Servo

SIMPLE MOTION Module

This course is available as part of an online training (e-Learning) system for those working to establish a Motion control system using a Simple Motion Module for the first time.
This course provides an opportunity for beginners who want to construct Motion control systems using Simple Motion Modules to learn all about the procedures and tasks needed for working with a Simple Motion Module for the first time from the design, installation, and wiring to operation using the MELSOFT GX Works2 Programmable Controller Engineering Software.

For this course, you will need to have a basic knowledge of the MELSEC-Q series PLCs, AC servos, and positioning control.

It is recommended that beginners to the Mitsubishi Electric FA e-learning courses take the following courses:
- MELSEC Q series Basics course
- MELSERVO Basics course
- Introduction to FA Devices (Positioning) course

These courses will provide you with a solid foundation on FA devices and relevant topics.
Course Structure

The contents of this course are as follows. We recommend that you start from Chapter 1.

**Chapter 1 - Overview and Practical Examples of a Simple Motion Module**

You will be given an overview and shown some practical examples of a Simple Motion Module in this chapter.

**Chapter 2 - Equipment Configuration and Wiring**

You will be shown examples of the equipment configuration as well as wiring layouts with a Simple Motion Module.

**Chapter 3 - GX Works2 and the Simple Motion Module Setting Tool**

You will learn how to complete settings for the Simple Motion Module system and various parameters.

**Chapter 4 - Positioning Control**

You will learn how to perform positioning control with a Simple Motion Module.

**Chapter 5 - Construction of a Sample System (Positioning)**

You will learn how to construct sample systems designed for positioning tasks.

**Chapter 6 - Synchronous Control**

You will learn how to perform synchronous control with a Simple Motion Module.

**Chapter 7 - Construction of a Sample System (Synchronous Control)**

You will learn how to construct the sample systems designed for synchronous control.

**Final Test**

Passing grade: 60% or higher.
<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go to the next page</td>
<td>Go to the next page.</td>
</tr>
<tr>
<td>Back to the previous page</td>
<td>Back to the previous page.</td>
</tr>
<tr>
<td>Move to the desired page</td>
<td>&quot;Table of Contents&quot; will be displayed, enabling you to navigate to the desired page.</td>
</tr>
<tr>
<td>Exit the learning</td>
<td>Exit the learning. Window such as &quot;Contents&quot; screen and the learning will be closed.</td>
</tr>
</tbody>
</table>
**Safety precautions**

When you learn by using actual products, please carefully read the safety precautions in the corresponding manuals.

**Precautions in this course**

- The displayed screens of the software version that you use may differ from those in this course.

  This course is for the following software version:
  - GX Works2 Version 1.87R
  - MR Configurator2 Version 1.12N

**Reference materials**

Below is a list of references related to the topics in this course. (Please note that these reference materials are not absolutely necessary as you can still complete this course without using them.)

Click on the name of the reference file to download.

<table>
<thead>
<tr>
<th>Name of reference</th>
<th>File format</th>
<th>File size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample program</td>
<td>Compressed file</td>
<td>473 kB</td>
</tr>
<tr>
<td>Recording paper</td>
<td>Compressed file</td>
<td>8.17 kB</td>
</tr>
</tbody>
</table>
Chapter 1  Overview and Practical Examples for a Simple Motion Module

In chapter 1, you will be given an overview and shown some practical examples of a Simple Motion Module.

1.1  Overview of the Simple Motion Module

A Simple Motion Module is an intelligent function module used to provide positioning control using commands from a PLC CPU.

System Configuration

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Software

Programmable Controller Engineering Software
MELSOFT GX Works2

Servo Setup Software
MR Configuration2

---

Rotary Servo Motor
Direct Drive Motor
Rotary Servo Motor
Linear Servo Motor
Rotary Servo Motor
# Differences between a Simple Motion Module and a regular positioning module

A Simple Motion Module is a more advanced positioning module that is backwards-compatible with previous positioning modules. Simple Motion Modules provide standard positioning control as well as other advanced controls not available on a regular positioning module such as synchronous control and cam control with the feel of a regular positioning module.

<table>
<thead>
<tr>
<th></th>
<th>Simple Motion Module</th>
<th>Positioning module</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>QD77MS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LD77MH</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>QD75MH</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum number of control axes</td>
<td>2 axes/4 axes/16 axes</td>
<td>4 axes/16 axes</td>
</tr>
<tr>
<td>Compatible servo amplifiers</td>
<td>MR-L4 series</td>
<td>MR-L3 series</td>
</tr>
<tr>
<td><strong>Main positioning functions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTP control</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Linear interpolation</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>OPR control</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>JOG operation</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Electronic gear</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Absolute position system</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td><strong>Advanced functions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchronous control</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Cam control</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Speed control</td>
<td>☑</td>
<td>☑</td>
</tr>
<tr>
<td>Torque control</td>
<td>☑</td>
<td>☑</td>
</tr>
</tbody>
</table>
1.3 **Practical Examples of Simple Motion Modules**

Simple Motion Modules can be applied to systems in a variety of applications as they easily perform positioning control.

- Sealing
- X-Y table
- Conveyance line

- Continuous orbit control
- Linear/circular interpolation
- Synchronous control
- High-speed, high-accuracy orbit calculation

- 2-axis linear interpolation
- 2-axis circular interpolation
- 3-axis linear interpolation
- Continuous orbit control

- 2-axis linear interpolation
- Continuous positioning control
- Synchronous control
- Cam control

In this course, you will learn how to construct the above conveyance lines with a QD77MS model Simple Motion Module using positioning control and synchronous/cam control.
1.4 Overview of a Sample System

Check the control details (control flow) in the sample system in this course with the provided animation.
1.5 Summary

In this chapter, you have learned:

- Overview of the Simple Motion Module
- Differences between a Simple Motion Module and a regular positioning module
- Practical Examples of Simple Motion Modules

Important points

The following points are very important, so please review them again to ensure that you have familiarized yourself with their content.

<table>
<thead>
<tr>
<th>Overview of the Simple Motion Module</th>
<th>A Simple Motion Module is an intelligent function module used to provide simple positioning control using commands from a PLC CPU.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Differences between a Simple Motion Module and a regular positioning module</td>
<td>A Simple Motion Module is a more advanced positioning module that is backwards-compatible with standard positioning modules. Simple Motion Modules provide standard positioning control as well as other advanced controls not available on a regular positioning module such as synchronous control and cam control with the feel of a regular positioning module.</td>
</tr>
<tr>
<td>Practical Examples of Simple Motion Modules</td>
<td>Simple Motion Modules can be applied to systems in a variety of applications including sealing, X-Y tables, and conveyance lines as they easily perform positioning control.</td>
</tr>
</tbody>
</table>
Chapter 2  Equipment Configurations and Wiring

In Chapter 2, you will learn about equipment configurations and wiring layouts for the sample system.

2.1  Equipment configurations for sample systems

Below is shown the equipment configuration of the sample system used in this course.
2.2 Review of safe design

Here, we will learn about safe design principles for the Motion Control System. We will review important mechanisms in place that are designed to unfailingly stop the system in emergencies to prevent device damage and malfunction and accidents from occurring when problems arise in the system. There are three safety measures used in the sample system in this course, which are described below.

Click the button that you would like to learn more about. (Click "Display all circuits" button to check out safety measure devices for all circuits.)
2.3 Installation

Here, we will learn about the installation of PLCs and servo amplifiers that are equipped with Simple Motion Modules.

2.3.1 Installation of PLCs

Below is the diagram for installation of PLCs equipped with Simple Motion Modules. Leave open the amount of space indicated in the bottom diagram both above and below the modules and around structures and parts to ensure adequate ventilation to prevent overheating and to make it easier to replace parts when necessary.

You may need to leave more space than that indicated in the below diagram in some cases depending on the configuration of the system in use.

Installation of PLCs

(Note-1): For wiring duct with 50 [mm] (1.97 inch) or less height, 40 [mm] (1.58 inch) or more for other cases.

(Note-2): 20 mm (0.79 inch) or more when the adjacent module is not removed and the extension cable is connected.

Cautions

• Attach the PLCs to a vertical wall making sure to orient it correctly with the top facing up and the bottom facing down.
• Use it in an environment with a room temperature ranging from 0° C to 55° C (32° F to 131° F).
2.3.2 Installation of servo amplifiers

Below is instructions on how to install servo amplifiers.

**Installation of servo amplifiers**

If installing two or more units attached together

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Cautions

- Attach the servo amplifier to a vertical wall making sure to orient it correctly with the top facing up and the bottom facing down.
- Use it in an environment with a room temperature ranging from 0°C to 55°C (32°F to 131°F).
- Use a cooling fan to prevent system overheating.
- Be careful not to allow any foreign objects or material to enter devices during assembly or from the cooling fan.
- Use an air purge system if installing servo amplifiers in locations with toxic gas fumes or high in dust (to feed in normal pressure from outside of the control box to increase the internal pressure until it is higher than the external pressure).
2.4 Device wiring

First, we will complete wiring to the PLC, servo amplifier, and servo motor. Next, we will learn about device wiring in the sample system.

2.4.1 Connections to external I/O devices

Click the button of the connection example that you would like to check out. (Click “Display all circuits” button to check out safety measure devices for all circuits.)
2.4.2 Servo amplifier wiring (Power supply, motor)

A power supply is connected to the servo amplifier with the connectors for the main circuit power and the control circuit power. Make sure to connect a molded case circuit breaker (MCCB) to the input line of the power supply. Make sure to also connect magnetic contactors (MCs) between the main circuit power supply and the L1, L2, and L3 terminals on the servo amplifier, and wire it so that the main circuit power supply is shut off when the magnetic contactor (MC) is turned On by an alarm.

A wiring diagram is shown below for a three-phase, 200 V AC to 230 V AC power supply to an MR-J4W2-22B unit.

※ Connect the grounding terminal on the servo motor to CNP3A, CNP3B, and CNP3C protective earth terminals. Connect the protective earth (PE) terminal on the bottom of the front surface of the servo amplifier to the protective earth (PE) terminal on the control box to ground the servo amplifier.
2.4.3 SSCNET III/H Wiring

Here, we will learn about the methods for connecting a Simple Motion Module and servo amplifier. The MR-J4W2-22B model servo amplifiers come equipped with an SSCNET III/H interface. The SSCNET III/H provides high-speed, full duplex communications with excellent noise immunity using an optical communications system.

There is a special cable provided for connecting the devices. The cable comes with connectors that can be plugged in and unplugged easily.

Be sure to carefully observe the below precautions when handling the SSCNET III cable.

- Be careful not to strike the cable forcibly or apply pressure, pull on it, bend it sharply, twist, or otherwise apply force as doing so could cause the internal wires to become deformed or bent, which could cause optical communications to fail.
- Be careful not to use the fiber optic cable near fire or at high temperatures as it is made of a synthetic resin that could become deformed if heated, which could cause optical communications to fail.
- Be careful not to let dirt and other foreign matter collect on either end of the fiber optic cable as it could block the transmission of light and cause devices to malfunction.
- Do not attempt to look directly into the light emitted from the connector or cable terminal ends.
- For safety and protective reasons, place the accompanying caps on unused connectors (CN1B) on the servo amplifier of the final axis to block emitted light.
2.5 Display Unit for the Simple Motion Module

The display unit for the Simple Motion Module is shown below. (For the QD77MS16)

The LED display can be used to check operating conditions and statuses for the Simple Motion Module and operating axes.

<table>
<thead>
<tr>
<th>LED display</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN = AX</td>
<td>Hardware failure watch dog timer error</td>
</tr>
<tr>
<td>ERR =</td>
<td>System error</td>
</tr>
<tr>
<td>RUN = AX</td>
<td>During axis stop, during axis standby</td>
</tr>
<tr>
<td>ERR =</td>
<td>During axis operation</td>
</tr>
<tr>
<td>RUN = AX</td>
<td>Axis error</td>
</tr>
<tr>
<td>ERR =</td>
<td>Hardware failure</td>
</tr>
</tbody>
</table>

- **RUN indicator LED**: Indicates the running status of the module.
- **ERR indicator LED**: Indicates an error status.
- **Axis display LED**: Displays the axis number.
- **External I/O connector**: Connects to external devices.
- **SSCNET III cable Connector**: Connects to the SSCNET III network.
- **Serial number plate**: Contains the serial number of the module.
2.6 Display Unit for the Servo Amplifier

The display unit for the servo amplifier is shown below. (For the MR-J4W2-8 model servo amplifier)
The display unit uses a seven-segment display to indicate axis servo conditions and provide alarm notifications.

(1) Normal display
Axis operating status and conditions will be displayed in order if there is no alarm triggered.

(2) Alarm display
"b": Indicates ready-off and servo-off status.
"c": Indicates ready-on and servo-off status.
"d": Indicates ready-on and servo-on status.
2.6 Display Unit for the Servo Amplifier

(2) Alarm display

When an alarm occurs, after alarm status are displayed, a two-digit alarm number and a one-digit alarm detail code are displayed. The example shown here indicates that an "AL. 16 encoder initial communications error 1" has occurred on the A-axis and an "AL. 32 overcurrent error" on the B-axis.

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"n": Indicates that an alarm has been generated.
2.7 Summary

In this chapter, you have learned:

- Review of safe design
- Installation of PLCs
- Installation of servo amplifiers
- Servo amplifier wiring
- SSCNET III/H Wiring
- Display Unit for the Simple Motion Module
- Display Unit for the Servo Amplifier

Important points

The following points are very important, so please review them again to ensure that you have familiarized yourself with their content.

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<th>We will review important mechanisms in place that are designed to unfailingly stop the system in emergencies to prevent device damage and malfunction and accidents from occurring when problems arise in the system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of PLCs</td>
<td>Leave open an adequate amount of space both above and below the modules and around structures and parts to ensure adequate ventilation to prevent overheating and to make it easier to replace parts when necessary.</td>
</tr>
</tbody>
</table>
| Installation of servo amplifiers | • Attach the servo amplifier to a vertical wall making sure to orient it correctly with the top facing up and the bottom facing down.  
• Use it in an environment with a room temperature ranging from 0°C to 55°C (32°F to 131°F). (Ranging from 0°C to 45°C (32°F to 113°F) if using servo amplifiers stacked together.)  
• Use a cooling fan to prevent system overheating.  
• Be careful not to allow any foreign objects or material to enter devices during assembly or from the cooling fan.  
• Use an air purge system if installing servo amplifiers in locations with toxic gas fumes or high in dust.  
• The 200-V class servo amplifiers with a power rating of 3.5 kW or below and the 100-V class servo amplifiers with a power rating of 400 W or below can be mounted closely. |
## Summary

### Mounting Servo Amplifiers
- The 200-V class servo amplifiers with a power rating of 3.5 kW or below and the 100-V class servo amplifiers with a power rating of 400 W or below can be mounted closely.
- When mounting the servo amplifiers closely, leave a clearance of 1 mm between the adjacent servo amplifiers in consideration of mounting tolerances.

<table>
<thead>
<tr>
<th>Servo amplifier wiring</th>
<th>A power supply is connected to the servo amplifier with the connectors for the main circuit power supply and the control circuit power supply. Make sure to connect a molded case circuit breaker (MCCB) to the input line of the power supply.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSCNET III/H Wiring</td>
<td></td>
</tr>
<tr>
<td>Simple Motion Module display unit</td>
<td>The LED display can be used to check operation statuses for the Simple Motion Module and operating axes.</td>
</tr>
<tr>
<td>Display Unit for the Servo Amplifier</td>
<td>The servo amplifier display unit is located inside the cover on top of the front surface of the unit. The display unit uses a seven-segment display to indicate axis servo conditions and provide alarm notifications.</td>
</tr>
</tbody>
</table>
Chapter 3  GX Works2 and the Simple Motion Module Setting Tool

In Chapter 3, we will learn how to complete settings for a Simple Motion Module system and various parameters.

3.1 Creation of GX Works2 projects

Try creating a new project in GX Works2. Check to make sure that a project tree is created when you complete the settings shown below.
3.2 Addition of Simple Motion Modules

In this section, we will try adding a Simple Motion Module to the GX Works2 project. Right-click on the intelligent function module in [Project] in GX Works2, select [New Module...] and then set the Module Model Type, Module Name, and Specify start XY Address on the "New Module" screen to add a Simple Motion Module to the project.

A QD77MS has been added.
3.3 Confirmation of I/O assignments

On the PC Parameters screen, check and set the model type, model name, number of occupied I/O points, and start I/O number for each module in the base unit.

Check to confirm that the module information is reflected properly for all added Simple Motion Modules.

Check to confirm that the module information is reflected properly for all added Simple Motion Modules.
3.4 Connection between the PLC CPU and PC

Connect the PLC CPU module and USB port on the PC together using a USB cable.
3.5 Connection Settings for the GX Works2 and PLC CPU Connection

Once you finish connecting the PC and PLC CPU together, next complete settings for the GX Works2 and PLC connection. You will not be able to start communications automatically merely by connecting GX Works2 and the PLC together using a USB cable.

To get communications to work properly, complete the "Connection Destination".

An example of the settings screen for Setting Connection Destinations is shown below.
3.6 Writing to the PLC

The PC parameters and other settings set in GX Works2 are written to the PLC CPU.
Before writing data to the PLC CPU, check to confirm that the CPU module is stopped and that the PC and CPU module are connected together properly.

After selecting [Online] → [Write to PLC...] in GX Works2, click on [Parameter+Program] and then click [Execute] to start writing data to the PLC CPU.
3.7 Saving of GX Works2 Projects

Here, we will try saving a created GX Works2 project. If you exit GX Works2 without saving a project, any settings that you made will be discarded without being saved.

When wanting to save a new project, set a file name. It is recommended that you select a name that can be used to identify the content of the project (using the control details, system name, or other easily recognizable text). Files are saved with the "gxw" file extension.

Save folder path
Specify a folder in which to save. (Up to 256 characters in length including the file name and extension.)

List of Files
If there are one or more files in the same save folder path, they are given in list form.

File Name
Specify a file name. (Up to 32 characters in length, not including the file extension.)

Title
Specify a title. (Up to 128 characters in length.) Use this when you want to use a name that exceeds 32 characters. (You can skip the title if you wish as it is not necessary.)
3.8 Creation of Setting Tool Projects

In this section, we will learn how to start the Simple Motion Module Setting Tool and create a new project. After double clicking on Simple Motion Module Settings under [Project] in GX Works2 and starting the Simple Motion Module Setting Tool, click on [Project] → [New...] in the Simple Motion Module Setting Tool.

Please be aware that the parameters and other settings set in GX Works2 will not be reflected in Simple Motion Module Setting Tool projects.
3.9 **Simple Motion Module Settings**

There are three types of data used in parameters needed for positioning control with Simple Motion Modules. Settings data, control data, and monitor data. Settings data is set separately for each axis using the Simple Motion Module Setting Tool.

- **Setting data**
  - Parameters
    - Positioning parameters
      - OPR parameter
      - Servo parameters
    - Synchronous control parameters
      - Pr
  - Synchronous control data
  - Control data
    - System control data
      - Cd
    - Axis control data
      - Cd
  - Synchronous control data
    - Cd

Control commands created using the control data are produced by the PLC program.

- **Monitor data**
  - Md

The monitor data can be checked on PLC program and Setting Tool monitoring.
3.10 System settings (SSCNET settings)

In this section, you will learn how to set the system configuration settings for a Simple Motion Module. Double-click on [System Setting]-[System Structure] in the Project window of the Simple Motion Module Setting Tool to pull up the system configuration. Double-click [SSCNET Setting] in the system configuration diagram of the Simple Motion Module Setting Tool to open the option that allows you to select the SSCNET communications type.
3.11 System settings (Servo amplifier settings)

Here, we will learn how to set the system configuration settings for a Simple Motion Module. Double-click on [System Setting]-[System Structure] in the Project window of the Simple Motion Module Setting Tool to pull up the system configuration.

To set a servo amplifier, double-click on the icon for the servo amplifier of the axis that you want to set in the system configuration.
3.11 System settings (Servo amplifier settings)

Set the proper control axis No. to the servo amplifier based on the system configuration. Control axis numbers are assigned separately for each servo amplifier in order to identify the control axis to use. Any number axis from Axis 1 to Axis 16 can be used independent of the order of connection. Be careful not to assign the same control axis No. to multiple servo amplifiers within the same servo system as it could cause system operation to fail.

For the servo amplifier, set the servo control axis No. using a combination of the settings for the axis selection rotary switch (SW1) located inside the front cover on the servo amplifier and the auxiliary axis number setting switches (SW2-5, SW2-6).
3.11 System settings (Servo amplifier settings)

* Be sure to restart the main circuit power and control circuit power of the servo amplifier after making any changes to the axis selection rotary switch (SW1) and auxiliary axis number setting switches (SW2).
3.12 Servo Parameter Settings

Set parameters specific to the servo amplifier for each axis. It is recommended that you use the MELSOFT MR Configurator2 Servo amplifier setup software to set the servo parameters.

Be particularly careful with the below parameters when setting:

<table>
<thead>
<tr>
<th>Parameter Item</th>
<th>Function Explanation</th>
<th>Initial values</th>
<th>Settings Values for the Sample System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation direction selection</td>
<td>Use this option to set the rotation direction of the servo motor when being moved by forward rotation commands. The rotation direction is either counter-clockwise (CCW) or clockwise (CW) as seen from the load side (side attached to the machine).</td>
<td>CCW for forward rotation command,</td>
<td>CCW for forward rotation command,</td>
</tr>
</tbody>
</table>
## 3.12 Servo Parameter Settings

<table>
<thead>
<tr>
<th>Parameter Item</th>
<th>Function Explanation</th>
<th>Initial values</th>
<th>Sample System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation direction</td>
<td>Use this option to set the rotation direction of the servo motor when being moved by forward rotation commands. The rotation direction is either counter-clockwise (CCW) or clockwise (CW) as seen from the load side (side attached to the machine).</td>
<td>CCW for forward rotation command, CW for reverse</td>
<td>CCW for forward rotation command, CW for reverse</td>
</tr>
<tr>
<td>Selection</td>
<td>Counter-clockwise (CCW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clockwise (CW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>We will now review the rotation direction from the machine specifications. Each of the axes in the sample system are made to rotate in the counter-clockwise direction (CCW) using forward rotation commands.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Servo forced stop</td>
<td>Turn this option ON to enable use of the forced stop input (EM2 or EM1) signal. The initial value is set to [Enabled] for safety reasons. To disable the signal in the sample system, set this option to [Disabled].</td>
<td>Enabled (Either forced stop input EM2 or EM1 is used)</td>
<td>Disabled (Neither forced stop input EM2 nor EM1 is used)</td>
</tr>
<tr>
<td>Selection</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.13 Parameter settings

Here, you will learn how to set the Positioning parameters for the Simple Motion Module. Set the parameters at system startup based on machine equipment and motor used and the system configuration.

Be careful not to set the Basic Parameters 1 incorrectly as it could cause the motor to rotate in the opposite direction or fail to run altogether.
3.13.1 Parameter settings (Electronic gear)

The mechanical systems (example, ball screw) connected to the servo motor use units of mm (in.), degree, and so on. Positioning control uses the same units as those of the mechanical systems. However, as servo motor rotation is measured in units of number of pulses, quantities in commands issued to the servo motor need to be converted to pulse units. Once the electronic gear parameters have been set, the Simple Motion Module will be set up to convert position commands issued in mechanical system units into pulse units.

Use the below parameter settings if there are any ball screws (ball screw pitch: 10 mm (0.4 in.)) connected to the servo motor (4194304 pulses/rotation).

Distance of 10 mm (0.4 in.) moved × Electronic gear = 4191304 pulses

Parameter settings for actual machines such as rotary tables and conveyors are much more complicated as there is such a wide variety of types and there are other parts connected to the system in addition to ball screws, such as speed change gears and gears. Use of “Compute Basic Parameter 1” will enable you to set parameter settings for the electronic gear easily.
3.13.1 Parameter settings (Electronic gear)

- **Display Filter**: Display All
- **Compute Basic Parameters 1**

<table>
<thead>
<tr>
<th>Item</th>
<th>Axis #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic parameters 1</td>
<td></td>
</tr>
<tr>
<td>Pr.1: Unit setting</td>
<td></td>
</tr>
<tr>
<td>Pr.2: No. of pulses per rotation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4194304 PLS</td>
</tr>
</tbody>
</table>

Set according to the machine (This parameter becomes valid).

**Machine Components**: Ball screw, Horizontal

**Unit Setting**: 0 mm

**Load of Ball screw/PB**: 13000.0 Lm

**Reduction Gear Ratio (NL/PM)**

**Encoder Resolution**: 4194304 [PLS/Rev]

**Calculation Result**

As a result of calculation, no error occurs in the movement amount.

- Movement amount set: 10000.0 μm
- Movement amount per pulse: 10000.0 μm
- Unit Magnification: 1:1 Times

Applying the calculation result above, the error for the movement amount is 0.0 μm. You want to perform this at 0.0 μm. Error Calculation.
### 3.13.2 Parameter settings (Speed limit value)

Set the maximum speed for the command speed during control mode as the "Speed limit value."

Example involving calculation of the speed limit value:

- Maximum rotation speed for the servo motor (HG-KR053) = 6000 r/min.
- Amount of movement per rotation of the servo motor 1 = 6000 r/min.

= 60000000 μm/min. (2362.2 in./min.)

= 60000 mm/min. (2362.2 in./min.)

<table>
<thead>
<tr>
<th>Parameter item</th>
<th>Setting details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr. 8: Speed limit value</td>
<td>Set the speed limit value (maximum speed during control mode).</td>
</tr>
<tr>
<td>Pr. 31: JOG speed limit value</td>
<td>Set the speed limit value for the JOG operation (maximum speed during control mode).  (Make sure to keep the following value: [Pr. 31: Speed limit value for JAOG operation ≤ Pr. 8 Speed limit value].)</td>
</tr>
</tbody>
</table>
### 3.13.3 Parameter settings (External input signal selection)

Set the logic and type for the external input signal.

<table>
<thead>
<tr>
<th>Parameter item</th>
<th>Setting details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pr. 22: Input signal logic selection: Lower limit</td>
<td>Set the logic for the external input signals (Upper/lower limit switches) selected in Pr. 80. The initial setting value is set to [Negative Logic] for safety reasons. If not using this signal, set the type to [Positive Logic].</td>
</tr>
<tr>
<td>Pr. 22: Input signal logic selection: Upper limit</td>
<td></td>
</tr>
<tr>
<td>Pr. 80: External input signal selection</td>
<td>Use this to select which to use for the external input signal (Upper/lower limit switches, Near-point dog signal, stop signal) from &quot;Simple Motion Module External Input Signal/Servo Amplifier Input Signal/Simple Motion Module Buffer Memory.&quot;</td>
</tr>
</tbody>
</table>
3.14 Saving of Setting Tool Projects

Save a project including parameters after the parameter setting.
If you exit the Simple Motion Module Setting Tool without saving a project, the set parameter contents will be discarded.

When wanting to save a new project, set a file name.
It is recommended that you select a name that can be used to identify the content of the project (using the control details, system name, or other easily recognizable text).
Files are saved with the ".pcw" file extension.

- **Save folder path**
  Specify a folder in which to save.
  (Up to 200 characters in length including the file name and extension.)

- **List of Files**
  If there are one or more files in the same save folder path, they are given in list form.

- **File Name**
  Specify a file name. (Up to 30 characters in length, not including the file extension.)

- **Title**
  Specify a title. (Up to 128 characters in length.)
  Use this when you want to use a name that exceeds 30 characters. (You can skip the title if you wish as it is not necessary.)
3.15 Writing to the Simple Motion Module

Use [Write to Module...] in the Setting Tool to write to the QD77MS. The Setting Connection Destinations use the same settings as those set in GX Works2.
3.16 Summary

In this chapter, you have learned:

- System Settings
- Confirmation of I/O assignments
- Connection Settings for the GX Works2 and PLC CPU Connection
- Servo Parameter Settings
- Parameter settings (Electronic gear)
- Parameter settings (Speed limit value)
- Parameter settings (External input signal selection)

Important points

The following points are very important, so please review them again to ensure that you have familiarized yourself with their content.

<table>
<thead>
<tr>
<th>System Settings</th>
<th>System settings for the Simple Motion Module are set using the Simple Motion Module Setting Tool in GX Works2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirmation of I/O assignments</td>
<td>Set the model type, model name, number of occupied I/O points, and head I/O number for each module in the base unit.</td>
</tr>
<tr>
<td>Connection Settings for the GX Works2 and PLC</td>
<td>You will not be able to start communications automatically merely by connecting GX Works2 and the PLC together using a USB cable.</td>
</tr>
<tr>
<td>Servo Parameter Settings</td>
<td>Set parameters specific to the servo for each axis. It is recommended that you use the MELSOFT MR Configurator2 Servo amplifier setup software to set the servo parameters.</td>
</tr>
<tr>
<td>Parameter settings (Electronic gear)</td>
<td>This item is used to determine how many times the motor is to be rotated (how many pulses) with the electronic gear, which is used to move the machine the select movement amount specified by the commands.</td>
</tr>
<tr>
<td>Parameter settings</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>(Speed limit value)</td>
<td>Set the maximum speed for the command speed during control mode.</td>
</tr>
<tr>
<td>(External input signal selection)</td>
<td>Set the logic and type for the external input signal.</td>
</tr>
</tbody>
</table>
Chapter 4  Positioning Control

In Chapter 4, you will learn about positioning control using a Simple Motion Module with the QD77MS4 used as an example.

4.1  PLC CPU and Simple Motion Module

Total control is handled by the PLC CPU, and positioning control is performed by the Simple Motion Module, calculating the position.

The PLC CPU and Simple Motion Module transmit and receive data using the I/O signals and buffer memory. 
*The layout of the I/O signals and buffer memory may vary depending on the model of Simple Motion Module. Please be aware that the layouts of those for the QD77MS2/QD77MS4 and QD77MS16 in particular differ dramatically.

I/O signal List <PDF>
Chapter 4  Positioning Control

- Designation method for the buffer memory

Designation: U\nG  
Buffer memory address (Set range: 0 to 65536 in decimal)
Head I/O number for the Simple Motion Module (Set range: 00H to FFH)
Setting: First two digits of the head I/O number when expressed as a three-digit value
For XY010  … XY010
  Designation: 01

Example of buffer memory access: MOV P1 U1 G1500
"1" is transferred to the buffer memory address 1500 of the module with the head I/O number of XY010
4.2 Simple Motion Module and Servo Amplifier

The Simple Motion Module controls the servo amplifier through SSCNET III/H communications. The Simple Motion Module generates positioning commands for every command communication cycle and transmits those commands to the servo amplifier to control positioning.

The servo amplifier must be set to the Servo-on status in order to allow it to be controlled by the Simple Motion Module. Once the servo amplifier has been placed in the Servo-on status, the servo motor is servo-locked, and positioning control is enabled.

Below, a program example is shown.
Below, a program example is shown.

**PLC ready signal ON program**

<table>
<thead>
<tr>
<th>SM403</th>
<th>M25</th>
<th>M27</th>
<th>X7R</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF for one scan only after RUN</td>
<td>Parameter initialization command storage</td>
<td>Flash ROM write command storage</td>
<td>PLC ready ON</td>
</tr>
</tbody>
</table>

**Servo ON program**

<table>
<thead>
<tr>
<th>X0</th>
<th>Y0</th>
<th>X1</th>
</tr>
</thead>
<tbody>
<tr>
<td>QD77 READY</td>
<td>PLC READY</td>
<td>Synchronization flag</td>
</tr>
<tr>
<td>All axis servo ON</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.3 JOG operation

JOG operation is a function used to manually operate a servo motor in the forward or reverse run direction at a constant speed. It is used for a teaching or test operation when a system is constructed.

After the JOG speed and other settings have been made, turning the JOG start signal ON starts JOG operation and turning it OFF initiates deceleration and brings JOG operation to a stop. Required signals and data produced for JOG operation using a QD77MS4 model as an example are given below.

<table>
<thead>
<tr>
<th>I/O signals</th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward run JOG start signal</td>
<td>Y8</td>
<td>YA</td>
<td>YC</td>
<td>YE</td>
</tr>
<tr>
<td>Reverse run JOG start signal</td>
<td>Y9</td>
<td>YB</td>
<td>YD</td>
<td>YF</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Buffer memory</th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Cd. 17] JOG speed</td>
<td>1518</td>
<td>1618</td>
<td>1718</td>
<td>1818</td>
</tr>
<tr>
<td>[Pr. 32] JOG operation acceleration time selection</td>
<td>50</td>
<td>200</td>
<td>350</td>
<td>500</td>
</tr>
<tr>
<td>[Pr. 33] JOG operation deceleration time selection</td>
<td>51</td>
<td>201</td>
<td>351</td>
<td>501</td>
</tr>
</tbody>
</table>

Examples of JOG operation
For JOG operation of Axis 1 in the forward run direction

1. Once the start signal is turned ON, acceleration starts in the specified direction.
2. Once the JOG speed is reached the set speed, operation proceeds with constant speed movement.
3. When the start signal is turned OFF, deceleration starts.
4. Operation stops once the speed is reached 0.
4.4 Original point return (OPR)

4.4.1 Overview of Original Point Return (OPR)

Original point return (OPR) is a function that is used to move a machine to its original position and match the OP addresses of the machine and the Simple Motion Module at that position. It is used to return machines to the original position when the power is turned on and at other times as necessary.

There are two types of OPR control for the Simple Motion Module:
- Machine OPR... Used to establish the original position for positioning control.
- Fast OPR... Used to set positioning directed toward the original position.

There are five methods available for establishing the "original position" using the machine OPR operation. Set the OPR parameters specified for the machine model.

<table>
<thead>
<tr>
<th>OPR method</th>
<th>Operation details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Near point dog method</td>
<td>The position of the zero point of the motor after the Near point dog is switched from ON → OFF is set as the original position.</td>
</tr>
<tr>
<td>Count method ①</td>
<td>The position of the zero point of the motor after the Near-point dog is switched from OFF → ON and the machine moved for the specified distance is set as the original position.</td>
</tr>
<tr>
<td>Count method ②</td>
<td>The position at which the machine stops when moved to the set distance after the Near-point dog is switched from OFF → ON is set as the original position.</td>
</tr>
<tr>
<td>Data set method</td>
<td>The position at which OPR is used is set as the original position. No Near-point dog is used in this case.</td>
</tr>
<tr>
<td>Scale origin signal detection method</td>
<td>After the Near-point dog is switched from OFF → ON, the machine is moved in the direction opposite to the OPR direction, and the position at which the original position signal (zero point) is detected is set as the OPR.</td>
</tr>
</tbody>
</table>

After OPR is completed, the current feed value and machine feed value are written to the original address.
4.4.2 Start of OPR

The machine OPR operation starts after the OPR parameters are set and the positioning start No. is set to "9001," the OPR designation, which turns ON the positioning start signal.

Required signals and data needed for the start of the machine OPR operation are given below using a QD77MS4 model as an example.

**I/O signals**

<table>
<thead>
<tr>
<th></th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positioning start signal</td>
<td>Y10</td>
<td>Y11</td>
<td>Y12</td>
<td>Y13</td>
</tr>
</tbody>
</table>

**Buffer memory**

<table>
<thead>
<tr>
<th></th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
<th>Setting value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Cd. 3] Positioning start No.</td>
<td>1500</td>
<td>1600</td>
<td>1700</td>
<td>1800</td>
<td>9001</td>
</tr>
</tbody>
</table>

Example of the Start of OPR
When performing machine OPR using the near-point dog method on Axis 1

- **Sequence program**

  - Machine OPR command
  - MOV P K9001 G1500
  - Axis 1 Positioning start No.
  - SET Y10

- **OPR parameters**

  - OPR basic parameters
    - FR.43: OPR method
    - FR.44: OPR direction
    - FR.45: OPR address
    - FR.46: OPR speed
    - FR.47: Creep speed

  - Set the values required for OPR (This parameter becomes valid)
    - Near-point Dog Method
    - Forward Direction (Address Increase Direction)
    - 0.0 μm
    - 1000.00 mm/min
    - 100.00 mm/min

  - Set using the Simple Motion Module Setting Tool.
4.4.3 OPR operation

The operations used for near-point dog method of OPR along Axis 1 are as given below.

1. The machine OPR operation starts. The machine moves in the [Pr. 44] OPR direction at the [Pr. 46] OPR speed.

2. The near-point dog ON state is detected, which triggers the machine to start decelerating.

3. The machine decelerates to the [Pr. 47] creep speed and then moves along at the creep speed.

4. Deceleration stops after the Near-point dog is turned OFF. The machine stops at the initial motor zero point position later on.

5. The OPR complete flag (Md. 31 status: b4) switches from OFF → ON.
4.5 Positioning Control

4.5.1 Overview of the Positioning Control Function

The Simple Motion Module performs positioning control with the setting of the target position, command speed, and other settings to the positioning data, which triggers start up of the module.

Details for the main positioning control performed with the Simple Motion Module are as listed below.

<table>
<thead>
<tr>
<th>Main positioning control</th>
<th>Details</th>
<th>Interpolation control</th>
<th>Operation chart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position control</td>
<td>Linear control continues from the start point address (current stop position) to the target position.</td>
<td>○ (Up to 4 axes)</td>
<td>&lt;2-axis linear control&gt;</td>
</tr>
<tr>
<td>Linear control</td>
<td></td>
<td></td>
<td>End point address (target position)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Start point address</td>
</tr>
<tr>
<td>2-axis circular interpolation control</td>
<td>Circular interpolation control is performed from the start point address (current stop position) to the target position using two axes. There are two kinds of circular interpolation available, one based on sub point designation and one based on center point designation.</td>
<td>○ (2-axis)</td>
<td>&lt;2-axis circular interpolation control by sub point designation&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>End point address (target position)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sub point</td>
</tr>
<tr>
<td>Speed control</td>
<td>After the command is executed, control proceeds at the command speed until the stop command is input.</td>
<td>○ (Up to 4 axes)</td>
<td>Stop command</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Speed</td>
</tr>
</tbody>
</table>

![Diagram of 2-axis linear control](image)
### 4.5 Positioning Control

<table>
<thead>
<tr>
<th>Speed control</th>
<th>After the command is executed, control proceeds at the command speed until the stop command is input. (Up to 4 axes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed-position switching control</td>
<td>Positioning starts with speed control, switching to position control when the speed-position switching signal is input from external, which performs positioning for the specified movement amount.</td>
</tr>
</tbody>
</table>

**Stop command**

![Diagram of Speed control](chart1.png)

**Switching command**

![Diagram of Speed-position switching control](chart2.png)

There are two methods available for specifying the target position, an absolute system and an increment system.

<table>
<thead>
<tr>
<th>Absolute system (ABS)</th>
<th>This method specifies the original position as a standard position (absolute address).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increment system (INC)</td>
<td>This method specifies the movement amount and movement distance using the current stopping position as the start point.</td>
</tr>
</tbody>
</table>
4.5.2 Positioning data

The positioning data settings need to be completed in order to enable main positioning control. There are six hundred positioning data points per axis to be set using the Simple Motion Module Setting Tool.

If the Data Settings Assistant is used, the appropriate control data for the positioning control system can be set simply and quickly.

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Control system</th>
<th>Axis to be interpolated</th>
<th>Acceleration time No.</th>
<th>Deceleration time No.</th>
<th>Positioning address</th>
<th>Arc address</th>
<th>Command speed</th>
<th>Dwell time</th>
<th>M code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0:END</td>
<td>0Ah;ABS Linear 2</td>
<td>Axis #1</td>
<td>0:1000</td>
<td>0:1000</td>
<td>10000.0 μm</td>
<td>0.0 μm</td>
<td>10000.00 mm/min</td>
<td>0 ms</td>
<td>0</td>
</tr>
</tbody>
</table>

[Positioning data]

<table>
<thead>
<tr>
<th>Setting item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Da.1 Operation Pattern</td>
<td>Used to set the way in which continuous positioning data is to be controlled. (For details, refer to 4.5.5.)</td>
</tr>
<tr>
<td>Da.2 Control method</td>
<td>Used to set the defined control method for main positioning control.</td>
</tr>
<tr>
<td>Da.3 Acceleration time No.</td>
<td>Used to select and set the acceleration time to use when control is started.</td>
</tr>
<tr>
<td>Da.4 Deceleration time No.</td>
<td>Used to select and set the deceleration time to use when control is started.</td>
</tr>
</tbody>
</table>
### Positioning data

<table>
<thead>
<tr>
<th>Da.4</th>
<th>Deceleration time No.</th>
<th>Used to select and set the deceleration time to use when control is stopped.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Da.6</td>
<td>Positioning address</td>
<td>Used to set the address for the target position for positioning control.</td>
</tr>
<tr>
<td>Da.7</td>
<td>Arc address</td>
<td>Used to set the address for the sub or center point during circular interpolation control.</td>
</tr>
<tr>
<td>Da.8</td>
<td>Command speed</td>
<td>Used to set the speed for execution of the control operation.</td>
</tr>
<tr>
<td>Da.9</td>
<td>Dwell time</td>
<td>Used to set the length of time after which the positioning complete signal is to be turned ON after positioning is completed.</td>
</tr>
<tr>
<td>Da.10</td>
<td>M code</td>
<td>Set when the M code output function is used.</td>
</tr>
</tbody>
</table>
4.5.3 Start of Positioning

After the positioning data settings have been made, the start of positioning control is triggered when the positioning data No. to be started is set to the positioning start No. and the positioning start signal is turned No.

Required signals and data needed for the start of positioning are given below using a QD77MS4 model as an example.

<table>
<thead>
<tr>
<th>I/O signals</th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positioning start signal</td>
<td>Y10</td>
<td>Y11</td>
<td>Y12</td>
<td>Y13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Buffer memory</th>
<th>Setting value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Cd. 3] Positioning start Number</td>
<td>1500</td>
</tr>
</tbody>
</table>

Example for the Start of Positioning
For positioning of Axis 1 to 100000 μm at 3000 mm/min.

- **Sequence program**

```
M6

<table>
<thead>
<tr>
<th>U01</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOVP K1 G1500</td>
</tr>
<tr>
<td>Axis 1 Positioning start No.</td>
</tr>
<tr>
<td>SET Y10</td>
</tr>
<tr>
<td>Axis 1 Positioning start signal</td>
</tr>
<tr>
<td>RST M6</td>
</tr>
<tr>
<td>Axis 1 Positioning start command storage</td>
</tr>
</tbody>
</table>
```

- **Positioning data**

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Control system</th>
<th>Axis to be interpolated</th>
<th>Acceleration time No.</th>
<th>Deceleration time No.</th>
<th>Positioning address</th>
<th>Arc address</th>
<th>Command speed</th>
<th>Dwell time</th>
<th>M code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0:END</td>
<td>01h:ABS Linear 1</td>
<td>-</td>
<td>0.1000</td>
<td>0.1000</td>
<td>100000.0 μm</td>
<td>0.0 μm</td>
<td>3000.00 mm/min</td>
<td>0 ns</td>
<td>0</td>
</tr>
</tbody>
</table>

Set using the Simple Motion Module Setting Tool.
## 4.5.4 Positioning operation

Operation for positioning of Axis 1 to 100000 µm at 3000 mm/min proceeds as described below.

1. When the start signal is turned ON, the machine accelerates in the direction of the 100000 µm address.

2. Once the command speed of 3000 mm/min is reached, the machine continues moving with constant speed movement.

3. Positioning is completed when the machine stops at the 100000 µm address. The positioning complete signal switches from OFF → ON.
4.5.5 Continuous Positioning Control

The Simple Motion Module performs continuous positioning control by starting from the positioning data No. specified by the [Cd. 3] positioning start No. The "Operation pattern" in the positioning data is to set whether to execute the next set of positioning data.

<table>
<thead>
<tr>
<th>Operation Pattern</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>End</td>
<td>Positioning of the next positioning data No. is not executed.</td>
</tr>
<tr>
<td>Continuous</td>
<td>After positioning is completed, the machine is stopped temporarily and then positioning of the next positioning data No. is executed. (Continuous positioning control)</td>
</tr>
<tr>
<td>Location</td>
<td>After positioning is completed, positioning of the next positioning data No. is executed without the machine being decelerated or stopped. (Continuous path control)</td>
</tr>
</tbody>
</table>

1. Continuous positioning control

2. Continuous path control

- When the speed is constant

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Command address</th>
<th>Command speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Continuous</td>
<td>A</td>
<td>a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Command address</th>
<th>Command speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Path</td>
<td>A</td>
<td>a</td>
</tr>
</tbody>
</table>
### 4.5.5 Continuous Positioning Control

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Command address</th>
<th>Command speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Continuous</td>
<td>A</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>End</td>
<td>B</td>
<td>a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Command address</th>
<th>Command speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Path</td>
<td>A</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>End</td>
<td>B</td>
<td>a</td>
</tr>
</tbody>
</table>

**Diagram 1:**
- **V** axis represents velocity.
- **t** axis represents time.
- **Stopped temporarily.**
- Data No. 1: A
- Data No. 2: B

**Diagram 2:**
- **V** axis represents velocity.
- **t** axis represents time.
- **Not stopped.**
- Data No. 1: A
- Data No. 2: B
### 4.5.5 Continuous Positioning Control

- When the speed varies

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Command address</th>
<th>Command speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Path</td>
<td>A</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>End</td>
<td>D</td>
<td>b</td>
</tr>
</tbody>
</table>

After positioning to A, the speed is changed without the machine being stopped.

![Diagram](image-url)
4.5.6 Interpolation control

The Simple Motion Module performs interpolation control using two to four motors to control the machine such that it travels along the specified path. There are different types of interpolation controls available including linear and circular interpolation control, the type to use being set in the control system for the positioning data. One of the axes set in the control system is referred to as the "reference axis" and the other as the "interpolation axis". The Simple Motion Module performs control of the reference axis following the positioning data set for the reference axis, with the interpolation axis being controlled along a linear or circular path in response.

- 2-axis linear interpolation control

![Linear interpolation control diagram](image)

Linear interpolation control is performed from \((X_1, Y_1)\) to \((X_2, Y_2)\).

- 2-axis circular interpolation control

![Circular interpolation control diagram](image)

Circular interpolation control is performed such that the machine passes through the sub point.
### Start of Interpolation Control

In interpolation control, the control system, positioning address, command speed, and other settings are made for the positioning data of the reference axis whereas only the positioning address is set for the same positioning data No. of the interpolation axis.

In interpolation control, after the positioning data settings are made, the positioning data No. to be started is set to the positioning start No. of the reference axis and the positioning start signal for the reference axis is turned ON, which triggers the start of interpolation control.

Required signals and data needed for the start of the interpolation control are given below using a QD77MS4 model as an example.

#### I/O signals (Reference axis)

<table>
<thead>
<tr>
<th>I/O signals</th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positioning start signal</td>
<td>Y10</td>
<td>Y11</td>
<td>Y12</td>
<td>Y13</td>
</tr>
</tbody>
</table>

#### Buffer memory (Reference axis)

<table>
<thead>
<tr>
<th>Buffer memory (Reference axis)</th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
<th>Setting value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Cd. 3] Positioning start Number</td>
<td>1500</td>
<td>1500</td>
<td>1700</td>
<td>1800</td>
<td>1 to 600</td>
</tr>
</tbody>
</table>

**Example Showing the Start of Interpolation Control**

When Axis 1 and 2 (100000 µ, 50000 µ respectively) are controlled by linear interpolation control at 3000 mm/min.

- **Sequence program**

  ```
  M6
  U0\L
  MOV P K1 G1500
  SET Y10
  RST M6
  ```

- **Positioning data**

  Axis 1
### 4.5.7 Start of Interpolation Control

#### Positioning data

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Control system</th>
<th>Axis to be interpolated</th>
<th>Acceleration time No.</th>
<th>Deceleration time No.</th>
<th>Positioning address</th>
<th>Arc address</th>
<th>Command speed</th>
<th>Dwell time</th>
<th>M code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>U:BWD</td>
<td>UAN:ABS Linear 2</td>
<td>Axis #2</td>
<td>U:1000</td>
<td>U:1000</td>
<td>1000000.0 μm</td>
<td>0.0 μm</td>
<td>3000.00 mm/min</td>
<td>0 ms</td>
<td>U</td>
</tr>
</tbody>
</table>

**Set using the Simple Motion Module Setting Tool.**
4.5.8 **Interpolation Control Operation**

Operation for linear interpolation control for positioning of Axis 1 to 100000 µm and Axis 2 to 50000 µm at 3000 mm/min proceeds as described below.

1. When the start signal is turned ON, the machine accelerates in the directions of the positioning addresses for each axis.

2. Once the command speed of 3000 mm/min is reached, the machine continues moving with constant speed movement.

3. Positioning is completed when the machine stops along Axis 1 at the 100000 µm address and along Axis 2 at the 50000 µm address. The positioning complete signal switches from OFF → ON.
4.6 Summary

In this chapter, you have learned:
- PLC and Simple Motion Module
- JOG operation
- Original point return (OPR)
- Positioning Control
- Positioning data
- Continuous Positioning Control
- Interpolation control

Important points
The following points are very important, so please review them again to ensure that you have familiarized yourself with their content.

<table>
<thead>
<tr>
<th>PLC and Simple Motion Module</th>
<th>For positioning control using a Simple Motion Module, total control is handled by the PLC CPU and position calculations are performed by the Simple Motion Module.</th>
</tr>
</thead>
<tbody>
<tr>
<td>JOG operation</td>
<td>JOG operation is a function used to manually operate a servo motor in the forward or reverse run direction at a constant speed.</td>
</tr>
<tr>
<td>Original point return (OPR)</td>
<td>Original point return (OPR) is a function that is used to move a machine to its original position and match the OP addresses of the machine and the Simple Motion Module at that position</td>
</tr>
<tr>
<td>Positioning Control</td>
<td>The Simple Motion Module performs positioning control with the setting of the target position, command speed, and other settings to the positioning data, which triggers start up of the module.</td>
</tr>
<tr>
<td>Positioning data</td>
<td>The positioning data is used to set the operation pattern, control system, and other settings for positioning control.</td>
</tr>
</tbody>
</table>
### Summary

<table>
<thead>
<tr>
<th>Continuous Positioning Control</th>
<th>The Simple Motion Module starts positioning in order from the positioning data No. specified by the [Cd. 3] positioning start No. The &quot;Operation pattern&quot; in the positioning data sets whether to execute the next set of positioning data.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpolation control</td>
<td>There are different types of interpolation control available including linear and circular interpolation control, the type to use being set in the control system for the positioning data. One of the axes set in the control method is referred to as the &quot;reference axis&quot; and the other as the &quot;interpolation axis. The Simple Motion Module performs control of the reference axis following the positioning data set for the reference axis, with the interpolation axis being controlled along a linear or circular path in response.</td>
</tr>
</tbody>
</table>
Chapter 5  Construction of the Sample System (Positioning)

In Chapter 5, you will learn how to construct sample systems designed for positioning tasks.

5.1 Flow Chart of Control Principles

The following shows a flowchart of the control details in the sample system.

Point your mouse cursor on the flowchart to display details.

- Startup of the material handling system
  - Original point return performed on all axes
    - Move Robot 1 to the wait position
    - Move Robot 2 to the wait position
      - Start signal = ON
        - Lower Robot 1 onto Conveyor 1
          - Grasp the workpiece
            - Raise Robot 1 directly above Conveyor 1
              - Move Robot 1 directly above the stacker
                - Lower Robot 1 onto the stacker
        - Move Robot 2 directly above the stacker
          - Lower Robot 2 onto the stacker
            - Grasp the workpiece
              - Raise Robot 2 directly above the stacker
                - Move Robot 2 directly above Conveyor 2
5.2 Assignment of Device Numbers

Create a correspondence table of I/O devices and device numbers to use in the sample system. Creating a correspondence table will reduce programming glitches and streamline your programs.

You can download an example of assigned device number correspondence table for the sample system through the below link.

<PDF of Assigned Device Numbers>
5.3 Operation of a Sample System

The sample system is designed to operate as shown below under normal operating conditions.
5.4 Monitoring of the sample system

You can use the monitoring function of the Simple Motion Module Setting Tool to monitor and display current locations, error codes, and other information for all axes in operation at once.

Can be used to select the monitoring item.
5.4 Monitoring of the sample system

- **Monitoring item**: Display the monitoring item set in Monitoring Item Selection.
- **Monitoring display column**: Display the monitoring value of the axis set in Monitoring Axis Selection.
- **Module information list**: Display the module information.
5.5 Summary

In this chapter, you have learned:

- Assignment of Device Numbers
- Monitoring of the sample system

Important points

The following points are very important, so please review them again to ensure that you have familiarized yourself with their content.

<table>
<thead>
<tr>
<th>Assignment of Device Numbers</th>
<th>Create a correspondence table of I/O devices and device numbers to use in the sample system. Creating a correspondence table will reduce programming glitches and streamline your programs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring of the sample system</td>
<td>You can use the monitoring function of the Simple Motion Module Setting Tool to monitor and display current locations, error codes, and other information for all axes in operation at once.</td>
</tr>
</tbody>
</table>
Chapter 6  Synchronous Control

In Chapter 6, you will learn about synchronous control using a Simple Motion Module with the QD77MS4 used as an example.

6.1 Overview of Synchronous Control

Synchronous control is a type of control in which multiple other axes (slave shafts) are synchronized to the standard axis (main shaft).

Below is given a description of general synchronous control involving a conveyance device as an example.

With synchronous control

- Objects can be continuously transported without the conveyor having to stop.

Without synchronous control

- The conveyor needs to be stopped every time that it transports objects.

There are several advantages to use synchronous control, some of which are given below.

- Improved productivity...As there is no standby time between operations as with sequential operation, tact time can be shortened, improving productivity.
- Safe control...As the slave shafts are all synchronized to the main shaft and stopped when the main shaft is stopped, the risk of damage to the equipment can be reduced.
6.2 Synchronous Control with the Simple Motion Module

The Simple Motion Module is able to provide mechanical synchronous control using gears, shafts, speed change gears, cams, and other parts, quite simply with the mere setting of synchronous parameters and other such settings.

Synchronize the operation of Axis 1 through Axis 3 using the synchronous parameters.

**Advantages**
- Machine is more compact and costs are lower.
- There are no worries over friction and service life for the main shaft, gear and clutch.
- Changing initial setup is simple.
- There is no error caused by mechanical precision, and system performance improves.

Traditional mechanical synchronous control
6.3 Flow of Synchronous Control

The flow of synchronous control for the Simple Motion Module is shown below. The main shaft in the Simple Motion Module is referred to as the input axis and the axis to be synchronized as the output axis.

There are synchronous parameters to be set for each output axis that determine how the output axis is to be synchronized and to which input axis.

Start of positioning
6.4 Cam control

The output axis for synchronous control uses cam operation. Cam control performed using a traditional mechanical cam is reproduced as electronic cam control using cam data.

Control using a mechanical cam

As electronic cam control for the Simple Motion Module is processed using software, the ideal cam pattern is produced without any worries caused from traditional cam control such as errors due to problems with mechanical accuracy. Replacement of the cam due to changes in the model used can be completed quite simply with mere changes to the cam pattern.
6.5 Cam data

The output axis is controlled using values (current feed values) converted from the set cam data using current values for one cycle of the cam axis as the input values. There are three types of operations in the cam data, for the two-way cam, the feed cam, and the linear cam.

- **Two-way cam**

  The two-way cam operates back and forth across the constant cam stroke range.

- **Feed cam**

  The feed cam operates to change the cam reference position for each cycle.
6.5 Cam data

- Cam data

- Operation Example

- Linear cam

  The linear cam operates along a straight line that produces a stroke ratio of 100% for one cycle.
The linear cam is registered to the Simple Motion Module Setting Tool as cam No. 0.
6.6 **Creation of Cam Data**

Cam data is created using the Simple Motion Module Setting Tool.

Let’s try to create the cam data on the next screen.
This completes the settings for the cam data.
Click the button to proceed to the next screen.
6.7 Synchronous Parameter Settings

For cam control in which Axis 2 is synchronized to Axis 1, synchronous parameters need to be set for Axis 2. The synchronous parameters are set using the Simple Motion Module Setting Tool.

Let’s try to set the synchronous parameters on the next screen. The cam data created on the previous screen is used for cam control.
6.7 Synchronous Parameter Settings

Set the time to advance or delay the cam axis current value per cycle phase:
-2147483648 to 2147483647 µs

This completes the settings for the synchronous parameters for Axis 2.
Click to proceed to the next screen.
6.8 Start of Synchronous Control

Synchronous control starts after the synchronous parameters and cam data have been set and the synchronous control start command has been turned ON. Required signals and data needed for the start of synchronous control are given below using a QD77MS4 model as an example.

<table>
<thead>
<tr>
<th>Buffer memory</th>
<th>Axis 1</th>
<th>Axis 2</th>
<th>Axis 3</th>
<th>Axis 4</th>
<th>Setting value</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Cd. 380] Synchronous control start</td>
<td></td>
<td></td>
<td></td>
<td>36320</td>
<td>Set the target axis as a four-bit code. bit 0 (Axis 1) to bit3 (Axis 4)</td>
</tr>
<tr>
<td>[Md. 26] Axis operation conditions</td>
<td>809</td>
<td>909</td>
<td>1009</td>
<td>1109</td>
<td>OFF: Synchronous control ends</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ON: Synchronous control starts</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>The axis operation conditions are stored in memory.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0: Standby</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5: Analyzing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15: Synchronous control</td>
</tr>
</tbody>
</table>

Example Showing the Start of Synchronous Control
When Axis 2 is synchronized to Axis 1

- Sequence program

```
X56   <Synchronous control start>  U0
    [MOV H02 G36320]

Synchronous positioning No. setting
X56   <Synchronous control end>    U0
    [MOV H0 G36320]

Synchronous positioning No. setting
SM403 U0
    = K15 G909 (M90)

OFF for one scan only after RUN executed  Synchronous control
```

- Synchronous parameters and cam data

Use the setting example on the previous screen.
6.9 Synchronous Control Operation

Operation for cam control in which Axis 2 is synchronized to Axis 1 proceeds as described below.

Positioning control is performed on Axis 1 using the positioning data.

1. Once the synchronous control start signal is turned ON, the [Md. 26] Axis Operation Status changes to "5: Analyzing."

2. After the analysis is completed, the [Md. 26] Axis Operation Status changes to "15: Synchronous control," and the BUSY signal turns ON.

3. After the [Md. 26] Axis Operation Status is confirmed as being "15: Synchronous control," the positioning start signal (Y10) for Axis 1 turns ON. When the positioning of Axis 1 starts, Axis 2 is synchronized to Axis 1, and the cam starts operating.

4. After the synchronous control start signal is turned from ON → OFF, the BUSY signal turns OFF, and the status changes to "0: Standby"
6.10 Virtual Servo Amplifier Function

The Simple Motion Module is equipped with a function that serves as an axis (a virtual servo amplifier axis) that generates only virtual commands without actual connection to a servo amplifier. Use of the virtual servo amplifier axis as the input axis enables synchronous control using virtual input commands.

The virtual servo amplifier axis settings are completed on the Servo Amplifier Settings screen under System Configuration.

The flow of synchronous control using a virtual servo amplifier axis as the input axis is shown below.
6.10 Virtual Servo Amplifier Function

Positioning Control
Positioning data

Synchronous parameters

Composite gear

Speed Change Gear

Interpol

Gear

Clutch

Speed Change Gear

Cam

Output

Cam data

Servo amplifier

Servo motor

Simple Motion Module
In this chapter, you have learned:

- Synchronous Control
- Synchronous parameters
- Cam control
- Cam data
- Virtual Servo Amplifier Function

Important points
The following points are very important, so please review them again to ensure that you have familiarized yourself with their content.

<table>
<thead>
<tr>
<th>Synchronous Control</th>
<th>Synchronous control is a type of control in which multiple other axes (slave shafts) are synchronized to the standard axis (main shaft).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous parameters</td>
<td>The main shaft in the Simple Motion Module is referred to as the input axis and the axis to be synchronized as the output axis. There are synchronous parameters to be set for each output axis using the Simple Motion Module Setting Tool that determine how the output axis is to be synchronized and to which input axis.</td>
</tr>
<tr>
<td>Cam control</td>
<td>The output axis for synchronous control uses cam operation. Cam control performed using a traditional mechanical cam is reproduced as electronic cam control using cam data.</td>
</tr>
<tr>
<td>Cam data</td>
<td>The output axis is controlled using values (current feed values) converted from the set cam data using current values for one cycle of the cam axis as the input values.</td>
</tr>
<tr>
<td>Virtual Servo Amplifier Function</td>
<td>The Simple Motion Module is equipped with a function that serves as an axis (a virtual servo amplifier axis) that generates only virtual commands without actual connection to a servo amplifier. Use of the virtual servo amplifier axis as the input axis enables synchronous control, using virtual input commands.</td>
</tr>
</tbody>
</table>
Chapter 7  Construction of a Sample System (Synchronous Control)

In Chapter 7, you will learn how to construct sample systems designed for synchronous control.

7.1  Flow Chart of Control Principles

The following shows a flowchart of the control details in the sample system.

Point your mouse cursor at the symbols in the flowchart to display details for each control details.

[Diagram showing flowchart with steps:
- Startup of the material handling system
- Original point return performed on all axes
- Move Robot 1 to the wait position
- Move Robot 2 to the wait position
- Start signal = ON
- Control of Robot 1 with cam data
- Control of Robot 2 with cam data
- Automatic operation]
7.2 Assignment of Device Numbers

Create a correspondence table of I/O devices and device numbers to use in the sample system. Creating a correspondence table will reduce programming glitches and streamline your programs.

You can download an example assigned device number correspondence table for the sample system through the below link.

<PDF of Assigned Device Numbers>
7.3 Operation of a Sample System

The sample system is designed to operate as shown below under normal operating conditions.

All four axes (X1, X2, Z1, Z2) are controlled in synchronization.
7.4 Cam Control in a Sample System

The cam data used in the sample system is as shown below.

Cam data for X1

Cam data for X2

Cam data for Z1

Cam data for Z2
7.5 Summary

In this chapter, you have learned:

- Assignment of Device Numbers

Important points

The following points are very important, so please review them again to ensure that you have familiarized yourself with their content.

<table>
<thead>
<tr>
<th>Assignment of Device Numbers</th>
<th>Create a correspondence table of I/O devices and device numbers to use in the sample system. Creating a correspondence table will reduce programming glitches and streamline your programs.</th>
</tr>
</thead>
</table>

Now that you have completed all of the lessons of the Servo SIMPLE MOTION Module Course, you are ready to take the final test.
If you are unclear on any of the topics covered, please take this opportunity to review those topics.
There are a total of 3 questions (7 items) in this Final Test.
You can take the final test as many times as you like.

How to score the test
After selecting the answer, make sure to click the Answer button. Your answer will be lost if you proceed without clicking the Answer button. (Regarded as unanswered question.)

Score results
The number of correct answers, the number of questions, the percentage of correct answers, and the pass/fail result will appear on the score page.

- Correct Answers: 2
- Total Questions: 9
- Percentage: 22%

To pass the test, you have to answer 60% of the questions correct.

- Click the Proceed button to exit the test.
- Click the Review button to review the test. (Correct answer check)
- Click the Retry button to retake the test again.
Select the two software programs necessary for performing positioning control using a Simple Motion Module (select two options).

- CX Works2
- MT Works2
- GT Works3
- MR Configurator2
- PX Developer
- MX Component

[Answer] [Back]
Select the number from “Terms to select” box below the table for the correct operation pattern that matches the operating example shown below.

Terms to select
1. Continuous
2. Path
3. End

Continuous Positioning Control

Continuous path control

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Command address</th>
<th>Command speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>▼</td>
<td>A</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>▼</td>
<td>B</td>
<td>a</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Operation pattern</th>
<th>Command address</th>
<th>Command speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>▼</td>
<td>A</td>
<td>a</td>
</tr>
<tr>
<td>2</td>
<td>▼</td>
<td>B</td>
<td>a</td>
</tr>
</tbody>
</table>
Please answer the below questions.

1. Select the correct cam data graph for a Two-way cam from the below diagrams.

   A
   ![Graph A]
   One cycle

   B
   ![Graph B]
   One cycle

   C
   ![Graph C]
   One cycle

2. Select the cam No. for a linear cam registered using the Simple Motion Module Setting Tool.

   ![Select --]
You have completed the Final Test. Your results are as follows.
To end the Final Test, proceed to the next page.

Correct answers: 0
Total questions: 3
Percentage: 0%

You failed the test.
You have completed the Servo SIMPLE MOTION Module Course.

Thank you for taking this course.

We hope you enjoyed the lessons and the information you acquired in this course will be useful in the future.

You can review the course as many times as you want.

Review  Close