = 80004002 hex
Mode/Data_Type = 12 hex
Size = 0001 hex
Data = 0002 hex
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.
If an error occurs, perform step 5 and end the adjustment operation.

4. Send the following data to initialize the absolute encoder.

Command = MEM_WR
Address = 80004002 hex
Mode/Data_Type = 12 hex
Size = 0001 hex
Data = 0001 hex
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.
If an error occurs, perform step 5 and end the adjustment operation.

5. Send the following data to end the adjustment operation.

Command = MEM_WR
Address = 80004000 hex
Mode/Data_Type = 12 hex
Size = 0001 hex
Data = 0000 hex
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.

(2) Procedure for Setting a Multiturn Limit

Use the multiturn limit setting when you need to perform position control for a rotor, such as a turntable.
Refer to *8.5.5 Multiturn Limit Setting* and *8.5.6 Multiturn Limit Disagreement Alarm (A.CC0)* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on how to use the multiturn limit setting with the SigmaWin for Σ-V-SD (MT).
Use the following procedure to use the multiturn limit setting with the MEM_WR (1E hex) command from the host controller.
After initialization, always turn the power supply to the SERVOPACK OFF and ON again.

1. Make sure that the servo is OFF for an axis before you initialize the absolute encoder.

If the servo is ON, use the Servo OFF command (SV_OFF: 32 hex) to turn OFF the servo.

2. Write the multiturn limit value to SERVOPACK parameter Pn205 with the SVPRM_WR (41 hex) command.

Command = SVCMD_WR (41 hex)
No = 205 (Multiturn Limit Value Pn205)
Size = 2 (2 bytes)
Mode = 10 hex (Write to RAM)
Parameter =XXXX (data to write)
Processing has finished when RCMD is SVPRM_WR (= 41 hex) and CMD_STAT.CMDRDY is 1.

3. Execute the MEM_WR (1E hex) command as the MECHATROLINK-III main command or subcommand.

Command = MEM_WR (1E hex)
Address = 80004000 hex
Mode/Data_Type = 12 hex
Size = 0001 hex
Data = 1013 hex (Request code: 1013 hex is the multiturn limit setting operation.)
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.
If an error occurs, perform step 6 and end the adjustment operation.

4. Send the following data and begin preparations for execution.

Command = MEM_WR
Address = 80004002 hex
Mode/Data_Type = 12 hex
Size = 0001 hex
Data = 0002 hex
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.
If an error occurs, perform step 6 and end the adjustment operation.

5. Send the following data to initialize the absolute encoder.

Command = MEM_WR
Address = 80004002 hex
Mode/Data_Type = 12 hex
Size = 0001 hex
Data = 0001 hex
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.
If an error occurs, perform step 6 and end the adjustment operation.

6. Send the following data to end the adjustment operation.

Command = MEM_WR
Address = 80004000 hex
Mode/Data_TYPE = 12 hex
Size = 0001 hex
Data = 0000 hex
Processing has finished when RCMD is MEM_WR (= 1E hex) and CMD_STAT.CMDRDY is 1.

4.5.5 Related Parameter Settings

Set the following parameters to use absolute position detection.

⚠ CAUTION

- Set Pn205 (Multiturn Limit Setting) as instructed for the initialization of the absolute encoder. If these instructions are not followed, the current position may vary when the power supply is turned ON, which can damage the machine.

■ SERVOPACK Parameters Related to Absolute Position Detection

Parameter	Name	Setting Range	Unit	Set Value
Pn000.0	Direction Selection	0: Sets counterclockwise (CCW) as the forward direction. 1: Sets clockwise (CW) as the forward direction. (Reverse Rotation Mode)	–	–
Pn205	Multiturn Limit Setting	0 to 65535	Rev	65535*
Pn002.2	Absolute Encoder Usage	0: Use absolute encoder as an absolute encoder. 1: Use absolute encoder as an incremental encoder.	–	0

* Refer to *8.5.5 Multiturn Limit Setting* in the *S-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on the multiturn limit setting for infinite-length axes.

4.5.6 Origin Offset

If you use an absolute encoder, you can set an offset for the encoder position and the machine coordinate system position. You can use the offset to set the mechanical origin in the absolute value coordinate system. The origin offset can be stored in the host controller or in the SERVOPACK.

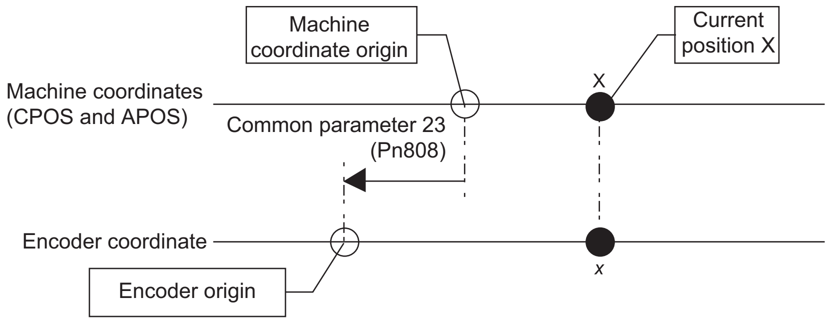
(1) Storing the Origin Offset in the Host Controller

Allocate memory (registers) to store the origin offset in the host controller.
The memory used to store the origin offset must meet the following specifications.

- To save the origin permanently, use non-volatile memory or memory with a battery backup for storage.
- Use a 32-bit register to store the origin.
- The origin offset can be in the forward or reverse direction, so it can be set in a range from $-(2^{31} - 1)$ to $(2^{31} - 1)$.

To set the encoder coordinate position (x) as the machine coordinate origin (0), set the origin offset memory to -x.

CPOS: Command position
APOS: Coordinate system position (feedback position)



$X = \chi$ + Origin offset memory value

Use the following procedure to set the origin offset.

1. After the power supply is turned ON, use the Turn Sensor ON command (SENS_ON: 23 hex) to turn ON the encoder.
2. Set up the coordinate system for the host controller by using the reference position (CPOS) and align the coordinates for the SERVOPACK and host controller.
3. Turn ON the main circuit power supply for the SERVOPACK and use the SV_ON (31 hex) command to turn ON the servo.
4. Use manual operation to move the machine axis to the machine reference point.

   Now, set the origin in the host controller. With the current machine coordinate system position as APOS and the reference point machine coordinate system position as $APOS_{new}$, we get the following formula.

   New origin offset = Previous origin offset - $(APOS - APOS_{new})$

   Write the new origin offset value to the host controller's internal non-volatile memory or memory with a battery backup.

5. Use this newly set origin offset value to reset the coordinate system.

   Origin offset completes when the coordinate system reset completes.

(2) Storing the Origin Offset in the SERVOPACK

Use SERVOPACK parameter Pn808 to set the origin offset.

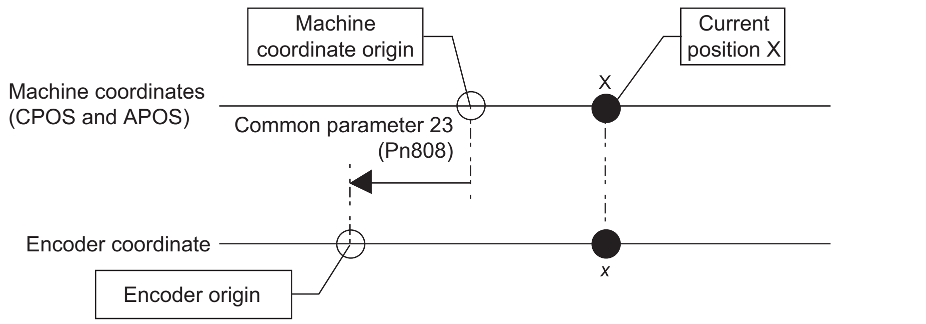
Pn808	Absolute Encoder Origin Offset				Classification
	Setting Range	Setting Unit	Factory Setting	When Enabled	
	-1073741823 to 1073741823	Reference units	0	Immediately*	Setup

* Effective after SENS_ON.

Example

To set the encoder coordinate position (x) as the machine coordinate origin (0), set Pn808 to -x.
Use the Write Servo Parameter command (SVPRM_WR: 41 hex) command to specify the setting.

CPOS: Command position
APOS: Coordinate system position (feedback position)



Use the following procedure to set the origin offset.

1. After the power supply is turned ON, use the Turn Sensor ON command (SENS_ON: 23 hex) to turn ON the encoder.
2. Set up the coordinate system for the host controller by using the reference position (CPOS) and align the coordinates for the SERVOPACK and host controller.
3. Turn ON the main circuit power supply for the SERVOPACK and use the SV_ON (31 hex) command to turn ON the servo.
4. Use manual operation to move the machine axis to the machine reference point.

   Now, set the origin in the host controller. With the current machine coordinate system position as APOS and the reference point machine coordinate system position as $APOS_{new}$, we get the following formula.

   New origin offset (Pn808) = Previous value of Pn808 - (APOS - $APOS_{new}$)

   Use the SVPRM_WR (41 hex) command to write the new origin offset value to SERVOPACK parameter Pn808.

5. Use the SV_OFF (32 hex) command to turn OFF the servo.
6. Use the SENS_OFF (24 hex) command to turn OFF the encoder.
7. Use the SENS_ON (23 hex) command to turn ON the encoder.

   The SERVOPACK will read the position data from the encoder and SVCMD_STAT.POS_RDY will change to 1 when the coordinate system position (APOS) is ready. This enables the origin offset that was set above.
   If an error occurs in the encoder, SVCMD_STAT.POS_RDY will remain 0 even if the SENS_ON (23 hex) command is executed, but CMD_RDY will change to 1. Treat this as a current position detection alarm at the host controller.

8. Use the coordinate system position (APOS) to set the coordinate system on the host controller.

   Origin offset completes when the coordinate system reset completes.

4.5.7 Origin Settings

This section describes the procedure for setting the origin (i.e., the absolute origin or the origin of the machine coordinate system) of an absolute encoder and the procedures for storing the machine coordinate system origin offset.

(1) Calculating the Origin of the Machine Coordinate System

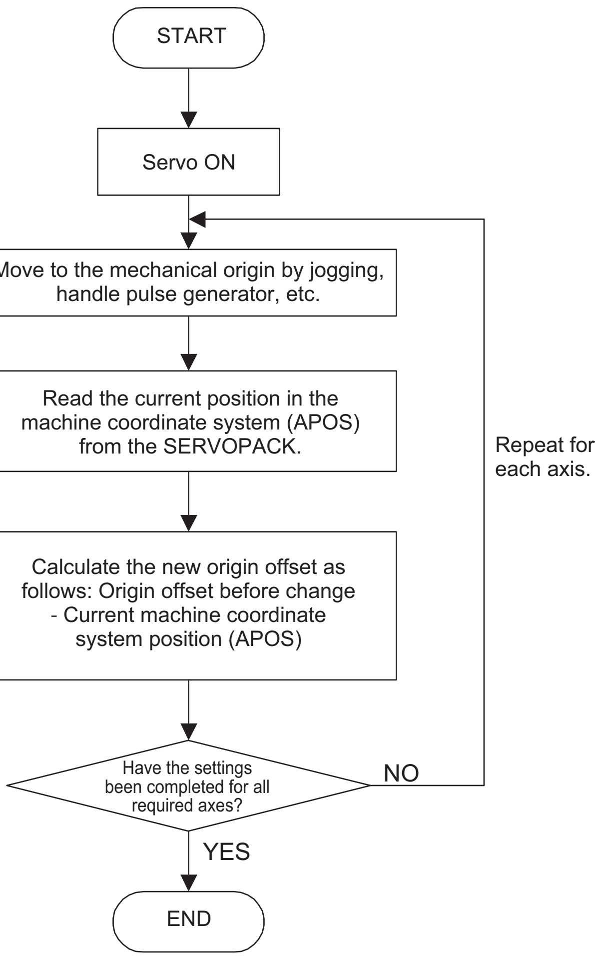
If an absolute encoder is used, the host controller calculates the axis position (i.e., the current position in the machine coordinate system) as follows when the power supply is turned ON:

Current machine coordinate system position^{*1} = Current encoder coordinate system position^{*2} + Origin offset

*1. The current position in the machine coordinate system designates the current position of the machine. The feedback position from the Servomotor is considered to be a positive value.
*2. The current encoder coordinate system position is determined by the following formula: Multiturn data × Number of pulses per encoder rotation + Initial incremental pulses + Incremental pulses.

Example
To set the current machine coordinate system position as the origin (0), set the value of -(current encoder coordinate position from the origin). If the current machine coordinate system position is 10,000 and the origin offset is 100, the value of -(current encoder coordinate position) would be as follows:
Origin offset (100) - Current machine coordinate system position (10,000) = -9,900
You can set this value of -9,900 as the origin offset to set the current position in the machine coordinate system as the machine coordinate origin (0).
For details on how to set the origin offset, refer to *4.5.6 Origin Offset*.

(2) Setting the Origin

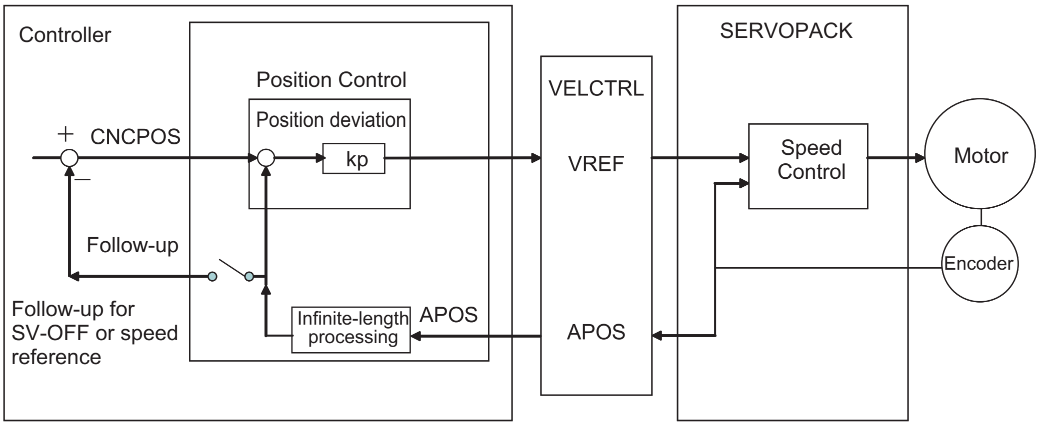


Feed Axis Operation

4

4.6 Speed References When Performing Position Control from the Host Controller

In systems that use MECHATROLINK-III, generally the SERVOPACK performs position control and speed control. In some cases, however, the host controller performs position control while the SERVOPACK performs only speed control. In this case, the host controller has a position control loop and sends speed references (in pulses/s) to the SERVOPACK via MECHATROLINK-III communications.



4.6.1 Communications Cycle and Transmission Cycle Settings

In systems that use the host controller to perform position control and the SERVOPACK to perform speed control, sending speed references to the SERVOPACK and receiving feedback data must be performed with a faster cycle.
Therefore, we recommend a communications cycle of 1 ms or less and a transmission cycle of 250 µs.
Set the transmission cycle in the *t_mcyc* member of the JL100_USER_PAR structure in the MECHATROLINK-III access driver. Set the communications cycle in the COM_TIM parameter to the CONNECT command.

■ Terminology: Communications Cycle

This is the cycle for communications for sending the references that are created by the host controller.

■ Terminology: Transmission Cycle

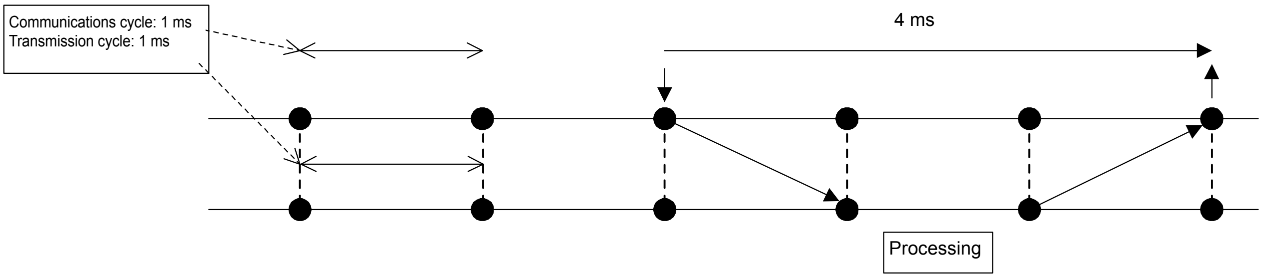
This is the cycle for cyclic communications.

Example

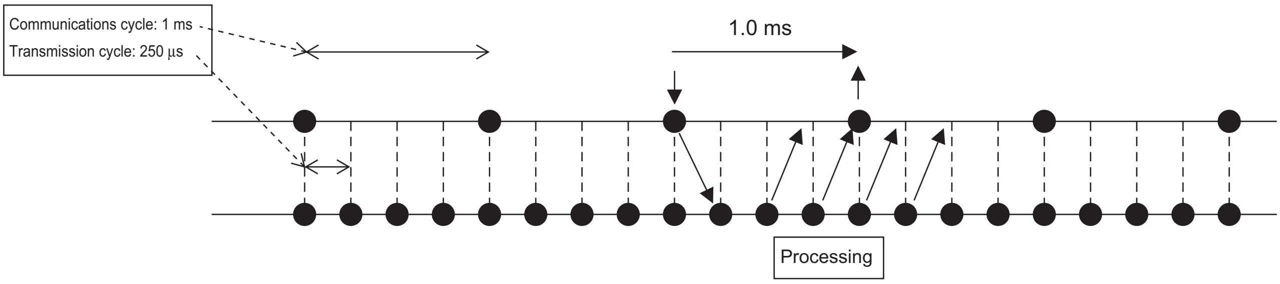
Transmission cycle: 250 µs, Communications cycle: 250 µs → COM_TIM = 1
Transmission cycle: 250 µs, Communications cycle: 500 µs → COM_TIM = 2
Transmission cycle: 250 µs, Communications cycle: 1 ms → COM_TIM = 4

By setting the transmission cycle to the minimum time of 250 µs, you can minimize the delay required by the host controller to retrieve the latest information from the SERVOPACK.

(1) Transmission Cycle: 1 ms, Communications Cycle: 1 ms



(2) Transmission Cycle: 250 μs, Communications Cycle: 1 ms



A cyclic communications interrupt (INT1) is input to the host controller every transmission cycle, so send and receive processing is performed during this interrupt between communications cycles. For all other interrupts, the send and receive processing must be skipped and the cyclic communications interrupt processing must be ended. Do not wake up the send and receive processing every time entering into interrupt handler.

4.6.2 Speed Control Command (VELCTRL: 3C Hex)

Use the VELCTRL (3C hex) command to send speed references from the host controller to the SERVOPACK. The speed reference unit that is used by the Speed Control command is set in common parameters 41 (PnA82) and 42 (PnA84).
The factory settings are for reference units/s to pulses/s.

Field	Description
CMD	Ox3C
CMD_CTRL	–
SVCMD_CTRL	–
SVCMD_IO	–
TFF	Torque Feedforward The torque unit is set in common parameters 47 and 48. Normally, the percent of the rated torque is selected.
VREF	Speed Reference The speed unit is set in common parameters 41 and 42. Normally, reference units/s is selected.
ACCR	Acceleration Rate When the host controller is used to perform position control, set the maximum acceleration rate (FFFF FFFF hex).
DECR	Deceleration Rate When the host controller is used to perform position control, set the maximum deceleration rate (FFFF FFFF hex).
TLIM	Torque Limit The torque unit is set in common parameters 47 and 48. Normally, FFFF FFFF hex (i.e., no torque limit) is set.

Usable Phase	2 or 3
Processing Time	Within the communications cycle

Byte	VELCTRL	
	Command	Response
0	3C hex	3C hex
1	WDT	RWDT
2	CMD_CTRL	CMD_STAT
3		
4	SVCMD_CTRL	SVCMD_STAT
5		
6		
7		
8	SVCMD_IO	SVCMD_IO
9		
10		
11		
12	TFF	CPRM_SEL_MON1
13		
14		
15		
16	VREF	CPRM_SEL_MON2
17		
18		
19		
20	ACCR	MONITOR1
21		
22		
23		
24	DECR	MONITOR2
25		
26		
27		
28	TLIM	MONITOR3
29		
30		
31		

Note 1. The VELCTRL (3C hex) command does not accept speed feedforward (VFF) references. Create a speed reference that includes the speed feedforward in the host controller.
2. You can select the gain (SVCMD_IO.G-SEL) with the VELCTRL (3C hex) command as well.
However, the SERVOPACK's position loop gain (kp) does not affect motor behavior. Prepare the position loop gain (kp) at the host controller and select the position loop gain to match the gain selection (SVCMD_IO.G-SEL).

4.6.3 Precautions when Performing Position Control from the Host Controller

When the host controller is used to perform position control, speed references are sent to the SERVOPACK with the VELCTRL (3C hex) command. When doing so, observe the following precautions.

(1) Servo ON Command (SV_ON: 31 Hex)

For feed axes, the SV_ON (31 hex) command is sent to recover from an emergency stop or during the startup sequence after the power supply is turned ON. When the SV_ON (31 hex) command is sent as a CNCPOS position reference from the host controller, the CNCPOS and SERVOPACK feedback position (APOS) must match.

Confirm that execution of the SV_ON (31 hex) command was completed by checking that SVCMD_STAT.SV_ON is 1, then start to update the reference position in the reference control section.

(2) Servo OFF Command (SV_OFF: 32 Hex)

The SV_OFF (32 hex) command must be sent when position control is being performed by the host controller. The position control section of the host controller is always in operation, so send the SV_OFF (32 hex) command for one communications cycle only and then send the VELCTRL (3C hex) command during the next communications cycle.
Check that SVCMD_STAT.SV_ON is 0 to confirm that execution of the SV_OFF (32 hex) command has been completed. Set the speed reference (VREF) to 0 when the servo is turned OFF. Also, read the feedback position (APOS) and follow up to ensure that the position deviation in the position control section is 0.

■ Terminology: Follow-up

Follow-up is the process of updating the position reference CNCPOS so that the feedback position (APOS) is CNCPOS and the position deviation ERROR is 0 (speed reference VREF = 0) for each position control cycle when the reference position is set as CNCPOS in the host controller's position control section.

Follow-up eliminates any sudden axis movement caused by accumulated position deviation when the SV_ON
(31 hex) command is next sent.

(3) Alarm Processing

Perform alarm and warning processing in the same way as for position control with a SERVOPACK.
Refer to *Chapter 7 Alarm and Warning Processing* for details on alarms.

4.7 Homing

Homing is the act of positioning to move an axis to the machine coordinate origin.
Generally, homing is performed for all feed axes simultaneously, but in some cases homing may be performed one axis at a time to avoid interference with other axes or the workpiece. Choose whether to perform homing for all axes simultaneously or for individual axes depending on the load configuration requirements.
There are two types of homing depending on the servomotor encoder used, as described below.

■ Absolute Encoder Used as an Absolute Encoder (Factory Setting)

In this case, homing refers to positioning to move to the origin. Homing is performed from the host controller for all axes or individual axes one at a time with the origin as the target position.

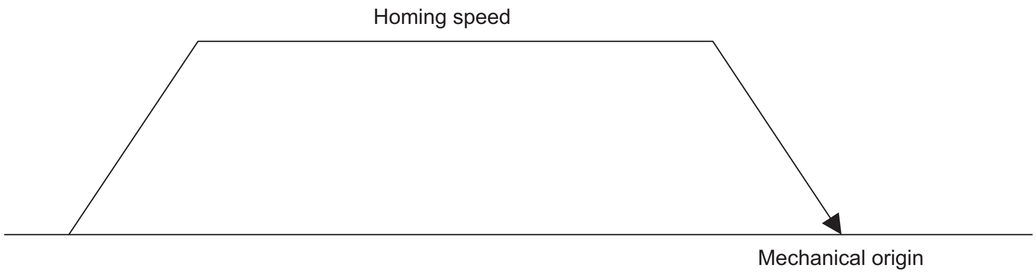
In the SERVOPACK, we recommend that you perform absolute position detection as described in *4.5 Absolute Position Detection* if the servomotor has an absolute encoder that is used as an absolute encoder (i.e., the factory setting).
Absolute position detection enables the recognition of the absolute position in machine coordinates. This eliminates the need to perform homing immediately after the power supply is turned ON.

■ Absolute Encoder Used as an Incremental Encoder (Parameter Pn002.1 = 1)

For incremental encoders, the homing method that is described in *4.7.2 Homing Method When Using an Absolute Encoder as an Incremental Encoder* is used to return to the origin.
Create an operation sequence so that the homing sequence is executed according to the load configuration from the host controller. The homing sequence must always be performed immediately after the power supply is turned ON.

4.7.1 Homing Method (Absolute Encoder as an Absolute Encoder)

If the servomotor's absolute encoder is used as an absolute encoder (i.e., if parameter Pn002.1 is set to 0), the current position data is saved after the origin has been set, even if the power supply to the SERVOPACK is turned OFF and ON again. Therefore, no homing is necessary. However, homing is required when setting up the machine or attaching a jig to the machine.
In this case, homing performs positioning to the mechanical origin. Perform this positioning to the mechanical origin as follows:



4.7.2 Homing Method When Using an Absolute Encoder as an Incremental Encoder

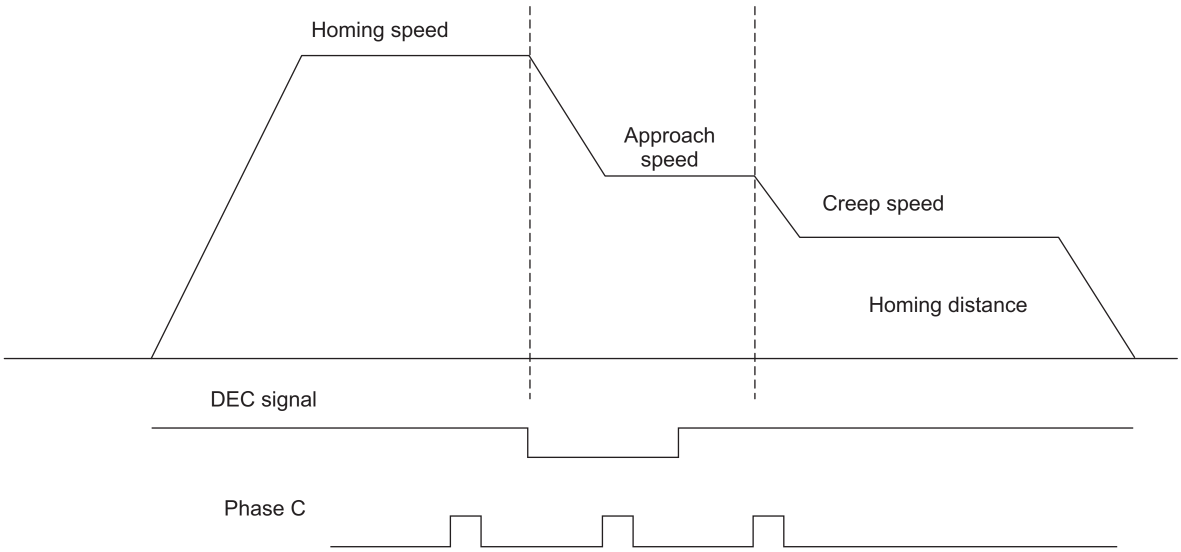
If the servomotor's absolute encoder is used as an incremental encoder (i.e., if parameter Pn002.1 is set to 1), the coordinate system and current position data are lost if the power supply to the SERVOPACK is turned OFF and ON again. Therefore, homing must be performed when the power supply is turned ON again to establish a new coordinate system.
Select from the following homing methods as appropriate for your particular load configuration.

- Deceleration dog + Phase-C pulse
- Deceleration dog + Zero signal (a signal from EXT1 to EXT3)
- Phase-C pulse
- Zero signal (EXT1 to EXT3)
- OT & phase-C pulse

(1) Deceleration Dog + Phase-C Pulse

The feed axis starts to move at the homing speed in the specified direction.
When the rising edge of the deceleration dog signal (DEC signal) is detected, the axis will decelerate to the approach speed.
When the first phase-C pulse is detected after passing the DEC signal at the approach speed, the speed will be reduced to the creep speed and positioning is performed only for the homing distance.
When positioning has been completed, the machine coordinate system is established with the position at the end of positioning as the origin.
Make the following settings to use the DEC signal.

Bit 1 in common parameter 93 (Pn826) = 1 (Enable DEC signal.)



Step 1:
Motion is started at the homing speed in the specified direction. The host controller sequentially updates and calculates the target position (TPOS) every communications cycle and sends the INTERPOLATE (34 hex) command so that the axis moves at the homing speed.
INTERPOLATE command = 34 hex
TPOS = Target position (Reference is sent so that the axis moves at the homing speed.)

Step 2:
On the falling edge of the DEC signal, the speed changes from the homing speed to the approach speed.
INTERPOLATE (34 hex) command: SVCMD_IO.DEC changes from 1 to 0 (falling edge).

Step 3:
Monitoring is performed for the rising edge of the DEC signal while moving the axis at the approach speed.
INTERPOLATE (34 hex) command: SVCMD_IO.DEC changes from 0 to 1 (rising edge).

Step 4:
After the DEC signal changes (i.e., after the deceleration dog passes), a phase-C latch request is made. The latch position (LPOS1) is specified for one of the SMON1 to SMON3 monitors to read the phase-C latch position at the same time.
The INTERPOLATE (34 hex) command is sent as follows:
- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,0) (Selects phase C.)
- SVCMD_CTRL.LT_REQ1 (bit 8) = 1 (Requests a phase-C latch.)
- SVCMD_CTRL.SMON1 = 3 (Select LPOS1 (set for SMON1, SMON2, or SMON3).)

Step 5:
Monitoring is performed for SVCMD_STAT.L_CMP1 (bit 8) to change to 1 to detect the completion of the phase-C latch operation while feeding the axis at the approach speed.

Step 6:
When the latch operation is completed, the latch request is turned OFF and the latch position (LPOS1) is read from the specified monitor.
The homing distance is added to the read position to find the origin, then positioning is performed at the creep speed for the remaining distance.

The INTERPOLATE (34 hex) command is sent as follows:

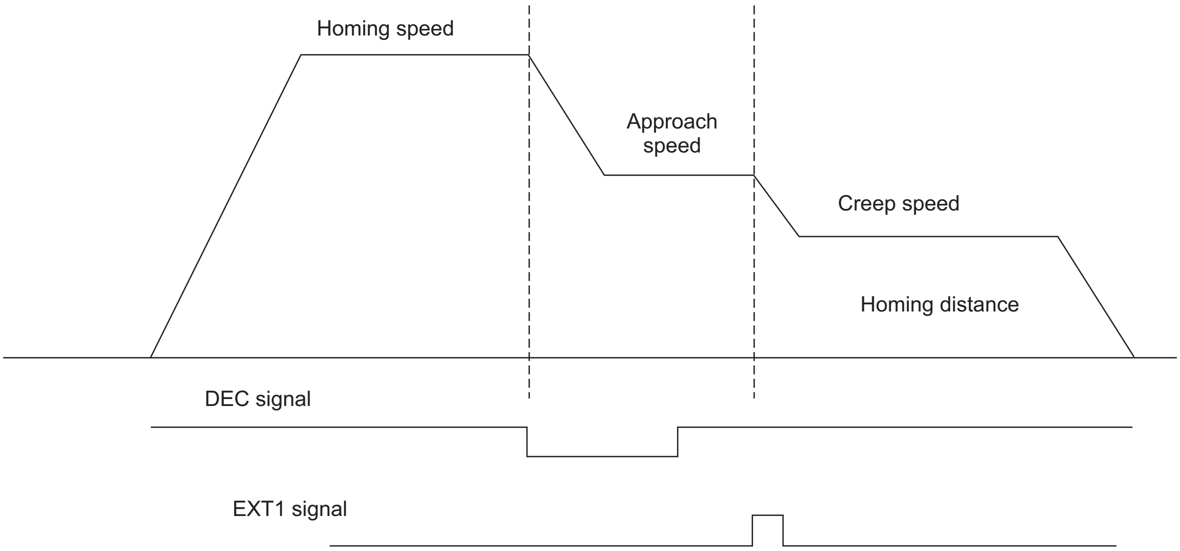
- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,0) (Selects phase C.)
- SVCMD_CTRL.LT_REQ1 = 0 (Turns OFF latch request.)

Step 7:
Execution of homing is completed when positioning is completed. Set the host controller's machine coordinate system with the origin as the reference position (CPOS) at this time.

(2) Deceleration Dog + Zero Signal (EXT1 to EXT3)

The feed axis starts to move at the homing speed in the specified direction.
When the rising edge of the deceleration dog signal (DEC signal) is detected, the axis will decelerate to the approach speed. When the first zero signal is detected after passing the DEC signal at the approach speed, the speed will be reduced to the creep speed and positioning is performed only for the homing distance.
When positioning has been completed, the machine coordinate system is established with the position at the end of positioning as the origin.
Make the following settings to use the DEC signal and external input signals (EXT1 to EXT3).

Common parameter 93 (Pn826) Bit 1 = 1	(Enables the DEC signal.)
Bit 4 = 1	(Enables the EXT1 signal.)
Bit 5 = 1	(Enables the EXT2 signal.)
Bit 6 = 1	(Enables the EXT3 signal.)



Step 1:
Motion is started at the homing speed in the specified direction. The host controller sequentially updates the target position (TPOS) every communications cycle and sends the INTERPOLATE (34 hex) command so that the axis moves at the homing speed.
INTERPOLATE command = 34 hex
TPOS = Target position (Reference is sent so that the axis moves at the homing speed.)

Step 2:
On the falling edge of the DEC signal, the speed changes from the homing speed to the approach speed.
INTERPOLATE (34 hex) command: SVCMD_IO.DEC changes from 1 to 0 (falling edge).

Step 3:
Monitoring is performed for the rising edge of the DEC signal while moving the axis at the approach speed.
INTERPOLATE (34 hex) command: SVCMD_IO.DEC changes from 0 to 1 (rising edge).

Step 4:
After the DEC signal changes (i.e., after the deceleration dog passes), a zero signal (EXT1, EXT2, or EXT3) latch request is made. The latch position (LPOS1) is specified for one of the SMON1 to SMON3 monitors to read the position at this time.
In the following example, external input signal 1 (EXT1) is used as the zero signal and monitor 1 is used as the latch position (LPOS) monitor.

The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,1) (Selects external input signal 1.)
- SVCMD_CTRL.LT_REQ1 (bit 8) = 1 (Requests a phase-C latch.)
- SVCMD_CTRL.SMON1 = 3 (Select LPOS1 (set for SMON1, SMON2, or SMON3).)

Step 5:
Monitoring is performed for SVCMD_STAT.L_CMP1 (bit 8) to change to 1 to detect the completion of the phase-C latch operation while feeding the axis at the approach speed.

Step 6:
When the latch operation is completed, the latch request is turned OFF and the latch position (LPOS1) is read from the specified monitor.
The homing distance is added to the read position to find the origin, then positioning is performed at the creep speed for the remaining distance.
The INTERPOLATE (34 hex) command is sent as follows:

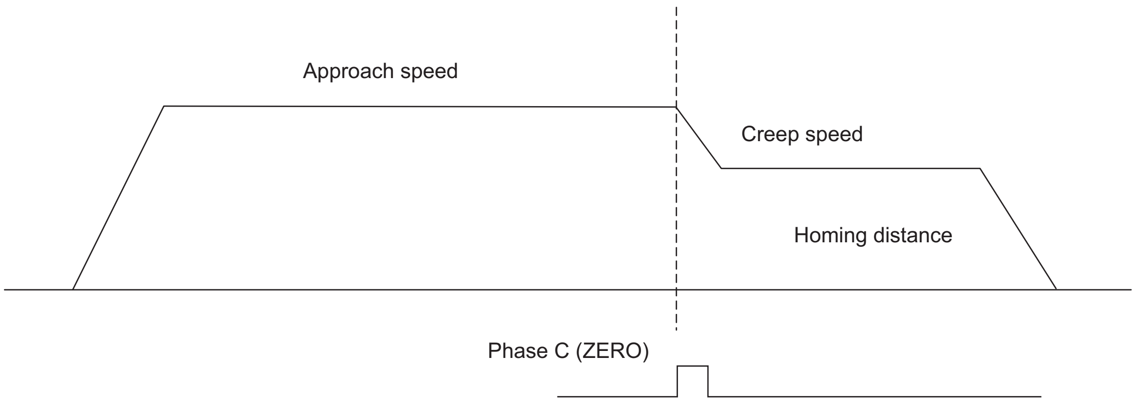
- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,1) (Selects external input signal 1.)
- SVCMD_CTRL.LT_REQ1 = 0 (Turns OFF latch request.)

Step 7:
Execution of homing is completed when positioning is completed. Set the host controller's machine coordinate system with the origin as the reference position (CPOS) at this time.

(3) Phase-C Pulse

The feed axis starts to move at the approach speed in the specified direction. When the rising edge of the phase-C signal is detected, the speed is reduced to the creep speed and positioning is performed for the homing distance.

When positioning has been completed, the machine coordinate system is established with the position at the end of positioning as the origin.



Step 1:
Motion is started at the homing speed in the specified direction. The host controller sequentially updates the target position (TPOS) every communications cycle and sends the INTERPOLATE (34 hex) command so that the axis moves at the approach speed. Also, a phase-C latch is requested.
The latch position (LPOS1) is specified for one of the SMON1 to SMON3 monitors to read the phase-C latch position.
In the following example, monitor 1 is used as the latch position (LPOS) monitor.
The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,0) (Selects phase C.)
- SVCMD_CTRL.LT_REQ1 (bit 8) = 1 (Requests a latch.)
- SVCMD_CTRL.SMON1 = 3 (Selects LPOS1 (set for SMON1, SMON2, or SMON3).)

Step 2:
Monitoring is performed for SVCMD_STAT.L_CMP1 (bit 8) to change to 1 to detect the completion of the latch operation while feeding the axis at the approach speed.

Step 3:
When the latch operation is completed, the latch request is turned OFF and the latch position (LPOS1) is read from the specified monitor.

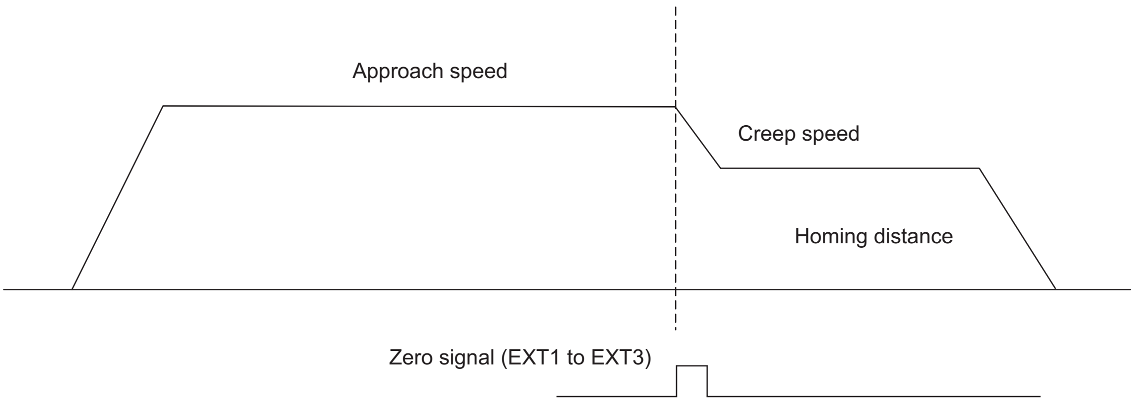
The homing distance is added to the read position to find the origin, then positioning is performed at the creep speed for the remaining distance.
The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,0) (Selects phase C.)
- SVCMD_CTRL.LT_REQ1 = 0 (Turns OFF latch request.)

Step 4:
Execution of homing is completed when positioning is completed. Set the host controller's machine coordinate system with the origin as the reference position (CPOS) at this time.

(4) Zero signal (EXT1 to EXT3)

The feed axis starts to move at the approach speed in the specified direction.
When the rising edge of the zero signal (EXT1, EXT2, or EXT3) is detected, the speed is reduced to the creep speed and positioning is performed for the homing distance.
When positioning has been completed, the machine coordinate system is established with the position at the end of positioning as the origin.



Step 1:
Motion is started at the homing speed in the specified direction. The host controller sequentially updates the target position (TPOS) every communications cycle and sends the INTERPOLATE (34 hex) command so that the axis moves at the approach speed.
Also, a zero signal latch is requested.
The latch position (LPOS1) is specified for one of the SMON1 to SMON3 monitors to read the zero signal latch position. One of the SERVOPACK's external input signals (EXT1 to EXT3) is used as the zero signal for the latch.
In the following example, external input signal 1 (EXT1) is used as the zero signal and monitor 1 is used as the latch position (LPOS) monitor.
The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,1) (Selects external input signal 1.)
- SVCMD_CTRL.LT_REQ1 (bit 8) = 1 (Requests a latch.)
- SVCMD_CTRL.SMON1 = 3 (Selects LPOS1 (set for SMON1, SMON2, or SMON3).)

Step 2:
Monitoring is performed for SVCMD_STAT.L_CMP1 (bit 8) to change to 1 to detect the completion of the latch operation while feeding the axis at the approach speed.

Step 3:
When the latch operation is completed, the latch request is turned OFF and the latch position (LPOS1) is read from the specified monitor.
The homing distance is added to the read position to find the origin, then positioning is performed at the creep speed for the remaining distance.
The INTERPOLATE (34 hex) command is sent as follows:

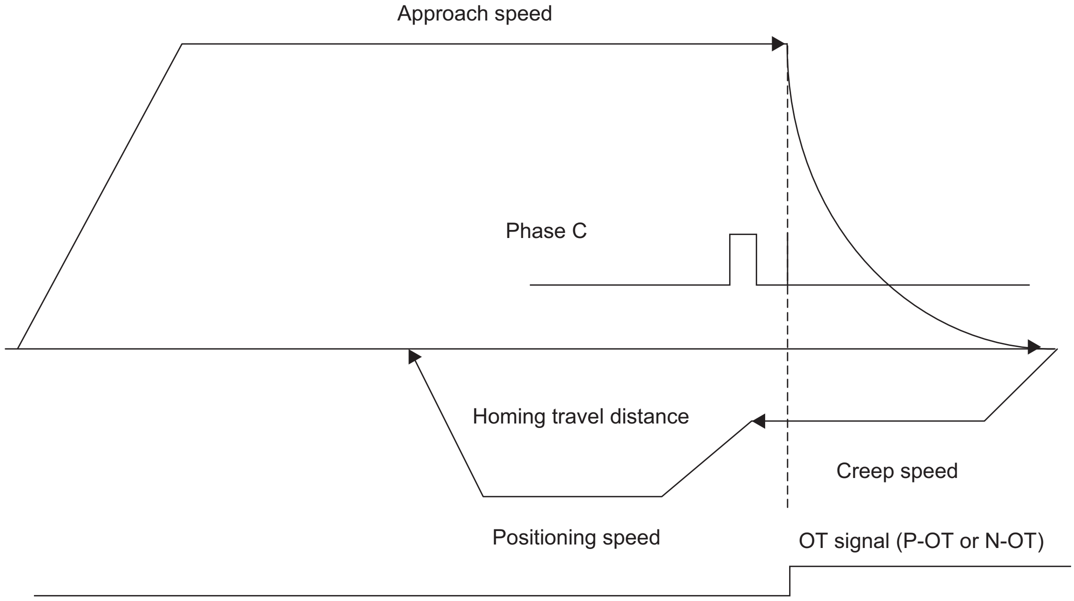
- SVCMD_CTRL.LT_SEL1 (bit 10, bit 11) = (0,1) (Selects external input signal 1.)
- SVCMD_CTRL.LT_REQ1 = 0 (Turns OFF latch request.)

Step 4:
Execution of homing is completed when positioning is completed. Set the host controller's machine coordinate system with the origin as the reference position (CPOS) at this time.

(5) OT & Phase-C Pulse

The feed axis starts to move at the approach speed in the specified direction.
When the rising edge of the overtravel signal (P-OT or N-OT) is detected, the travel direction is reversed and the axis moves at the creep speed. When the first phase-C pulse is detected after passing the overtravel signal (P-OT or N-OT), positioning is performed to move the axis the homing distance at the positioning speed.
When positioning has been completed, the machine coordinate system is established with the position at the end of positioning as the origin.
Make the following settings to use the overtravel signal (P-OT or N-OT).

Parameter Pn001.1 = 1 (Changes the motor stop method from deceleration to a stop to zero clamp during the overtravel operation.)
Parameter Pn406 (Sets the torque to decelerate to a stop during the overtravel operation.)
Parameter Pn50A.3 = 1 (Inputs the Forward Run Prohibited signal (P-OT) from CN1-7.)
Pn50B.0 = 1 (Inputs the Forward Run Prohibited signal (P-OT) from CN1-8.)
Bit 2 in common parameter 93 (Pn826) = 1 (Enable P-OT signal.)
Bit 3 in common parameter 93 (Pn826) = 1 (Enable N-OT signal.)



Step 1:
Motion is started at the approach speed in the specified direction. The host controller sequentially updates the target position (TPOS) every communications cycle and sends the INTERPOLATE (34 hex) command so that the axis moves at the approach speed.
INTERPOLATE command = 34 hex
TPOS = Target position (Reference is sent so that the axis moves at the approach speed.)

Step 2:
On the rising edge of the overtravel signal (P-OT or N-OT) at the approach speed, the axis stops at the torque specified in parameter Pn406 and positioning is performed from that point.

Step 3:
The movement direction of the axis is reversed and the axis moves at creep speed.
The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_IO.P-OT = 0 to 1 (rising edge of P-OT signal)
- SVCMD_IO.N-OT = 0 to 1 (rising edge of N-OT signal)
- TPOS = Target position (Reference is sent so that the axis moves at the creep speed.)

Step 4:
Monitoring is performed for the rising edge of the overtravel signal (P-OT or N-OT) while moving the axis at the creep speed.
The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_IO.P-OT = 1 to 0 (falling edge of P-OT signal)
- SVCMD_IO.N-OT = 1 to 0 (falling edge of N-OT signal)

Step 5:
After the overtravel signal (P-OT or N-OT) changes (after passing the overtravel signal), a phase-C latch is requested. The latch position (LPOS1) is specified for one of the SMON1 to SMON3 monitors to read the phase-C latch position at the same time.
The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_CTRL.LT_SEL1 (bits 10 and 11) = (0,0) (Selects phase C.)
- SVCMD_CTRL.LT_REQ1 (bit 8) = 1 (Requests a phase-C latch.)
- SVCMD_CTRL.SMON1 = 3 (Selects LPOS1 (set for SMON1, SMON2, or SMON3).)

Step 6:
Monitoring is performed for in SVCMD_STAT.L_CMP1 (bit 8) to change to 1 to detect the completion of the phase-C latch operation while feeding the axis at the creep speed.

Step 7:
When the latch operation is completed, the latch request is turned OFF and the latch position (LPOS1) is read from the specified monitor.
The homing distance is added to the read position to find the origin, then positioning is performed at the positioning speed for the remaining distance.
The INTERPOLATE (34 hex) command is sent as follows:

- SVCMD_CTRL.LT_SEL1 (bits 10 and 11) = (0,0) (Selects phase C.)
- SVCMD_CTRL.LT_REQ1 = 0 (Turns OFF latch request.)

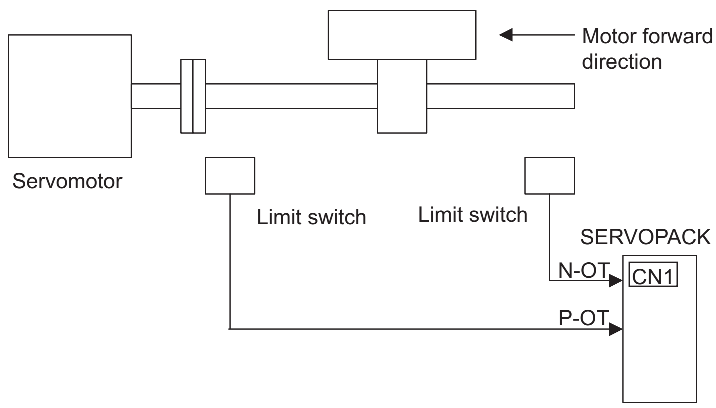
Step 8:
Execution of homing is completed when positioning is completed. Set the host controller’s machine coordinate system with the origin as the reference position (CPOS) at this time.

4.8 Overtravel Function

Overtravel forces the machine to stop when any moving part of the machine exceeds the safe range of movement by forcibly stopping the servomotor with a limit switch signal input.
Overtravel is not always required for rotational applications such as a rotary table or magazines, and in those cases the overtravel input signals do not need to be wired.
The overtravel function is not affected by the set value of Pn01E.0 (Motor Type/Application Selection Setting).
There are two ways to implement overtravel protection: with the overtravel function built into the SERVOPACK or by implementing the overtravel function at the host controller.

4.8.1 Using the SERVOPACK Overtravel Function

For linear drive applications, connect the limit switches to the P-OT and N-OT pins of CN1 as shown in the following figure to prevent damage to the machine.
Use an NC contact to prevent accidents in case there are any problems with the limit switch contacts or wiring.

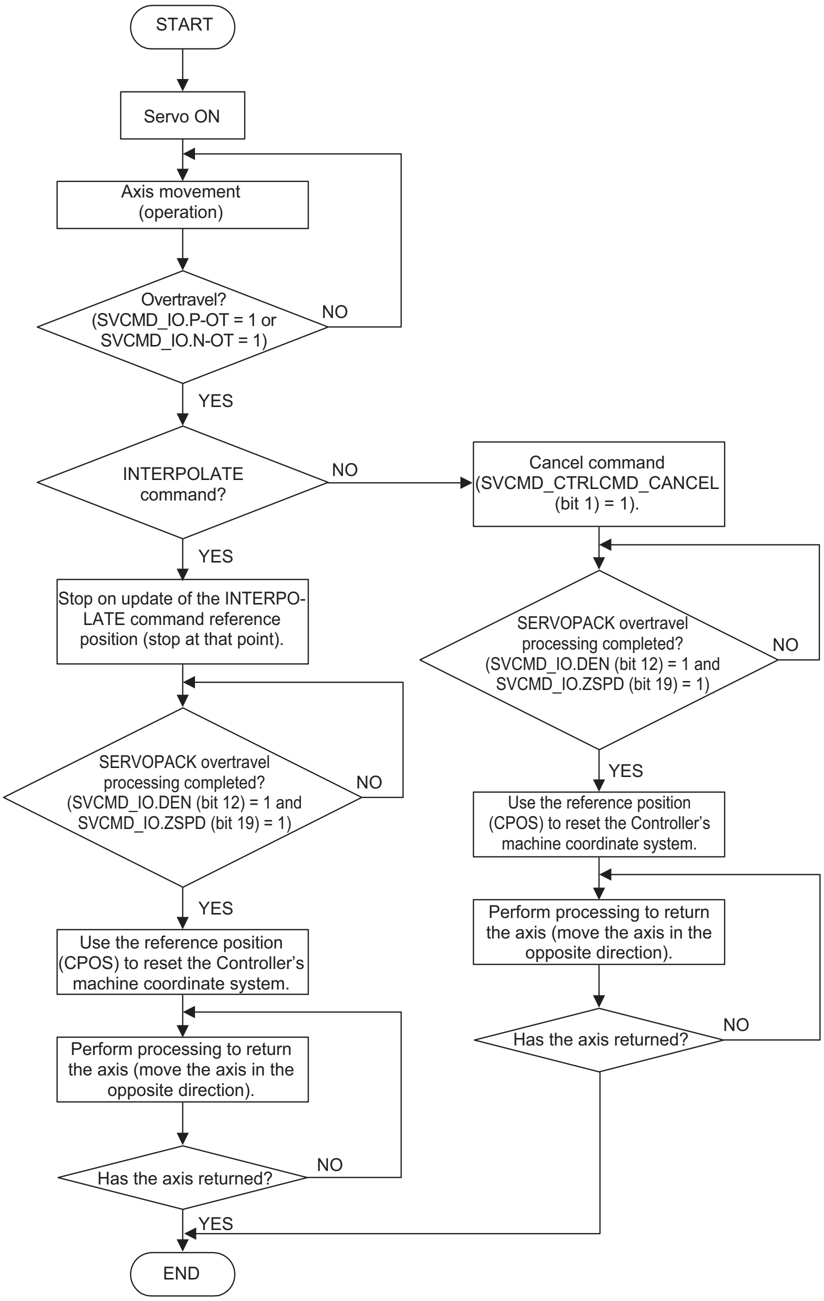


■ Warnings for External Forces Applied to Servomotor Axes during Overtravel

Vertical Axes:
When overtravel occurs, the SERVOPACK's /BK signal turns ON (break released). This may cause moving parts (e.g., workpieces) to fall from vertical axes (including inclined axes). To prevent moving parts from falling, set the zero clamp state (Pn001.1 = 1) after the servomotor stops.

Other Axes Subject to External Forces:
When overtravel occurs, the axis becomes base blocked after it stops. In some cases, the servomotor may be pushed back by external forces from the load axis. To prevent this from occurring, set the zero clamp state (Pn001.1 = 1) after the servomotor stops.

Perform processing according to the following flowchart to use the overtravel function.



(1) Signal Settings

Type	Signal Name	Setting	Meaning
Input	P-OT	ON	Forward run allowed (normal operation)
		OFF	Forward run prohibited (forward overtravel)
	N-OT	ON	Reverse run allowed (normal operation)
		OFF	Reverse run prohibited (reverse overtravel)

Even during overtravel, command input for reverse operation is allowed.

■ Connector Pin Numbers for SERVOPACK for One Axis

P-OT	CN1-6
N-OT	CN1-7

■ Connector Pin Numbers for SERVOPACK for Two Axes

	Axis 1	Axis 2
P-OT	CN1-8	CN1-10
N-OT	CN1-9	CN1-11

(2) Overtravel Function Selection

Parameters Pn50A and Pn50B can be set to enable or disable the overtravel function.
If the overtravel function is disabled, no wiring for overtravel input signals is required.

Parameter		Meaning	When Enabled	Classification
Pn50A	n.1□□□ (factory setting)	Inputs the Forward Run Prohibited signal (P-OT) from CN1-6.*1	After restart	Setup
	n.8□□□	Disables the Forward Run Prohibited signal and enables forward operation at all times.		
Pn50B	n.□□□2 (factory setting)	Inputs the Reverse Run Prohibited signal (N-OT) from CN1-7.*2		
	n.□□□8	Disables the Reverse Run Prohibited signal and enables reverse operation at all times.		
Pn517	n.□□□0	Enables the overtravel function.	Immediately	Setup
	n.□□□1	Disables forward overtravel only (disables the Forward Run Prohibited signal and enables forward operation at all times).		
	n.□□□	Disables reverse overtravel only (disables the Reverse Run Prohibited signal and enables reverse operation at all times).		
	n.□□□	Disables the overtravel function in both directions.		

*1. For a SERVOPACK for two axes: CN1-7 (P-OT1), CN1-9 (P-OT2)
*2. For a SERVOPACK for two axes: CN1-8 (N-OT1), CN1-10 (P-OT2)

(3) Servomotor Stopping Method Selection When Overtravel Is Used

There are three servomotor stopping methods when overtravel occurs.

- Dynamic brake (DB): The servomotor comes to an immediate stop by short-circuiting the electrical circuits. If a spindle motor is used, the motor coasts to a stop instead of stopping immediately.
- Decelerate to a stop: Decelerates to a stop by using the emergency stop torque. (This method is recommended.)
- Coasting to a stop: Stops naturally by using the friction of the rotating motor.

There are two possible motor states after the servomotor stops.

- Coast status: The servomotor is stopped naturally due to the rotational friction.
- Zero clamp status: A position loop is formed by using the position reference zero. (This method is recommended.)

The stopping method that is set in Pn001 is used when overtravel occurs.
The factory setting of Pn001 depends on the model.
Refer to *8.2.2 Overtravel* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on overtravel.

<table>
<tr><th colspan="2">Parameter</th><th>Motor Stop Method</th><th>Status after Motor Stops</th><th>When Enabled</th><th>Classification</th></tr>
<tr><td rowspan="5">Pn001</td><td>n.□□00</td><td rowspan="2">DB</td><td rowspan="3">Coasting</td><td rowspan="5">After restart</td><td rowspan="5">Setup</td></tr>
<tr><td>n.□□01</td></tr>
<tr><td>n.□□02</td><td>Coasting</td></tr>
<tr><td>n.□□1□</td><td rowspan="2">Deceleration</td><td>Zero clamp</td></tr>
<tr><td>n.□□2□</td><td>Coasting</td></tr>
</table>

Note 1. The motor cannot decelerate to a stop during torque control. The servomotor stops by dynamic braking or coasting to a stop, depending on the setting of Pn001.0, and then enters the coasting state.
Refer to *8.2.4 Stopping Servomotor after SV_OFF Command or Alarm Occurrence* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on the stop methods that are used when the servo is OFF or an alarm occurs.
2. Coasting to a stop is always performed regardless of the set value of Pn001 if a spindle motor is used.

■ Decelerating to a Stop

You can set the emergency stop torque in parameter Pn406. Set the emergency stop torque based on the axis load configuration.

<table>
<tr><td rowspan="3">Pn406*</td><td colspan="5">Emergency Stop Torque</td></tr>
<tr><td>Setting Range</td><td>Setting Unit</td><td>Factory Setting</td><td>When Enabled</td><td>Classification</td></tr>
<tr><td>0 to 800%</td><td>1%</td><td>800%</td><td>Immediately</td><td>Setup</td></tr>
</table>

* If a spindle motor is used, a stop will be performed using the torque values that are set for Pn430 and Pn431.

- The setting unit is a percentage of the rated torque.
- The factory setting is 800%. This value is large enough to ensure that the servomotor always operates at the maximum torque possible.
  However, the actual effective maximum value of the emergency stop torque is limited by the maximum torque of the servomotor.

(4) Confirming the Overtravel Status

An alarm does not occur when overtravel occurs. Therefore, you must use one of the following methods to monitor for overtravel.

- Constantly monitor for SVCMD_IO.P-OT (bit 2) and SVCMD_IO.N-OT (bit 3) to change from 0 to 1.
- If Pn00D.3 is set to 1, an Overtravel Warning (A.9A0) will occur if overtravel is detected. You can see if a warning has occurred by checking if CMD_STAT.D_WAR (bit 1) changes from 0 to 1.
  Refer to *8.2.2 (4) Overtravel Warning Function* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on the overtravel warning function.

(5) Handling Overtravel

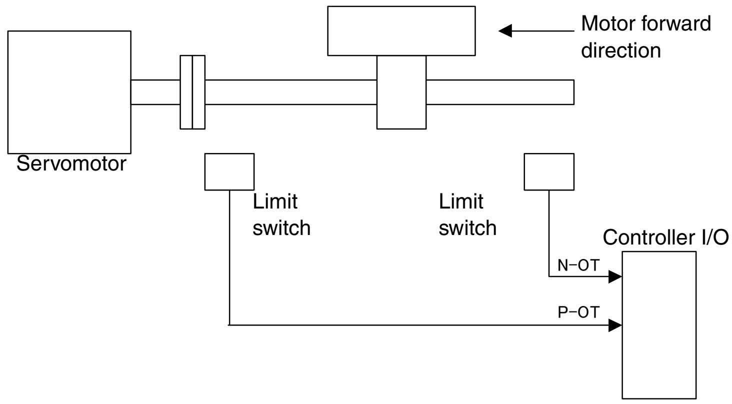
When an axis enters the overtravel state, the axis will decelerate to a stop and enter the zero clamp state. At the host controller, the position reference for the INTERPOLATE (34 hex) command stops being updated and the axis stops moving.

(6) Clearing the Overtravel Status

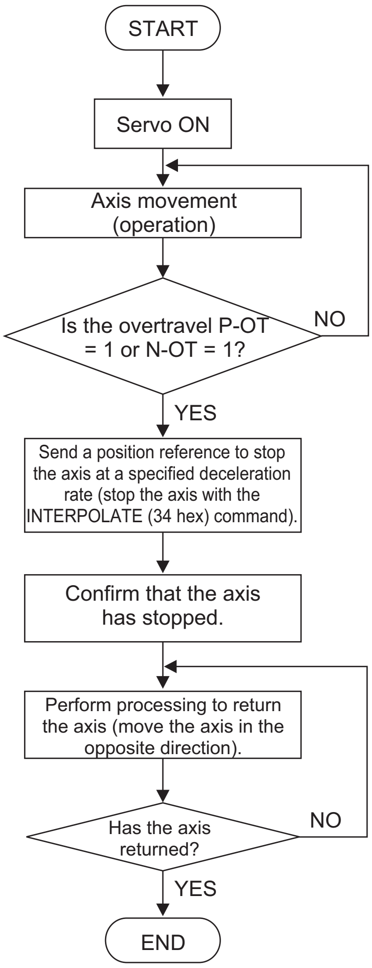
To clear the overtravel status of an axis, you must move the axis back in the opposite direction from which the overtravel occurred.
Perform this return operation for each axis individually. Send the INTERPOLATE (34 hex) command to move the axis for the return operation with the current reference position (CPOS) as the current stop position.
When this return operation is performed and the overtravel status is cleared (i.e., when SVCMD_IO.P-OT is 0 or SVCMD_IO.N-OT is 0), execution of the return operation has been completed.

4.8.2 Implementing the Overtravel Function on the Host Controller

For linear drive applications, connect the limit switches to the I/O inputs on the host controller as shown in the following figure to prevent damage to the machine.
Use an NC contact to prevent accidents in case there are any problems with the limit switch contacts or wiring.



Perform the processes according to the following flowchart to implement the overtravel function on the host controller.



(1) Confirming Overtravel Status

The I/O signal inputs of the host controller must be monitored constantly to determine if overtravel has occurred. Use a PLC ladder program for monitoring or perform the monitoring in the processing cycle (scanning cycle) of the host controller.

(2) Handling Overtravel

When overtravel occurs, create a reference position for the INTERPOLATE (34 hex) command to decelerate the axis to a stop from the host controller. Set the deceleration rate so that the maximum torque of the servomotor is not exceeded.

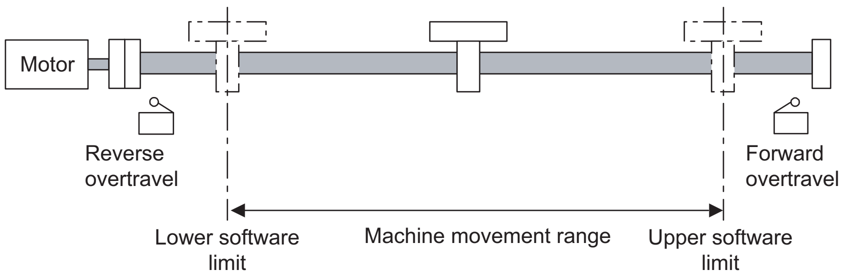
(3) Clearing the Overtravel Status

To clear the overtravel status of an axis, you must move the axis back in the opposite direction from which the overtravel occurred. Perform this return operation for each axis individually. Send the INTERPOLATE (34 hex) command from the host controller to move the axis for the return operation using the current coordinate system position (APOS).
When this return operation is performed and the overtravel status is cleared (i.e., when P-OT = 0 or N-OT is 0), execution of the return operation has been completed.

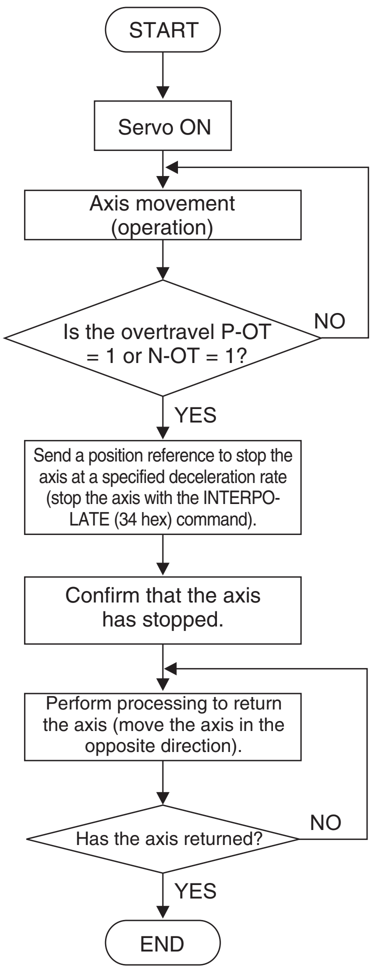
IMPORTANT	When implementing the overtravel function on the host controller, be aware of the scan time of the overtravel signal (the signal monitor time interval) or the time until distribution of the deceleration reference is completed, the deceleration rate of the axis, and the distance to the stroke end of the machine from the limit switches. If the axis begins to overtravel at its maximum speed, the axis may be unable to stop until it collides with the stroke end of the machine.

4.9 Software Limits

Software limits are used to set upper and lower limits for the range of machine movement so that the host controller can constantly monitor the operating range of the machine. Software limits can be used to help prevent machine runaway or damage due to incorrect operation or errors in a motion program.
To implement software limits, the reference and feedback positions must constantly be monitored from the host controller. Monitor the reference position (the position reference (CPOS) to the SERVOPACK) and check whether the upper and lower software limits are exceeded to ensure safe operation of the machine.



Perform the processes according to the following flowchart to implement the software limits on the host controller.



(1) Reference Position Confirmation

Compare the position reference value that is sent to the SERVOPACK and the upper and lower software limits to make sure the upper and lower software limit values are not exceeded.
Monitor the position reference value regardless of the operation status of the axis.
However, if the origin has not been set, the mechanical origin will not yet be established. Do not monitor the position reference value in this case.

(2) Stopping an Axis When a Software Limit Is Exceeded

If the position reference value exceeds the upper or lower software limit, decelerate the axis to a stop immediately.
Make sure that the deceleration rate when this occurs can be set by the host controller in advance.

(3) Clearing the Software Limit Status

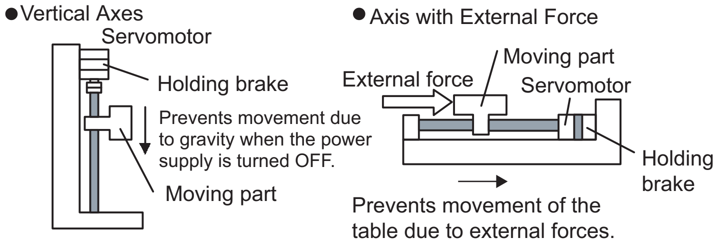
To clear the software limit status of an axis, you must move the axis back in the opposite direction from which the software limit was exceeded. Perform this return operation for each axis individually. Send the INTERPOLATE (34 hex) command from the host controller to move the axis for the return operation using the current coordinate system position (APOS).
When this return operation is performed and the software limit status is cleared, execution of the return operation has been completed.

IMPORTANT

When implementing software limits at the host controller, be aware of the monitor scan time of the position reference (the signal monitor time interval) or the time until distribution of the deceleration reference is completed, the deceleration rate of the axis, and the distance to the stroke end of the machine from the software limits. If the axis begins to exceed a software limit at its maximum speed, the axis may be unable to stop until it collides with the stroke end of the machine.

4.10 Controlling Vertical Axes

When the power supply to a servo for a vertical axis (including inclined axes) is turned OFF, gravity will cause any moving parts (such as the table or workpiece) to move.
Refer to the following figure.



Use a servomotor with a holding brake to prevent these parts from moving. The holding brake of the servomotor is controlled through the brake output (/BK) signal from the SERVOPACK.
This can be controlled from the host controller, but because the timing for when to apply the brake depends on when the servo is turned ON or OFF or when a SERVOPACK alarm occurs, we recommend using the SERVOPACK's holding brake function instead.
Refer to *8.2.2 (4) Overtravel Warning Function* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on the holding brake.

4.11 Motor Stop Methods When the Servo is OFF or an Alarm Occurs

Feed axes are stopped from the SERVOPACK when the SV_OFF (32 hex) command is sent during feed axis motion or when an alarm occurs in the SERVOPACK (including power outages).
Refer to *8.2.4 Stopping Servomotor after SV_OFF Command or Alarm Occurrence* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on the motor stop methods that are used when the servo is OFF or an alarm occurs.
Feed axes are often used for linear drive applications, so perform the following settings.

4.11.1 Motor Stop Methods When the Servo Is Turned OFF

Pn001.1 = 0 (Motor stop method = dynamic brake, Motor stop status = dynamic brake)

Parameter		Motor Stop Method	Status after Motor Stops	When Enabled	Classification
Pn001	n.□□□0	DB	Coasting	After restart	Setup
	n.□□□1		DB		
	n.□□□2	Coasting	Coasting		

4.11.2 Motor Stop Methods When an Alarm Occurs

The method used to stop the motor when a Gr1. alarm occurs is the same as described in *4.11.1 Motor Stop Methods When the Servo Is Turned OFF*.
The method used to stop the motor when a Gr2. alarm occurs is as shown in the following table.
Pn00B.2 = 0 (Motor stop method = zero speed stop, Motor stop status = dynamic brake)

Parameter		Motor Stop Method	Status after Motor Stops	When Enabled	Classification
Pn00B	Pn001				
n.□□0□	n.□□□0	Zero speed*	DB	After restart	Setup
	n.□□□1		Coasting		
	n.□□□2				
n.□□1□	n.□□□0	DB	DB		
	n.□□□1		Coasting		
	n.□□□2	Coasting			

* Zero speed: Set the speed reference to 0 in the SERVOPACK to perform an immediate stop.

IMPORTANT

If a hard wire base block function is used and the axis enters the HWBB state, the brake output signal (/BK) turns OFF (i.e., the brake is applied).

Refer to *7.7 Using the Hard Wire Base Block Function (HWBB)* for details on hard wire base block function.

5

Spindle Axis Operation

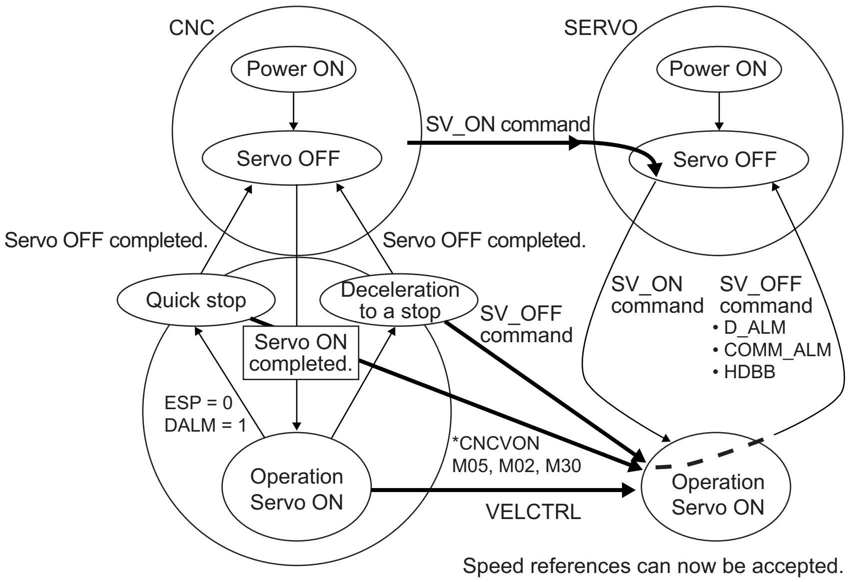
This chapter describes the operation of a spindle axis.

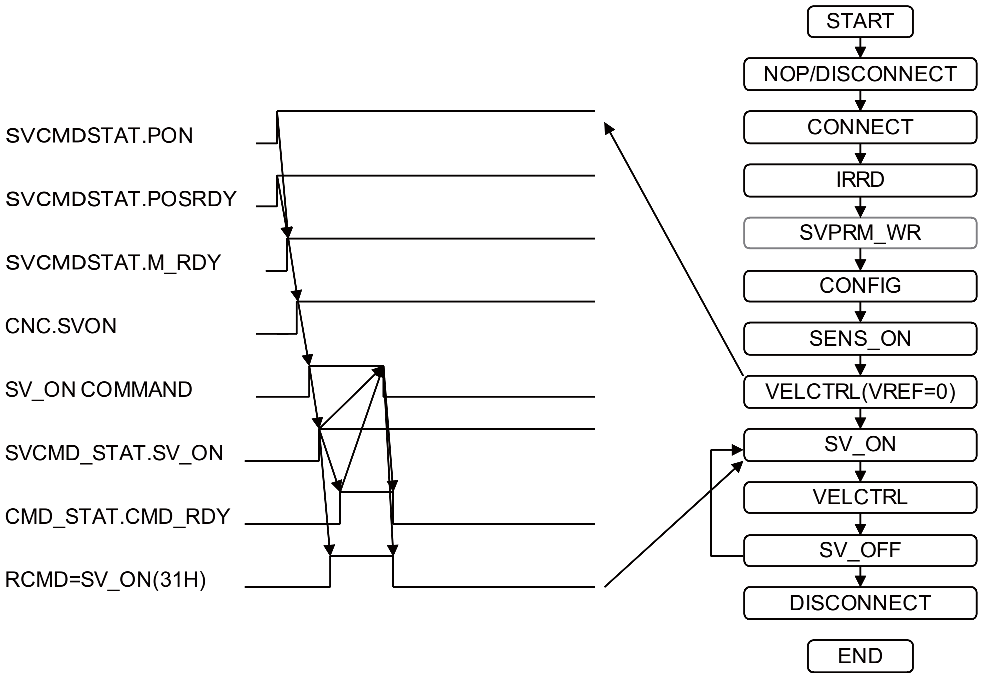
5.1 Speed Control Operation

Depending on the type of machine used, the speed unit for feed axis speed references can be mm/rev or mm/min.
You can execute the Speed Control Command (VELCTRL: 3C hex) to select the Speed Control Mode.

Note: When the power to a SERVOPACK is turned ON, the SERVOPACK is in Position Control Mode. Execute the VELCTRL (3C hex) command before you turn ON the servo to change to Speed Control Mode.

Control is performed as shown in the following transition chart.





■ Speed Control Command (VELCTRL: 3C Hex)

This command changes to speed control in which a target speed reference (VREF) is sent each communications cycle.
Jogging, other manual operations, automatic operation (memory operation), and other operations related to spindle axis operation are performed with the VELCTRL (3C hex) command.
Position control with the INTERPOLATE (34 hex) command is recommended for orientation or tapping operations.
You can specify a speed reference for the VELCTRL (3C hex) command with VREF and use ACCR/DECR to specify the acceleration and deceleration rates.

Command Field	Meaning	Description
CMD	-	Ox3C
CMD_CTRL	-	-
SVCMD_CTRL	-	-
SVCMD_IO	-	-
TFF	Torque Feedforward	The torque unit is set in common parameters 47 and 48. Normally, the percent of the rated torque is selected.
VREF	Speed Reference	The speed unit is set in common parameters 41 and 42. Normally, reference units/s is selected.
ACCR	Acceleration Rate	When the host controller is used to perform position control, set the maximum acceleration rate (FFFF FFFF hex).
DECR	Deceleration Rate	When the host controller is used to perform position control, set the maximum deceleration rate (FFFF FFFF hex).
TLIM	Torque Limit	The torque unit is set in common parameters 47 and 48. Note: The torque limit setting is ignored for a spindle axis (i.e., when Pn01E.0 is 3).

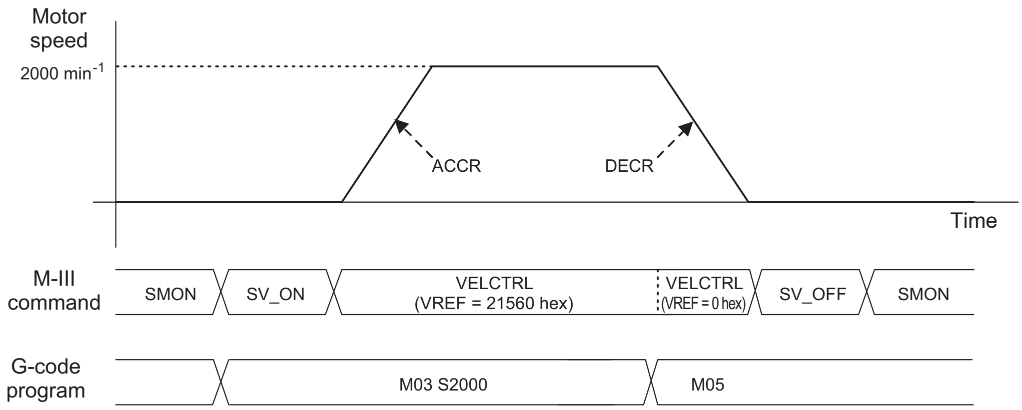
Usable Phase	2 or 3
Processing Time	Within the communications cycle

Byte	VELCTRL	
	Command	Response
0	3C hex	3C hex
1	WDT	RWDT
2	CMD_CTRL	CMD_STAT
3		
4	SVCMD_CTRL	SVCMD_STAT
5		
6		
7		
8	SVCMD_IO	SVCMD_IO
9		
10		
11		
12	TFF	CPRM_SEL_MON1
13		
14		
15		
16	VREF	CPRM_SEL_MON2
17		
18		
19		
20	ACCR	MONITOR1
21		
22		
23		
24	DECR	MONITOR2
25		
26		
27		
28	TLIM	MONITOR3
29		
30		
31		

Note 1. The VELCTRL (3C hex) command does not accept speed feedforward (VFF) references. Create a speed reference that includes the speed feedforward in the host controller.
2. You can select the gain (SVCMD_IO.G-SEL) with the VELCTRL (3C hex) command as well. However, the SERVOPACK's position loop gain (kp) does not affect motor behavior. Prepare the position loop gain (kp) at the host controller and select the position loop gain to match the gain selection (SVCMD_IO.G-SEL).

Speed references for the VELCTRL (3C hex) command are in reference units/s, but for spindle axes the reference unit is in pulses, so the speed reference is given in pulses/s.
If the pulse encoder conforms to standard specifications, the speed reference for a spindle axis is 4,096 pulses/rev.
Some spindle axes are equipped with gears and gear-switching functions, depending on the machine. In this case, the gear ratio must be maintained from the host controller and the VREF speed reference must be specified as the motor speed based on that gear ratio.

Note: The number of pulses is the number of feedback pulses per single rotation of the spindle motor.



Observe the following precautions for the operating speed of spindle axes in speed control.

- The SERVOPACK is in Position Control Mode when it is first turned ON. Execute the VELCTRL (3C hex) command to change to Speed Control Mode.
- Due to the characteristics of the spindle motor, do not execute the SV_ON (31 hex) command immediately after executing the SV_OFF (32 hex) command. This can subject the spindle motor to shock and vibration.
- Start the operating speed (e.g., M03 S2000) by executing the VELCTRL (3C hex) command after the SV_ON (31 hex) command. To stop an axis (e.g., M05), set the speed reference in VREF to 0 with the VELCTRL (3C hex) command to decelerate the spindle motor to a stop. After the spindle motor decelerates to a stop, execute the SV_OFF (32 hex) command to turn the servo OFF.
- Torque limits are generally not used in Speed Control Mode. The torque limit setting (TLIM) is also not effective for the VELCTRL (3C hex) command. Set parameters Pn430 (Torque Limit (Powering)) and Pn431 (Torque Limit (Regeneration)) to limit the torque.

5.2 Spindle Axis Orientation

Spindle axis orientation is positioning the spindle axis to a specified position.
Positioning is performed to a specified position while the spindle axis is stopped or rotating. Send a reference from the host controller to shorten the time that is required until the axis stops (i.e., the orientation time).

5.2.1 Implementing Orientation

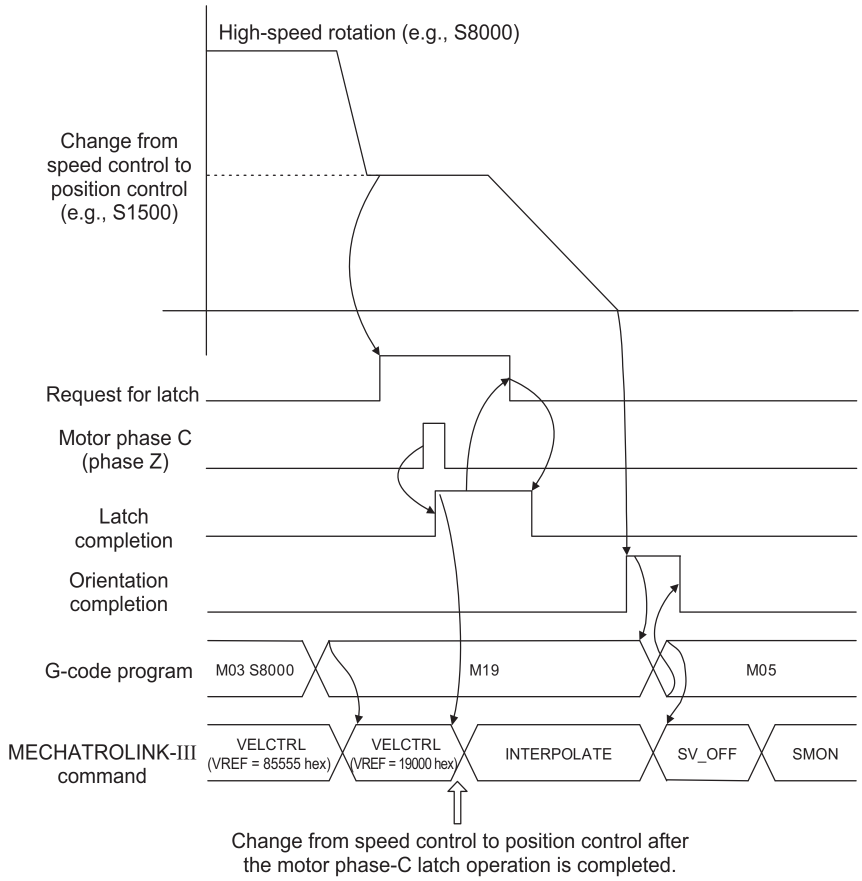
There are four ways to implement orientation.

1. Perform positioning via speed control of the spindle axis. Perform position control from the host controller and perform positioning to the specified stop position. Orientation is performed with speed control, but this method has the disadvantage of the positioning accuracy being poor when the axis is stopped.
2. Decelerate (or in some cases, accelerate) the spindle axis to a specified speed with speed control, then change to position control and perform positioning to the specified position from the host controller.
   Refer to *5.2.2 Performing Orientation by Changing from Speed Control to Position Control* for details on changing from speed control to position control.
   This is the most standard method to use for orientation, but if the correct speed is not selected for the switch from speed control to position control, the orientation operating time may increase.
3. Decelerate the spindle axis with position control and then perform positioning to the specified position from the host controller.
   Spindle axis orientation is performed with position control, but the orientation operating time may increase due to the difficulty of using all the motor output torque in Position Control Mode.
4. Use the SERVOPACK's high-speed orientation function and set the target position from the host controller to perform positioning to the specified position.
   For details, refer to *5.2.3 Orientation Using the QUICK_ORT Command.*
   Control is performed so that the operations in item 2, above, are performed by the SERVOPACK to minimize the time required until positioning, therefore minimizing the orientation operating time.

5.2.2 Performing Orientation by Changing from Speed Control to Position Control

When orientation is started, the orientation operation depends on whether the spindle axis is in rotation (high-speed rotation or low-speed rotation) or if the spindle axis is stopped.

(1) Orientation Operation from High-speed Rotation



Step 1:
The spindle axis is in high-speed rotation for speed control.
Command = VELCTRL (3C hex)
VREF = 85555 hex (8,000 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
Distribution of the speed reference has been completed when RCMD = VELCTRL (= 1C hex) and CMD_STAT.CMDRDY is 1. Check if SVCMD_IO.V_CMP is 1 to determine if the motor speed has reached the reference speed.

Step 2:
The axis decelerates to the speed required to change from speed control to position control. A speed that is less than the base motor speed (e.g., 1,500 min^{-1}) is recommended when changing the control mode.
Command = VELCTRL (3C hex)
VREF = 19000 hex (1,500 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
Distribution of the speed reference has been completed when RCMD = VELCTRL (= 1C hex) and CMD_STAT.CMDRDY is 1. Check if SVCMD_IO.V_CMP is 1 to determine if the motor speed has reached the reference speed.

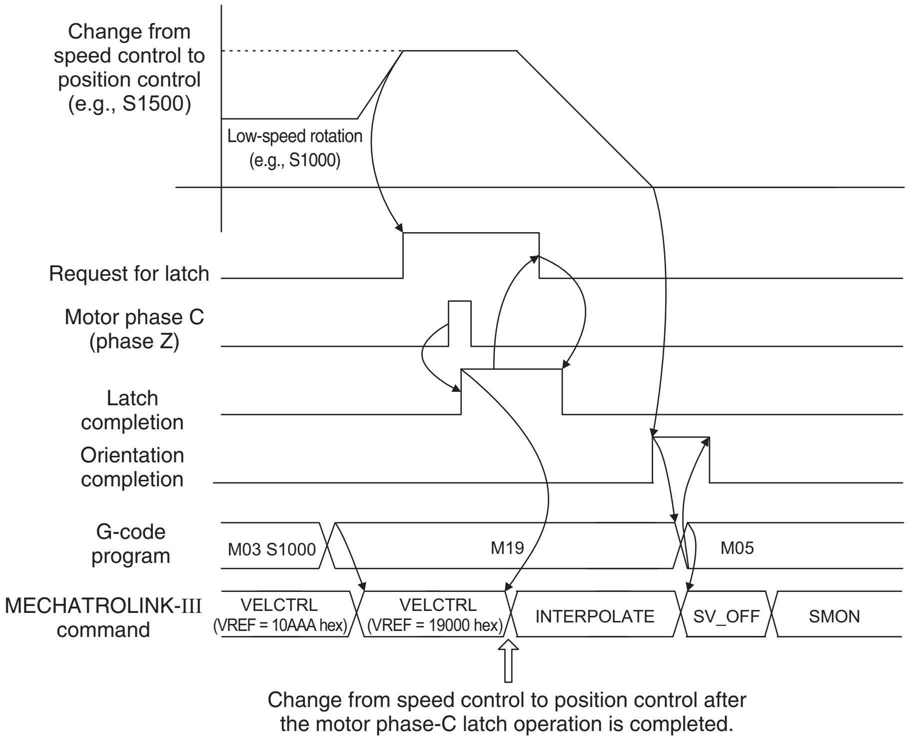
Step 3:
To change to position control, the position coordinates for the spindle axis are created. A spindle motor phase-C (phase-Z) latch request is performed for this purpose.
The following example uses Latch Request 1 (LT_REQ1). In this case, set Latch Signal Selection 2 (LT_REQ2) for Latch Request 2 to a setting other than phase C (phase Z).
Command = VELCTRL (3C hex)
VREF = 19000 hex (1,500 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
SVCMD_CTRL.LT_SEL1 = 0
SVCMD_CTRL.LT_REQ1 = 1
SVCMD_CTRL.SEL_MON3 = 3 (Selects LPOS1.)
SVCMD_CTRL.LT_SEL2 = 1, 2, or 3 (Set to a different value from LT_SEL1.)
Execution of the latch has been completed when SVCMD_STAT.L_CMP changes to 1.

Step 4:
After execution of the latch has been completed, the latch position (LPOS1) is immediately read from the host controller and the latch request is cancelled.
Command = VELCTRL (3C hex)
VREF = 19000 hex (1,500 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
SVCMD_CTRL.LT_SEL1 = 0
SVCMD_CTRL.LT_REQ11 = 0
SVCMD_CTRL.SEL_MON3 = 3 (Selects LPOS1.)

Step 5:
The travel distance from the spindle motor's phase-C (phase-Z) latch position to the orientation position (stop position within one revolution of the spindle motor) is calculated and then the position reference is calculated so that the spindle motor can stop at the designated deceleration rate.
Command = INTERPOLATE (34 hex)
TPOS = xxxxxxxx hex (target position until the motor decelerates to a stop)
VFF = 0
TFF = 0 hex

Step 6:
After the spindle motor stops at the target position (i.e., the orientation position), the orientation operation has been completed and the spindle motor stays in that state (TPOS = 0 hex for the INTERPOLATE (34 hex) command). To execute any operation other than the orientation operation from the host controller (e.g., M05 (spindle axis servo OFF), execute the command for that operation.

(2) Orientation Operation from a Stopped State or Low-speed Rotation



Step 1:
The spindle axis is stopped or in low-speed rotation for speed control. (The above figure shows the axis in low-speed rotation.)
Command = VELCTRL (3C hex)
VREF = 10AAA hex (1,000 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
Distribution of the speed reference has been completed when RCMD = VELCTRL (= 1C hex) and CMD_STAT.CMDRDY is 1.
Also, check if SVCMD_IO.V_CMP is 1 to determine if the motor speed has reached the reference speed.

Step 2:
The axis accelerates to the speed required to change from speed control to position control. A speed that is less than the base motor speed (e.g., 1,500 min^{-1}) is recommended when changing the control mode.
Command = VELCTRL (3C hex)
VREF = 19000 hex (1,500 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
Distribution of the speed reference has been completed when RCMD = VELCTRL (= 1C hex) and CMD_STAT.CMDRDY is 1.
Check if SVCMD_IO.V_CMP is 1 to determine if the motor speed has reached the reference speed.

Step 3:
To change to position control, the position coordinates for the spindle axis are created. A spindle motor phase-C (phase-Z) latch request is performed for this purpose.
The following example uses Latch Request 1 (LT_REQ1). In this case, Latch Signal Selection 2 is set for Latch Request 2 (LT_REQ2) to a setting other than phase C (phase Z).
Command = VELCTRL (3C hex)
VREF = 19000 hex (1,500 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
SVCMD_CTRL.LT_SEL1 = 0
SVCMD_CTRL.LT_REQ1 = 1
SVCMD_CTRL.SEL_MON3 = 3 (Selects LPOS1.)
SVCMD_CTRL.LT_SEL2 = 1, 2, or 3 (Set to a different value from LT_SEL1.)
Execution of the latch has been completed when SVCMD_STAT.L_CMP changes to 1.

Step 4:
After execution of the latch has been completed, the latch position (LPOS1) is immediately read from the host controller and the latch request is cancelled.
Command = VELCTRL (3C hex)
VREF = 19000 hex (1,500 min^{-1})
TFF = 0 hex
ACCR/DECR = FFFFFFFF hex
SVCMD_CTRL.LT_SEL1 = 0
SVCMD_CTRL.LT_REQ11 = 0
SVCMD_CTRL.SEL_MON3 = 3 (Selects LPOS1.)

Step 5:
The travel distance from the spindle motor's phase-C (phase-Z) latch position to the orientation position (stop position within one revolution of the spindle motor) is calculated and then the position reference is calculated so that the spindle motor can stop at the designated deceleration rate.
Command = INTERPOLATE (34 hex)
TPOS = xxxxxxxx hex (target position until the motor decelerates to a stop)
VFF = 0
TFF = 0 hex

Step 6:
After the spindle motor stops at the target position (i.e., the orientation position), the orientation operation has been completed and the spindle motor stays in that state (TPOS = 0 hex for the INTERPOLATE (34 hex) command). To execute any operation other than the orientation operation from the host controller (e.g., M05 (spindle axis servo OFF), execute the command for that operation.

5.2.3 Orientation Using the QUICK_ORT Command

The Σ-V-SD Drive supports quick orientation.

(1) QUICK_ORT Command Format

Usable Phase	2 or 3	Command Type	Vendor-specified command	Non-synchronized command
Processing Time	Within the communications cycle	Subcommand Extension	Possible	

Byte	Command	Response	Description
0	QUICK_ORT (CA hex)	QUICK_ORT (CA hex)	• The axis accelerates or decelerates to the specified target speed (TSPD) in the direction of the specified target position (TPOS), then decelerates to the target position. • Confirm that RCMD is QUICK_ORT (CA hex) and CMD_STAT.CMDRDY is 1 to confirm that execution of the command has been completed. • Output of the movement reference data has been completed when SVCMD_IO.DEN changes to 1. Positioning has been completed when SVCMD_IO.PSET changes to 1. However, the motor will perform positioning to the specified position even if execution of the latch operation is not completed for some reason. In this case, SVCMD_IO.DEN and SVCMD_IO.PSET will both change to 1, but SVCMD_IO.L_CMP will be 0. Therefore, be sure to also check the Latch Completed signal when positioning has been completed. • The monitor data that is set in common parameter 87 or 88 is set in the response for CPRM_SEL_MON1 or CPRM_SEL_MON2. • Execution of the position latch operation for a latch signal has been completed when SVCMD_STAT.L_CMP1 changes to 1. Application Precautions • When this command is executed, you must select a latch signal in LT_SEL1 of SVCMD_CTRL and request the latch by setting LT_REQ1 to 1. • TPOS (Target Position): Sets the target position from the latch position. This data is unsigned 4-byte data. The position reference range is as follows: 0 ≤ TPOS < Travel distance per machine rotation [reference units] Always check the setting of Pn830. • TSPD (Target Speed): Sets the target speed. This data is unsigned 4-byte data. This value is corrected internally based on the rotation direction. This affects latch requests and control mode changes. The upper limit of TSPD must be less than the base speed. • POS_TREF (Torque Reference for Positioning): This value is used for the generation of acceleration/deceleration rates and torque feedforward during positioning. • T_LIM (Torque Limit): Sets the torque limit value. This data is unsigned 4-byte data. However, this setting is not effective for spindle axes. • Do not execute the POS_SET command during execution of this command. • Set SVCMD_IO.SV_MOD (bit 30) to 1 when you use this command. • Do not change winding selection during execution of the QUICK_ORT command. Doing so may affect control changes and moment of inertia identification, and operation may become unstable. • After the QUICK_ORT command is executed and any changes are made to the target position, target speed, positioning torque reference, and torque limit, perform the latch operation again and finally perform positioning. The command is ignored if it is executed with the same target position, target speed, positioning torque reference, and torque limit. • When in Servo Mode, set POS_TREF to a value that is higher than T_LIM. Limiting torque with T_LIM may cause saturation.
1	WDT	RWDT	
2	CMD_CTRL	CMD_STAT	
3			
4	SVCMD_CTRL	SVCMD_STAT	
5			
6			
7			
8	SVCMD_IO	SVCMD_IO	
9			
10			
11			
12	TPOS	CPRM_SEL_MON1	
13			
14			
15			
16	TSPD	CPRM_SEL_MON2	
17			
18			
19			
20	POS_TREF	MONITOR1	
21			
22			
23			
24	-	MONITOR2	
25			
26			
27			
28	T_LIM	MONITOR3	
29			
30			
31			

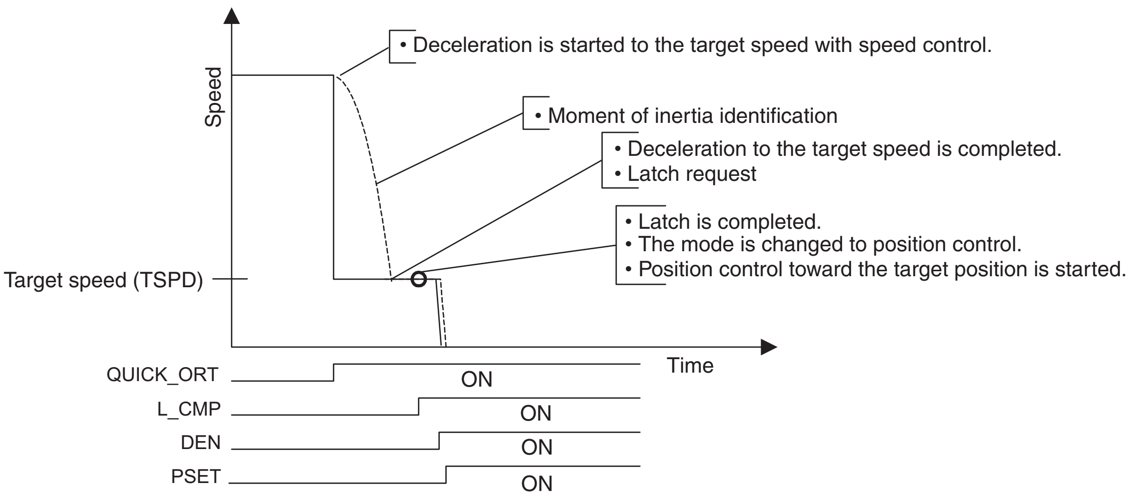
(2) QUICK_ORT Command Operation

■ Positioning

Absolute Speed	Basic Operation	Latching	Control Mode
Current speed ≥ Target speed (before latch completion)	The axis is decelerated to the target speed (TSPD) with speed control using stepwise deceleration references. Moment of inertia identification is performed during deceleration, and then a latch is requested after the target speed is reached. After the latch operation has been completed*1, positioning is performed to the target position using the operation for when the current reference speed is less than or equal to the target speed.	Executed.	Speed Control
Current speed ≤ Target speed (before latch completion)	The axis is accelerated to the target speed (TSPD) with speed control using stepwise acceleration references. Moment of inertia identification is performed during acceleration, and then a latch is requested after the target speed is reached. After the latch operation has been completed*1, positioning is performed to the target position using the operation for when the current reference speed is less than or equal to the target speed.	Executed.	Speed Control
Current speed ≤ Target speed (after latch completion)	Positioning is performed towards the target position with position control according to the deceleration rate calculated from the maximum torque*2 (POS_TREF) and moment of inertia. In this case, following performance is increased by using a torque feedforward that is equal to the positioning torque reference that is specified in CMD and in the speed feedforward to match the deceleration rate.	Completed.	Position Control

*1. If the latch is not completed (i.e., when the Latch Completed signal is FALSE), positioning is performed to a position that can be reached by POS_TREF from the current position.
*2. The POS_TREF command can be used to limit the torque during deceleration and enable a more gradual stop.

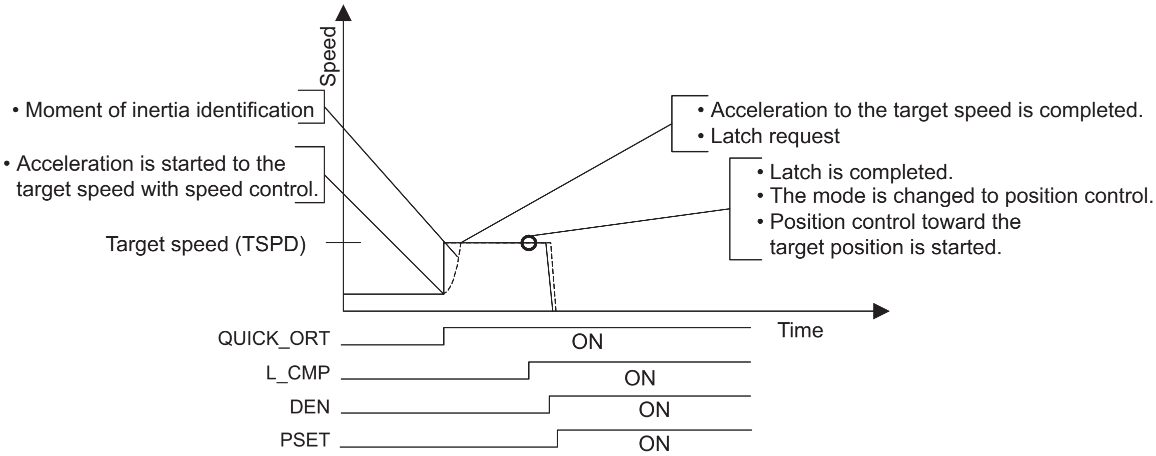
• Executing the QUICK_ORT Command from a Speed Faster Than the Target Speed



If the QUICK_ORT command is executed from a speed that is slower than the target speed, the spindle motor operates as follows:

1. The spindle motor accelerates while identifying the moment of inertia up to the target speed for speed control.
2. A latch is requested after the target speed is reached.
3. The control mode is changed from speed control to position control after the latch has been completed.
4. After changing to position control, positioning is performed towards the target position at the deceleration rate that is calculated from the maximum torque and moment of inertia.

- Executing the QUICK_ORT Command from a Speed Slower Than the Target Speed



If the QUICK_ORT command is executed from a speed that is slower than the target speed, the spindle motor operates as follows:

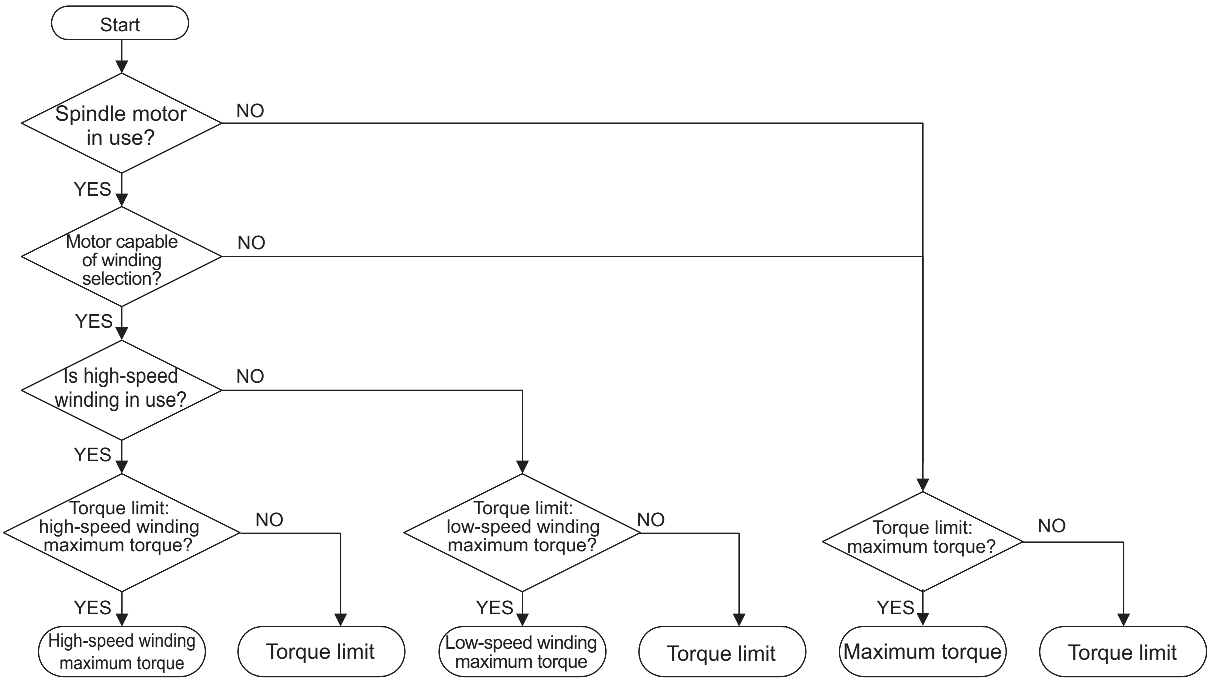
1. The spindle motor accelerates while identifying the moment of inertia up to the target speed for speed control.
2. A latch is requested after the target speed is reached.
3. The control mode is changed from speed control to position control after the latch has been completed.
4. After changing to position control, positioning is performed towards the target position at the deceleration rate that is calculated from the maximum torque and moment of inertia.

■ Pause/Cancel Command Operation

The QUICK_ORT command is disabled when a command is paused or canceled.
An alarm or warning will occur if a pause or cancel request is received during execution of the QUICK_ORT command, in the same way as for the INTERPOLATE and TRQCTRL commands.

■ Maximum Possible Torque Output during Positioning

The maximum torque for this command is as follows:



The maximum torque, high-speed winding maximum torque, and low-speed winding maximum torque can be found in the characteristics table for each motor.
However, if the torque limit or maximum torque output is less than the maximum torque, it will be clamped at the torque limit.
The rated torque can be determined with PnA0E and PnA12.
If torque saturation occurs due to the torque limit and you want to limit the torque to execute this command, set the POS_TREF percentage in bytes 20 to 23 of the command to perform acceleration or deceleration at a limited torque.
With the torque used for deceleration as T_{dec}, and the rated torque as T_{rated}, the POS_TREF can be calculated as $T_{dec} \div T_{rated}$.

Note: T_{dec} is calculated as DECR (Deceleration rate) × J (Moment of inertia).
Torque is affected by the values that are set for Torque Unit Selection (common parameter 47) and Torque Base Unit (common parameter 48).
Torque = (Common parameter 47) × $10^{\text{(Common parameter 48)}}$

(3) Alarms

Alarm Number	CMD_ALM	Name	Description	Reset
A.94B	9	Data Setting Warning 2	The command data is out of range.	Auto reset
A.95A	A	Command Warning 1	The command was sent even though the command conditions have not all been met.	Auto reset
A.97B	1	Data Setting Warning (Data Clamp)	The set command data is clamped to the minimum or maximum value of the range that was exceeded.	Auto reset

(4) Related Parameters

Parameter No.	Name	Rotary/ Linear	Unit	Setting Range	Factory Setting	When Enabled
Pn830	Reference Unit Amount per Machine Rotation	Rotary	ref	1 to 1073741823 (2^{30}-1)	4096	After restart

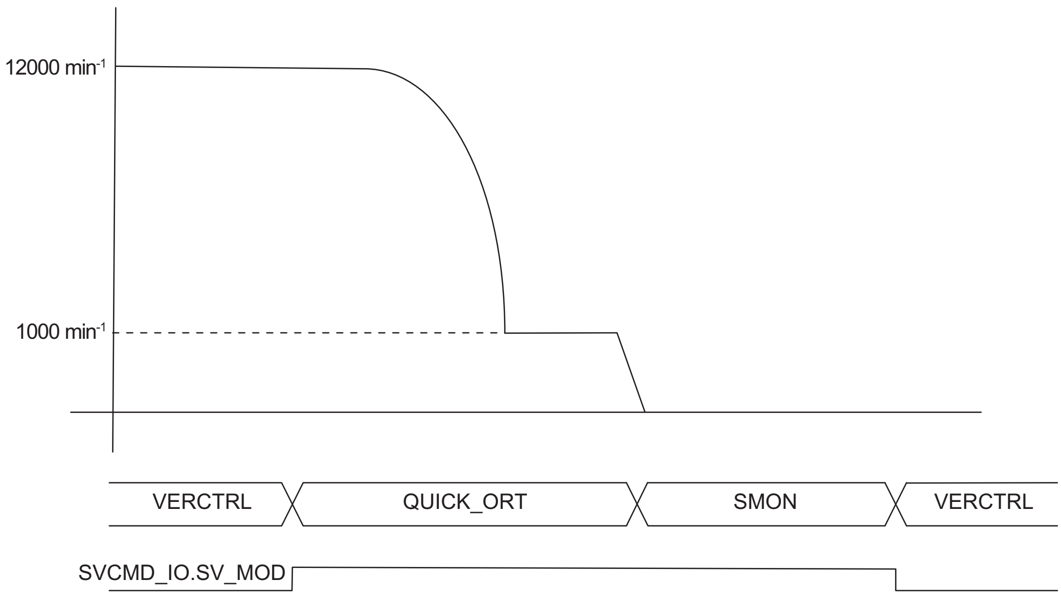
(5) QUICK Orientation Example

The QUICK orientation command is executed as follows:
Ex:
In this example, orientation is performed for the spindle axis from 12,000 min^{-1} revolutions to the target revolutions of 1,000 min^{-1}.

CMD: QUICK_ORT = 0CA hex	
SVCMD_CTRL. STOP_MODE = 0	Deceleration to a stop
SVCMD_CTRL. ACCFIL = 0	No position reference filter
SVCMD_LT_REQ1 = 1	Latch request
SVCMD_LT_SEL1 = 0	Phase-C latch selection
SVCMD_IO. G-SEL = 2	Gain selection (speed loop gain and position loop gain selection)
SVCMD_IO. SV_MOD = 1	Servo mode selection
TPOS = 1024	90° 90*4096/360 pulseWhen common parameter 44 is 0
TSPD = 68267	1000 min^{-1}1000*4096/60 pulse/sWhen common parameter 42 is 0
POS_TREF = 10000	100%: Positioning torque reference* [%]
T_LIM = 0FFFFFFFF hex	Torque limit

* Set 100% to set the rated torque for the positioning torque reference.

Set the above commands in the SERVOPACK to execute them.



5.2.4 Versatile Spindle Axis System Orientation

Orientation must be flexible enough to handle the following items in order to build a versatile system that can be applied to a variety of uses.

- Motor pulse generator
- External pulse generator
- Multilevel gear selection
- Winding selection

For a system with gears, winding, and four gain banks per servo drive, you must normally select a gain bank. (SVCMD_G-SEL)
Each gear can have its own gain setting. Therefore, orientation can be executed for the appropriate feed for these gain settings.
However, it is necessary to consider the system requirements before implementation.
Refer to *5.4 Spindle Axis Gain Selection* for details on gain banks.

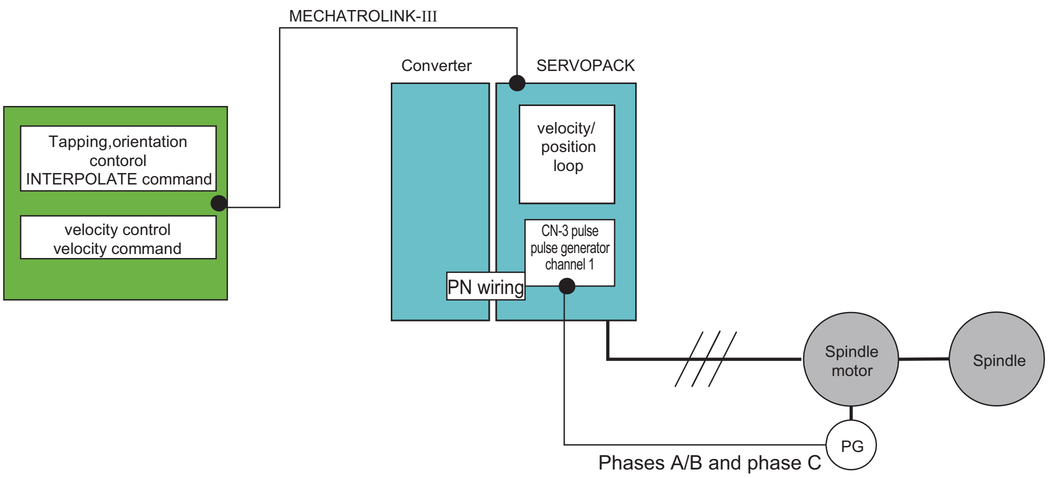
5.3 Tapping Operation

This section describes how to implement tapping operation from the host controller.

Tapping with a Σ-V-SD driver is performed through interpolation control between the spindle and feed axes. The host controller performs linear acceleration/deceleration interpolation calculations between the spindle and feed axes each communications cycle. The results of those calculations are sent to the spindle and feed axes through the MECHATROLINK-III INTERPOLATE or VELCTRL command.
Use the VELCTRL command if forming a position loop with the host controller.
Or, use the INTERPOLATE command if forming a position loop with the servo.
The position of the spindle axis is managed by the feedback value of the spindle axis pulse generator (or motor pulse generator for direct drive systems), in the same way as for servomotors.

To perform tapping at a high speed and with high accuracy, you must take measures to reduce synchronization error.
In order to implement an easy-to-use, flexible tapping function, you must include feed hold tap return, return speedup, deep hole tapping, and inclined tapping functions.
Rigid tapping must balance the tap size, tap length, tap pitch, material, acceleration/deceleration rates, and maximum number of revolutions based on the characteristics of the motor that is used.

The following system block diagram shows a position loop that is formed with the servo driver for the spindle axis.



5.3.1 Tapping Position Management

There are two methods of tapping position management, as described below.

- Spindle axis rotation is performed with speed references. When tapping is started, orientation is performed to determine the home position and manage the current position value.
- When the power supply is first turned ON, a phase-C latch is performed on the first revolution of the spindle axis. This saves the latch position in the host controller and manages the current position value of the spindle axis by determining the home position from the position offset between the phase C and spindle axis home position.

Use one of the above methods to determine the home position and perform position management for tapping. By performing position management for tapping, the position of the spindle axis can be managed whether speed control or position control is used to rotate the spindle axis.

5.3.2 Spindle Axis Servo Drive-based Position Loop Tapping

To switch to a position loop and perform tapping, Servo Mode must be set to provide a constant excitation current to maintain the speed linearity.
Set SVCMD_IO.SV_MOD to 1 in the VELCTRL or INTERPOLATE command.
When SV_MOD is set, 200 to 300 ms of delay is required to establish 100% of the required excitation current. (Allocate this time with a timer on the host controller.)
Be careful, because any position references that are sent during this time will not function correctly and cause vibration.

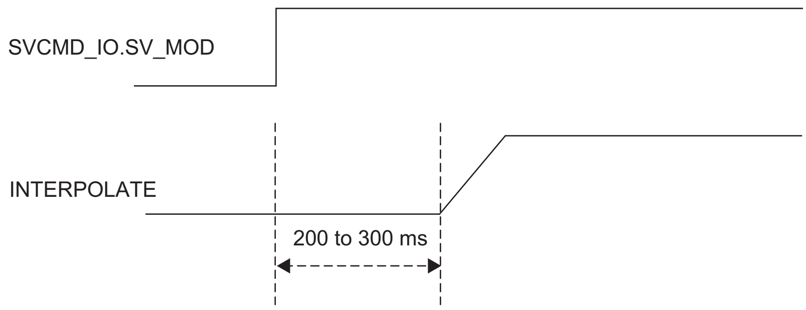
Additional Information

- Servo Mode establishes and maintains feed linearity and continuously provides excitation current, even when the axis is stopped.
  This preserves control loop response and increases constraint when the axis is stopped in the same way as a servo.
- If SV_MOD is turned OFF, the excitation current is not supplied when the axis is stopped.
  Also, the constraint when the axis is stopped is reduced.

The following figure shows the relationship between Servo Mode and the INTERPOLATE command.

SVCMD_IO.SV_MOD

Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
WND_CHG	SV_MOD	Reserved.					



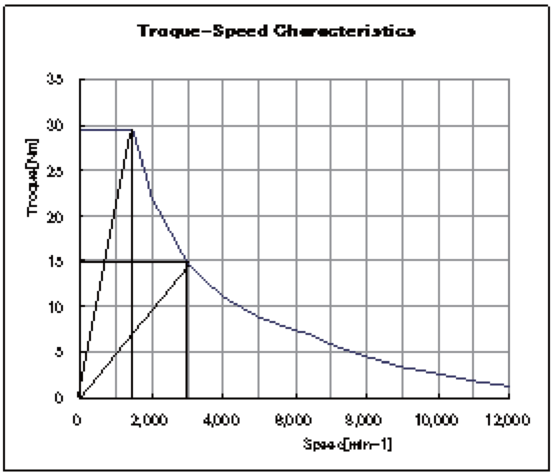
Therefore, the INTERPOLATE command can be executed 200 to 300 ms after the mode is changed to Servo Mode for tapping and other spindle axis feeding operations.
If tapping is continued, SV_MOD will not turn ON or OFF, producing a constant reference.
For a position loop for a spindle axis, you can send the MECHATROLINK-III INTERPOLATE command to smoothly change from speed control to position loop control as long as Servo Mode is set and the constant torque range is not exceeded.

5.3.3 Relationship between the Spindle Axis Base Speed and Magnetic Flux Density in Servo Mode

Constant torque output is required for a spindle axis in Servo Mode, but the output must be within the base speed, where the required torque can be maintained.

The base speed is 1,500 min^{-1}. To perform tapping at a higher number of revolutions than this, you must lower the magnetic flux density to increase the base speed to maintain a higher level of constant torque.

Note: When the constant-output region is entered, a sufficient output cannot be achieved to maintain the acceleration rate, which results in non-linear acceleration/deceleration.



For example, to rotate the axis at a constant torque up to 3,000 min^{-1}, the following parameter settings must be changed.

- Servo Mode Base Speed Ratio (Pn434) = 200%
- Servo Mode Flux Level (Pn433) = 50%

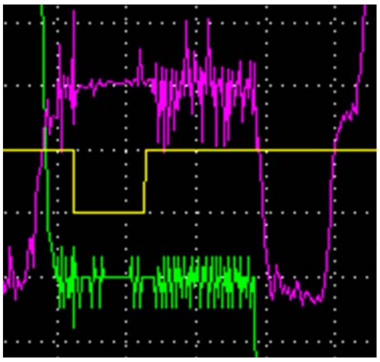
However, the acceleration rate must be appropriate for that amount of torque.

Pn433	Servo Mode Flux Level (for High-speed Winding)	%	30 to 100
Pn434	Servo Mode Base Speed Ratio (for High-speed Winding)	%	100 to 500
Pn435	Servo Mode Flux Level (for Low-speed Winding)	%	30 to 100
Pn436	Servo Mode Base Speed Ratio (for Low-speed Winding)	%	100 to 500

(1) Gain Selection

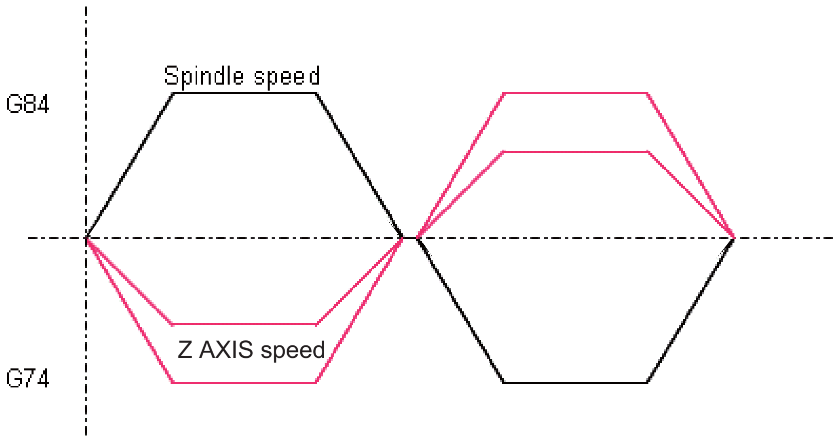
Select the gain for both spindle and feed axes with SVCMD_IO.G-SEL.
To maintain synchronization, the position loop gain for both spindle and feed axes must be set to the same value.
During tapping, a separate feed gain must be prepared in addition to the standard gain.
If the spindle axis gain for tapping is too high, vibration may occur when the spindle axis is stopped.
To reduce the vibration, lower the gain.
You must also allocate the gain that is required and switch to the gain that is necessary for the operating speed.

Pn128 (Kv)	Speed operation	20.0
Pn12C (Ti)		40.0
Pn12D (Kp)		20.0
Pn12E (Kv)	Tapping	30.0
Pn12F (Ti)		25.68
Pn130 (Kp)		40.0



(2) Tapping Interpolation Control

For tapping, linear acceleration/deceleration interpolation with a constant acceleration rate is performed for the spindle and feed axes.
(The spindle axis revolutions, pitch, tap length, and acceleration rate are specified as parameters.)
The tap acceleration rate is set as a host controller parameter, and tapping acceleration/deceleration interpolation is performed using the feed axis acceleration rate or the spindle axis orientation acceleration rate, whichever is the lowest.
Interpolation calculations are synchronized with the MECHATROLINK-III communications cycle.
Use the travel distances that are calculated for linear acceleration/deceleration interpolation between the spindle axis and servo to determine the target positions TPOSs and TPOSz (target value pulses) every communications cycle for the tapping position references.

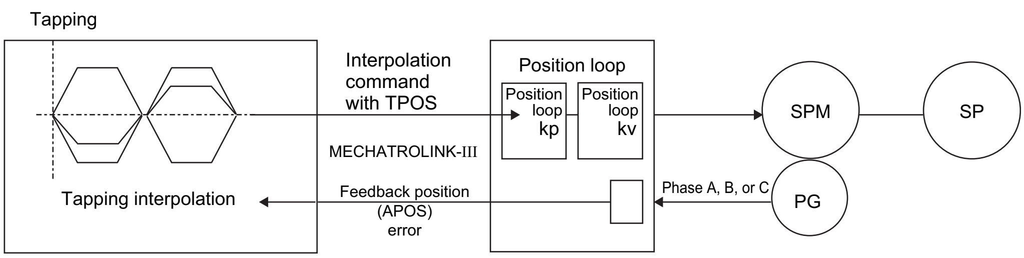


Linear Acceleration/Deceleration Interpolation for Tapping

Linear acceleration/deceleration interpolation for tapping is sent each communications cycle for the following settings.
MECHATROLINK-III INTERPOLATE command
COMMAND INTERPOLATE = 34 hex
SVCMD_CTRL
SVCMD_IO.G-SEL = 2 (gain selection)
SV_MOD=1 (SV_MOD)

Set the TPOSz and TPOSs target positions as the numbers of pulses (interpolation calculation results).
VFF ΔZ*% pulses/s if speed feedforward is applied.

The target values TPOSs and TPOSz, SVCMD_IO.G_SEL = 2, and SVCMD_IO.SV_MOD = 1 are loaded for each servo driver during each communications cycle, and CPOS (reference value) is sent as a servo driver reference.
The servo driver takes the difference between the reference value CPOS and the feedback value APOS, applies the position loop gain as the position speed deviation, and performs position loop control.



To confirm if a tap has reached the base of the hole, check if positioning has been completed (DEN + PSET) after function generator pulse distribution has been completed (DEN), calculate the return tap, and finally perform a similar sequence for the return.
DEN and PSET can be checked in SVCMD_IO.DEN and SVCMD_IO.PSET.

5.3.4 Tapping Control with a Continuous Jerk Function

High-speed, highly accurate tapping can be performed by specifying a continuous speed, acceleration rate, and jerk.
First, generate a quintic speed equation for continuous jerk.
The conditions for the quintic speed equation are as follows:

- The initial speed is 0 mm/s.
- End acceleration at X mm.
- The target speed when acceleration finishes is Y mm/s.
- The acceleration when acceleration begins and ends is 0.
- The jerk when acceleration begins and ends is also 0.

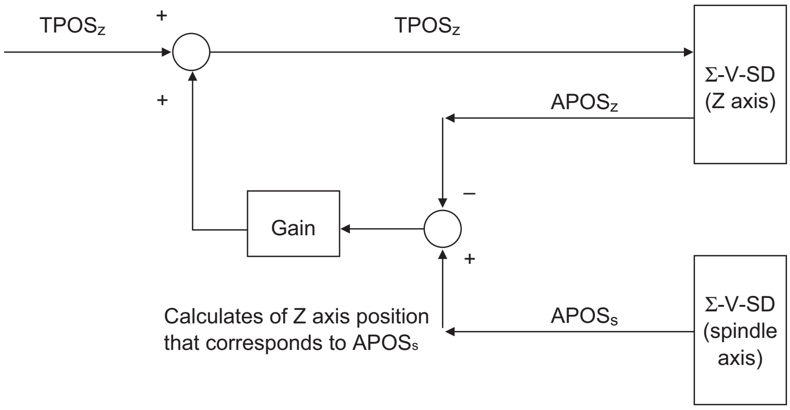
Satisfy the above conditions in the following quintic speed equation to determine the jerk.
When $t = 0$, $v = At^5 + Bt^4 + Ct^3 + Dt^2 + Et + F$
$A = 5At^4 + 4Bt^3 + 3Ct^2 + 2Dt + E$ (differential of the speed)
$\alpha = 20At^3 + 12Bt^2 + 6Ct^1 + 2D$ (differential of the acceleration)

The initial speed is calculated with a polynomial expression that solves the above formulas.
$v, A, \alpha = 0$, so $D, E, F = 0$
This results in the following expressions.
$v = At^5+Bt^4+Ct^3$
$A = 5At^4+4Bt^3+3Ct^2$
$\alpha = 20At^3+12Bt^2+6Ct^1$
If the time to finish acceleration is t1, the acceleration is calculated as $A = 5At_1{}^4 + 4Bt_1{}^3 + 3Ct_1{}^2 = 0$ ... (1)
The speed when acceleration finishes is Y mm/s, so $Y = At_1{}^5 + Bt_1{}^4 + Ct_1{}^3$ ... (2)
The distance when acceleration ends is the integral of v, so $X = At_1{}^6 \div 6 + Bt_1{}^5 \div 5 + Ct_1{}^4 \div 4$ ... (3)
The jerk when acceleration begins and ends is 0, so $0 = 20At_1{}^3 + 12Bt_1{}^2 + 6Ct_1{}^1$ ... (4)
Now let’s calculate the speed Y and distance X during linear acceleration/deceleration from the spindle axis revolutions, pitch, tap length, acceleration, and jerk, using the spindle axis pulses as a base.
Then, substitute those values into (2) and (3) above to solve equations (1), (2), (3), and (4) to find t_1, A, B, and C.

Calculate the spindle axis motor speed, feed axis value corresponding to the speed, and the target positions for the spindle and feed axes each communications cycle, then send the INTERPOLATE command to the Σ-V-SD drive.
Also, calculate the time in the constant speed area, the speed of the spindle axis during deceleration, and the value of the feed axis, then send the INTERPOLATE command.

5.3.5 How to Eliminate Synchronization Error between Spindle and Feed Axes

Tapping is performed with linear interpolation, but even if the loop gain is set correctly, linearity can still be lost when tapping begins or due to some other disturbance. Therefore, corrections can be made to eliminate synchronization error.
The corrections to eliminate synchronization error are created on the host controller.
The specifications for this function are as follows: the APOS (feedback data) is read sequentially from the response data returned through MECHATROLINK-III communications, the ideal feed axis position for the $APOS_S$ feedback value of that spindle axis is calculated, and the difference between that value and the $APOS_S$ feedback value of the feed axis is determined.
Gain is applied to the calculated difference to determine the amount of correction that is required, and this value is added to the reference for the next feed axis and referenced as the target value for the feed axis. This gain corresponds to the gain that is set in the host controller parameters.
This eliminates any sources of disturbances and enables accurate, standards-compliant tapping.



Spindle Axis Operation

5

5.3.6 Tapping Applications

(1) Feed Hold Tap Return

If feed hold resistance is encountered during tapping, the tap may break off if the axis continues on without stopping. To prevent this, decelerate the axis to a stop and return the axis in the opposite direction.
For the reversal, use interpolation to maintain the shape of the tap and stop the axis after execution of the return operation has been completed.

(2) Specified Speed Return during Tapping

For large-diameter tapping, there is a difference in the cutting torque between the forward and return passes, so the return spindle axis speed can be set to increase to a specified speed. The return interpolation speed is also increased for the return operation.
However, speed is controlled so that the torque is not saturated.

(3) Deep Hole Tapping

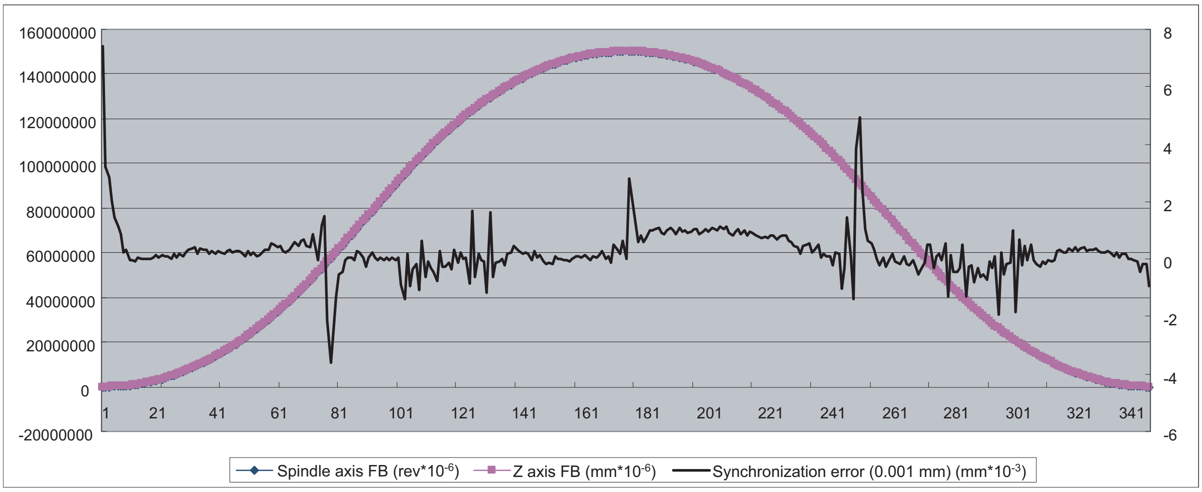
During tapping, the tap can be repeatedly returned to remove any cutting chips and inserted again to tap deeper in order to cut deep hole taps.

(4) Maximum Speed, Acceleration Time, and Acceleration/Deceleration of Tapping Spindle Axes

The acceleration rate in position control (without torque saturation) must be sufficient enough to maintain linearity.

(5) Spindle Axis-based Feed Axis Synchronization Error Indicator for Tapping

To adjust and calibrate tapping properly, you must have some way to check the synchronization error of the feed axis using the spindle axis as a base.
To achieve this, you need to develop an error indicator as shown below.



You must trace the difference between the positive value $APOS_{ZS}$ of the tap position and the APOS feedback position of the tap in regards to the $APOS_S$ revolution position of the spindle axis, then perform any adjustments that are required to keep the synchronization error within the accuracy of the tap.

5.4 Spindle Axis Gain Selection

You can select the gain for a spindle axis based on the C axis, tap, orientation, speed reference, or other requirements. Use SVCMD_IO.G-SEL to select the gain.
You can specify any of the following four gain banks for axes such as spindle axes or rotating tool spindle axes.

Gain Parameter	Gain Bank			
	0	1	2	3
Speed loop gain	Pn100	Pn104	Pn12B	Pn12E
Speed loop integral time constant	Pn101	Pn105	Pn12C	Pn12F
Position loop gain	Pn102	Pn106	Pn12D	Pn130
Torque reference filter	Pn401	Pn412	Pn413	Pn414

5.5 Changing the Gain Selection Parameter

Spindle axes have three gear levels: high-speed, low-speed, and medium-speed, and sometimes they have special replaceable attachments.
The appropriate gain must be selected to withstand the load for spindle axis gear conversion or when replacing attachments for a gear.
The gain parameters are stored in the host controller and a specific gain area in the servo is overwritten as required. Use the SVPRM_WR main command and subcommand to select the parameter number and change the required parameter.

5.5.1 How to Handle More than Four Sets of Gain Settings

For example, if a mechanical gear has four settings: "Gear 1 (Low)," "Gear 2 (Middle)," "Gear 3 (High)," and "not used," the load that is incurred when different types of attachments are added will cause the gain to no longer match.
If you know this can occur, you can temporarily change the gain to prevent this from happening.

Example

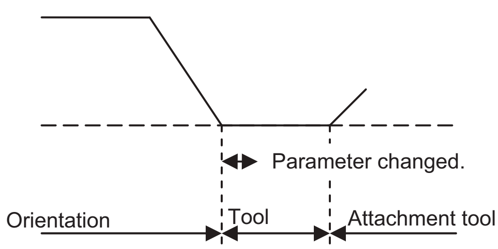
In this example, there are two different load possibilities for each gear, one with an attachment and one without.
In this case, the gains must be set for the load when an attachment is present and when there is no attachment. Gain 3 is assigned for the gain selection area for the "not used" gear as a software gain setting area. Gain 3 is then selected when the SVPRM_WR command is used to write the gain setting to Gain 3.

Gear Type	No ATT	ATT1	ATT2	ATT3
Gear 1 (low)	Gain 0	Software gain (setting 1)	Software gain (setting 4)	Software gain (setting 7)
Gear 2 (medium)	Gain 1	Software gain (setting 2)	Software gain (setting 5)	Software gain (setting 8)
Gear 3 (high)	Gain 2	Software gain (setting 3)	Software gain (setting 6)	Software gain (setting 9)
Not used (software gain setting)	Gain 3 (Pn12E)			

When speed control is used to control a spindle axis, the tapping and orientation position loop gains are handled by the host controller.

5.5.2 Gain Parameter Overwrite Timing for Tool Replacement (M06)

Gain parameter overwriting for tool replacement (M06) is performed when the spindle axis is stopped for tool replacement.
The parameters for Gain 3 are overwritten when the orientation that is performed for the gain selection (0 to 3) for the tool replacement has been completed and tool replacement has started.
When the M06 sequence starts, the gain number for the next tool is found from the gear and attachment tool number. If the gain number is higher than 4, write that gain data to Gain 3 when the tool replacement orientation has been completed and the actual tool replacement begins. If the communications cycle is 250 µs, the parameter write time will be approximately 7 to 8 ms.
Afterwards, if Gain 3 is selected after the tool has been replaced, all control after that point is executed with the gain for that attachment tool.



5.5.3 Sequence for Gain Selection in Speed Control Mode

A sequence example for gain selection in Speed Control Mode is provided below.

Step 1:
CMD = VELCTRL (3C hex)
SVCMD_IO.G-SEL = 1: Selects Gain 0, Gain 1, Gain 2, or Gain 3.
SVCMD_IO.SVMOD = 0: Spindle axis mode
VREF: Reference speed
ACCR: Acceleration rate
DECR: Deceleration rate
Subcommand
SUBCMD SVCMD_WR = 41 hex
NO = 12E: Speed Loop Gain (Pn12E)
SIZE = 2: 2 bytes
MODE = 0B hex: RAM area only
PARAMETER = XXXX: Write data
Execution of the process has been completed when RSUBCMD is SVPRM_WR (41 hex) and SUB-_STAT.SUBCMDRDY is 1.

Step 2:
CMD=VELCTRL (3C hex)
SVCMD_IO.G-SEL = 3: Selects Gain 3.
SVCMD_IO.SVMOD = 0: Spindle axis mode
VREF: Reference speed
ACCR: Acceleration rate
DECR: Deceleration rate

When the power supply is turned ON, an attachment tool may already be attached. Therefore, you must determine the gain to use based on the gear and attachment selection before the servo is turned ON.

5.6 Winding Selection

This section describes the methods that are used to perform winding selection from the SERVOPACK.

5.6.1 Characteristics of a Winding Selection Wide-range Constant-output Servo Drive for a Spindle Axis

Winding selection for an AC spindle motor is an effective way to extend the constant-output control range of the servo driver that drives the spindle axis.
The characteristics of this type of servo driver are described below.

- Wide Constant-output Control Range

The servo driver for the spindle axis can achieve a constant-output range of 1:12 without the use of a gearbox.

- Small Drive Capacity

If the constant-output range of the servo driver for a spindle axis is expanded, the motor current in the low-speed area is forced to increase, and therefore the capacity of the servo driver must also be increased.
If winding selection is used, you can simply change the motor winding connection to obtain a constant-output control of 1:12 with a standard servo driver capacity.

- Good Control Stability

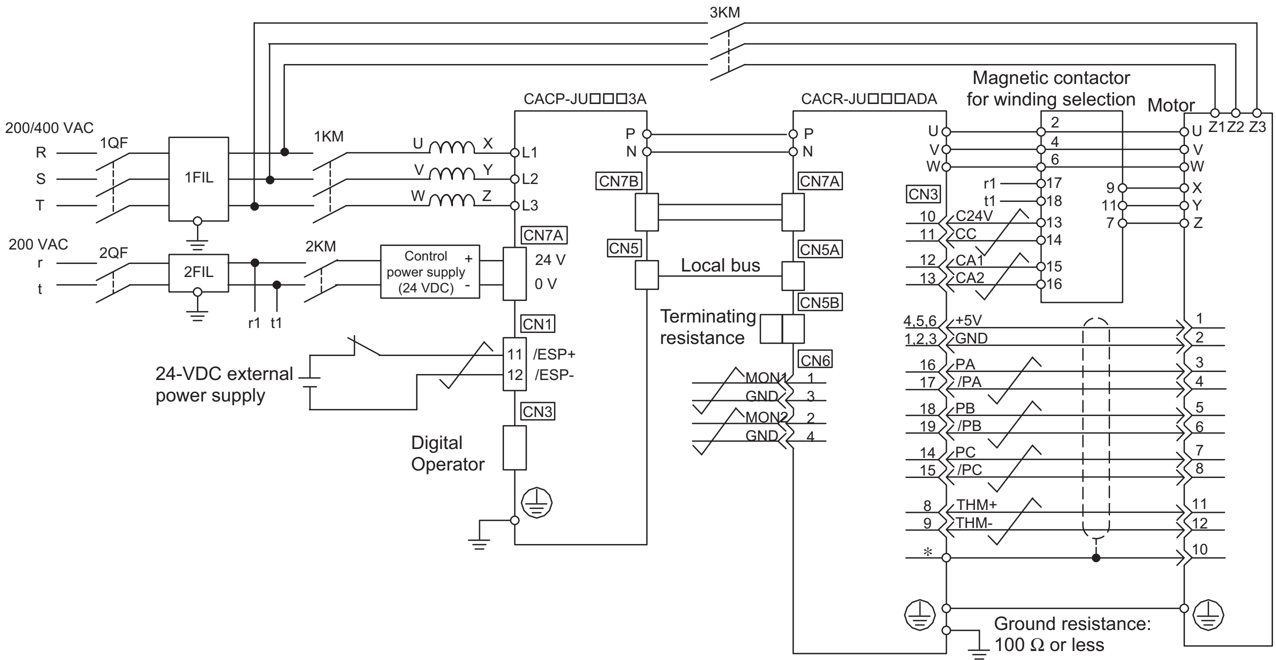
Winding selection separates the constant-output control range between low-speed winding and high-speed winding for optimal control.
Therefore, the loop gain can also be increased for more stable control.

- Magnetic Contactor for Winding Selection

This is a compact magnetic contactor developed specifically for winding selection.
A transfer contact configuration enables a mechanical lifetime of over 5,000,000 uses and direct drive from the host controller.

5.6.2 Winding Selection Motor Standard Connections Diagram

As shown in the following diagram, this system requires winding selection signals in addition to speed reference signals such as the FWD and REV signals.
A special magnetic contactor that can be driven directly from the SERVOPACK with transfer contacts is also used to switch the winding.



* Connected to the CN3 connector shell.

5.6.3 Related Parameters

The parameters related to winding selection are listed below.

Parameter No.	Name	Unit	Setting Range	Factory Setting	When Enabled
Pn01E	Application Function Select Switch 1E	-	0x0000 to 0x0025	0x0000	After restarting
Pn433	Servo Mode Flux Level (for High-speed Winding)	%	30 to 100	100	Immediately
Pn434	Servo Mode Base Speed Ratio (for High-speed Winding)	%	100 to 500	100	Immediately
Pn435	Servo Mode Flux Level (for Low-speed Winding)	%	30 to 100	100	Immediately
Pn436	Servo Mode Base Speed Ratio (for Low-speed Winding)	%	100 to 500	100	Immediately

The flux level and base speed ratio control parameters are used to expand the constant-torque range for tapping and other operations.

5.6.4 Application Function Select Switch 1E

Use the following parameters to select the motor type, use, and winding selection.

Parameter No.	Setting Range	Description	Factory Setting
Motor Type Setting and Application Selection Pn01E.0	0	SPM motor for servo	0
	1	SPM motor for spindle axis	
	2	Induction motor for servo	
	3	Induction motor for spindle axis	
	4	IPM motor for servo	
	5	IPM motor for spindle axis	
Winding Selection Pn01E.1	0	None	0
	1	Mechanical winding selection	
	2	Electronic winding selection	

5.6.5 Winding Selection Operation

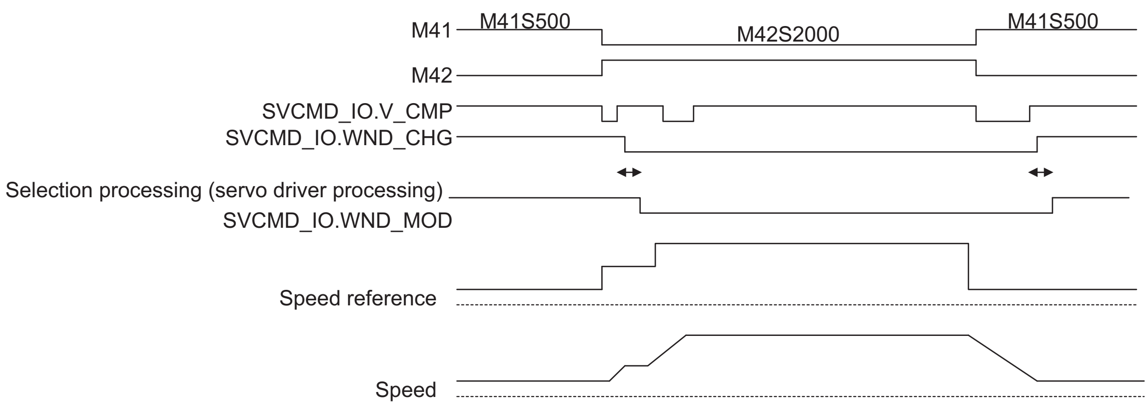
Refer to the following three methods to design a circuit for winding selection that sufficiently utilizes the characteristics of the motor that is used.

- Winding selection control with M codes
- Control by monitoring the switching speed through the SERVOPACK’s speed feedback
- Control by monitoring the switching speed through speed references and the SERVOPACK’s speed feedback

5.6.6 Winding Selection Control with M Codes

This method treats the winding selection of the servo driver for a machine tool’s spindle axis as an electronic gear and provides NC M codes (M41 low-speed winding and M42 high-speed winding).

Winding Selection Sequence



Note: The speed reference is a step reference with an acceleration of ACCR (the maximum acceleration rate).
Set the hysteresis for the detection of the switching speed.

The procedure for the operating sequence of the above time chart is as follows:

- Winding Selection Speed Control with M42

1. When an M42 S reference is specified, the switching speed (1,250 min^{-1}) is used if the S reference is larger than the switching speed.
2. SVCMD_IO.V_CMP will be 1 if the switching speed (1,250 min^{-1}) has been reached.

3. The high-speed winding request (SVCMD_IO.WND_CHG = 0) and high-speed winding gain selection (SVCMD_IO.G-SEL) are specified simultaneously.

The SERVOPACK performs the winding selection sequence,* and then returns SVCMD_IO.WND_-MOD = 0 after execution of the winding selection operation has been completed.

* The SERVOPACK receives the winding selection signal and starts the selection sequence if any changes are detected.
After entering the SV_OFF state and a base block is set, the output to the magnetic contactor for winding selection is changed to high-speed winding after 10 ms.
In the control section, load the gain settings for the selected G-SEL and set for high-speed winding.
Make sure that the magnetic contactor for winding selection is actually set for high-speed winding.
This removes the base block and changes to the SV_ON state.

4. The host controller checks the high-speed winding state (SVCMD_IO.WND_MOD = 0) from the SERVOPACK.

5. The speed of the specified S reference is output and a check is made to see if the speed matches (SVCMD_IO.V_CMP = 1).

This concludes the process for winding selection with M42.

• Winding Selection Speed Control with M41

1. When an M41 S reference is specified, the speed of the S reference is specified without performing winding selection if the S reference is larger than the switching speed.

However, if the S reference is smaller than the switching speed, the speed of the S reference is specified as-is.

2. The host controller checks to confirm that the speed matches (SVCMD_IO.V_CMP = 1).

3. The low-speed winding request (SVCMD_IO.WND_CHG = 1) and low-speed winding gain selection (SVCMD_IO.G-SEL) are executed simultaneously.

The SERVOPACK performs the winding selection sequence, and then returns SVCMD_IO.WND_MOD = 1 after execution of the winding selection operation has been completed.

4. The host controller checks the low-speed winding state (SVCMD_IO.WND_MOD = 1) from the SERVOPACK.

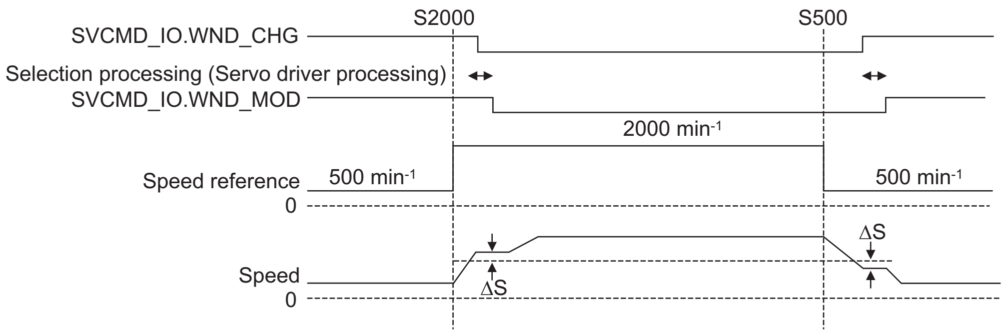
This concludes the process for winding selection with M41.

Note: The speed reference is a step reference with an acceleration of ACCR (the maximum acceleration rate).
Set the hysteresis for the detection of the switching speed.

5.6.7 Control by Monitoring the Switching Speed through the SERVOPACK's Speed Feedback

This section describes how to automatically perform winding selection by only monitoring the speed feedback received from the MECHATROLINK to determine the motor's actual speed.

Winding Selection Sequence



The procedure for the operating sequence of the above time chart is as follows:

• Changing from Low-speed Winding at 500 min^{-1} to High-speed Winding at 2,000 min^{-1}

1. If an S reference is specified for the current winding, the speed of the S reference is executed.

2. The speed feedback (FSPD) is read from the SERVOPACK and a check is made to confirm that it is higher than the switching speed + ΔS.

3. The high-speed winding request (SVCMD_IO.WND_CHG = 0) and high-speed winding gain selection (SVCMD_IO.G-SEL) are executed simultaneously.

The SERVOPACK performs the winding selection sequence,* and then returns SVCMD_IO.WND_-MOD = 0 to show the high-speed winding status after execution of the winding selection operation has been completed.

* The SERVOPACK takes the differential of the winding selection signal and starts the selection sequence if any changes are detected.
After entering the SV_OFF state and a base block is set, the output to the magnetic contactor for winding selection is changed to high-speed winding after 10 ms.
In the control section, load the gain settings for the selected G-SEL and set for high-speed winding.
Make sure that the magnetic contactor for winding selection is actually set for high-speed winding.
This removes the base block and changes to the SV_ON state.

4. The host controller checks to confirm that SVCMD_IO.WND-MOD is 0.

5. The host controller checks to confirm that the speed matches (SVCMD_IO.V_CMP = 1).

This concludes the winding selection sequence to change from the low-speed winding to high-speed winding.

• Changing from High-speed Winding at 2,000 min^{-1} to Low-speed Winding at 500 min^{-1}

1. If an S reference is specified for the current winding, the speed of the S reference is executed.

2. The speed feedback (FSPD) is read from the SERVOPACK and a check is made to confirm that it is lower than the switching speed - ΔS.

3. The low-speed winding request (SVCMD_IO.WND_CHG = 1) and low-speed winding gain selection (SVCMD_IO.G-SEL) are executed simultaneously.

The SERVOPACK performs the winding selection sequence, and then returns SVCMD_IO.WND_MOD = 1 to show the low-speed winding status after execution of the winding selection operation has been completed.

4. The host controller checks the low-speed winding state (SVCMD_IO.WND_MOD = 1) from the SERVOPACK.

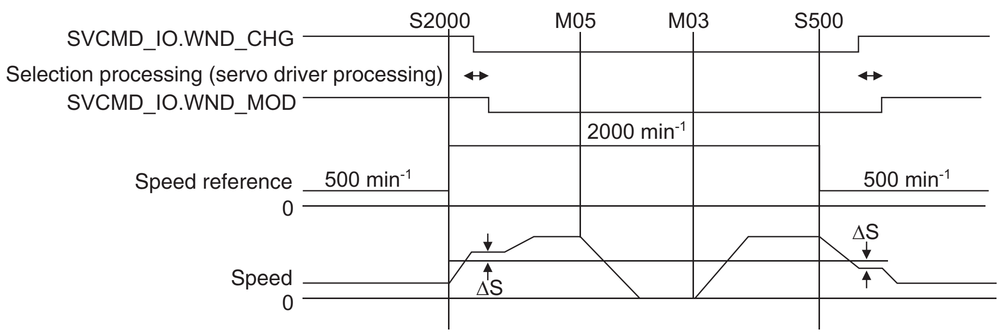
5. The host controller checks to confirm that the speed matches (SVCMD_IO.V_CMP = 1).

This concludes the winding selection sequence to change from the high-speed winding to low-speed winding.

5.6.8 Control by Monitoring the Switching Speed through Speed References and the SERVOPACK's Speed Feedback

This method uses the speed reference and SERVOPACK feedback speed to determine if the speed reference and actual motor speed are in the high-speed or the low-speed winding selection range and select the appropriate winding.
Compared to performing this selection based only on the actual feedback speed, this method requires less switching of the magnetic contactor.

Winding Selection Sequence



Speed Reference Speed	Speed Reference	
	Speed Reference > Switching Speed - ΔS	Speed Reference < Switching Speed - ΔS
Speed > Switching Speed - ΔS	High-speed winding selected.	No winding selected.
Speed < Switching Speed - ΔS	No winding selected.	Low-speed winding selected.

The procedure for the operating sequence of the above time chart is as follows:

- Changing from Low-speed Winding at 500 min^{-1} to High-speed Winding at 2,000 min^{-1}

1. If an S reference is specified for the current winding, the speed of the S reference is executed.
2. The speed feedback (FSPD) is read from the SERVOPACK and a check is made to confirm that it is higher than the switching speed + ΔS.
3. The high-speed winding request (SVCMD_IO.WND_CHG = 0) and high-speed winding gain selection (SVCMD_IO.G-SEL) are executed simultaneously.

   The SERVOPACK performs the winding selection sequence,* and then returns SVCMD_IO.WND_-MOD = 0 to show the high-speed winding status after execution of the winding selection operation has been completed.

   * The SERVOPACK takes the differential of the winding selection signal and starts the selection sequence if any changes are detected. After entering the SV_OFF state and a base block is set, the output to the magnetic contactor for winding selection is changed to high-speed winding after 10 ms.
   In the control section, load the gain settings for the selected G-SEL and set for high-speed winding.
   Make sure that the magnetic contactor for winding selection is actually set for high-speed winding.
   This removes the base block and changes to the SV_ON state.
4. The host controller checks to confirm that SVCMD_IO.WND-MOD is 0.
5. The host controller checks to confirm that the speed matches (SVCMD_IO.V_CMP = 1).

   This concludes the winding selection sequence to change from the low-speed winding to high-speed winding.

- If M05 (Stop Spindle Axis) Is Executed

1. If M05 (Stop Spindle Axis) is executed, the host controller sends a speed reference of 0 min^{-1}.
2. The host controller confirms a zero speed (SVCMD_IO.ZSPD = 1) from the SERVOPACK.

   This concludes the sequence for M05 (Stop Spindle Axis).

- If M03 (Spindle Axis Forward Run) Is Executed

1. If M03 (Spindle Axis Forward Run) is executed, the host controller sends a speed reference of 2,000 min^{-1}.
2. The host controller confirms that the speed matches (SVCMD_IO.V_CMP = 1) from the SERVOPACK.

   This concludes the sequence for M03 (Spindle Axis Forward Run).

- Changing from High-speed Winding at 2,000 min^{-1} to Low-speed Winding at 500 min^{-1}

1. If an S reference is specified for the current winding, the speed of the S reference is executed.
2. The speed feedback (FSPD) is read from the SERVOPACK and a check is made to confirm that it is lower than the switching speed - ΔS.
3. The low-speed winding request (SVCMD_IO.WND_CHG = 1) and low-speed winding gain selection (SVCMD_IO.G-SEL) are executed simultaneously.

   The SERVOPACK performs the winding selection sequence, and then returns SVCMD_IO.WND_MOD = 1 to show the low-speed winding status after execution of the winding selection operation has been completed.
4. The host controller checks the low-speed winding state (SVCMD_IO.WND_MOD = 1) from the SERVOPACK.
5. The host controller checks to confirm that the speed matches (SVCMD_IO.V_CMP = 1).

   This concludes the winding selection sequence to change from the high-speed winding to low-speed winding.

5.6.9 Winding Selection Reference

Winding selection references are sent from the host with the MECHATROLINK-III SVCMD_IO.WND_CHG servo command.
Monitor the actual feedback speed to see if it is within the range that is allowed for winding selection and execute SVCMD_IO.WND_CHG (bit 31, HIGH = 0, LOW = 1).

Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
MC-ON	Reserved.						
Bit 31	**Bit 30**	**Bit 29**	**Bit 28**	**Bit 27**	**Bit 26**	**Bit 25**	**Bit 24**
WND_CHG	SV_MOD	Reserved.					

Bit	Name	Meaning	Value	Setting
Bit 31	WND_CHG	Winding Selection Reference	0	High-speed winding
			1	Low-speed winding

5.6.10 Winding State

You can check the winding state with MECHATROLINK-III communications.
The states for SVCMD_IO.WND_MOD are given below.

Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
WND_MOD	Reserved. (0)						

Bit	Name	Meaning	Value	Setting
Bit 31	WND_MOD	Winding State	0	High-speed winding
			1	Low-speed winding

5.6.11 Precautions for Motor Drives that Require Magnetic Pole Detection

Observe the following precautions when using a motor that requires magnetic pole detection, such as IPM and DD motors.

On MECHATROLINK-III SERVOPACKs, the MECHATROLINK control section sends out a magnetic pole detection reference with the first Servo ON command that is sent after the power supply is turned ON. The servo executes the magnetic pole detection sequence. After execution of the magnetic pole detection sequence has been completed, the servo is turned ON and returns notification that execution has been completed.
Winding selection motors that require the above magnetic pole detection perform the detection with the low-speed winding.
Therefore, when SV_ON is executed after the power supply is turned ON, a control selection command must be executed to select low-speed winding (SVCMD_IO.WND_CHG = 1).

5.6.12 Parameters That Are Managed from the Host Controller

The following host controller parameters are required to perform winding selection.

- Winding switching speed, example: 1,250 min^{-1}
- Winding switching speed detection hysteresis, example: 5%

5.6.13 Related Alarms

The following table lists all relevant alarms.

Alarm Number	Name	Description	Stop Method	Reset
A.052	Motor Type Setting Mismatch	The Motor Type (Pn01E.0) does not match the motor parameter (PnF40.0).	Pn001.0	Required
A.053	Winding Selection Setting Mismatch	The Winding Selection (Pn01E.1) does not match the motor parameter (PnF40.2).	Pn001.0	Required
A.054	Unsupported Winding Selection Alarm	The SERVOPACK and motor are not compatible for winding selection (winding selection is used for SERVOPACKs that use a charge pump together with a magnetic motor).	Pn001.0	Required
A.540	Overspeed (during Low-speed Winding)	The low-speed winding maximum speed was exceeded during low-speed winding.	Pn001.0	Auto reset
A.690	Winding Selection Operation Fault	• During the winding selection operation check that is performed when the power is turned ON, the winding selector did not change according to the internal command. • Winding changeover was not completed within two seconds of receiving the winding selection command. • Chattering occurred in the winding selector when the winding selection command was not received.	Pn001.0	Required
A.C52	Magnetic Pole Detection Incomplete	• The servo was turned ON before the execution of magnetic pole detection was completed. • Magnetic pole detection was attempted during high-speed winding.	Pn001.0	Auto reset

Spindle Axis Operation

5

6

Additional Functions

This chapter describes additional functions of Σ-V-SD servo drivers.

6.1 C-S Axis Control

C axis control is required for some lathing.
There are two types of C axes: simple C axes and high-precision C axes.
Simple C axes have a reference unit of 0.001 degrees, while high-precision C axes require even higher precision.
C axes require their own external encoder, for which a serial encoder is normally used.
Generally, an encoder for fully-closed loop control is used.

Motor encoder:	18 bits
External encoder:	1,200 slits, 256x (capable of 12,000 revolutions)
	1,200 slits, 4,096x (capable of 5,400 revolutions)

To perform C-S control, you can use a Heidenhain sine-wave output (1 V) encoder for fully-closed loop control.
The motor encoder, external encoder, and fully-closed specifications must be set in parameters to support C-S axes when the power supply is turned ON.

6.1.1 Infinite-length Encoders

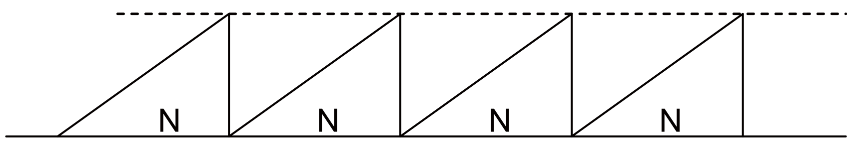
Make the following settings for counter control when the power supply is turned ON.

- APSO = 0
- TPOS = 0
- POS in CNC = 0
- Poscount = 0

Position management is performed with these current values as a base.

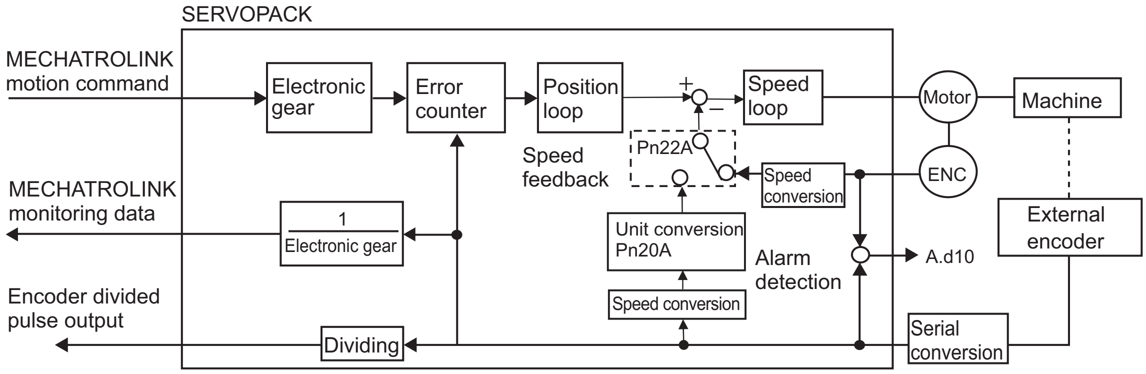
Make the following settings for position management in normal operation.
360,000 reference units for 1,200 slits and 256x multiplier = 307,200
ΔPOS = APOS (i+1) - APOS (i)
POS (i+1) = POS (i) + ΔPOS
if POS (i+1) ≥ 307,200 POS (I + 1) = POS (I + 1) -307,200 Poscount = + 1
if POS (I+1) < 0 POS (i+1) = 307,200 + POS (I + 1) Poscount = - 1
Note: APOS can be counted as 2*n.

Make the following settings for reference unit conversion and reverse conversion.
Reference unit conversion: Convert the reference number of pulses of 0 to 360,000 to 0 to 307,200.
Reference unit reverse conversion: Convert the feedback number of pulses of 0 to 307,200 to 0 to 360,000.



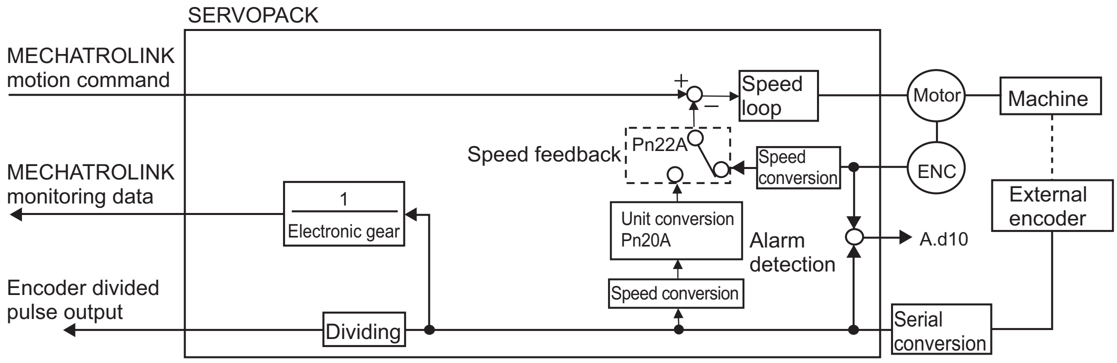
To perform speed control with fully-closed loop control, it also needs to be set in a parameter.

(1) Using an Infinite-length Encoder in Position Control



Note: Either an incremental encoder or absolute encoder can be used, but for an absolute encoder, you must set Pn002.2 to 1 and use the encoder as an incremental encoder.

(2) Using an Infinite-length Encoder in Speed Control



6.1.2 Related Parameters

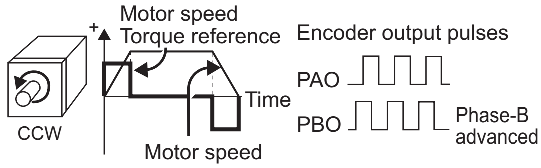
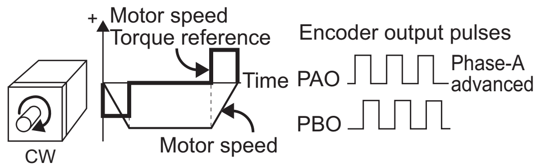
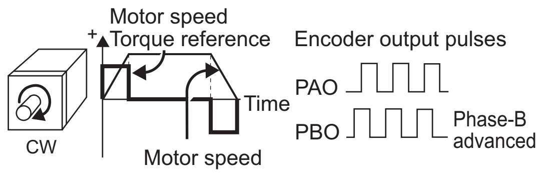
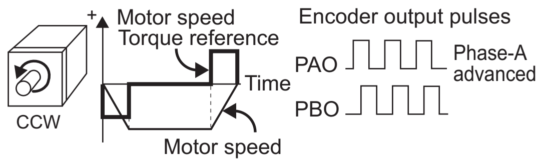
This section describes the settings of the parameters for fully-closed loop control.

Table 1. Parameters for Fully-closed Loop Control

Parameter No.	Name	Unit	Setting Range	Factory Setting	When Enabled
Pn000.0	Rotation Direction Selection	–	0 to 3	0	After restart
Pn002.2	Absolute Encoder Usage*1	–	0, 1	0	After restart
Pn002.3	External Encoder Usage	–	0 to 4	0	After restart
Pn006	Analog Monitor 1 Signal Selection	–	0000 to 005F	2	Immediately
Pn007	Analog Monitor 2 Signal Selection	–	0000 to 005F	0	Immediately
Pn20A	Number of External Scale Pitch	1 pitch/rev	4 to 1,048,576	32,768	After restart
Pn22A.3	Speed Feedback Selection at Fully-closed Control	–	0, 1	0	After restart
Pn51B	Excessive Error Level between Servo-motor and Load Positions*2	1 reference unit	0 to 1,073,741,824	1,000	Immediately
Pn52A	Multiplier per One Fully-closed Rotation	1%	0 to 100	20	Immediately
PnA06	Semi-closed/Fully-closed Type (read only)	–	–	–	–
Pn01E.0	Motor Type Setting and Application Selection	–	0 to 5	0	After restart
Pn01E.1	Winding Selection	–	0, 1	0	After restart
Pn01F.0	Encoder Type	–	0 to 2	0	After restart

*1. If an absolute external encoder is used, the external encoder will function as an absolute encoder even if Pn002.2 is set to 1.
*2. If Pn51B is set to 0, the Motor-load Position Error Overflow Alarm (A.d10) will not be output.

6.1.3 Motor Rotation Direction Setting

<table>
<tr><th colspan="2">Parameter</th><th>Forward/ Reverse Run Reference</th><th>Motor Rotation Direction and Encoder Output Pulses</th><th>Effective Overtravel (OT)</th></tr>
<tr><td rowspan="4">Pn000</td><td rowspan="2">n.□□□0
Sets counterclockwise (CCW) as the forward direction. (factory setting)</td><td>Forward run reference</td><td>
</td><td>P-OT</td></tr>
<tr><td>Reverse run reference</td><td>
</td><td>N-OT</td></tr>
<tr><td rowspan="2">n.□□□1
Sets clockwise (CW) as the forward direction. (Reverse Rotation Mode)</td><td>Forward run reference</td><td>
</td><td>P-OT</td></tr>
<tr><td>Reverse run reference</td><td>
</td><td>N-OT</td></tr>
</table>

6.1.4 Relationship between Motor Rotation Direction and External Encoder Pulse Direction

The relationship between the motor rotation direction and the external encoder pulse direction is shown in the following table.

<table>
<tr><th rowspan="2">Parameter</th><th rowspan="2" colspan="2">Set Value</th><th colspan="4">Pn002.3 (External Encoder Usage)</th></tr>
<tr><th>1</th><th>1</th><th>1</th><th>1</th></tr>
<tr><td rowspan="8">Pn000.0 (Motor Rotation Direction)</td><td rowspan="4">0</td><td>Reference direction</td><td>Forward run reference</td><td>Reverse run reference</td><td>Forward run reference</td><td>Reverse run reference</td></tr>
<tr><td>Motor rotation direction</td><td>CCW</td><td>CW</td><td>CCW</td><td>CW</td></tr>
<tr><td>External encoder output</td><td>cos advanced</td><td>sin advanced</td><td>sin advanced</td><td>cos advanced</td></tr>
<tr><td>Encoder output pulses</td><td>Phase-B advanced</td><td>Phase-A advanced</td><td>Phase-B advanced</td><td>Phase-A advanced</td></tr>
<tr><td rowspan="4">1</td><td>Reference direction</td><td>Forward run reference</td><td>Reverse run reference</td><td>Forward run reference</td><td>Reverse run reference</td></tr>
<tr><td>Motor rotation direction</td><td>CW</td><td>CCW</td><td>CW</td><td>CCW</td></tr>
<tr><td>External encoder output</td><td>sin advanced</td><td>cos advanced</td><td>cos advanced</td><td>sin advanced</td></tr>
<tr><td>Encoder output pulses</td><td>Phase-B advanced</td><td>Phase-A advanced</td><td>Phase-B advanced</td><td>Phase-A advanced</td></tr>
</table>

If the motor rotation direction is CCW, set Pn002.3 to 1 (standard operating direction) if the external encoder output is cos advanced, or set Pn002.3 to 3 (reverse on forward run reference) if the output is sin advanced.

Use the following procedure to check the external encoder output.
When Pn000.0 is 0 and Pn002.3 is 1, rotate the motor by hand in the counterclockwise direction. If the Un00E fully-closed feedback pulse counter counts up, set Pn002.3 to 1.
If it counts down, set Pn002.3 to 3.

If Pn002.3 is 1, the encoder pulse output will change to phase B advanced when the motor is rotated in the forward direction.
If Pn002.3 is 3, the encoder pulse output will change to phase A advanced when the motor is rotated in the forward direction.

6.1.5 External Encoder Sine Wave Pitch (Frequency) Setting

The number of external encoder pitches per motor revolution is set in Pn20A.
A setting example is given below.

Specifications External encoder pitch: 20 µm Ball screw pitch: 30 mm Speed: 1,600 mm/s

If a direct drive connection to the motor is used, 30 mm/0.02 mm = 1,500, so the set value is 1,500.

Note 1. If this results in a fractional number, round off the decimal portion.
2. If the number of external encoder pitches per motor revolution is not an integer, the position loop gain (Kp), feed-forward, and position reference speed monitor will deviate from the speed loop.
However, this will not affect position accuracy and therefore no position displacement will occur.

The following table lists the related parameters.

Pn20A	Number of External Scale Pitch (Position)				Classification
	Setting Range	Setting Unit	Factory Setting	When Enabled	
	4 to 1,048,576	1 pitch/rev	32,768	After start	Setup

6.1.6 Setting Alarm Detection

This section describes the parameters for alarm detection (Pn51B and Pn52A).

(1) Setting the Excessive Error Level between Servomotor and Load Positions (Pn51B)

This parameter detects the difference between the motor encoder feedback position and the fully-closed loop external encoder feedback position (i.e., the load position).
If the set value is exceeded, the Motor-load Position Error Overflow Alarm (A.d10) will be output.

Pn51B	Excessive Error Level between Servomotor and Load Positions (Position)				Classification
	Setting Range	Setting Unit	Factory Setting	When Enabled	
	0 to 1,073,741,824	1 reference unit	1,000	Immediately	Setup

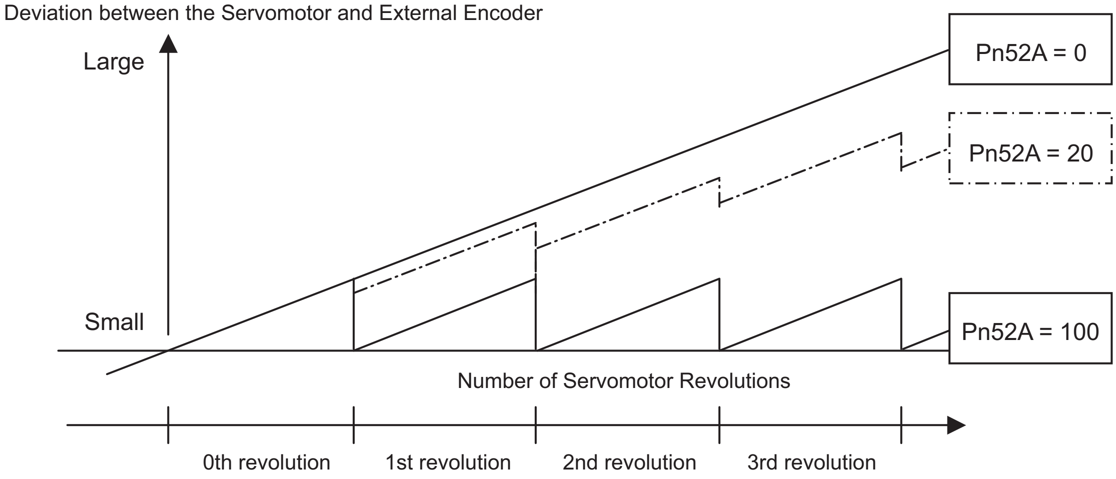
Note: If this parameter is set to 0, the Motor-load Position Error Overflow Alarm (A.d10) will not be output.

(2) Setting the Multiplier per One Fully-closed Rotation (Pn52A)

This parameter sets the deviation coefficient between the servomotor and external encoder per servomotor revolution.
This can protect against overrun due to external encoder malfunction and detect slipping in belt mechanisms.

■ Setting Example

Increase this value if the belt slip ratio or twisting is too high.
Set this value to 0 to read the external encoder value as is.
At the factory setting of 20, the second revolution of the servomotor begins from the point where the deviation in the first servomotor revolution is multiplied by 0.8.



6.1.7 Setting the Motor Type, Application Selection (Pn01E.0), and Winding Selection (Pn01E.1)

Parameter No.	Setting Range	Description	Factory Setting
Motor Type Setting and Application Selection Pn01E.0	0	SPM motor for servo	0
	1	SPM motor for spindle axis	
	2	Induction motor for servo	
	3	Induction motor for spindle axis	
	4	IPM motor for servo	
	5	IPM motor for spindle axis	
Winding Selection Pn01E.1	0	None	0
	1	Mechanical winding selection	

6.1.8 Setting the Encoder Type (Pn01F.0)

Parameter No.	Setting Range	Description	Factory Setting
Encoder Type Pn01F.0	0	Serial encoder	0
	1	Pulse encoder	
	2	Serial encoder (no servomotor constants)*	

* The servomotor constants are stored in the SERVOPACK for serial encoders with no servomotor constants.

6.1.9 Setting Absolute Encoder Usage (Pn002.2)

Parameter No.	Setting Range	Description	Factory Setting
Absolute Encoder Usage Pn002.2	0	Use absolute encoder as an absolute encoder.	0
	1	Use absolute encoder as an incremental encoder.	

Note: If an absolute external encoder is used, the external encoder will function as an absolute encoder even if Pn002.2 is set to 1.

6.1.10 Setting External Encoder Usage (Pn002.3)

Parameter No.	Setting Range	Description	Factory Setting
External Encoder Usage Pn002.3	0	Not used* (factory setting)	0
	1	Use in the standard operating direction.	
	2	Reserved parameter (Do not set.)	
	3	Use in the reverse operating direction.	
	4	Reserved parameter (Do not set.)	

* Set Pn002.3 to 0 to perform semi-closed position control.

6.1.11 Setting the Fully-closed Control Selection Switch (Pn22A.3)

This parameter selects the speed feedback method for fully-closed loop control.

Parameter No.	Setting Range	Description	Factory Setting
Fully-closed Control Selection Switch Pn22A.3	0	Use the Servomotor encoder speed.	0
	1	Use the external encoder speed.	

6.1.12 C Axis Commands

You can perform high-precision C-axis control by setting Pn22A.3 to 1.
When the power supply is turned ON, execute the VELCTRL command for the speed reference in the same way as for a spindle axis, and then use the INTERPOLATE command for position references. Use a latch command to perform homing for a C axis.
If this origin is defined where the C axis equals 0, the spindle axis and C axis can both be controlled with this same origin.
That is, the VELCTRL speed can be specified in pulses/s, and then the ACCR and DECR commands can be used to achieve the required acceleration or deceleration.
Acceleration and deceleration are controlled from the host controller. The spindle axis can accelerate or decelerate at maximum torque.
To perform interpolation control, you must change to Servo Mode (SV_MOD) and select bank 0 in Cutting Mode for the gain selection.
The INTERPOLATE command can be used in place of the VELCTRL command to establish a position loop.

6.2 Controlling a Rotating Tool Spindle Axis

In some cases, such as for a composite lathe, a rotating tool spindle axis must be controlled in addition to the standard spindle axis.
This type of control is possible with a MECHATROLINK-III single-axis control connection and allows the use of both the VELCTRL command and the INTERPOLATE command.
Forward (M03), reverse (M04), and stop (M05) control for a certain number of revolutions (S min^{-1}) can be performed with the VELCTRL command. (Control can be performed in the same way as for a spindle axis.)
Gain banks are also used to set gain settings in the same way as for spindle axes. Refer to *5.4 Spindle Axis Gain Selection*.
Orientation can be controlled through latches in the same way as for a standard spindle motor drive. Orientation can also be performed during operation.
Refer to *5.2 Spindle Axis Orientation* for details on orientation.

Synchronized control between a rotating tool spindle axis and a feed axis can also be performed.
The INTERPOLATE command is used to interpolate between the spindle and feed axes.
Therefore, tapping can be performed with the rotating tool spindle axis and feed axis in the same way as for a spindle axis.
Refer to *5.3 Tapping Operation* for details on tapping.

6.3 Synchronization between Spindle Axes

Composite lathes sometimes use a master spindle axis and slave spindle axis.
In systems that use master and slave axes, the two spindle axes must be synchronized when any of the following operations are performed.

- Synchronization between spindle axes to process a single workpiece with both spindle axes
- Synchronization between spindle axes to hold and transfer a workpiece between spindle axes

When synchronized operation is started, the positions of the spindle axes do not match, so they must be rotated to the same position.
Reading the feedback position is synchronized, so the position of the slave spindle axis is matched to the master spindle axis by reading the position of each spindle axis and using the master spindle axis as a base.

6.3.1 Chucking a Single Workpiece with Both Spindle Axes

Use the following procedure to perform chucking on a single workpiece with both spindle axes.

- The workpiece is grabbed while both spindle axes are stopped, and the differences between the current values of the axes and their positions are saved.
  Master spindle axis position: APOS (M_0)
  Slave spindle axis position: APOS (S_0)
  Spindle axis position difference: APOS (M_0) - APOS (S_0) = DEFM-S
- The first axis is defined as the master spindle axis, and the second axis is defined as the slave master axis. The same reference (ΔM) is sent to both axes.
- The current positions of both the master spindle axis and slave spindle axis (APOS(M_i), APOS(S_i)) are read each communications cycle. The positional displacement of the slave spindle axis is calculated with the master spindle axis as the base, and the rotations of the axes are synchronized by adjusting the speed reference of the slave axis.
  Master spindle axis speed reference value: ΔM
  Slave spindle axis speed reference value: ΔM + (APOS (M_i) - APOS (S_i) - DEFM-S) × Gain

However, the encoder ratio between the master and slave spindle axes is 1:1.

6.3.2 Transferring a Workpiece from the Master Spindle Axis to the Slave Spindle Axis

The motor speed and position of the slave spindle axis is matched to the motor speed and position of the master spindle axis while the main spindle axis is holding the workpiece and rotating.
After the rotation of the slave spindle axis is synchronized with the master spindle axis, the motor speeds and positions are maintained, the slave spindle axis approaches the transfer point, and chucking is performed.
After chucking is performed, the master slave axis unchucks the workpiece and the slave spindle axis returns to the starting point for processing.

- Position management for both axes is performed after orientation.
  Orientation master spindle axis origin position (position within 1 revolution): APOS (M_{org})
  Orientation slave spindle axis origin position (position within 1 revolution): APOS (S_{org})
  Master and slave spindle axis origin position difference: DEFORGM-S = APOS (M_{org}) - APOS (S_{org})
  Position difference when synchronization begins: DEFM-S = APOS (M_0) - APOS (S_0)
- The first axis is defined as the master spindle axis, and the second axis is defined as the slave master axis. The same speed reference (ΔM) is sent to both axes.
- The current positions of both the master spindle axis and slave spindle axis (APOS(M_i), APOS(S_i)) are read each communications cycle. The positional displacement of the slave spindle axis and the difference between the origin position of the master and slave spindle axes (DEFORGM-S) are calculated based on the master spindle axis, and the motor speeds of the axes are synchronized by adjusting the speed reference of the slave spindle axis.
  Master spindle axis speed reference value: ΔM
  Slave spindle axis speed reference value: ΔM + (APOS (M_i) - APOS (S_i) - DEFM-S - DEFORGM-S) × Gain
- Start the chucking operation after it is confirmed that the speeds are synchronized and the positions match. After that, execution of the workpiece transfer sequence is completed while maintaining the motor speeds and positions.

6.4 Superimposed Interpolation

Composite lathes sometimes add a slave axis to the master axis.
In these cases, the system may, for example, use CNC to generate functions for each axis and superimpose those results for operation.

Multi-axis superimposed control determines the travel distances in mm/rev in relation to the master axes.
Then, the reference values of the axes are calculated and operation is performed according to the travel distances of the master axes.
The relevant axis can be controlled during the communications cycle by adding or subtracting the movement of the controlled master axis to the calculated travel distance.

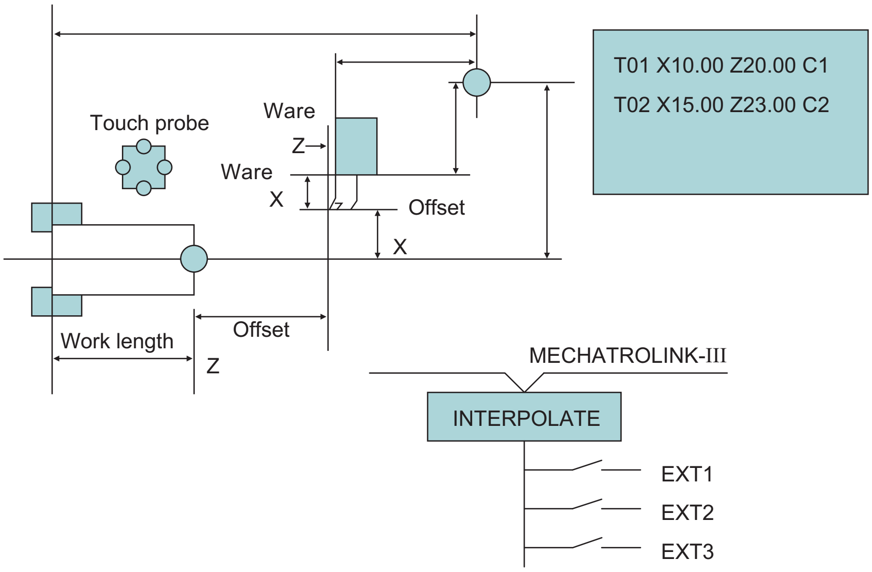
6.5 Implementing a Tool Presetter with Touch Sensors

A tool presetter is implemented with latching.
The operation of the tool presetter is as follows:

1. The latch source is connected to EXT1, EXT2, or EXT3.
2. The latch signal selection and latch request are set, and then manual or step feeding is performed with the INTERPOLATE command.
3. Feeding is stopped when execution of the latch operation is completed.
4. The positions where the sensor was touched is read from each servo.
5. The compensation value is calculated from the data read.

Note: Refer to *4.4 Latching* for details on latching.

The method that is used to calculate the compensation value depends on the compensation value that is set for CNC, but the tool ware compensation can be calculated from the mechanical origin, workpiece shift amount, work coordinates, tool compensation value, probe position compensation value, and other data.
You can also create tool coordinates to set the tool coordinates when a tool is selected either automatically or manually.
A tool presetter enables easier setup operations, the ability to clearly define the work coordinates and tool coordinates by setting up the machine system as described here, and easier programming that is based on the program origin.



7

Alarm and Warning Processing

This chapter describes alarm and warning processing.

7.1 Alarm and Warning Processing

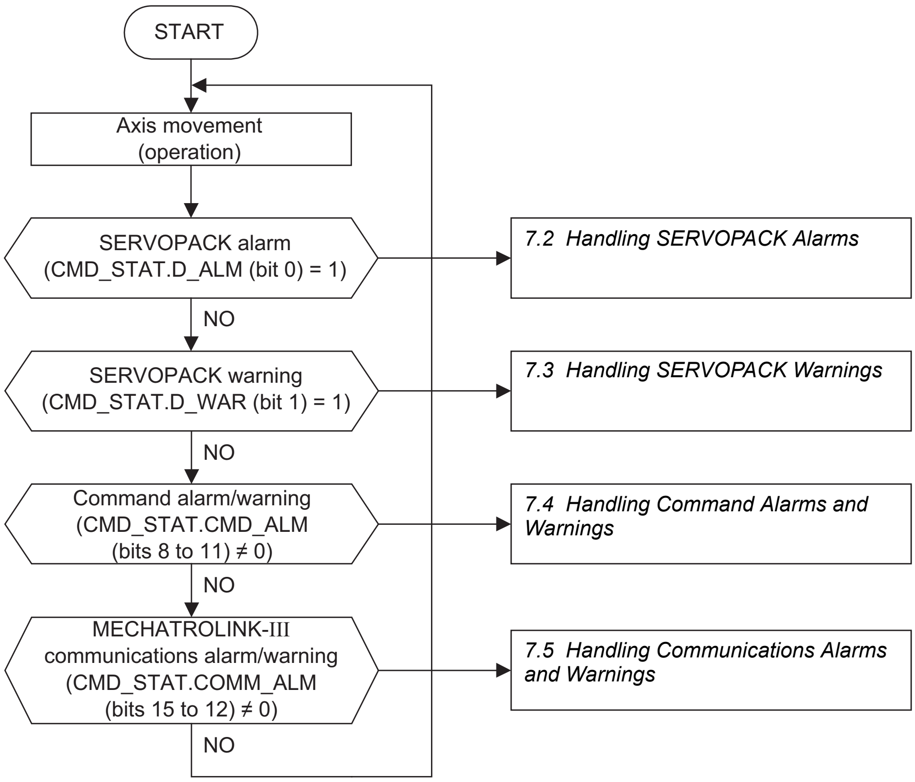
When an alarm or warning occurs in a Σ-V-SD servo driver, the axes are stopped immediately and the alarm is displayed.

7.1.1 Related Parameters

The method used to stop the motors when an alarm occurs is set in the SERVOPACK parameters.
Refer to *4.11 Motor Stop Methods When the Servo is OFF or an Alarm Occurs* for details on the methods used to stop the motors for feed and spindle axes.
When a warning occurs, the motors continue to operate, but if the warning state persists, it will become an alarm and stop the motors.

7.1.2 Checking Alarms and Warnings

The following flowchart shows the processing procedure for when an alarm or warning occurs.
Use the following procedure to check the details of the alarm or warning that has occurred and to recover from the alarm or warning.

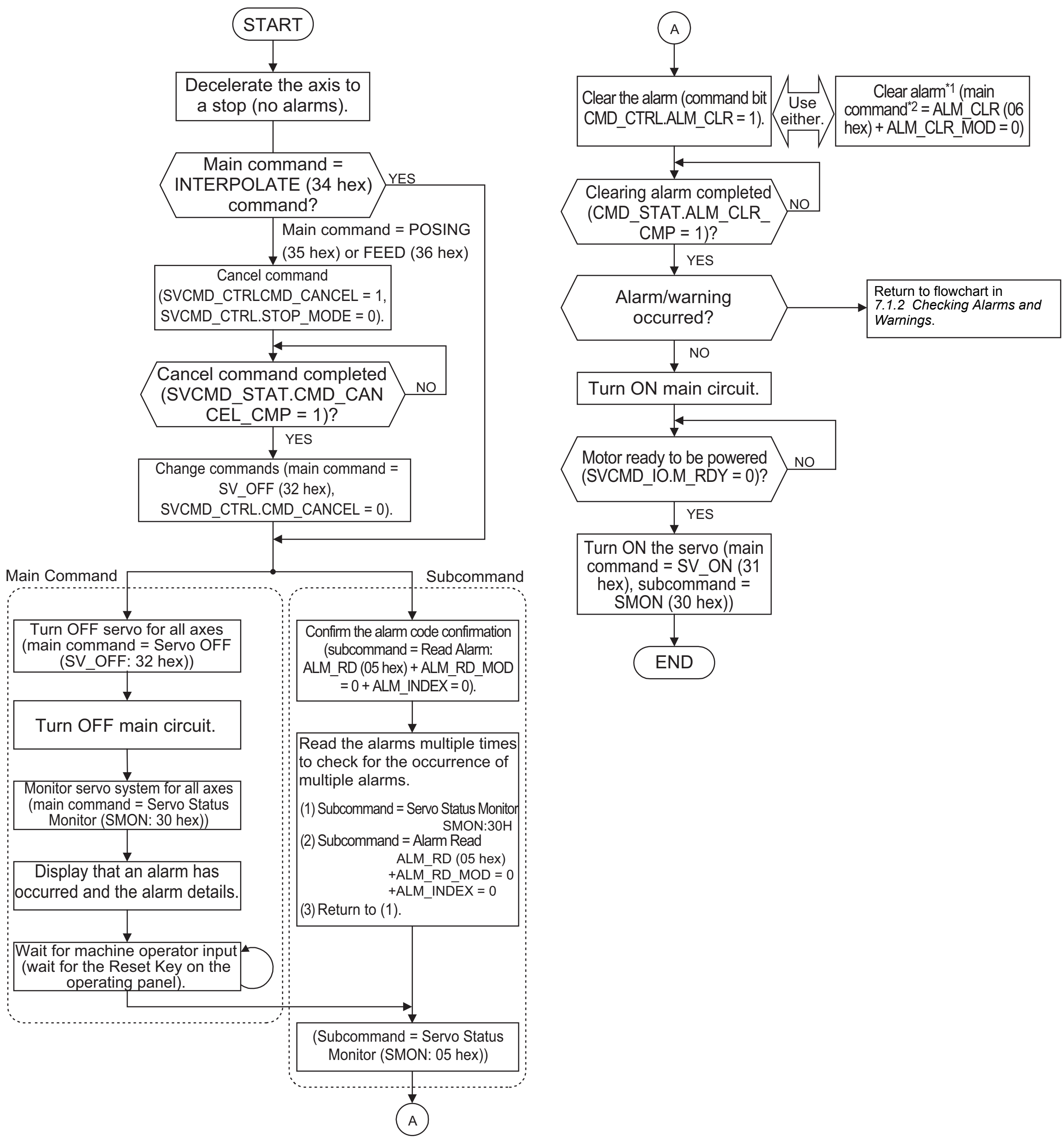


The host controller must constantly monitor to see if any alarms or warnings have occurred in the SERVOPACK.
If an alarm occurs in the SERVOPACK, you can determine the cause of the problem by checking the following information.

Item		Description
Servo operating status	Motor speed (min^{-1})	The coordinate system positions (APOS) are converted to a speed.
	Speed reference (min^{-1})	The target positions (TPOS) of the INTERPOLATE (34 hex) command are converted to a speed, or the speed references (VREF) of the VELCTRL (3C hex) command are converted to a speed.
	Torque reference (%)	The value of the reference torque (TRQ).
	Position deviation (pulse)	The value of the position deviation (PERR).
MECHATROLINK-III communications status	MECHATROLINK-III communications commands and status signals	• CMD, RCMD • CMD_CTRL, CMD_STAT • SVCMD_CTRL, SVCMD_STAT • SVCMD_IO (command and response)

7.2 Handling SERVOPACK Alarms

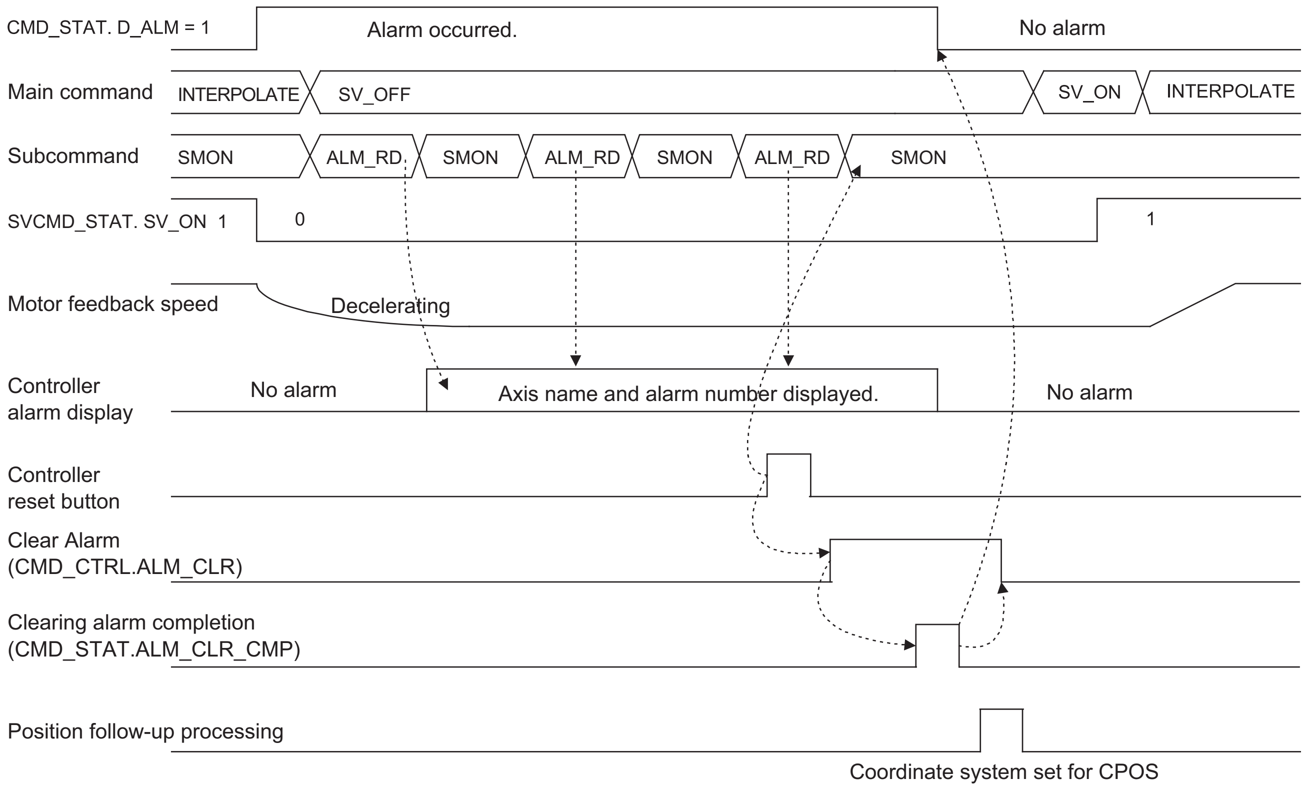
If an alarm occurs in the SERVOPACK, use the following procedure to resolve the problem.



*1. Clearing Alarms
We recommend using only the SV_ON, SV_OFF, and INTERPOLATE commands as main commands and using the command bit (CMD_CTRL.ALM_CLR) to clear alarms.

*2. When the ALM_CLR (06 hex) command is used as the main command, set the subcommand to NOP (00 hex) or SMON (30 hex). If any other subcommand is set, a Command Warning 5 Alarm (A.95E) will occur.

The following timing chart example describes when an alarm occurs when an axis is in motion for the INTERPOLATE (34 hex) command.



SERVOPACK alarms primarily relate to motor operations, SERVOPACK or Servomotor malfunctions, or cable disconnections.
When an alarm occurs, always determine the source of the problem and resolve that problem before starting operation again.
Refer to *11.2.2 Troubleshooting of Alarms* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on what causes alarms and how to resolve those problems.

Alarms that are related to motor operation can simply be cleared to resume operation, but the alarm may continue to occur unless the problem that causes the alarm is resolved.
However, if an alarm occurs repeatedly, the SERVOPACK or motor may be damaged. If the alarm cannot be cleared, resolve the cause of the alarm, and then turn the power supply OFF and ON again.

7.3 Handling SERVOPACK Warnings

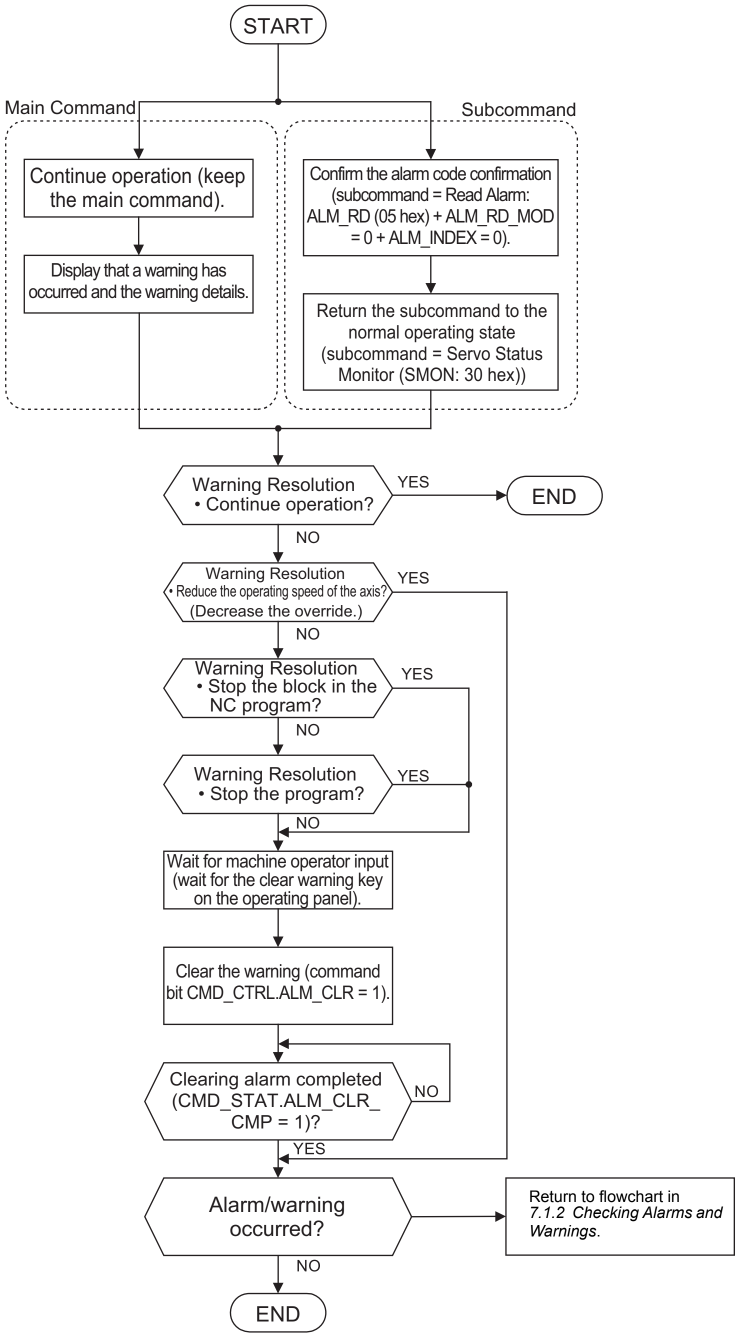
When a warning occurs in the SERVOPACK, normal SERVOPACK operation can be continued. However, if the warning remains for too long, it will become an alarm and operation will stop.
Therefore, when a warning occurs, stop the operation of the machine, reduce the speed, or take other measures necessary to prevent an alarm from occurring.

You can set parameter Pn008.2 to enable or disable warning detection.

Parameter		Meaning	When Enabled	Classification
Pn008	n.□0□□ (factory setting)	Enables detecting warnings.	After restart	Setup
	n.□1□□	Disables detecting warnings.		

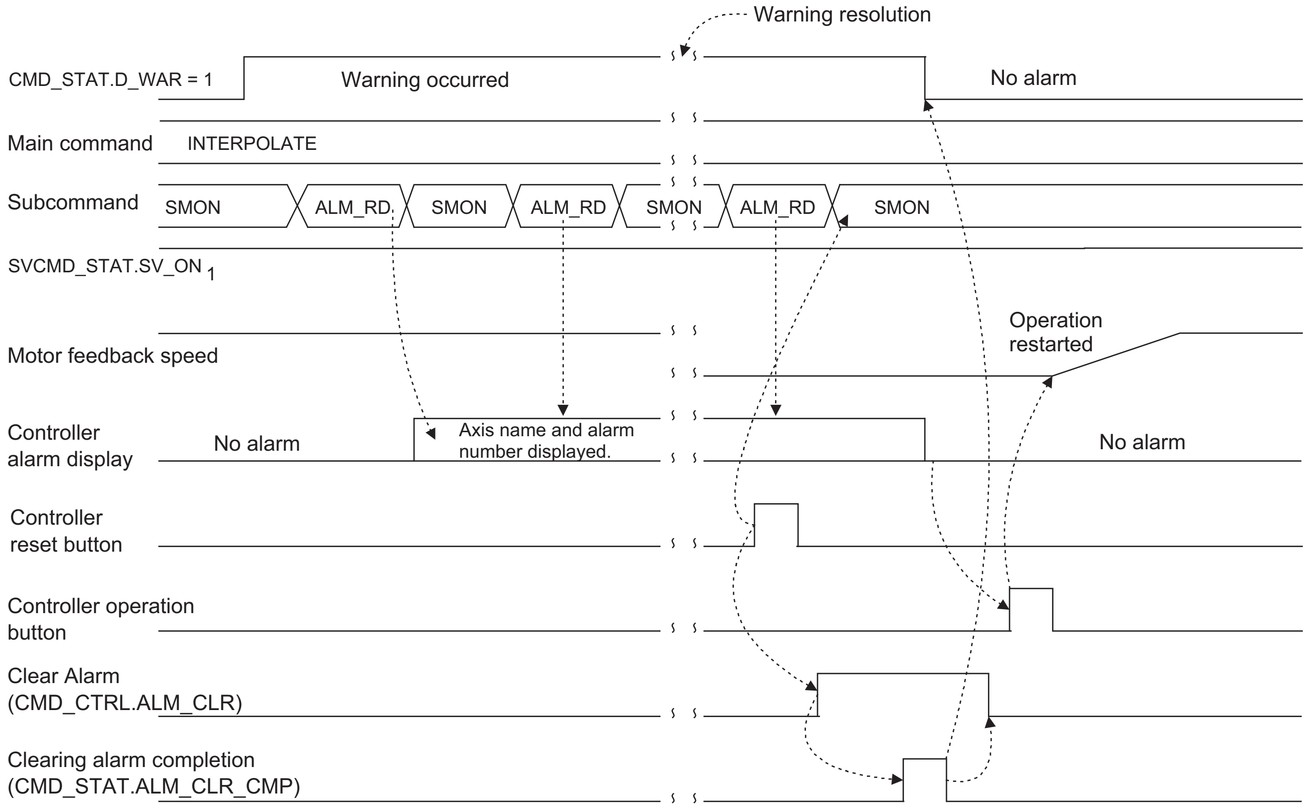
Warnings are used to warn of a problem so that it may be resolved before it becomes an alarm. Therefore, the factory setting (detect warnings) is recommended.

If a warning occurs in the SERVOPACK, use the following procedure to resolve the problem.



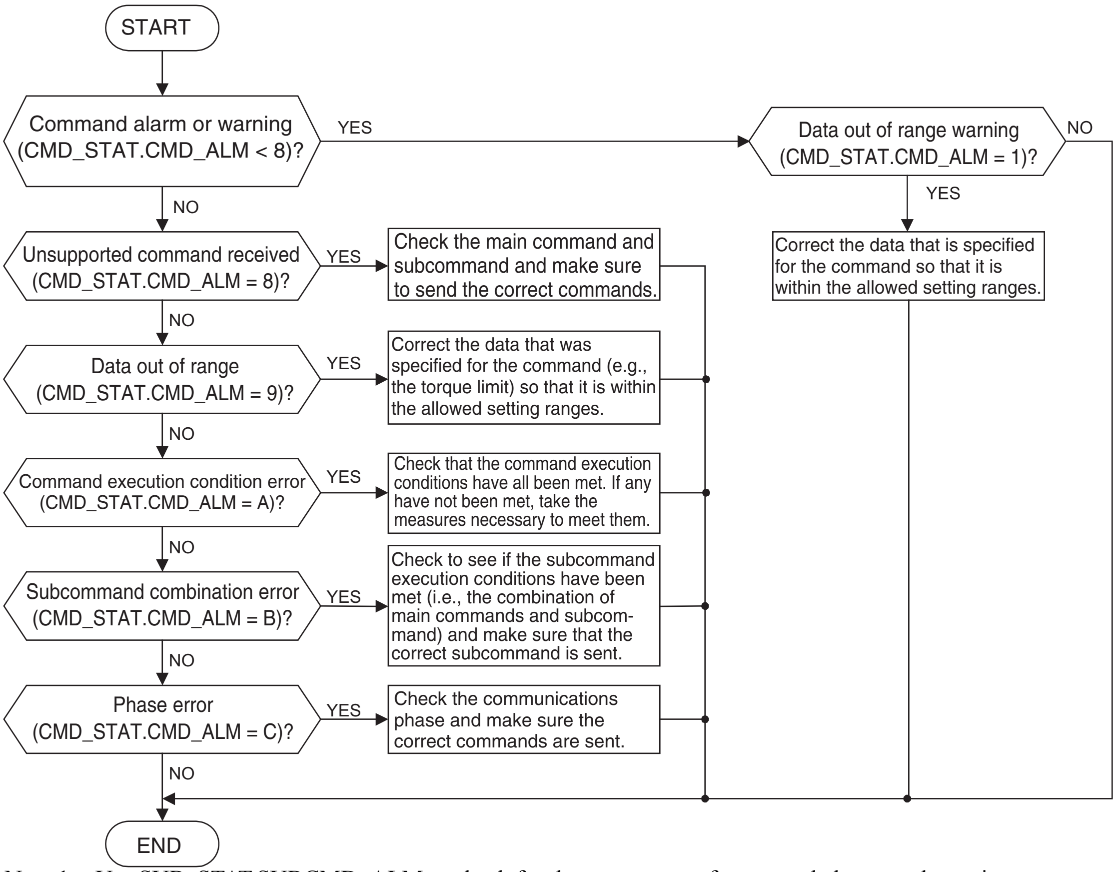
Note: Normal operation can be continued even if a warning occurs.
Because the INTERPOLATE command is used as the main command, use the command bit CMD_CTRL.ALM_-CLR to clear alarms.

The following timing chart example describes when a warning occurs when an axis is in motion for the INTERPOLATE (34 hex) command.



7.4 Handling Command Alarms and Warnings

If an alarm or warning occurs for a MECHATROLINK-III command that was sent from the host controller, use the following procedure to resolve the problem.
The following flowchart uses main commands for alarm and warning solutions, but subcommands can also be used in the same way.

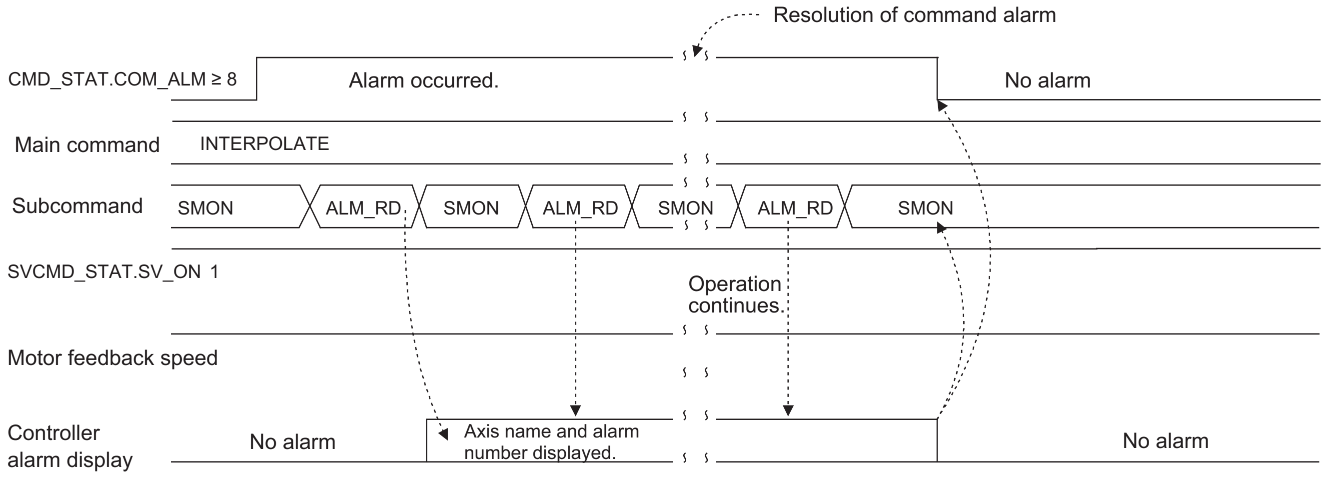


Note 1. Use SUB_STAT.SUBCMD_ALM to check for the occurrence of command alarms and warnings.
2. Refer to *7.2.2 Command Errors (CMD_ALM)* in *Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on command alarms, alarm codes, and how to resolve them.

Command alarms and warnings serve only as notifications about the current alarm status and therefore still allow for machine operation to continue.
The specified command is not executed, but if the command is sent properly, the alarm or warning will be reset automatically.
Therefore, command alarms and warnings do not necessarily need to be cleared.

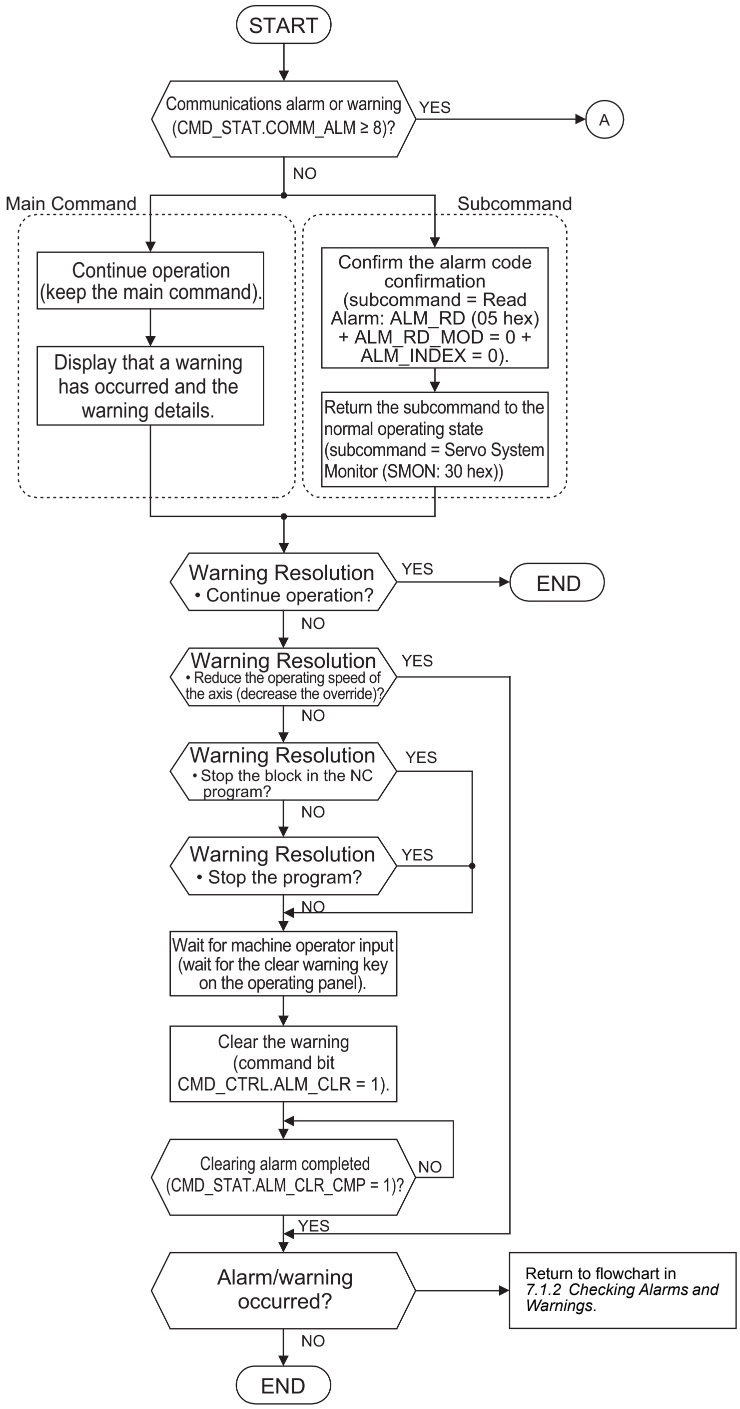
IMPORTANT	CMD_ALM is cleared automatically. Check CMD_ALM status every communications cycle and perform the necessary measures to resolve any problems.

The following timing chart example describes when a command alarm or warning occurs when an axis is in motion for the INTERPOLATE (34 hex) command.

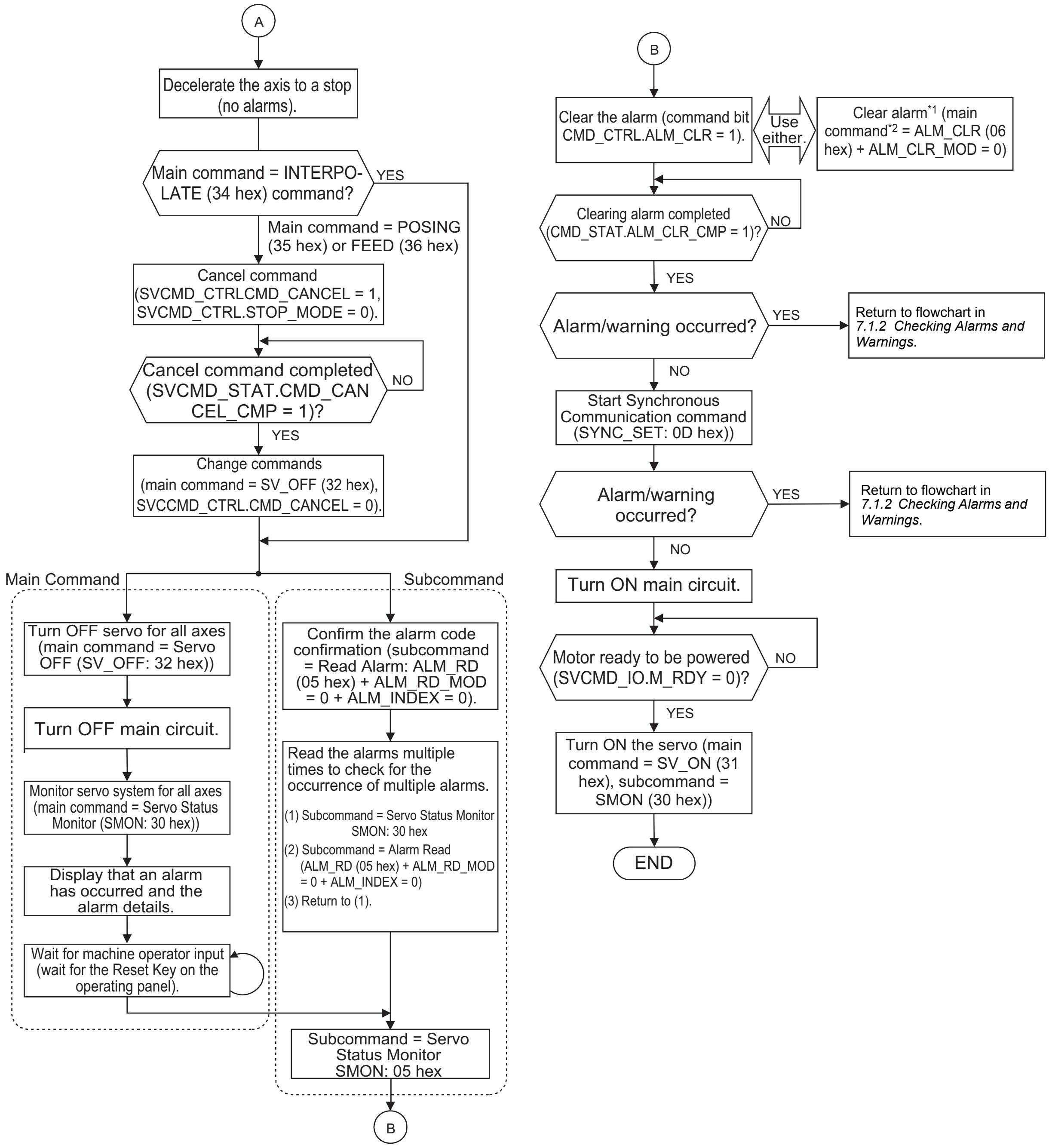


7.5 Handling Communications Alarms and Warnings

If an error occurs with MECHATROLINK-III communications, use the following procedure to resolve the problem.
Refer to *7.1 Communication Related Alarms* and *7.2.1 Communication Errors (COMM_ALM)* in the *Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on MECHATROLINK-III communications alarms, alarm codes, and how to resolve them.



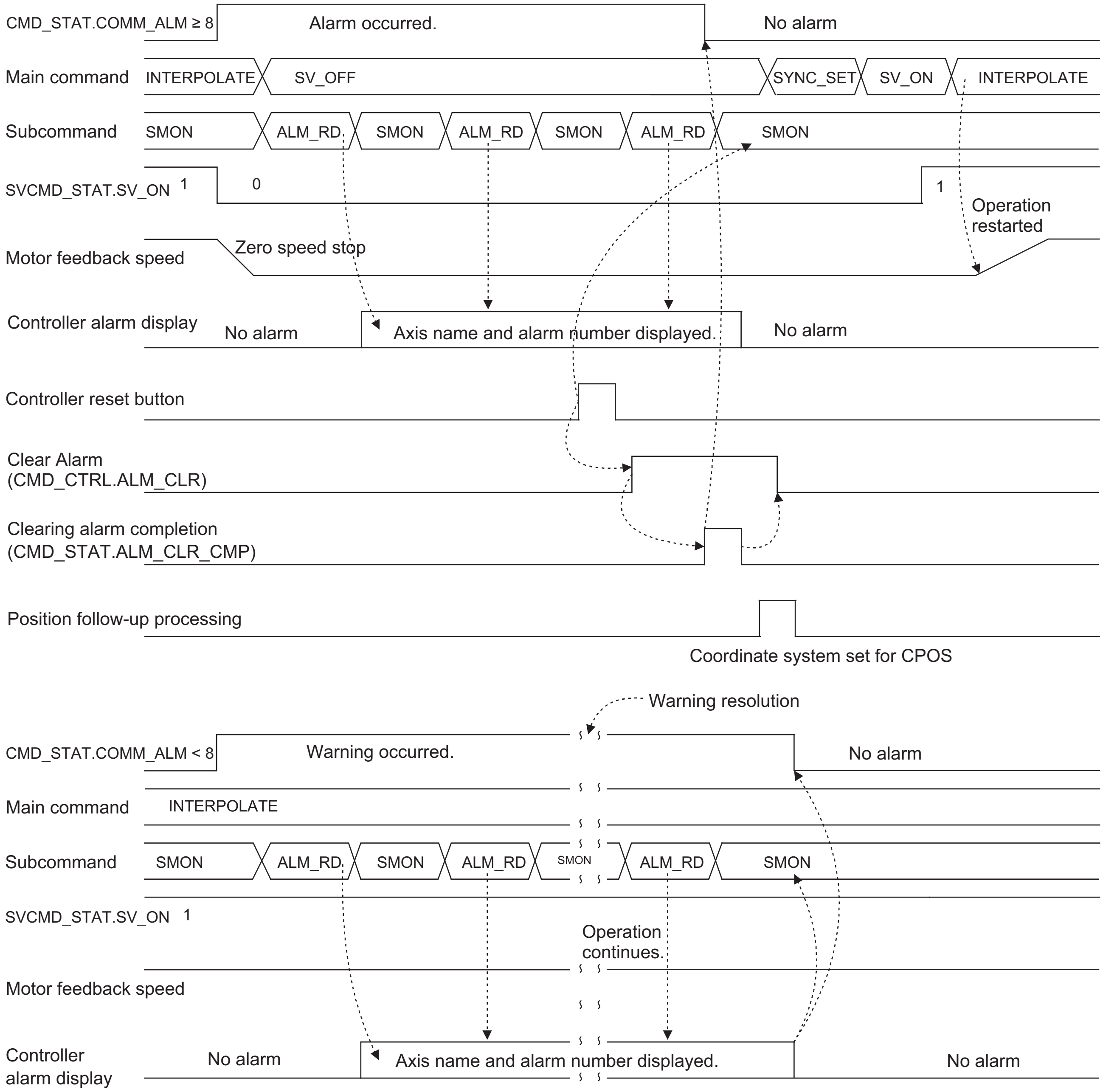
Note: Normal operation can be continued even if a warning occurs.
Because the INTERPOLATE command is used as the main command, use the command bit CMD_CTRL.ALM_-CLR to clear alarms.



*1. Clearing Alarms
We recommend using only the SV_ON, SV_OFF, and INTERPOLATE commands as main commands and using the command bit (CMD_CTRL.ALM_CLR) to clear alarms.

*2. When the ALM_CLR (06 hex) command is used as the main command, set the subcommand to NOP (00 hex) or SMON (30 hex). If any other subcommand is set, a Command Warning 5 Alarm (A.95E) will occur.

The following timing chart example shows when a communications alarm or warning occurs when an axis is in motion for the INTERPOLATE (34 hex) command.



7.6 Emergency Stop Processing

If an unexpected error occurs during machine operation, you must press the emergency stop button to stop the machine safely.
Emergency stop processing for axes can be performed from either the host controller or from the SERVOPACK.
Furthermore, turning OFF the main circuit after an emergency stop can be controlled by either the host controller or the power regeneration converter.

No	Emergency Stop Function	Main Circuit Magnetic Contactor Control	Remarks
1	Use the host controller for control.	Use the host controller for control.	This method uses the host controller to stop the axes and turn OFF the main circuit. The emergency stop processing can be performed based on the machine specifications, but the same axis stop command must be used for all axes from the host controller. Refer to *7.6.2 Using the Host Controller to Perform Emergency Stop Processing and Turn OFF the Main Circuit*.
2	Use the SERVOPACK for control.	Use the host controller for control.	This method does not require position control to perform emergency stops. After it has been confirmed that all axes are stopped, the main circuit is turned OFF by the host controller. Refer to *7.6.3 Using the SERVOPACK to Perform Emergency Stop Processing and the Host Controller to Turn OFF the Main Circuit*.
3	Use the SERVOPACK for control.	Use the power regeneration converter for control.	This method uses the Σ-V-SD servo driver to process both emergency stop and turning OFF the main circuit, which results in less load on the host controller. The time to wait from when emergency stop signal turns ON until the main circuit is turned OFF must be set as a parameter. Refer to *7.6.4 Using the SERVOPACK to Perform Emergency Stop Processing and the Power Regeneration Converter to Turn OFF the Main Circuit*.
4	Use the host controller for control.	Use the power regeneration converter for control.	This method uses the host controller to stop the axes. The emergency stop processing can be performed based on the machine specifications, but the same axis stop command must be used for all axes from the host controller. The time to wait from when emergency stop signal turns ON until the main circuit is turned OFF must be set as a parameter. Refer to *7.6.5 Using the Host Controller to Perform Emergency Stop Processing and the Power Regeneration Converter to Turn OFF the Main Circuit*.

Method 1 in the above table provides a high amount of freedom in control based on the state of the machine (e.g., the deceleration rates to stop axes can be controlled on an individual basis), but this also requires that the host controller perform control based on the state of the machine and individual axes for processing until the axes are stopped.
Method 3 uses the Σ-V-SD servo driver to both stop axes and turn OFF the main circuit.
Refer to the above table and select the optimal method for your particular machine configuration and axis stop processing requirements.
Methods 2 through 4 require setting parameters in the SERVOPACK.
Refer to *7.6.1 Emergency Stop and Main Circuit Magnetic Contactor Control Settings* for details on these parameter settings.
When the SERVOPACK is used to perform emergency stop processing and the power regeneration converter is used to control the main circuit magnetic contactor, the following restrictions apply to the combination of software used for the power regeneration converter and the SERVOPACK.

- Power regeneration converter: Software version 0008 or higher
- SERVOPACK: Software version 000B or higher

If the above versions are not used, the following alarm will occur.

Alarm Code	Alarm Name	Description	Alarm Stop Method	Reset
A.05B	Converter Combination Error	This alarm occurs when there is a problem with the combination of the power regeneration converter and SERVOPACK.	Gr.1	Required

7.6.1 Emergency Stop and Main Circuit Magnetic Contactor Control Settings

(1) Emergency Stop Selection

Set SERVOPACK parameter Pn01B to select whether to use the emergency stop function.
This setting is required for each axis individually.

Parameter		Meaning	When Enabled	Classification
Pn01B	n.□□□0 (factory setting)	Disables the emergency stop function.	After restart	Setup
	n.□□□1	Enables the emergency stop function.		

(2) Main Circuit Magnetic Contactor Control Selection

Set SERVOPACK parameter Pn01B to select whether to use main circuit magnetic contactor control.
This setting is required for each axis individually.

Parameter		Meaning	When Enabled	Classification
Pn01B*	n.□□0□ (factory setting)	Disables main circuit magnetic contactor control.	After restart	Setup
	n.□□1□	Enables main circuit magnetic contactor control.		

* For a SERVOPACK for two axes (CACR-JUM□□), this setting is required only for the first axis.
If the settings for the first and second axes do not match, only the setting for the first axis is used.

(3) Emergency Stop Torque

When an emergency stop is performed, the motor decelerates to a stop. The deceleration torque used at this time is set in parameter Pn406.

Parameter	Setting Range	Setting Unit	Factory Setting	When Enabled	Classification
Pn406	0 to 800%	1%	800%	Immediately	Setup

Note 1. For a spindle axis, set the instantaneous peak torque for the spindle motor to 120%.
2. For a feed axis, the deceleration torque when overtravel occurs is also the value that is set for parameter Pn406.
3. For a spindle axis, the deceleration torque when overtravel occurs is the value that is set in parameter Pn430 (powering) and Pn431 (regeneration).

(4) Delay from Emergency Stop Signal to Axis Stop Processing

The delay from when the emergency stop signal turns OFF (emergency stop state) until the SERVOPACK starts emergency stop processing (deceleration to a stop and then base block) is set in parameter Pn630. Normally, if the emergency stop button is pressed, the axes decelerate to a stop immediately and therefore the factory setting of 0 for Pn630 is recommended

Parameter	Setting Range	Setting Unit	Factory Setting	When Enabled	Classification
Pn630	0 to 10000	1 ms	0 ms	Immediately	Setup

(5) Delay Until the Main Circuit Turns OFF

The delay from the time the emergency stop signal turns OFF (emergency stop state) until the power regeneration converter turns OFF the main circuit magnetic contactor is set in parameter Pn631.
Set the time so that all axes that are connected to the power regeneration converter can completely stop before the main circuit is turned OFF. If the main circuit magnetic contactor is turned OFF during axis deceleration, an Undervoltage Alarm (A.410) will occur in the SERVOPACK.

Parameter	Setting Range	Setting Unit	Factory Setting	When Enabled	Classification
Pn631*	0 to 10000	1 ms	0 ms	After restart	Setup

* If multiple SERVOPACKs are connected to the power regeneration converter, the highest set value among those SERVOPACKs is used as the effective set value.

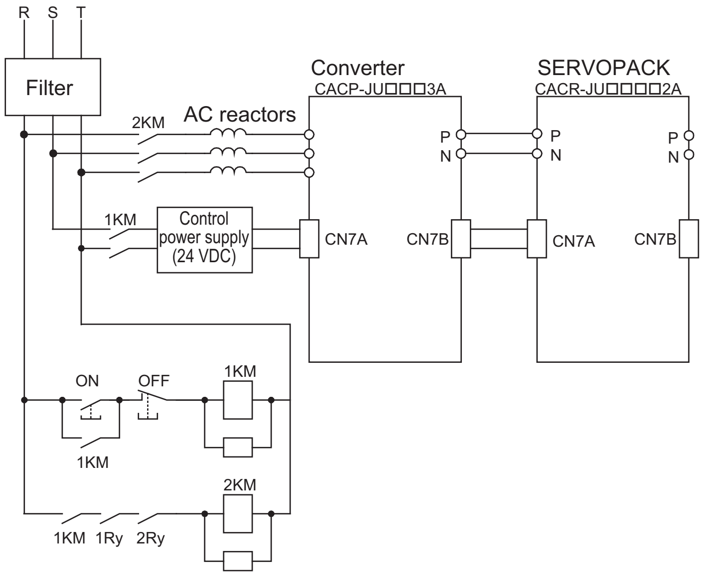
(6) Emergency Stop Signal Monitor

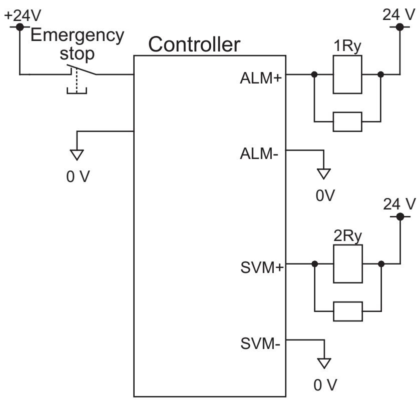
Assign the emergency stop signal state (ESTP2) with parameter Pn860 to monitor the status of the emergency stop signal through MECHATROLINK-III communications from the host controller.

Parameter		Meaning	When Enabled	Classification
Pn860	n.□□□0 (factory setting)	No ESTP2 assignment.	After restart	Setup
	n.□□□1	Assigns ESTP2 to bit 24.		
	n.□□□2	Assigns ESTP2 to bit 25.		
	n.□□□3	Assigns ESTP2 to bit 26.		
	n.□□□4	Assigns ESTP2 to bit 27.		
	n.□□□5	Assigns ESTP2 to bit 28.		
	n.□□□6	Assigns ESTP2 to bit 29.		
	n.□□□7	Assigns ESTP2 to bit 30.		

7.6.2 Using the Host Controller to Perform Emergency Stop Processing and Turn OFF the Main Circuit

Perform the following wiring to use the host controller to perform emergency stop processing and to turn OFF the main circuit.
Connect the emergency stop switch to the host controller's I/O.





(1) Emergency Stop Signal Confirmation

The emergency stop signal must constantly be monitored by the host controller.

(2) Emergency Stop Processing

When the emergency stop signal turns OFF (emergency stop state), perform the following processing.

- Use the INTERPOLATE (34 hex) command to change the target position for feed axes in motion so that they decelerate to a stop quickly. Set the target positions so that the axes decelerate to a stop at the desired rate.
- Set both the spindle and feed axes to decelerate to a stop in this way.
- If the servo driver is currently in Speed Control Mode, set the VELCTRL (3C hex) command to 0 and change the target position for the INTERPOLATE (34 hex) command so that the axes decelerate to a stop at the desired rate.
- Check to confirm that all axes (spindle and feed) have stopped.
- Use the SV_OFF (32 hex) command to base-block all axes.
- Use the SMON (30 hex) command for all axes.

(3) Processing to Turn OFF the Main Circuit

The host controller confirms that all axes have stopped, then turns OFF the main circuit magnetic contactor.

- Confirm that all axes are base-blocked (i.e., SVCMD_STAT.SV_ON (bit 13) = 0) and use the host controller to turn OFF the main circuit magnetic contactor (controlled by the 2KM:SVM signal).
- The host controller displays that an emergency stop was performed.

Note: Do not turn OFF the main circuit magnetic contactor (2KM) during motor deceleration. If the main circuit magnetic contactor (2KM) is turned OFF during axis deceleration, an Undervoltage Alarm (A.410) will occur.

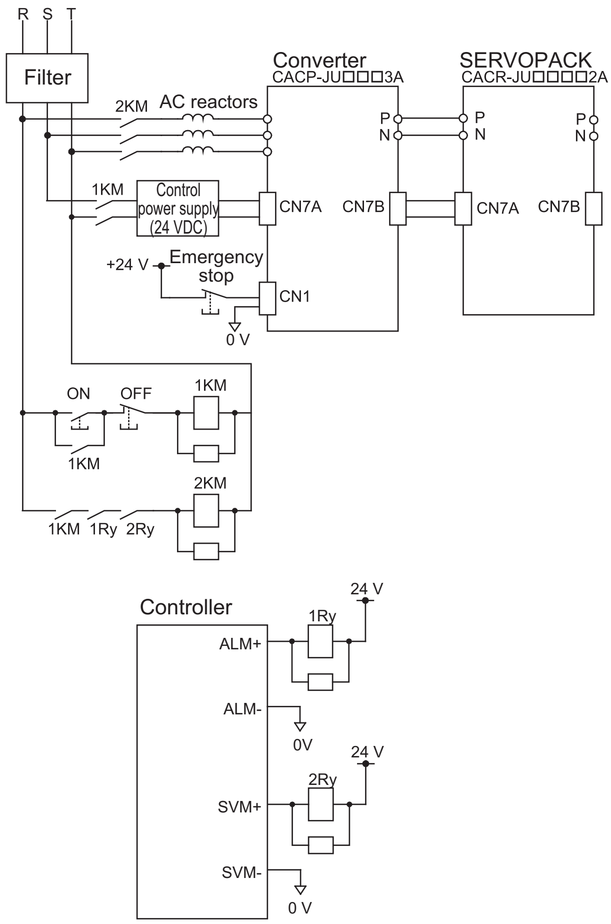
(4) Recovering after an Emergency Stop

Confirm that all axes have stopped and that SVCMD_IO.M_RDY is 1 for all axes.
When the emergency stop signal turns ON (emergency stop state released), perform the following processing.

- From the host controller, set SVCMD_IO.MC-ON (bit 23) to 1 to turn ON the main circuit magnetic contactor (controlled by the 2KM:SVM signal).
  If multiple SERVOPACKs are connected to the power regeneration converter, the main circuit magnetic contactor is activated as long as SVCMD_IO.MC-ON is 1 for one or more axes.
- Check that SVCMD_STAT.M_RDY (bit 12) is 1 to confirm that the servomotor is powered and ready.
- Use the SV_ON command to turn ON the servo for the feed axis.
- Resume operation of the machine.

7.6.3 Using the SERVOPACK to Perform Emergency Stop Processing and the Host Controller to Turn OFF the Main Circuit

Perform the following wiring to use the SERVOPACK to perform emergency stop processing.
Connect the emergency stop switch to the power regeneration converter's CN1 connector (/ESP+ and /ESP-).
Axis stop processing is performed by the SERVOPACK, and the host controller controls the main circuit magnetic contactor (2KM).



(1) Signal Wiring and Related Parameters

Type	Signal Name	Power Regeneration Converter Connector Pin Numbers	Setting	Meaning
Input	/ESP+ /ESP-	CN1-11, CN1-12	ON	Emergency stop released (normal operation).
			OFF	Emergency stop

To use the SERVOPACK to perform emergency stop processing, set the required parameters as described in *7.6.1 (1) Emergency Stop Selection*, *7.6.1 (3) Emergency Stop Torque*, and *7.6.1 (6) Emergency Stop Signal Monitor*.

(2) Emergency Stop Processing

When the emergency stop signal turns OFF (emergency stop state), the SERVOPACK performs the following processing.

- The axes that are in motion (both spindle and feed axes) decelerate to a stop at the torque that is set in parameter Pn406 (Emergency Stop Torque).
  If the servomotor for each axis is not stopped within 10 seconds after the emergency stop signal turns OFF (emergency stop state), an Emergency Stop Operation Failure Alarm (A.6B0) will occur.
- The axes are base-blocked after they stop.
- Confirm that SVCMD_IO.ESTP2 changes from 0 to 1 for each SERVOPACK.
- Use the SMON (30 hex) command for all axes.

(3) Processing to Turn OFF the Main Circuit

The host controller confirms that all axes have stopped, then turns OFF the main circuit magnetic contactor.

- Confirm that all axes are base-blocked (i.e., SVCMD_STAT.SV_ON (bit 13) = 0) and use the host controller to turn OFF the main circuit magnetic contactor (controlled by the 2KM:SVM signal).
- The host controller displays that an emergency stop was performed.

Note: Do not turn OFF the main circuit magnetic contactor (2KM) during motor deceleration. If the main circuit magnetic contactor (2KM) is turned OFF during axis deceleration, an Undervoltage Alarm (A.410) may occur.

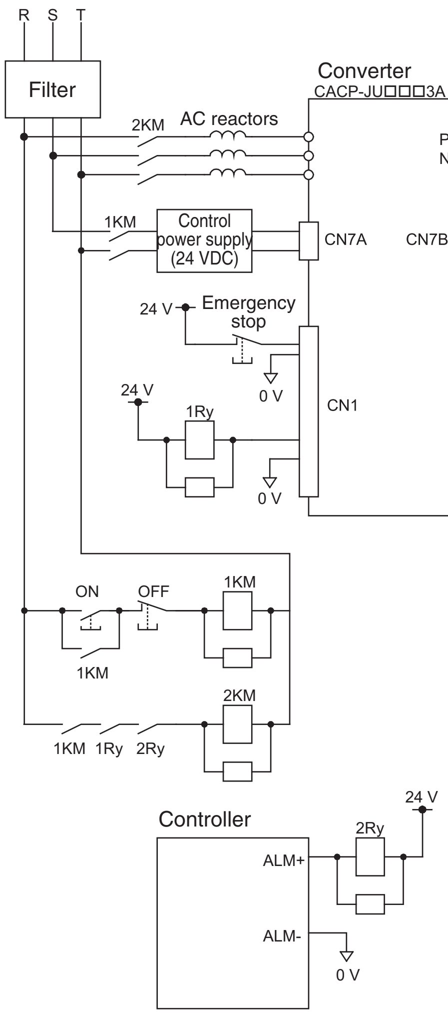
(4) Recovering after an Emergency Stop

Confirm that all axes have stopped and that SVCMD_IO.M_RDY (bit 12) is 1 for all axes.
When the emergency stop signal turns ON (emergency stop state released), perform the following processing.

- Check that SVCMD_IO.ESTP2 changes from 1 to 0 to confirm that the emergency stop signal turns ON (emergency stop release) for the SERVOPACK for each axis.
- From the host controller, set SVCMD_IO.MC-ON (bit 23) to 1 to turn ON the main circuit magnetic contactor (controlled by the 2KM:SVM signal).
  If multiple SERVOPACKs are connected to the power regeneration converter, the main circuit magnetic contactor is activated as long as SVCMD_IO.MC-ON is 1 for one or more axes.
- Check that SVCMD_STAT.M_RDY (bit 12) is 1 to confirm that the servomotor is powered and ready.
- Use the SV_ON (31 hex) command to turn ON the servo for the feed axis. Use the SMON (30 hex) command to base-block the spindle axis.
- Resume operation of the machine.

7.6.4 Using the SERVOPACK to Perform Emergency Stop Processing and the Power Regeneration Converter to Turn OFF the Main Circuit

Perform the following wiring to use the SERVOPACK to perform emergency stop processing.
Connect the emergency stop switch to the power regeneration converter's CN1 connector (/ESP+ and /ESP-).
The SERVOPACK performs axis stop processing.
Main circuit magnetic contactor (2KM) control is performed with the output signal from the power regeneration converter's CN1 connector (/MCON+ and /MCON-).



(1) Signal Wiring and Related Parameters

Type	Signal Name	Power Regeneration Converter Connector Pin Numbers	Setting	Meaning
Input	/ESP+ /ESP-	CN1-11, CN1-12	ON	Emergency stop released (normal operation).
			OFF	Emergency stop
Output	/MCON+ /MCON-	CN1-1, CN1-2	ON	Main circuit turned ON (normal operation).
			OFF	Main circuit turned OFF.

When the SERVOPACK is used to perform emergency stop processing and the power regeneration converter is used to control the main circuit magnetic contactor, set the parameters described in (1) to (6) in *7.6.1 Emergency Stop and Main Circuit Magnetic Contactor Control Settings*.

(2) Emergency Stop Processing

When the emergency stop signal turns OFF (emergency stop state), the SERVOPACK performs the following processing.

- The axes that are in motion (both spindle and feed axes) decelerate to a stop at the torque that is set in parameter Pn406 (Emergency Stop Torque).
  If the servomotor for each axis is not stopped within 10 seconds after the emergency stop signal turns OFF (emergency stop state), an Emergency Stop Operation Failure Alarm (A.6B0) will occur.
- The axes are base-blocked after they stop.
- Confirm that SVCMD_IO.ESTP2 changes from 0 to 1 for each SERVOPACK.
- Use the SMON (30 hex) command for all axes.

(3) Processing to Turn OFF the Main Circuit

When the emergency stop signal turns OFF (emergency stop state), the power regeneration converter performs the following processing.

- When the emergency stop signal turns OFF, turn OFF the main circuit magnetic contactor (controlled by the 2KM:SVM signal) from parameter Pn631.
- The host controller displays that an emergency stop was performed.

Note: Do not turn OFF the main circuit magnetic contactor (2KM) during motor deceleration. If the main circuit magnetic contactor (2KM) is turned OFF during axis deceleration, an Undervoltage Alarm (A.410) may occur.

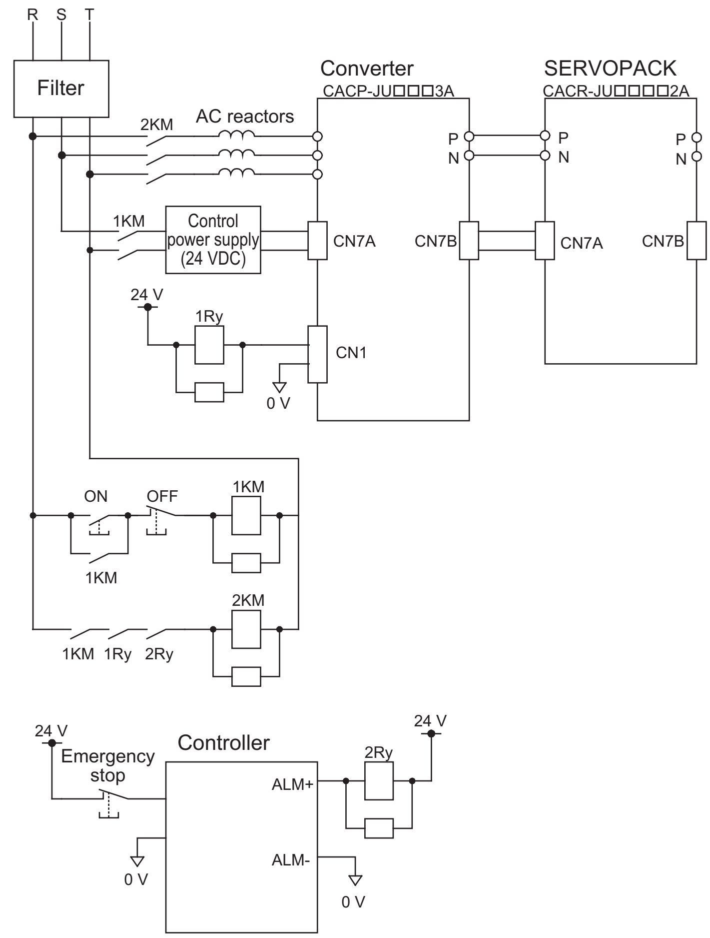
(4) Recovering after an Emergency Stop

Confirm that all axes have stopped and that SVCMD_IO.M_RDY (bit 12) is 1 for all axes.
When the emergency stop signal turns ON (emergency stop state released), perform the following processing.

- Check that SVCMD_IO.ESTP2 changes from 1 to 0 to confirm that the emergency stop signal turns ON (emergency stop release) for the SERVOPACK for each axis.
- From the host controller, set SVCMD_IO.MC-ON (bit 23) to 1 to turn ON the main circuit magnetic contactor (controlled by the 2KM:SVM signal).
  If multiple SERVOPACKs are connected to the power regeneration converter, the main circuit magnetic contactor is activated as long as SVCMD_IO.MC-ON is 1 for one or more axes.
- Check that SVCMD_STAT.M_RDY (bit 12) is 1 to confirm that the servomotor is powered and ready.
- Use the SV_ON (31 hex) command to turn ON the servo for the feed axis.
- Use the SMON (30 hex) command to base-block the spindle axis.
- Resume operation of the machine.

7.6.5 Using the Host Controller to Perform Emergency Stop Processing and the Power Regeneration Converter to Turn OFF the Main Circuit

Perform the following wiring to use the host controller to perform emergency stop processing and the power regeneration converter to turn OFF the main circuit.
Connect the emergency stop switch to the I/O of the host controller and perform axis stop processing.
Main circuit magnetic contactor (2KM) control is performed with the output signal from the power regeneration converter's CN1 connector (/MCON+ and /MCON-).



(1) Signal Wiring and Related Parameters

Type	Signal Name	Power Regeneration Converter Connector Pin Numbers	Setting	Meaning
Output	/MCON+ /MCON-	CN1-1, CN1-2	ON	Main circuit turned ON (normal operation).
			OFF	Main circuit turned OFF.

To use the power regeneration converter to control the main circuit magnetic contactor, set the parameters described in *7.6.1 (2) Main Circuit Magnetic Contactor Control Selection* and *7.6.1 (5) Delay Until the Main Circuit Turns OFF*.

(2) Emergency Stop Signal Confirmation

The host controller constantly monitors the emergency stop signal.
Set up the host controller so that it performs constant monitoring.

(3) Emergency Stop Processing

When the emergency stop signal turns OFF (emergency stop state), perform the following processing.

- Use the INTERPOLATE (34 hex) command to change the target position for feed axes in motion so that they decelerate to a stop quickly. Set the target positions so that the axes decelerate to a stop at the desired rate.
- Set both the spindle and feed axes to decelerate to a stop in this way.
  If the servo driver is currently in Speed Control Mode, set the VELCTRL (36 hex) command to 0 and change the target position for the INTERPOLATE (34 hex) command so that the axes decelerate to a stop at the desired rate.
- Check to confirm that all axes (spindle and feed) have stopped.
- Use the SV_OFF (32 hex) command to base-block all axes.
- Use the SMON (30 hex) command for all axes.

(4) Processing to Turn OFF the Main Circuit

To turn OFF the main circuit, first check from the host controller to confirm that the SERVOPACKs for all connected axes have stopped all axes and then turn OFF the main circuit magnetic contactor.

- Confirm that all axes are base-blocked (i.e., SVCMD_STAT.SV_ON (bit 13) = 0) and use the host controller to turn OFF the main circuit magnetic contactor (controlled by the 2KM:SVM signal).
- The host controller displays that an emergency stop was performed.

Note: Do not turn OFF the main circuit magnetic contactor (2KM) during motor deceleration. If the main circuit magnetic contactor (2KM) is turned OFF during axis deceleration, an Undervoltage Alarm (A.410) will occur.

(5) Recovering after an Emergency Stop

Confirm that all axes have stopped and that SVCMD_IO.M_RDY is 1 for all axes.
When the emergency stop signal turns ON (emergency stop state released), perform the following processing.

- From the host controller, set SVCMD_IO.MC-ON (bit 23) to 1 to turn ON the main circuit magnetic contactor (controlled by the 2KM:SVM signal).
  If multiple SERVOPACKs are connected to the power regeneration converter, the main circuit magnetic contactor is activated as long as SVCMD_IO.MC-ON is 1 for one or more axes.
- Check that SVCMD_STAT.M_RDY (bit 12) is 1 to confirm that the servomotor is powered and ready.
- Use the SV_ON (31 hex) command to turn ON the servo for the feed axis.
- Resume operation of the machine.

7.7 Using the Hard Wire Base Block Function (HWBB)

The hard wire base block function, or HWBB, is designed to base-block the motor (i.e., turn OFF the motor current) by using hard-wired circuits.

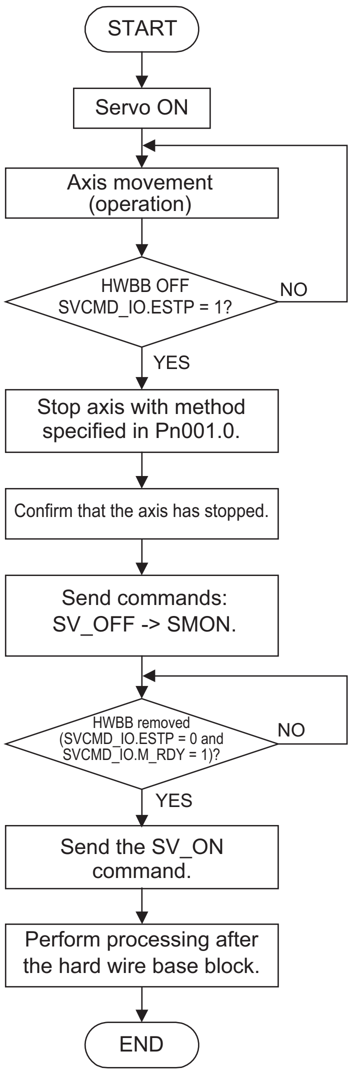
> **IMPORTANT**
>
> This functionality is not supported by Machine Directive 2006/42/EC.

To use the hard wire base block function, connect normally closed external contacts (e.g., switches) to the /HWBB1 and /HWBB2 signals of the SERVOPACK's CN1 connector.
Even if the hard wire base block function is not used, short-circuit connections must be made for the /HWBB1 and /HWBB2 signals of the SERVOPACK's CN1 connector. If these short-circuit connections are not made, the hard wire base block state persists and the motor cannot be driven.

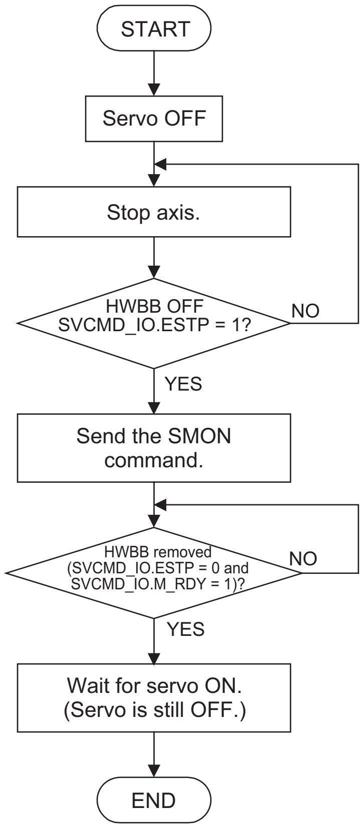
Refer to *8.6 Hard Wire Base Block (HWBB) Function* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on the hard wire base block function.
If you are not using the hard wire base block function, refer to *7.2.5 (2) Connection Diagram* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) and make short-circuit connections for the /HWBB1 and /HWBB2 signals.

Perform the processes according to the following flowchart to use the hard wire base block function.

■ Hard Wire Base Block Function While the Servo Is ON



■ Hard Wire Base Block Function While the Servo Is OFF



(1) Checking the Status of the Hard Wire Base Block

No alarm will occur when a SERVOPACK enters the hard wire base block state. Therefore, you must use the following method to manually monitor the hard wire base block state.

- Constantly monitor to see if SVCMD_IO.ESTP (bit 7) changes from 0 to 1.
- Check to see if SVCMD_STAT.M_RDY (bit 12) changes from 1 to 0 and SVCMD_STAT.SV_ON (bit 13) changes from 1 to 0.

(2) Hard Wire Base Block Procedures

■ Hard Wire Base Block Function While the Servo Is OFF

The host controller sends the SMON (30 hex) command and waits for the SERVOPACK to leave the hard wire base block state.

■ When Hard Wire Base Block Occurs While the Servo Is ON

The motor stops according to the setting of parameter Pn001.0.
From the host controller, send the SV_OFF command followed by the SMON (30 hex) command. Then, the host controller must wait until the hard wire base block is cleared.

Note: If the hard wire base block state is entered during execution of any of the following commands, a command warning will occur. The command warning is reset automatically when the correct command is received by the SERVOPACK. In this case, the warning is automatically reset when the SV_OFF (32 hex) command or any other command not listed below (e.g., the SMON (30 hex) command) is received.
- SV_ON
- INTERPOLATE
- POSING
- FEED

(3) Recovering from the Hard Wire Base Block State

Use the following procedure to restore operation after a hard wire base block.

1. Check to confirm that SVCMD_IO.ESTP (bit 7) has changed from 1 to 0.
2. Check to confirm that SVCMD_STAT.M_RDY (bit 12) has changed from 0 to 1.
3. Perform the recovery processing required on the host controller.

   Specifically, check the coordinate system position (APOS) and identifying the stop position of the machine.
   Also, you must determine how to handle motion processing after the recovery (i.e., whether to continue operation or perform return processing).

4. Send the SV_ON command to turn ON the servo.
5. Move the axis based on the processing performed after recovery.

8

Servo Drive Management

This chapter describes how to manage Σ-V-SD servo drivers from a host controller.

8.1 Embedding Servo Drive Management Functions

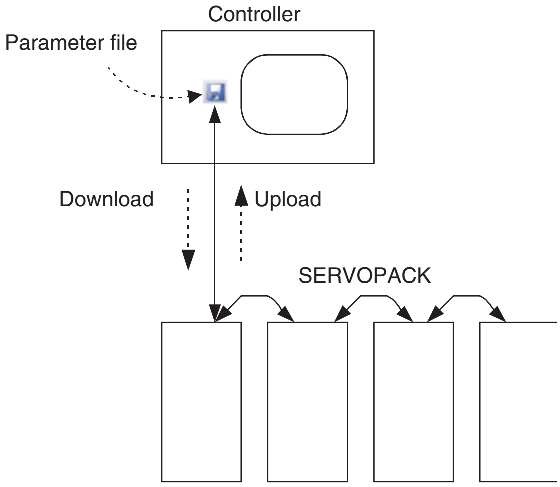
The following functions are required on the host controller to manage servo drives.

- SERVOPACK parameter uploading/downloading functions (required)
- Servo drive maintenance information display functions (required)
- Absolute encoder reset, multiturn limit setting, and other setting functions (recommended)
- SERVOPACK parameter management/editing functions (recommended)

The functions marked as required above must be implemented on the host controller.
These functions are required for machine mass production and field maintenance (SERVOPACK replacement, servomotor replacement, etc.).

8.2 SERVOPACK Parameter Uploading/Downloading Functions

These host controller functions upload (read) and download (write) parameters and spindle motor parameters that are set in the SERVOPACK.
They enable SERVOPACK parameters to be downloaded from the host controller, which makes setting up the SERVOPACK easy for mass production of the machine.
They also reduce the amount of time that is required to recover after SERVOPACK replacement in the event of a SERVOPACK malfunction in the field.



IMPORTANT

SERVOPACK parameter uploading/downloading functions are required on the host controller. These functions must be implemented on the host controller.

We recommend implementing both individual and batch upload/download functions for SERVOPACK parameters.

■ Uploading Parameters

- Uploading Individual SERVOPACK Parameters
  This function uploads a SERVOPACK parameter for the selected axis from a SERVOPACK that is connected to the host controller.
- Uploading Parameters from All SERVOPACKs
  This function uploads the SERVOPACK parameters from all of the SERVOPACKs that are connected to the host controller.

■ Downloading Parameters

- Downloading Individual SERVOPACK Parameters
  This function downloads a SERVOPACK parameter for the selected axis to a SERVOPACK that is connected to the host controller.
- Downloading Parameters from All SERVOPACKs
  This function downloads the SERVOPACK parameters to all of the SERVOPACKs that are connected to the host controller.

8.2.1 Initial Settings for SERVOPACK Parameters and Preparation for Mass Production

SERVOPACKs are shipped from the factory with factory settings for the parameters. Therefore, the parameters must be set specifically for different types of machines.

(1) Setup for a New Machine Type

When the power supply is turned ON to a new type of machine for the first time, the parameters, such as the direction of rotation or the stop method used when an alarm occurs, must be set for each SERVOPACK.
Write the parameter file for the spindle motor to the SERVOPACK that is used for the spindle axis with the SigmaWin for Σ-V-SD (MT).
After the parameter file is written, calibrate the servos and set the gains for each axis.

(2) Uploading SERVOPACK Parameters and Saving as a File

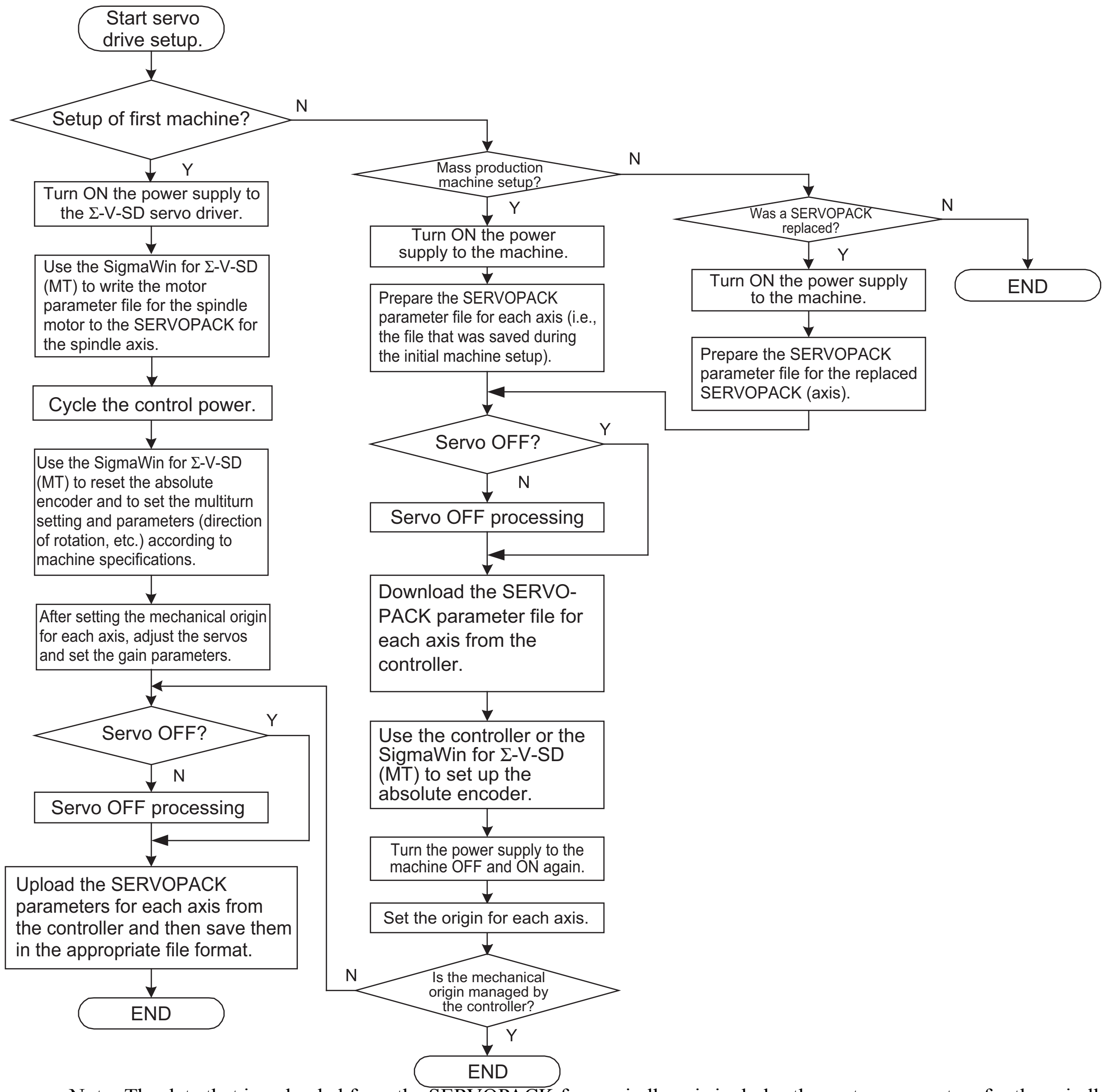
Upload the SERVOPACK parameters that are used to set up each axis for the machine to the host controller.
Save the SERVOPACK parameters that are uploaded for each axis in a format that is compatible with the file system of the host controller (e.g., ASCII text).

(3) Machine Mass Production

Download the SERVOPACK parameters that are saved as a file for each axis from the host controller. This enables you to easily set the SERVOPACK parameters for each axis as a batch.
The following flowchart shows the procedure to upload and download SERVOPACK parameters during SERVOPACK setup.

IMPORTANT

Observe the following precautions when you upload and download parameters.
- Turn OFF the servo before you upload or download SERVOPACK parameters.
- Never turn OFF the control power while SERVOPACK parameters are being uploaded or downloaded.
- Do not use the SigmaWin for Σ-V-SD (MT) when uploading or downloading SERVOPACK parameters.



Note: The data that is uploaded from the SERVOPACK for a spindle axis includes the motor parameters for the spindle motor.

Servo Drive Management

8

■ About SERVOPACK Parameter Files

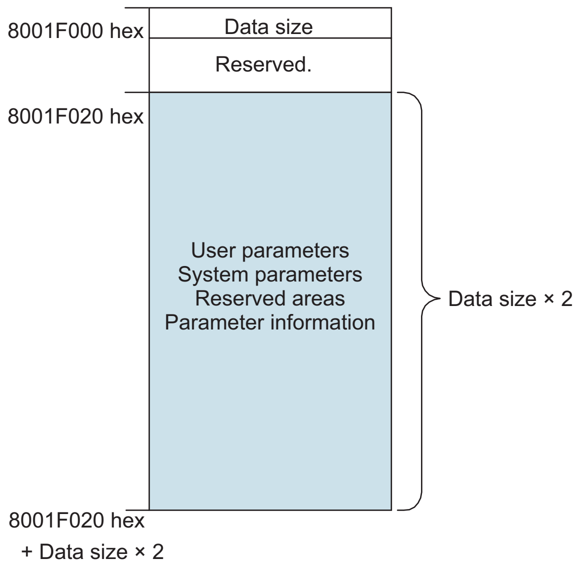
Save the uploaded data in a format that is compatible with the file system of the host controller.
We recommend that you use one file per axis.
Format the file names as shown in the following examples.

Target Device	File Name
Feed axis	XXXX_SV□□□□.PRM
Spindle axis	XXXX_SP□□□□.PRM

XXXX: Axis name (e.g., X1)
□□□□: Identifier (date, machine name, etc.)
The maximum length for file names depends on the file system of the host controller.

8.2.2 Memory Map

The parameters and motor parameters for uploading and downloading are accessed as virtual memory on the SERVOPACK.
The memory area for uploading and downloading parameters is approximately 2,000 words in size, including the reserved areas.
The reserved memory areas are for parameters to be added in the future. Therefore, the controller does not have to know when parameters are added to the SERVOPACK.
The following is a memory map of the virtual memory area.



8.2.3 Parameter Upload/Download Methods

The following parameter upload/download method is used when the Read Memory (MEM_RD: 1D hex) or Write Memory (MEM_WR: 1E hex) command is used.
Refer to *9.2.4 Uploading and Downloading Servo Drive Parameters* in the *Σ-V-SD AC Servo Drives Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on uploading and downloading parameters.

(1) Uploading Parameters

To upload parameters, use the MEM_RD (1D hex) command.

Usable Phase		2, 3
Processing Time		200 ms or less
Byte	MEM_RD	
	Command	Response
0	1D hex	1D hex
1	WDT	RWDT
2	CMD_CTRL	CMD_STAT
3		
4	Reserved.	Reserved.
5	MODE/ DATA_TYPE	MODE/ DATA_TYPE
6	SIZE	SIZE
7		
8	ADDRESS	ADDRESS
9		
10		
11		
12	Reserved.	DATA
13		
14		
15		
16		
17		
18		
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27		
28		
29		
30		
31		

MODE/DATA_TYPE = 13 hex
SIZE = 1
Data size: ADDRESS = 8001F000 hex
Data area: ADDRESS = 8001F020 hex to 8001F020 hex × 2 - 4

Note: Data is always read in 4-byte segments (i.e., segments of long data).

Servo Drive Management

8

Perform the following procedure to use the MEM_RD (1D hex) command to upload parameters.

1. Use the MEM_RD (1D hex) command to specify the following command parameters and read the data size from the address 8001F000 hex.

Command = MEM_RD (1D hex)
MODE/DATA_TYPE = 13 hex (RAM area, long size: 4 bytes)
SIZE = 0001 hex
ADDRESS = 8001F000 hex
Processing has finished when RCMD is MEM_RD (= 1D hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter upload operation.

2. Use the MEM_RD (1D hex) command to read the data from 8001F020 hex to 8001F020 hex + DATASIZE × 2 - 4, 4 bytes at a time.

Command = MEM_RD (1D hex)
MODE/DATA_TYPE = 13 hex (RAM area, long size: 4 bytes)
SIZE = 0001 hex
ADDRESS = 8001F020 hex to 8001F020 hex + DATASIZE × 2 - 4 (The address is incremented by +4 each time.)
Execution of the data read operation has been completed when RCMD = MEM_RD (1D hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter upload operation.

3. Store the data that is read in the memory area of the host controller.

Add the file header, axis name, checksum value, and other data in a file format that is compatible with the file system on the host controller, then store the file in the file area of the host controller.

(2) Downloading Parameters

To download parameters, use the MEM_WR (1E hex) command.

Usable Phase		2, 3
Processing Time		–
Byte	MEM_WR	
	Command	Response
0	1E hex	1E hex
1	WDT	RWDT
2	CMD_CTRL	CMD_STAT
3		
4	Reserved.	Reserved.
5	MODE/ DATA_TYPE	MODE/ DATA_TYPE
6	SIZE	SIZE
7		
8	ADDRESS	ADDRESS
9		
10		
11		
12	DATA	DATA
13		
14		
15		
16	Reserved.	Reserved.
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		

MODE/DATA_TYPE = 13 hex
SIZE = 1
Data size: ADDRESS = 8001F000 hex
Data area: ADDRESS = 8001F020 hex to 8001F020 hex × 2 - 4

Note: Data is always written in 4 byte segments (i.e., segments of long data).

Perform the following procedure to use the MEM_WR (1E hex) command to download parameters.

1. Use the MEM_RD (1D hex) command to specify the following command parameters and read the data size from the address 8001F000 hex.

Command = MEM_RD (1D hex)
MODE/DATA_TYPE = 13 hex (RAM area, long size: 4 bytes)
SIZE=0001 hex
ADDRESS = 8001F000 hex
Processing has finished when RCMD is MEM_RD (= 1D hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter download operation.

2. Use the MEM_WR (1E hex) command to write the data from 8001F020 hex to 8001F020 hex + DATASIZE × 2 - 4, 4 bytes at a time.

Command = MEM_WR (1E hex)
MODE/DATA_TYPE = 13 hex (RAM area, long size: 4 bytes)
SIZE=0001 hex
ADDRESS = 8001F020 hex to 8001F020 hex + DATASIZE × 2 - 4 (The address is incremented by +4 each time.)
DATA=XXXX
When RCMD = MEM_WR (1E hex) and CMD_STAT.CMDRDY changes to 1, all the data has been written successfully.

Note 1. If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter download operation.
2. When the final data is written, a few seconds are required to write the data to the non-volatile memory (EEPROM) in the SERVOPACK.
Check that CMD_STAT.CMDRDY is 1 before moving to the next process.
3. Do not turn OFF the power while the parameters are being downloaded.
If the power is turned OFF, the servo drive parameters may not be set to the correct values. Turn the power supply OFF and ON again to enable the downloaded parameter data.

8.2.4 GUI Operations on the Host Controller

Create a GUI on the host controller so that the user can specify whether to upload or download SERVOPACK parameters for individual axes or for all axes as a batch.
Uploading and downloading SERVOPACK parameters is performed to set up the machine or to perform maintenance.
Secure the SERVOPACK parameter upload/download GUI with a password or other security measure so that only authorized users can use it.

8.3 Servo Drive Maintenance Information Display

This function displays information such as the models and software versions of the SERVOPACKs that are connected to the host controller. This function is also required for machine mass production and onsite maintenance.
In particular, the model of the spindle motor is used to determine if the spindle motor parameter file has been written to the SERVOPACK correctly or not.

8.3.1 Maintenance Information

You can use the Read ID (ID_RD: 03 hex) or Read Memory (MEM_RD: 1D hex) command from the host controller to read the SERVOPACK information for each axis.
Design the display function so that the following SERVOPACK information can be displayed on the host controller for all connected axes.

No	Description	ID_CODE (ID_RD)	Virtual Address (MEM_RD)	Data Size (Bytes)	Data Type	Display Example
1	SERVOPACK model	80 hex	00000200 hex	32	ASCII-CODE	CACR-JU051D2A
2	SERVOPACK software version	03 hex	0000000C hex	4	Binary	For version 000A, 0000000A (hex). The upper two bytes are reserved.
3	Serial number	06 hex	00000018 hex	32	ASCII-CODE	D0107D332740020
4	Motor model name	90 hex	00000240 hex	32	ASCII-CODE	UAKAJ-19CZ100E
5	Motor encoder software version	98 hex	00000260 hex	4	Binary	For version 0002, 00000002 (hex). The upper two bytes are reserved.
6	External encoder model name	A0 hex	00000280 hex	32	ASCII-CODE	ERM 280
7	External encoder software version	A8 hex	000002A0 hex	4	Binary	00000001 (hex)

Note 1. ID_CODE is the ID data selection code that is specified with the ID_RD (03 hex) command.
2. The virtual address is the virtual address specified with the MEM_RD (1D hex) command.
3. The ASCII-CODE delimiter is 00.

8.3.2 Reading Maintenance Information (Read ID Command)

Use the Read ID (ID_RD: 03 hex) command to read the maintenance information.
The ID_RD (03 hex) command can be executed only as the main command.
If the size of the data to read is 24 bytes or less, set the OFFSET to 0 and the SIZE to the data size to read the data in a single read operation. If the data size is greater than 24 bytes, use the OFFSET and SIZE settings to perform multiple read operations and read all the maintenance information.
Refer to *9.2.1 ID Information Area* in the *Σ-V-SD AC Servo Drives Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on maintenance information.

Usable Phase		2, 3
Processing Time		Within the communications cycle
Byte	ID_RD	
	Command	Response
0	03 hex	03 hex
1	WDT	RWDT
2	CMD_CTRL	CMD_STAT
3		
4	ID_CODE	ID_CODE
5	OFFSET	OFFSET
6	SIZE	SIZE
7		
8	Reserved.	ID
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		

SERVOPACK Software Version Example
ID_CODE=03 hex
OFFSET=0
SIZE=4

SERVOPACK Model Example
Because the data length is 32 bytes, the read must be divided up into two operations: one of 24 bytes and one of 8 bytes.
First Read
ID_CODE=80 hex
OFFSET=0 hex
SIZE=18 hex

Second Read
ID_CODE=80 hex
OFFSET=18 hex
SIZE=8 hex

Example of Reading the SERVOPACK Software Version

Use the ID_RD (03 hex) command to specify the following command parameters and read the data.

Command = ID_RD (03 hex)
ID_CODE=03 hex
OFFSET=0
SIZE=0001 hex
Execution of the data read operation has been completed when RCMD = ID_RD (03 hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the read ID operation.

Example of Reading the SERVOPACK Model

The following procedure is used to read the SERVOPACK model information.

1. Use the ID_RD (03 hex) command to specify the following command parameters and read the first 24 bytes of the total 32 bytes of data.

Command = ID_RD (03 hex)
ID_CODE=80 hex
OFFSET=0 hex
SIZE=0018 hex (24 bytes)
Execution of the data read operation has been completed when RCMD = ID_RD (03 hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter upload operation.

2. Use the ID_RD (03 hex) command to specify the following command parameters and read the remaining 8 bytes of the total 32 bytes of data.

Command = ID_RD (03 hex)
ID_CODE=80 hex
OFFSET=18 hex
SIZE=0008 hex (8 bytes)
Execution of the data read operation has been completed when RCMD = ID_RD (03 hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter upload operation.

3. Combine the data that was read in steps 1 and 2 to complete the 32 bytes of data.

8.3.3 Reading Maintenance Information (Read Memory Command)

Use the Read Memory (MEM_RD: 1D hex) command to read the maintenance information.
The MEM_RD (1D hex) command can be executed as either the main command or a subcommand, but the number of bytes that can be read at once depends on which method is used.
If the size of the data to read is 20 bytes or less, set the DATA_TYPE and the SIZE to read the data in a single read operation.
If the data size is greater than 20 bytes, add 15 hex to the ADDRESS after the first 20 bytes are read, then specify the remaining data length for the SIZE to read the remaining data.
Refer to *9.2.1 ID Information Area* in the *Σ-V-SD AC Servo Drives Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) for details on maintenance information.

Usable Phase	2, 3
Processing Time	200 ms or less

Byte	MEM_RD	
	Command	Response
0	1D hex	1D hex
1	WDT	RWDT
2	CMD_CTRL	CMD_STAT
3		
4	Reserved.	Reserved.
5	MODE/ DATA_TYPE	MODE/ DATA_TYPE
6	SIZE	SIZE
7		
8	ADDRESS	ADDRESS
9		
10		
11		
12	Reserved.	DATA
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		

SERVOPACK Software Version Example
MODE/DATA_TYPE=13 hex
SIZE=1
Data size: ADDRESS = 0000000C hex

SERVOPACK Model Example
Because the data length is 32 bytes, the read must be divided up into two operations: one of 20 bytes and one of 12 bytes.
First Read
MODE/DATA_TYPE=13 hex
SIZE=5
ADDRESS=00000200 hex

Second Read
MODE/DATA_TYPE=13 hex
SIZE=3
ADDRESS=00000214 hex

Example of Reading the SERVOPACK Software Version

Use the MEM_RD (1D hex) command to specify the following command parameters and read the data.
Command = MEM_RD (1D hex)
MODE/DATA_TYPE=13 hex
SIZE=1
ADDRESS=0000000C hex
Processing has finished when RCMD is MEM_RD (= 1D hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the read ID operation.

Example of Reading the SERVOPACK Model

The following procedure is used to read the SERVOPACK model information.

1. Use the MEM_RD (1D hex) command to specify the following command parameters and read the first 20 bytes of the total 32 bytes of data.
   Command = MEM_RD (1D hex)
   MODE/DATA_TYPE=13 hex
   SIZE=5
   Data size: ADDRESS = 00000200 hex
   Execution of the data read operation has been completed when RCMD = MEM_RD (1D hex) and CMD_STAT.CMDRDY is 1.

Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter upload operation.

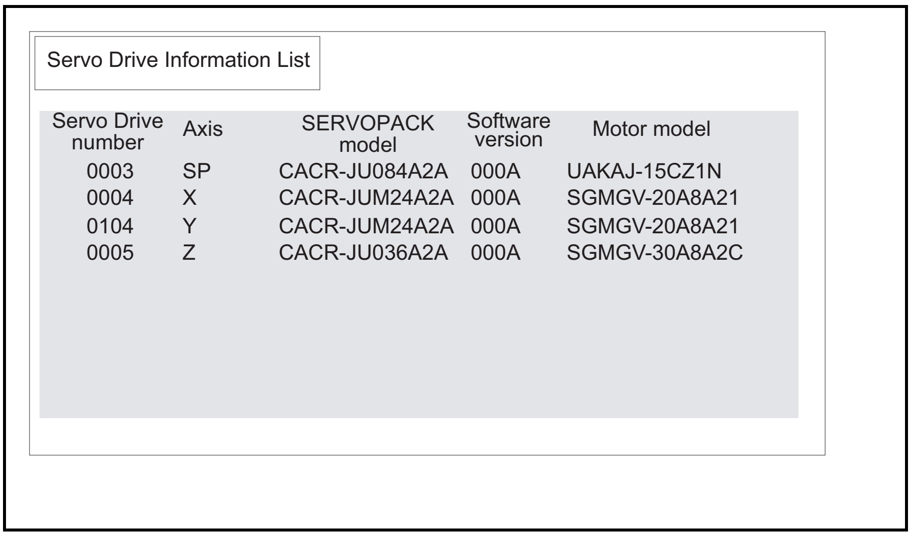
2. Use the MEM_RD (1D hex) command to specify the following command parameters and read the remaining 12 bytes of the total 32 bytes of data.
   Command = MEM_RD (1D hex)
   MODE/DATA_TYPE=13 hex
   SIZE=3
   Data size: ADDRESS = 00000214 hex
   Execution of the data read operation has been completed when RCMD = MEM_RD (1D hex) and CMD_STAT.CMDRDY is 1.

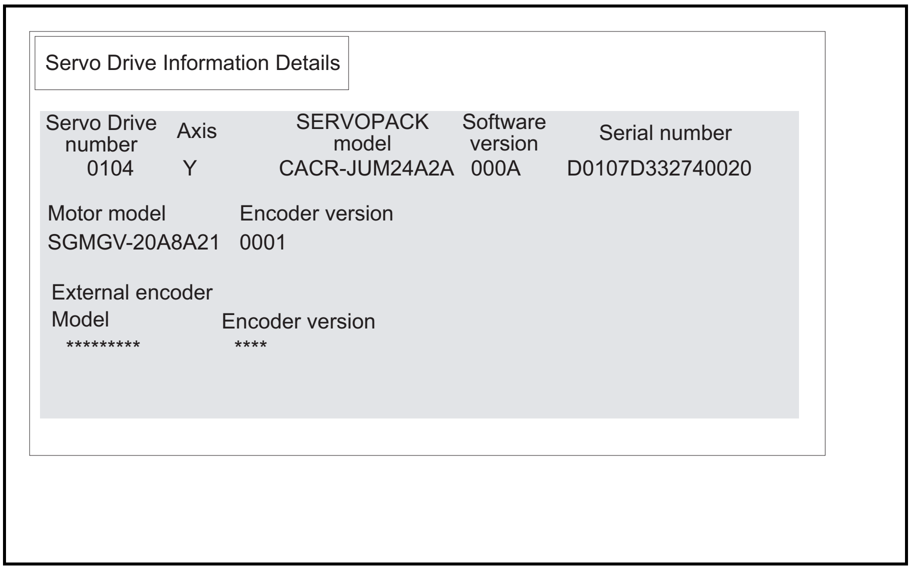
Note: If an error occurs, perform any necessary error processing and try again.
If an error still occurs, stop the parameter upload operation.

3. Combine the data that was read in steps 1 and 2 to complete the 32 bytes of data.

8.3.4 Display on the Host Controller

Design the GUI on the host controller so that the maintenance information can be easily viewed.
Design the GUI so that the servo drive information is displayed in a list and so that detailed servo drive information can be displayed when an axis is selected.




Servo Drive Information Details
Servo Drive number
Axis
SERVOPACK model
Software version
Serial number
0104
Y
CACR-JUM24A2A
000A
D0107D332740020
Motor model
Encoder version
SGMGV-20A8A21
0001
External encoder
Model
Encoder version
****
****

8.4 SERVOPACK Parameter Management and Editing

Sometimes you may need to change SERVOPACK parameters for servo adjustments, machine operation testing during trial operations, or other tasks.
For this reason, it is useful to have a way to change SERVOPACK parameters from the host controller GUI.
The following items and actions are required to edit SERVOPACK parameters from the host controller.

- A GUI to select the axis for which to display parameters
- Reading the parameters from the target SERVOPACK with the Read SERVOPACK Parameter (SVPRM_RD: 40 hex) command
- Displaying the parameter number and the current set value on the host controller GUI (You might want to display parameters for multiple axes at the same time.)
- The ability to select a parameter with the cursor and change the current set value, then write the new value to the SERVOPACK with the Write SERVOPACK Parameter (SVPRM_WR: 41 hex) command

Use another GUI design to create the GUI for the host controller.

SERVOPACK parameter management and editing is performed for machine setup and maintenance.
Protect all SERVOPACK parameter management and editing GUIs with a password or other security measure so that only authorized users can use them.

IMPORTANT

Observe the following precautions for parameter management and editing.

- Turn OFF the servo before you perform SERVOPACK parameter management or editing.
- Never turn OFF the control power while performing SERVOPACK parameter management or editing.
- Do not use the SigmaWin for Σ-V-SD (MT) when performing SERVOPACK parameter management or editing.

Servo Drive Management

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9

Monitoring

This chapter describes how to use the various monitoring information available for Σ-V-SD servo drivers.

9.1 SERVOPACK Monitors

Σ-V-SD servo drivers can monitor SERVOPACK and motor status through MECHATROLINK-III communications.
Monitor information can be used to help determine the cause of alarms, as maintenance information, and in many other useful ways.
Monitor information can also be used to draw the path of a motor axis to easily view the results of servo adjustments.
The host controller does not necessarily have to provide the ability to display monitor information, but this function can be very useful in many situations. You must determine in advance what types of monitor information to use, what GUIs to display, and what type of path tracing to perform on the host controller.
The primary functions are as follows:

- Servo tracing
- Path drawing (circular arc paths)
- Tapping synchronization accuracy drawings
- I/O monitoring

■ Selecting Monitor Information

Σ-V-SD servo drivers can constantly monitor a variety of SERVOPACK information.
Select the information to monitor in the monitor selection fields.
For common and optional monitors, the information to monitor is selected with a parameter.
A maximum of six different types of monitors can be obtained through a combination of main commands and subcommands. Refer to *4.2 Monitor Data* in the *Σ-V-SD Series User's Manual MECHATROLINK-III Standard Servo Profile Commands* (Manual No.: SIEP S800000 76) and *12.1 List of Parameters* in the *Σ-V-SD Series User's Manual* (Manual No.: SIEP S800000 78) for details on the types of monitor information and monitor information selection.

- Monitor Selections

The SVCMD_CTRL area for the main command is shown below.

Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
SEL_MON2				SEL_MON1			

Bit 31	Bit 30	Bit 29	Bit 28	Bit 27	Bit 26	Bit 25	Bit 24
Reserved (0).				SEL_MON3			

The SUB_CTRL area for the subcommand is shown below.

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
SEL_MON4				Reserved.			

Bit 23	Bit 22	Bit 21	Bit 20	Bit 19	Bit 18	Bit 17	Bit 16
SEL_MON6				SEL_MON5			

- Monitor Types

Selection Code	Monitor Name	Description	Remarks
0	APOS	Feedback position	–
1	CPOS	Command position	–
2	PERR	Position deviation	–
3	LPOS1	Latch position 1	–
4	LPOS2	Latch position 2	–
5	FSPD	Feedback speed	–
6	CSPD	Reference speed	–
7	TRQ	Reference torque	–
8	ALARM	Detailed information on the current alarm	If an alarm occurs after a warning, the alarm is displayed.
9	MPOS	Position reference	Input reference position for the position loop MPOS = APOS + PERR
A	–	Reserved.	–
B	–	Reserved.	–
C	CMN1	Common monitor 1	Selects the monitor data specified in Common Parameter 89.
D	CMN2	Common monitor 2	Selects the monitor data specified in Common Parameter 8A.
E	OMN1	Optional monitor 1	Selects the monitor data specified in Pn824.
F	OMN2	Optional monitor 2	Selects the monitor data specified in Pn825.

- Common Monitor Selection

Parameter No.	Size	Name		Setting Range	Setting Unit (Resolution)	Factory Setting	When Enabled	Classification
89 **PnB12**	4	Monitor Selection for SEL_MON1 (CMN1)		0 to 9	–	0000	Immediately	Setup
		0000 hex	TPOS (target position in reference coordinates)					
		0001 hex	IPOS (reference position in reference coordinates)					
		0002 hex	POS_OFFSET (offset value set with the POS_SET command)					
		0003 hex	TSPD (target speed)					
		0004 hex	SPD_LIM (speed limit value)					
		0005 hex	TRQ_LIM (torque limit value)					

(cont'd)

<table>
<tr><th>Param-eter No.</th><th>Size</th><th colspan="2">Name</th><th>Setting Range</th><th>Setting Unit (Resolution)</th><th>Factory Setting</th><th>When Enabled</th><th>Classi-fication</th></tr>
<tr><td rowspan="4">89
PnB12</td><td rowspan="4">4</td><td>0006 hex</td><td colspan="3">SV_STAT
Monitor Description
1st byte: Current communications phase
00 hex: Phase 0
01 hex: Phase 1
02 hex: Phase 2
03 hex: Phase 3
2nd byte: Current control mode
00 hex: Position Control Mode
01 hex: Speed Control Mode
02 hex: Torque Control Mode
3rd byte: Reserved.
4th byte: Extended signal monitor
<table>
<tr><th>Bit</th><th>Name</th><th>Description</th><th>Set Value</th></tr>
<tr><td rowspan="2">Bit 0</td><td rowspan="2">LT_RDY1</td><td rowspan="2">Latch detection processing status for SVCMD_C-TRL.LT_REQ1</td><td>0: Latch detection not processed.</td></tr>
<tr><td>1: Processing latch detection.</td></tr>
<tr><td rowspan="2">Bit 1</td><td rowspan="2">LT_RDY2</td><td rowspan="2">Latch detection processing status for SVCMD_C-TRL.LT_REQ2</td><td>0: Latch detection not processed.</td></tr>
<tr><td>1: Processing latch detection.</td></tr>
<tr><td rowspan="4">Bits 2 and 3</td><td rowspan="4">LT_SEL1R</td><td rowspan="4">Latch signal</td><td>0: Phase C</td></tr>
<tr><td>1: External input 1</td></tr>
<tr><td>2: External input 2</td></tr>
<tr><td>3: External input 3</td></tr>
<tr><td rowspan="4">Bits 4 and 5</td><td rowspan="4">LT_SEL2R</td><td rowspan="4">Latch signal</td><td>0: Phase C</td></tr>
<tr><td>1: External input 1</td></tr>
<tr><td>2: External input 2</td></tr>
<tr><td>3: External input 3</td></tr>
<tr><td>Bit 6</td><td colspan="3">Reserved (0).</td></tr>
</table></td><td rowspan="4">0000</td><td rowspan="4">Immediately</td><td rowspan="4">Setup</td></tr>
<tr><td>0007 hex</td><td colspan="3">Reserved parameter (Do not set.)</td></tr>
<tr><td>0008 hex</td><td colspan="3">INIT_PGPOS (Low)
This is the lower 32 bits of the 64-bit data representing the initial encoder position converted to reference units.</td></tr>
<tr><td>0009 hex</td><td colspan="3">INIT_PGPOS (High)
This is the upper 32 bits of the 64-bit data representing the initial encoder position converted to reference units.</td></tr>
<tr><td rowspan="2">8A
PnB14</td><td rowspan="2">4</td><td colspan="2">Monitor Selection for SEL_MON2 (CMN2)</td><td>0 to 9</td><td>–</td><td>0000</td><td rowspan="2">Immediately</td><td rowspan="2">Setup</td></tr>
<tr><td>0000 hex to 0009 hex</td><td colspan="4">Same as Monitor Selection for SEL_MON1.</td></tr>
</table>

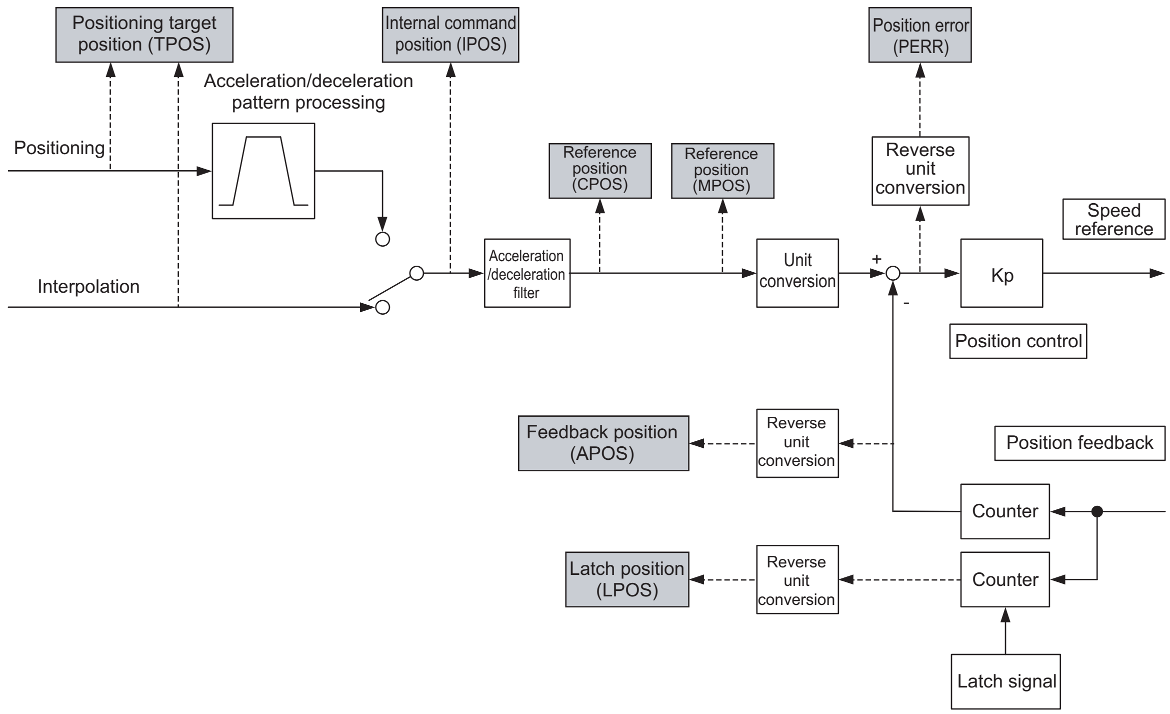
- Optional Monitor Selections

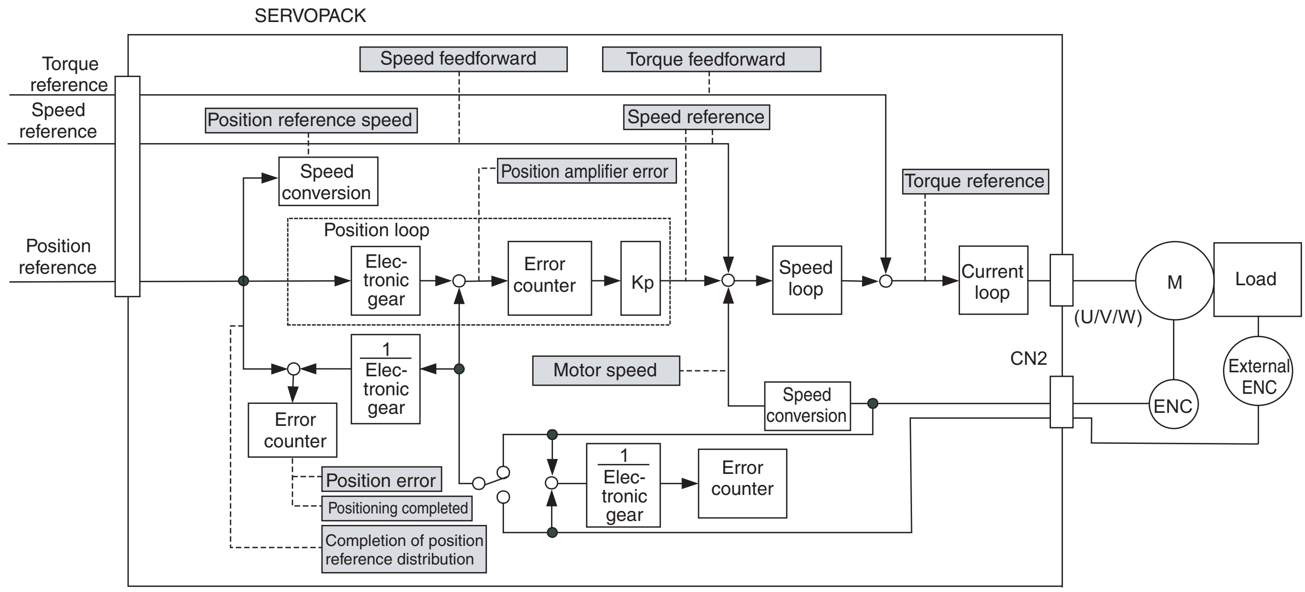
Parameter No.	Size	Name	Setting Range	Setting Unit	Factory Setting	When Enabled	Classification
Pn824	2	Optional Monitor 1 Selection	0000 to FFFF	–	0000	Immediately	Setup
		0000	Motor speed [1000000 hex/Overspeed detection speed]	High speed			
		0001	Speed reference [1000000 hex/Overspeed detection speed]	High speed			
		0002	Torque [1000000 hex/Maximum torque]	High speed			
		0003	Position error, lower 32 bits [reference units]	High speed			
		0004	Position error, upper 32 bits [reference units]	High speed			
		0005	Reserved parameter (Do not set.)	–			
		0006	Reserved parameter (Do not set.)	–			
		000A	Pulse generator count, lower 32 bits [reference units]	High speed			
		000B	Pulse generator count, upper 32 bits [reference units]	High speed			
		000C	FPG count, lower 32 bits [reference units]	High speed			
		000D	FPG count, upper 32 bits [reference units]	High speed			
		0010	Un000: Motor speed [min^{-1}]	Low speed			
		0011	Un001: Speed reference [min^{-1}]	Low speed			
		0012	Un002: Torque reference [%]	Low speed			
		0013	Un0013: Rotational angle 1 (encoder pulses from the origin)	Low speed			
		0014	Un004: Rotational angle 2 [deg]	Low speed			
		0015	Un005: Input position reference speed [min^{-1}]	Low speed			
		0016	Un006: Input signal monitor	Low speed			
		0017	Un007: Output signal monitor	Low speed			
		0018	Un008: Position error [reference units]	Low speed			
		0019	Un009: Accumulated load ratio [%]	Low speed			
		001A	Reserved parameter (Do not set.)	Low speed			
		001B	Un00B: Power consumed by DB resistance [%]	Low speed			
		001C	Un00C: Input reference pulse counter [pulses]	Low speed			
		001D	Un00D: Feedback pulse counter [pulses]	Low speed			
		001E	Un00E: Fully-closed feedback pulse counter [pulses]	Low speed			
		001F	Reserved parameter (Do not set.)	Low speed			
		0023	Initial multiturn data [rev]	Low speed			
		0024	Initial incremental data [pulses]	Fixed			
		0025	Reserved parameter (Do not set.)	Fixed			
		0026	Reserved parameter (Do not set.)	Fixed			
		003E	Load meter monitor	High speed			
		0080	Reserved parameter (Do not set.)	High speed			
		0081	Reserved parameter (Do not set.)	High speed			
		0084	Reserved parameter (Do not set.)	High speed			

(cont'd)

Parameter No.	Size	Name		Setting Range	Setting Unit	Factory Setting	When Enabled	Classification
Pn825	2	Optional Monitor 2 Selection		0000 to FFFF	–	0000	Immediately	Setup
		0000 to 0084	Same as Optional Monitor Selection 1.					

• Monitor Data Chart





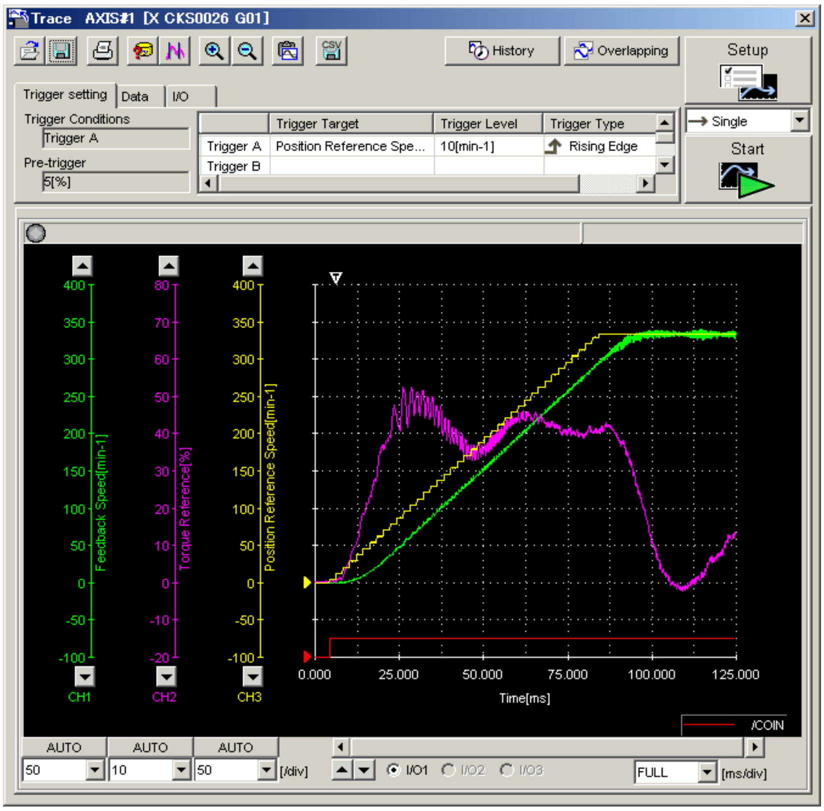
9.2 Servo Tracing

Displaying the behavior and operation of the motor on the host controller GUI is helpful to perform trial operation adjustments for the machine and servo adjustments.
A servo trace function requires the following capabilities:

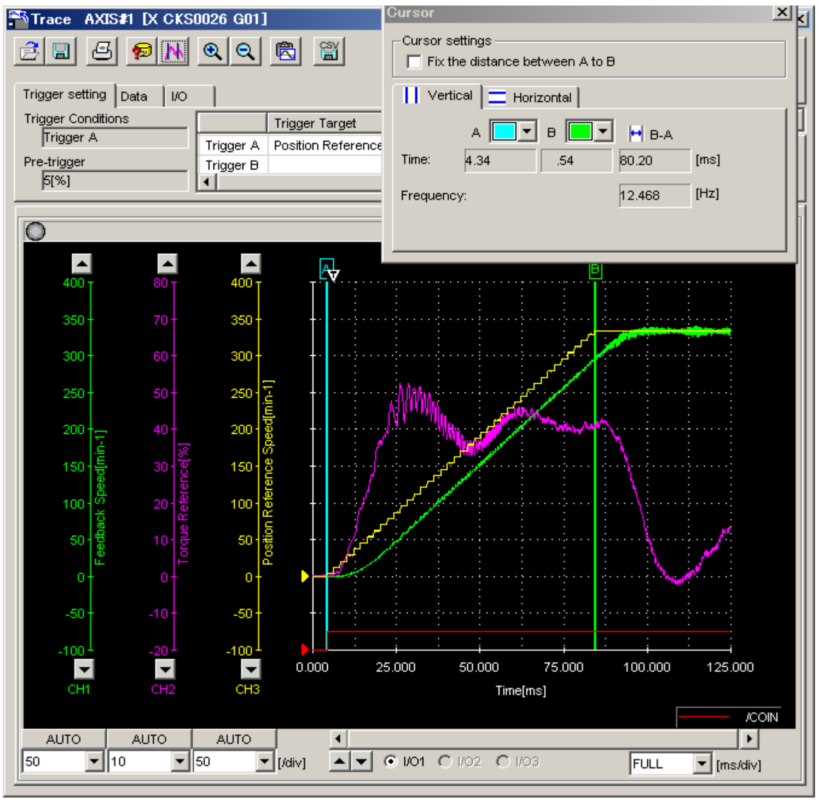
- Axis selection and waveform acquisition target* (trace target) selection
- Waveform acquisition cycle setting (sampling cycle and number of sampling points setting)
- Waveform acquisition trigger setting
- Waveform drawing and zoom in/out functions
- Cursor for X and Y axes on drawn waveforms and level/time measurement based on cursor position
- Ability to save and load measured waveforms
- Overlay comparison of measured waveforms (i.e., the ability to load past waveforms and overlay them on the current waveform)

* Refer to ■ *Selecting Monitor Information* for details on the waveform acquisition target.
It is also useful to be able to select input signal bits, such as CMD_STAT, SVCMD_STAT, and SVCMD_IO.
The Trace Dialog Boxes in the SigmaWin for Σ-V-SD (MT) PC engineering tool are included here for reference.

- Servo Trace Waveform



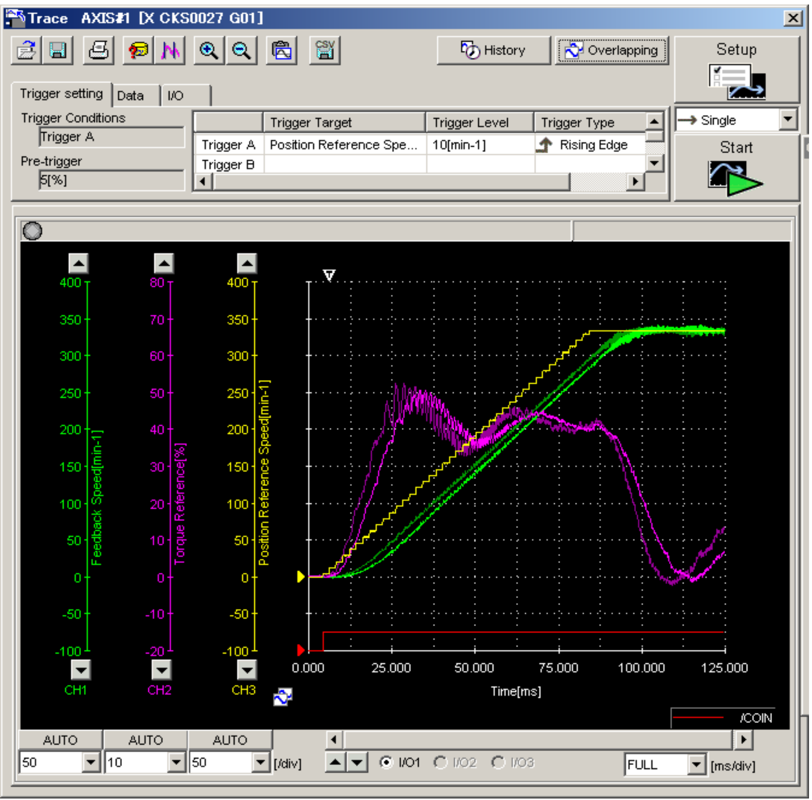
- Cursor-based Time Measurements



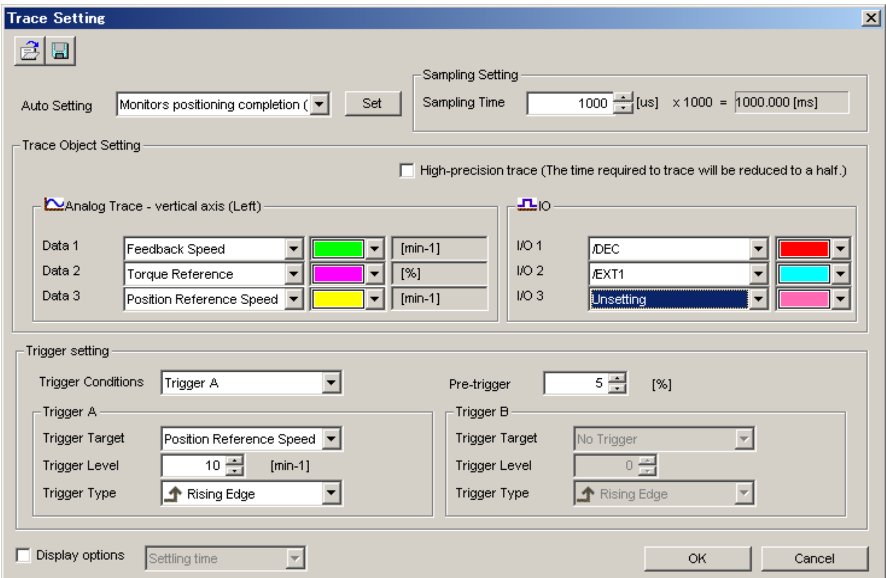
Monitoring

9

- Waveform Overlay



- Trigger Condition Settings



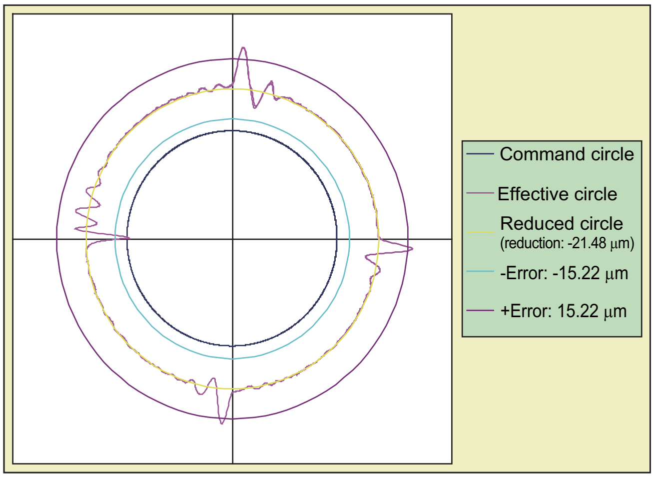
9.3 Path Drawing (Circular Arc Paths)

This function draws the circular arc path between two direct-drive axes. It is used to check the circular arc reduction and amount of quadrant projection.
The command and motor axis edge positions are drawn using the reference positions (CPOS) and coordinate positions (APOS) of the two axes.
If the circular path drawing can be viewed on the host controller GUI, this enables trial operation adjustments and servo adjustments to be performed smoothly.
A function to draw circular paths requires the following capabilities:

- Selection of the axes for which to perform the drawing (2 axes)
- Path data acquisition cycle setting*1 (sampling cycle and number of sampling points setting)
- Path data acquisition trigger setting*2
- Path drawing*3
- Path enlargement/reduction (i.e., the ability to change the scale of the X and Y axes)
- Measurement of circular arc reduction and quadrant projection amounts and the numeric value display of these amounts
- Ability to save and load measured path data
- Overlay comparison of measured path data (i.e., the ability to load past data and overlay them on the current data)

*1. This depends on the data storage memory area of the host controller.
*2. When drawing circular paths, it is recommended to begin data acquisition with an automatic trigger such as when the specified axis reverses or when the 1/2 of the circular movement speed is reached.
*3. The circular arc reduction and quadrant projection amount are on the level of a few µm in size. Therefore, if the circular path is drawn to scale, these tiny amounts will not be visible. Therefore, the circular path must be drawn magnified.

Refer to the following drawn path as a reference.



Monitoring

9

9.4 Tapping Synchronization Accuracy Drawings

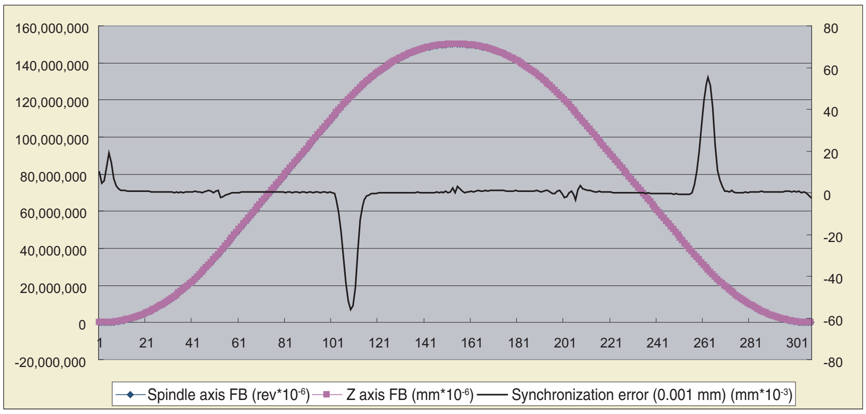
Tapping operations synchronize the operation of the spindle axis and feed axis (Z axis, etc.) to cut screw holes in workpieces. This requires the confirmation of the synchronization accuracy of the spindle and feed axes. The reference positions (CPOS) and coordinate positions (APOS) of the spindle and feed axes are used to draw the reference and position, position error, and motor speed.
To determine the tapping synchronization error, you must check for the area where the synchronization error is the greatest during the tapping operation.
A function to draw the tapping synchronization accuracy requires the following capabilities:

- Selection of the axes for which to perform the drawing (spindle and feed axes)
- Screw pitch (screw lead) setting for the tapping operation*1
- Data acquisition cycle setting*2 (sampling cycle and number of sampling points setting)
- Path data acquisition trigger setting*3
- Drawing the tapping synchronization error*4
- Synchronization error measurement and display of the greatest value
- Ability to save and load measured path data
- Overlay comparison of measured path data (i.e., the ability to load past data and overlay them on the current data)*5

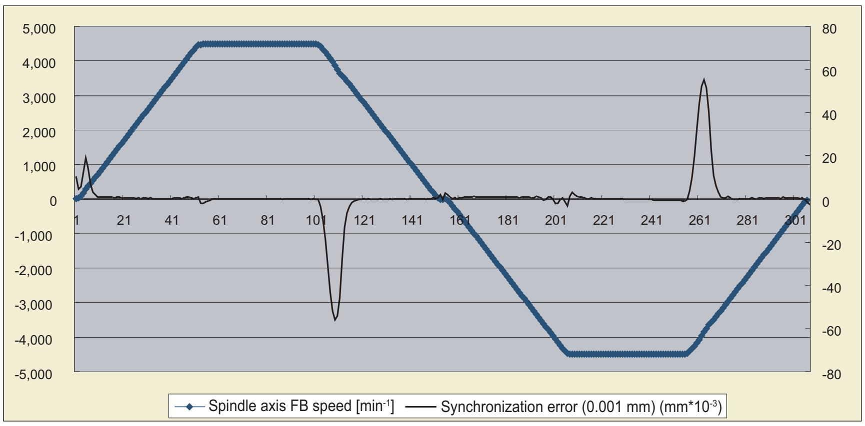
*1. The host controller can automatically obtain the screw pitch with a G-code command.
*2. This depends on the data storage memory area of the host controller.
*3. A sequence that automatically activates a trigger to start data acquisition when the spindle axis or the feed axis begins acceleration is recommended.
*4. Plot the synchronization error between the spindle and feed axes in µm. Plot the spindle axis position and spindle axis motor speed together to determine where the margin of error is greatest during the tapping operation.
*5. Read the past data and overlay it on top of the current data.

Refer to the following drawing of the tapping synchronization accuracy as a reference.

- Spindle Axis/Z Axis Positions and Tapping Synchronization Error



- Spindle Axis Motor Speed and Tapping Synchronization Error



9.5 I/O Monitoring

During machine trial operation and operation confirmation, the bit commands from the host controller, SERVOPACK status bits, and SERVOPACK input signal status are checked on the host controller GUI.
This allows for smooth trial operation confirmation and troubleshooting.
The following items are displayed on the host controller for I/O monitoring:

- Output signals: CMD_CTRL, SUB_CTRL, SVCMD_CTRL, and SVCMD_IO
- Input signals: CMD_STAT, SUB_STAT, SVCMD_STAT, and SVCMD_IO

If there are multiple SERVOPACKS connected to the host controller, it can be helpful to display the status of all I/O signals (bits) at the same time on the host controller GUI.

9.6 Spindle Axis Load Meter

When a SERVOPACK is used for the spindle axis (i.e., when Pn01E.0 is set to 1 or 5), use a load meter to determine how much of the capacity of the spindle axis is being used.
The load meter can be used to set the base spindle motor output with a parameter setting.
Set the load meter base setting, for example, to operate the spindle axis for a short period of time only to perform cutting or to perform continuous cutting with the spindle axis, based on the customer's needs.
Determine how to display the information from the spindle axis load meter on the host controller GUI so that it is easy to view, whether it be as numerical data or in the form of a bar graph or as a traditional needle-type display.
You can apply a filter at the SERVOPACK due to the rapid value changes that occur in short intervals from the load meter monitor.

IMPORTANT

The SERVOPACK software must be version 000A or higher to use the load meter.

9.6.1 Load Meter Monitor Selection

To monitor the load meter, select either Optional Monitor 1 or Optional Monitor 2 for the monitor selection and then select the load meter for parameter Pn824 or Pn825.
For details, refer to *9.1 SERVOPACK Monitors*.

Setting Example to Monitor the Load Meter with SEL_MON3

SVCMD_CTRL.SEL_MON3 = 0E hex (Selects Optional Monitor 1.)
Pn824 = 3E hex (Selects the load meter.)

9.6.2 Load Meter Base Selection

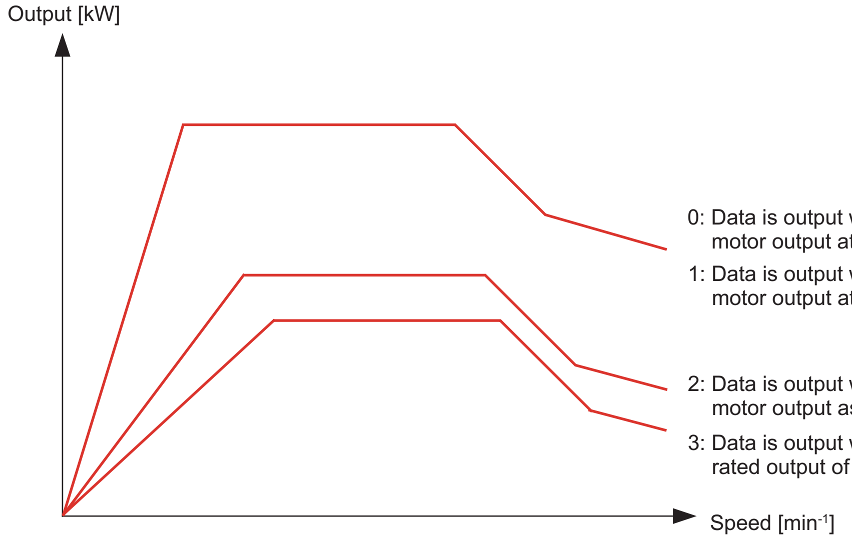
A parameter is set to select where the base setting of the load meter must be, based on the output characteristics of the spindle motor.

Parameter		Meaning	When Enabled	Classification
Pn01C	n.□□□0 (factory setting)	Data is output with the maximum motor output at 120%.	After restart	Setup
	n.□□□1	Data is output with the maximum motor output at 100%.		
	n.□□□2	Data is output with the rated short-term motor output (50% ED) as the 100% output.		
	n.□□□3	Data is output with a continuous motor rated output of 100%.		

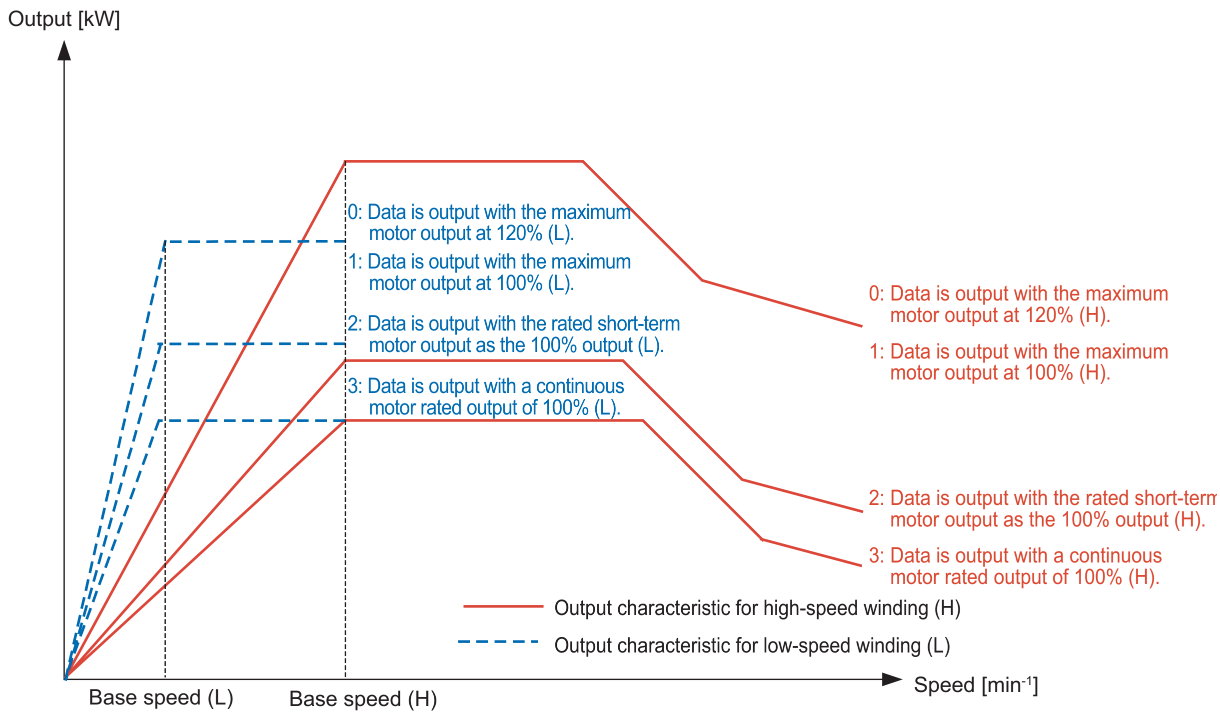
Note: When a motor for winding selection (UAKBJ-□□C) is used, the load meter base setting changes based on the output characteristics when low-speed or high-speed winding is selected.

The following figure shows the relationship between the spindle motor (single-winding spindle motor and winding-selection spindle motor) output characteristics and the load meter base setting.

(1) Single-winding Spindle Motor



(2) Winding-selection Spindle Motor



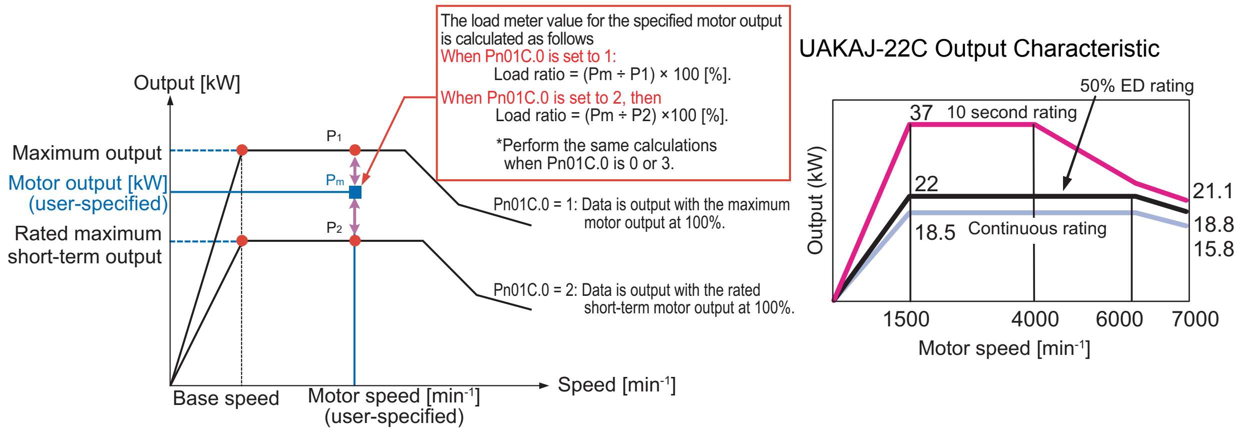
The load meter reflects the output of the spindle motor, so it is in a state of constant change. Therefore, a filter must be applied to the load meter monitor value when this value is displayed on the host controller.
You can use the following SERVOPACK parameters to set the filter.

Parameter No.	Name	Unit	Setting Range	Factory Setting	When Enabled
Pn43F	Load Ratio Meter Filter Time Constant	1 ms	0 to 5,000	100	Immediately

Note: Set this parameter to 0 to disable the filter.

9.6.3 Load Meter Output Example

The following example uses the UAKAJ-22C single-winding spindle motor and shows the load meter output calculations.



If the motor output is 26 kW when the spindle motor is rotating at 3,000 min^{-1}, the load meter monitor value for each load meter base setting is as follows:

- Pn01C.0 = 0: Data is output with the maximum motor output at 120%.
  Load meter = (26 kW ÷ 37 kW) × 120% = 84.3% = 843(0.1%) = 34B hex
- Pn01C.0 = 1: Data is output with the maximum motor output at 100%.
  Load meter = (26 kW ÷ 37 kW) × 100% = 70.3% = 703(0.1%) = 2BF hex
- Pn01C.0 = 2: Data is output with the rated short-term motor output (50% ED) as the 100% output.
  Load meter = (26 kW ÷ 22 kW) × 100% = 118.2% = 1182(0.1%) = 49E hex
- Pn01C.0 = 3: Data is output with a continuous motor rated output of 100%.
  Load meter = (26 kW ÷ 18.5 kW) × 100% = 140.5% = 1405(0.1%) = 57D hex

Revision History

The revision dates and numbers of the revised manuals are given on the bottom of the back cover.

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		Preface	Revision: ■ Disposal precautions
		Back cover	Revision: Address and format
June 2012	–	–	First edition

AC Servo Drives

Σ-V-SD Series

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For Application Development in Servo Systems

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