MITSUBISHI ELECTRIC
Changes for the Better

Servo

MOTION CONTROLLER Application (Virtual Mode)

This course is a training system for those who establish the motion control system using the motion CPU module of Mitsubishi motion controller Q series for the first time.

L(NA)00129ENG

Introduction Purpose of the Course

This course is for those who are going to establish the motion control system using the motion CPU module of MITSUBISHI motion controller for the first time.
To establish the system, you needs to learn the synchronous control in the SV22 virtual mode by using the motion controller engineering environment MELSOFT MT Works 2.

This course mainly consists of the contents intended for a person in charge of software who understands the programming basics and designs synchronous control. The contents for a person in charge of hardware, such as the system design, installation, wiring and so on are prepared in the "SERVO MOTION CONTROLLER BASICS (HARDWARE)" course. The basic contents for a person in charge of software, such as programming are prepared in the "SERVO MOTION CONTROLLER BASICS (REAL MODE: SFC)" course.

For this course, you are required to have knowledge about MELSEC-Q series PLC, AC servo and positioning control.
For those who take this course for the first time, we recommend you to take

- "MELSEC-Q SERIES BASICS" course
- "MELSERVO BASICS (MR-J3)" course
- "YOUR FIRST FACTORY AUTOMATION (POSITIONING CONTROL)" course
- "SERVO MOTION CONTROLLER BASICS (HARDWARE)" course
- "SERVO MOTION CONTROLLER BASICS (REAL MODE: SFC)" course.

Introduction Course Structure

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

Chapter 12 - REAL MODE AND VIRTUAL MODE

You will learn differences between the real mode and virtual mode.

Chapter 13 - MECHANICAL SYSTEM PROGRAM

You will learn about the mechanical system program and mechanical module used for control under the virtual mode.

Chapter 14 - CREATING CAM DATA

You will learn how to create cam data used with the mechanical module "CAM".

Chapter 15 - EXERCISE

You will learn about the mechanical system and how to create cam data using the sample system.

Chapter 16 - APPLICATION

You will learn about the limit switch output function, address clutch, and digital oscilloscope.

Final Test

Passing grade: 60% or higher.

Introduction How to Use This e-Learning Tool

Go to the next page		Go to the next page.
Back to the previous page		Back to the previous page.
Move to the desired page		“Table of Contents” will be displayed, enabling you to navigate to the desired page.
Exit the learning		Exit the learning. Window such as "Contents" screen and the learning will be closed.

Introduction Cautions for Use

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:

- MT Developer2 Version 1.18U

Reference

The following is the reference related to the learning. (You can learn without them.)
Click the reference name to download.

Reference name	File type	Size
Sample program	Compressed file	53,651 bytes
Recording paper	Compressed file	43.5 kB

Chapter 12 REAL MODE AND VIRTUAL MODE

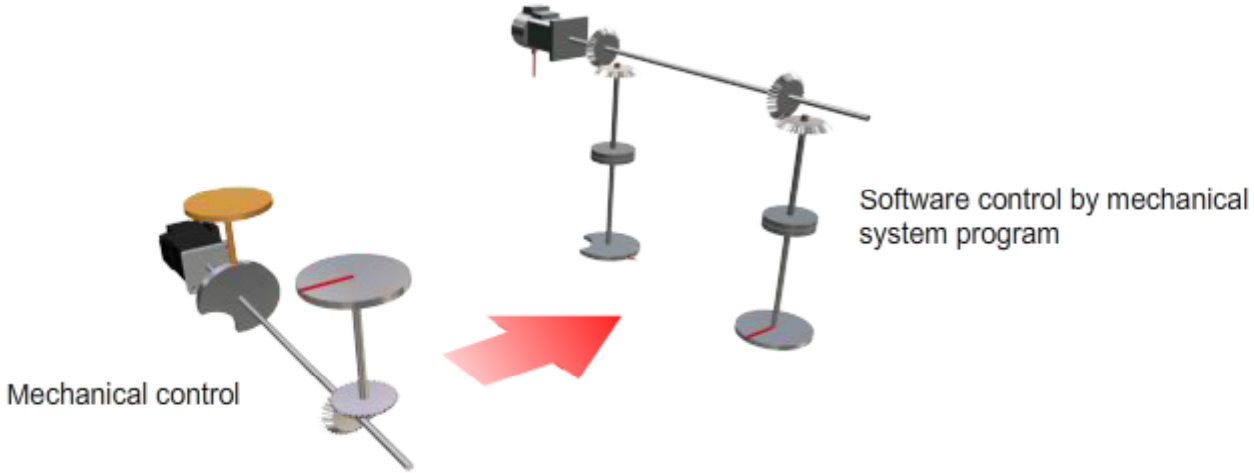
In this chapter, you will learn the differences between the real mode (SV13/SV22) and virtual mode (SV22).
The real mode is used to directly control a system using the servomotor(s) with a servo program.
For details of the real mode, refer to the "SERVO MOTION CONTROLLER BASICS (REAL MODE: SFC)" course.

12.1 Virtual Mode

Conventionally, a machine was controlled by mechanically linking shafts, gears, and clutches from each motor. The virtual mode replaces this mechanical operation by synchronizing the motors on the machine using the mechanical system program.
By giving commands to the virtual servomotor, the motors on the machine are controlled in accordance with the settings of the mechanical system program.

The virtual mode provides the following advantages over mechanically building the system:

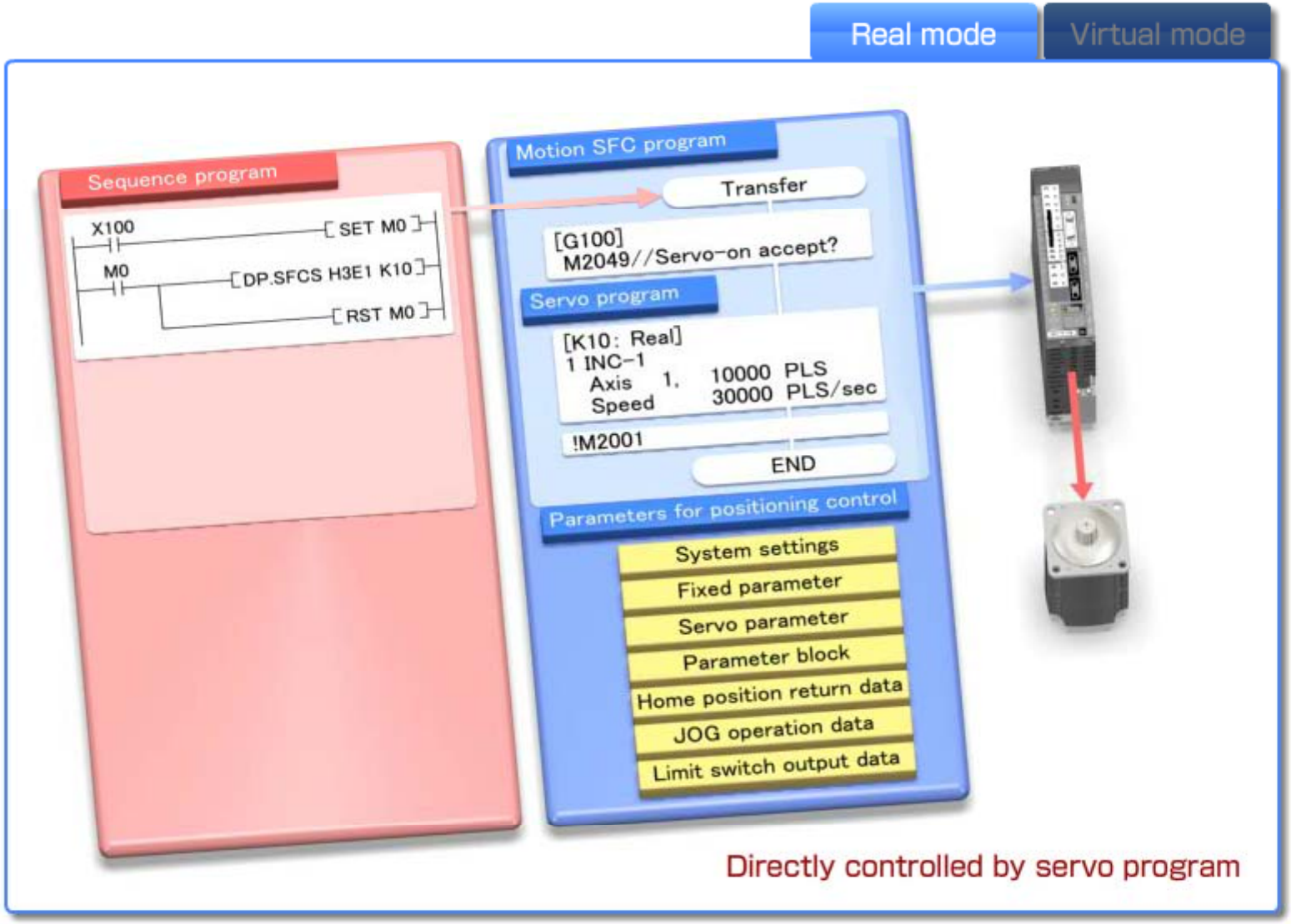
- Smaller and lower-cost machines can be manufactured.
- Wear and life of each part (main shaft, gear, and clutch) do not need to be considered.
- Tasks such as stage replacement become easier.
- System performance improves because errors due to mechanical precision do not exist.



12.2 Differences between Real Mode and Virtual Mode

The differences between the real mode and virtual mode on the motion controller are as follows:

Click [Real mode] and [Virtual mode] on the right to confirm differences between the real mode and virtual mode.

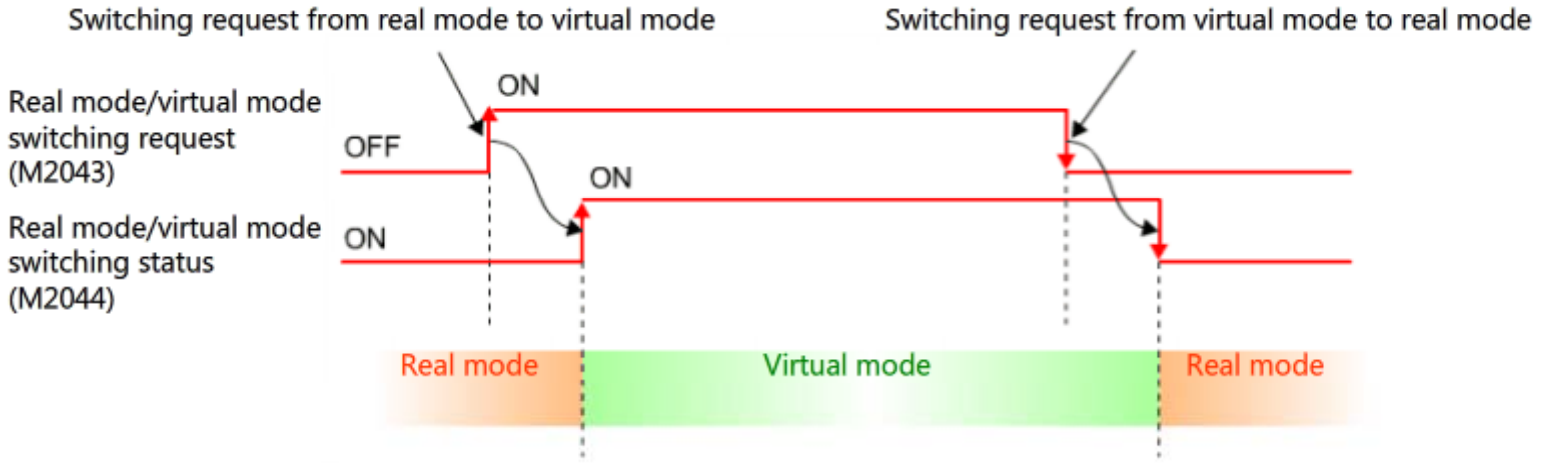


12.3 Procedure for Switching to Virtual Mode

In order to use the virtual mode functionality, the mode is to be switched to the virtual mode. To change the mode, turn on and off the real mode/virtual mode switching request (M2043).When switching from the real mode to the virtual mode, check the following to judge if switching is possible:

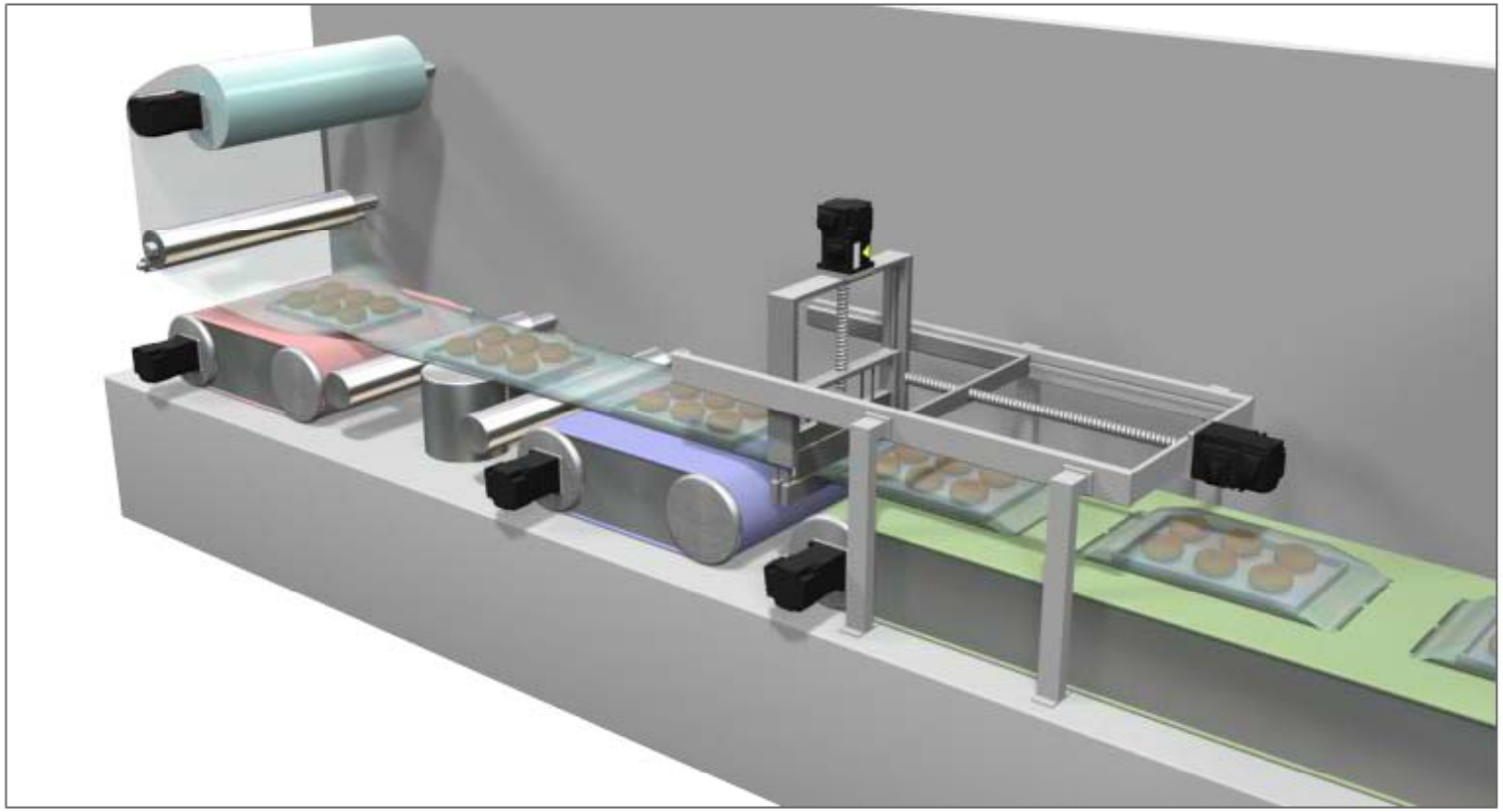
- Mechanical system program is registered.
- All axes servo-on command is turned on.
- All axes are stopped.
- No servo error exists with any of the axes.
- Home position return requests for all axes except for the roller axis are off.

Timing chart



12.4 Clarifying the Operation Mode

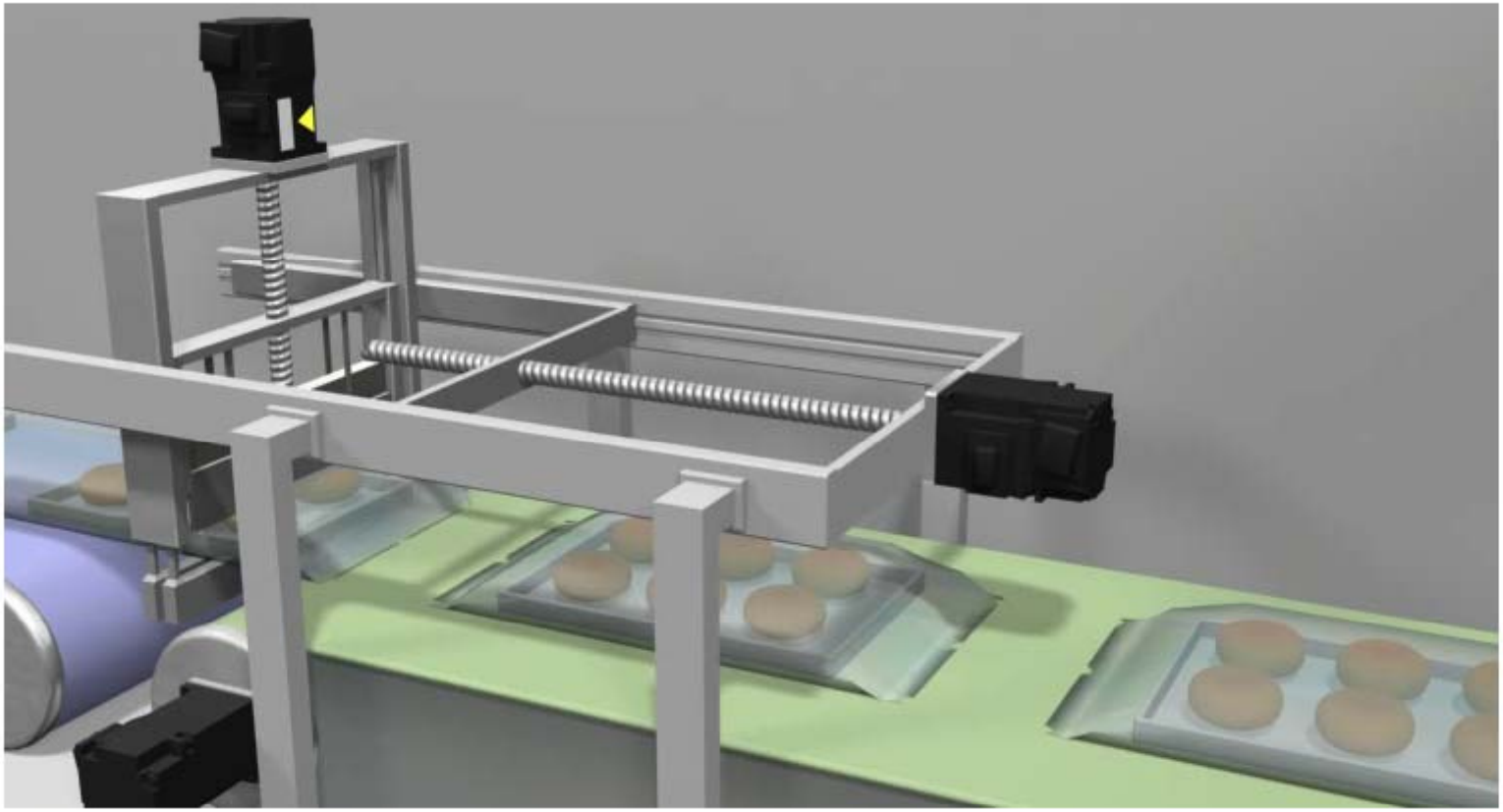
The sample system used in this course is the packaging machine of the sample system used in the "SERVO MOTION CONTROLLER BASICS (HARDWARE)" course and the "SERVO MOTION CONTROLLER BASICS (REAL MODE: SFC)" course.



(Duration: 00:05)

12.4.1 Packing machine control

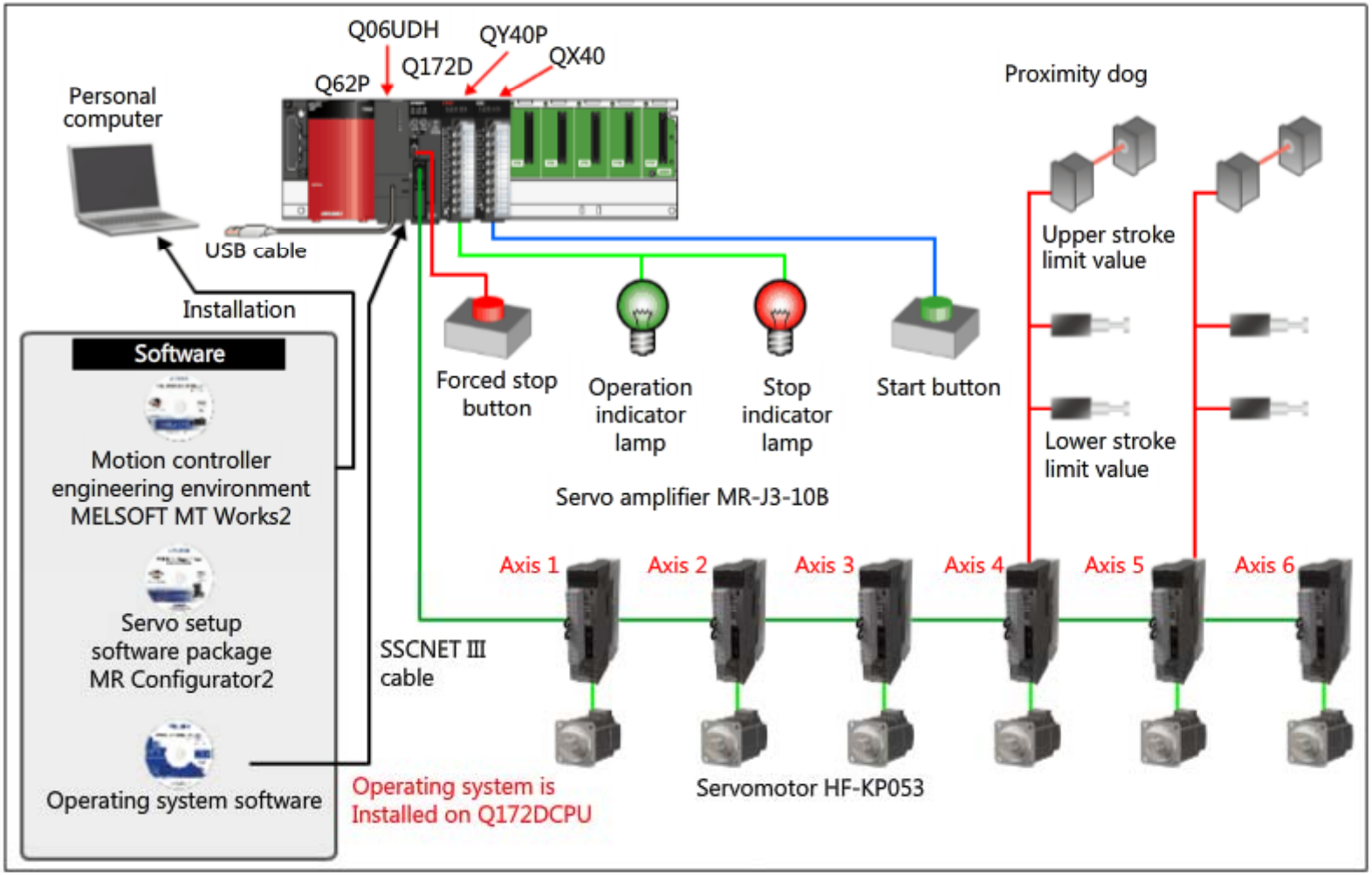
The operation mode (control flow) in the sample system for this course is as shown below.



(Duration: 00:19)

12.4.2 Equipment configuration of the sample system for this course

The following shows the equipment configuration of the sample system for this course.

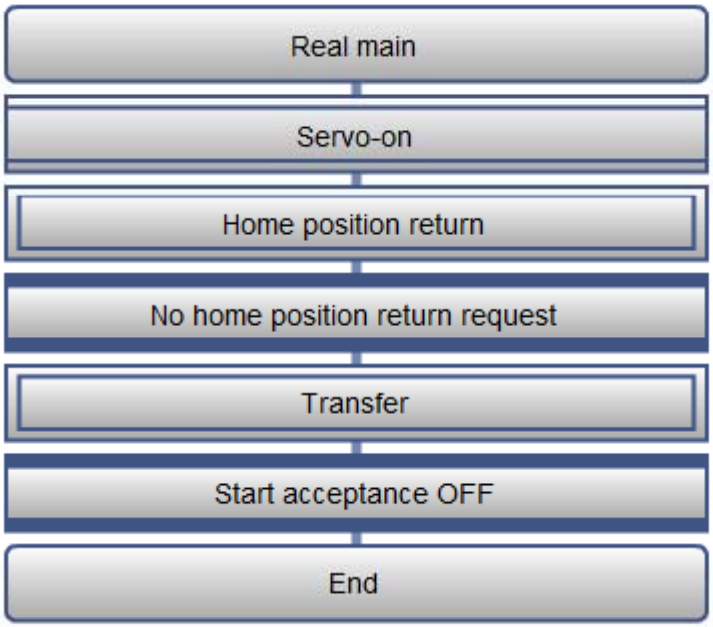


12.4.3 Motion program of packing machine

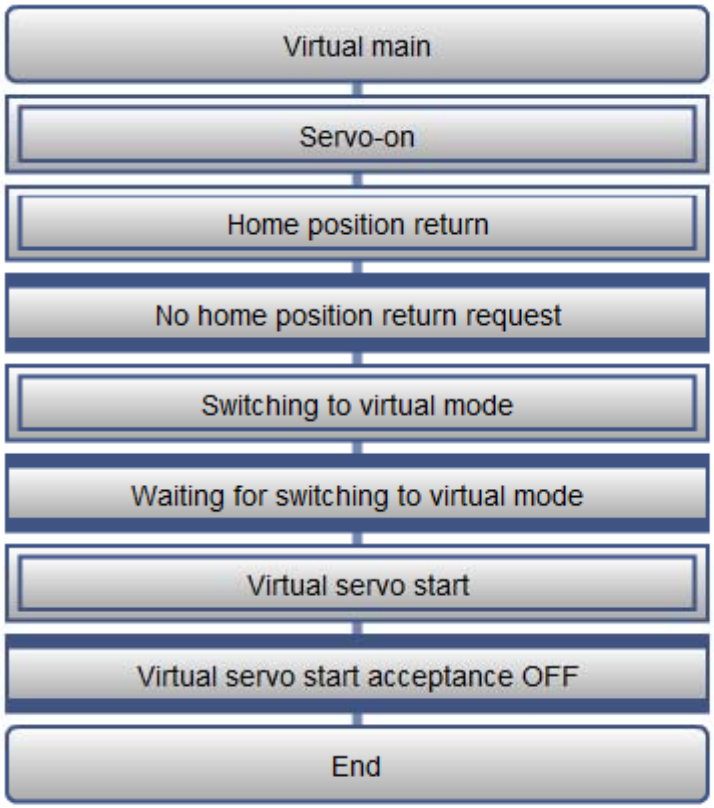
The operation flow of the motion SFC program used for the sample system is shown below.

Pointing the mouse cursor on the flow to display its detail.

Program example for real mode



Program example for virtual mode



12.5 Summary

In this chapter, you have learned:

- Virtual mode
- Differences between real mode and virtual mode

Important points

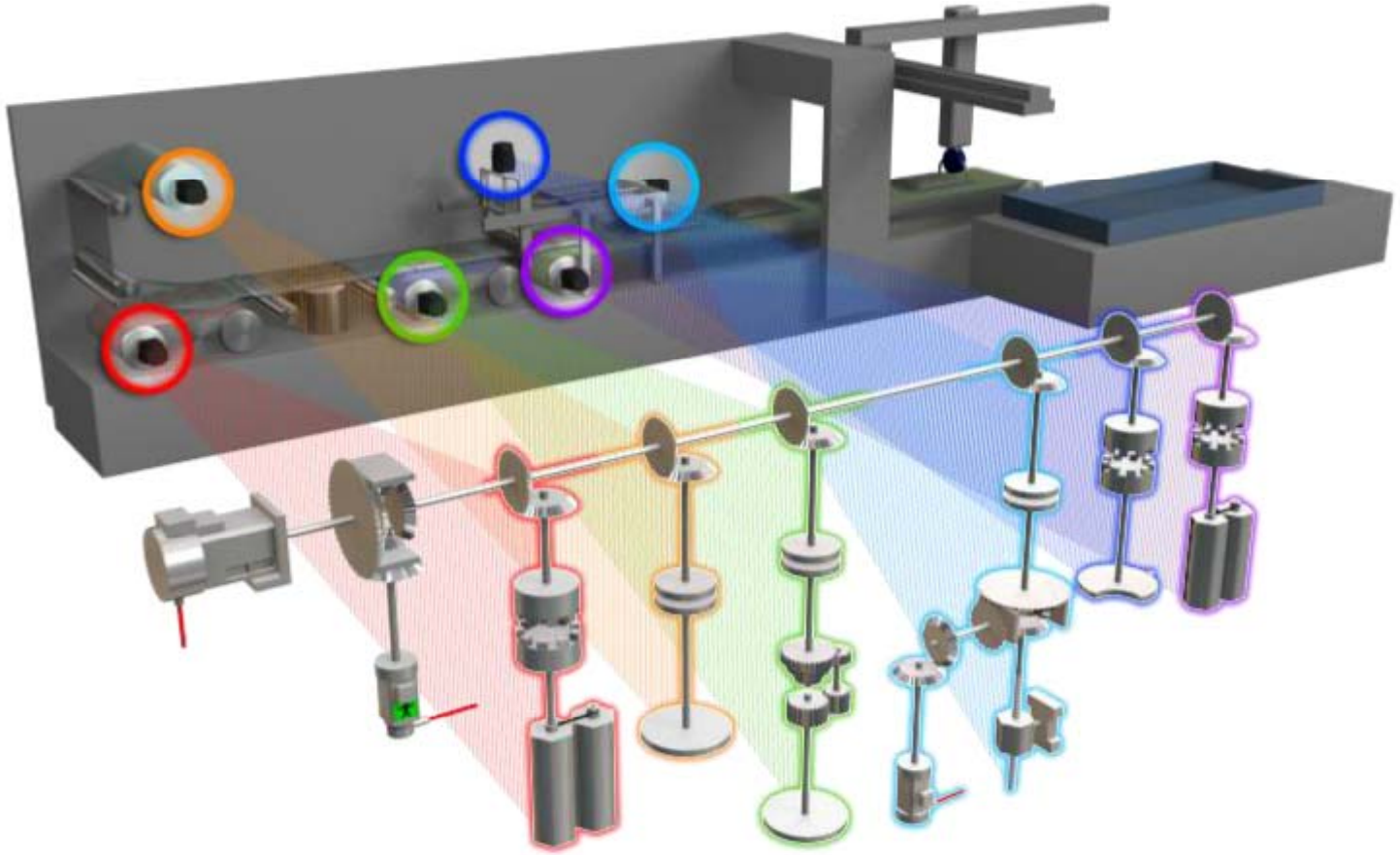
The contents you learned in this chapter are listed below.

Virtual mode	The virtual mode synchronizes the motors that were conventionally controlled mechanically, by the mechanical system program.
Procedure for switching to virtual mode	When switching from the real mode to the virtual mode, check if switching is possible.
Differences between real mode and virtual mode	The real mode directly controls individual axes. The virtual mode gives commands to the virtual servomotor and controls the axes by synchronizing them using the mechanical system program.

Chapter 13 MECHANICAL SYSTEM PROGRAM

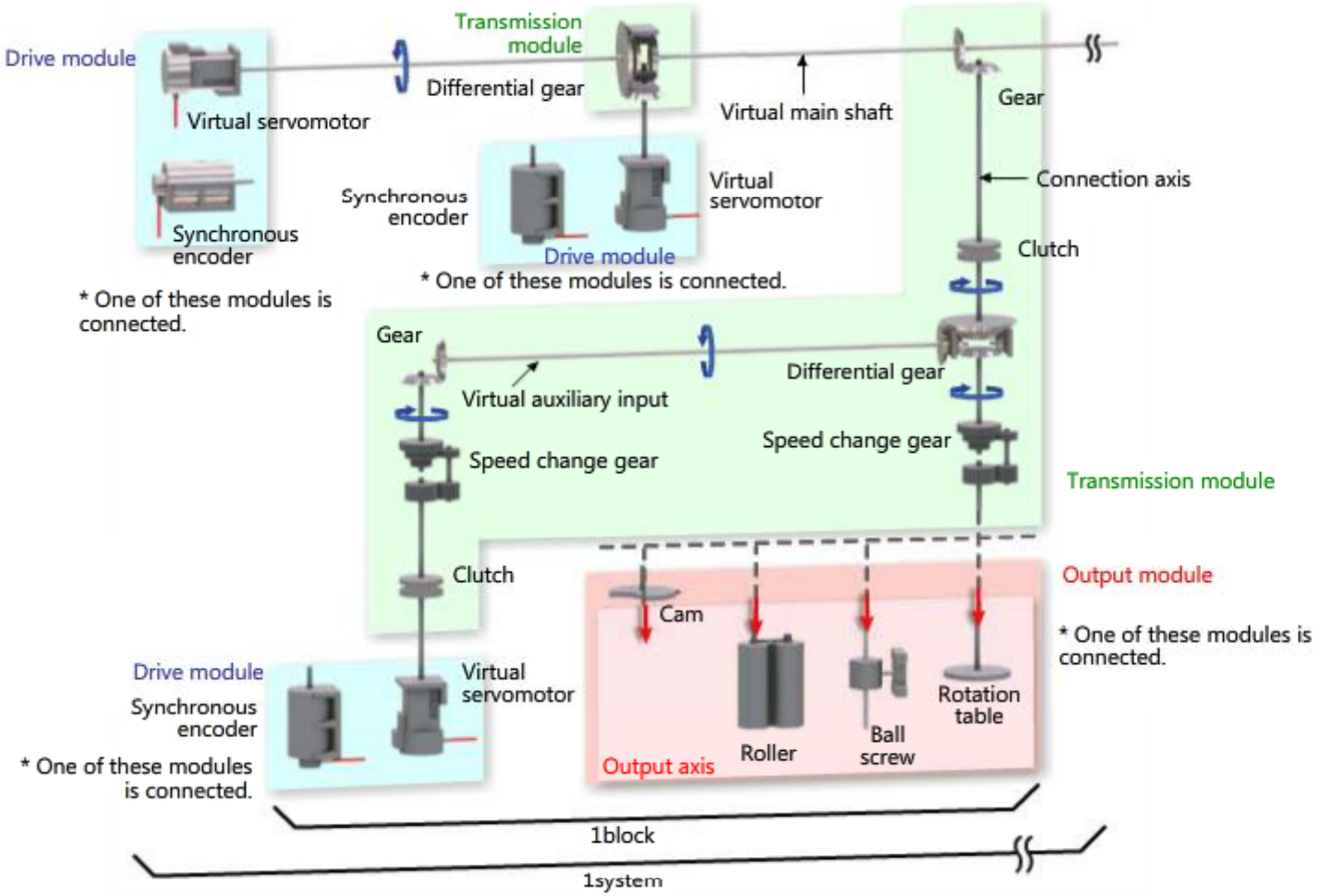
In this chapter, you will learn about the mechanical system program.

The mechanical system program uses mechanical modules including the virtual servomotor, synchronous encoder, gear, clutch, roller, and cam to perform synchronization control by software.



13.1 Mechanical Module Connection Diagram

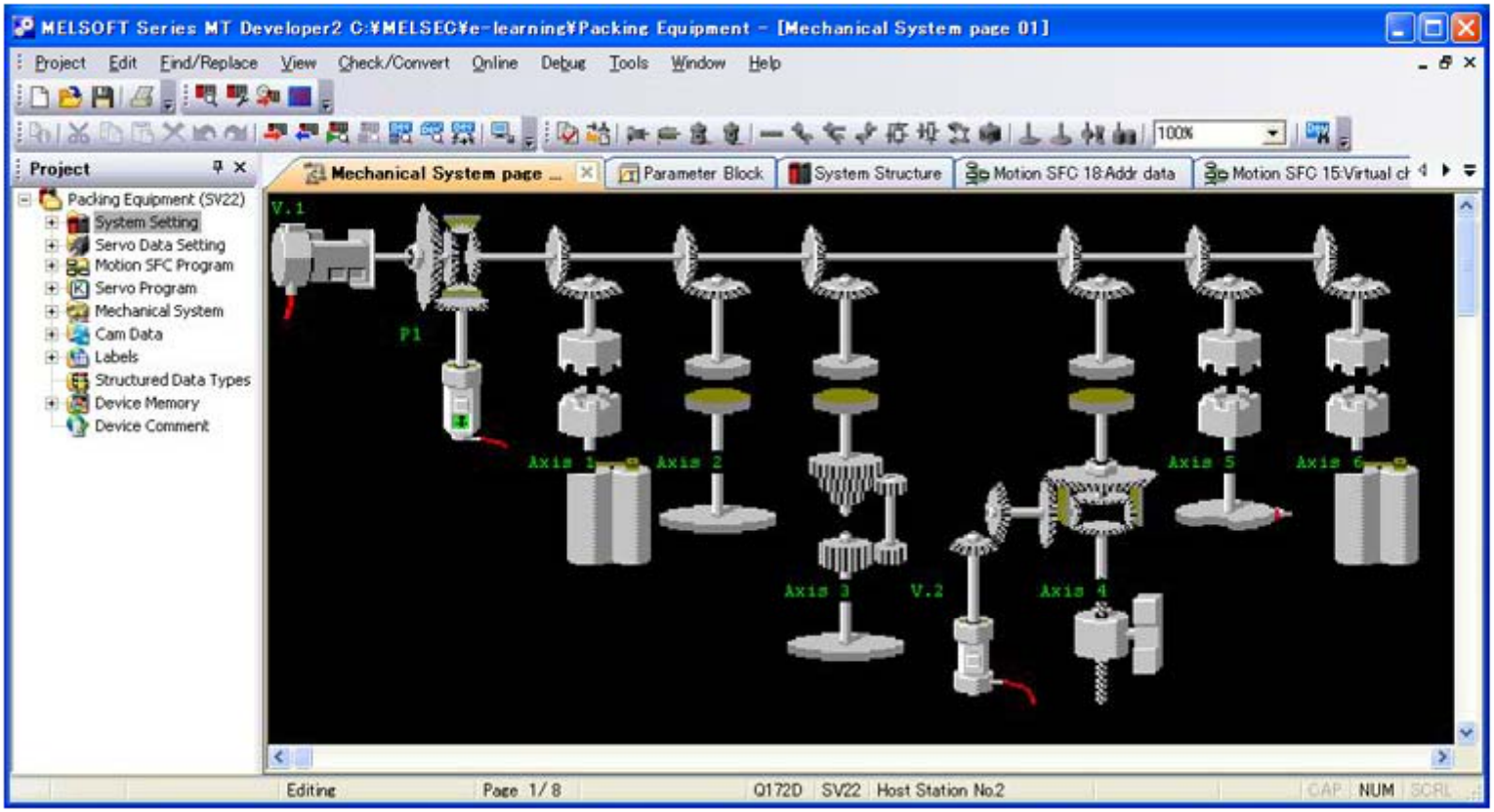
The mechanical module connection diagram is a virtual system diagram in which the mechanical modules are arranged.
The mechanical module connection diagram is shown below.



13.2 Sample Window of Machanical System

A sample window of mechanical system program used on the sample system in this course is shown below.

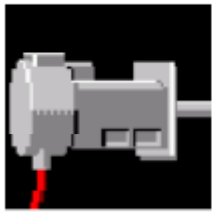
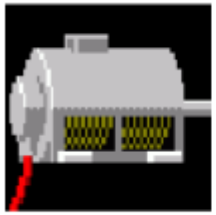
Pointing the mouse cursor on the module icon to display its explanation.



Axis	Axis detail
1	Roller for the belt conveyor below the packing film roll
2	Rotary table for the packaging film roller
3	Rotary table for the belt conveyor before the cutting device
4	Ball screw for adjusting the cutting position
5	Cam which controls the operation of the cutting device
6	Roller for the belt conveyor after the cutting device

13.3 Drive Module

The drive modules are the driving power source of the virtual axes (virtual main shaft and virtual auxiliary input axis).
The following two types of drive modules are available.

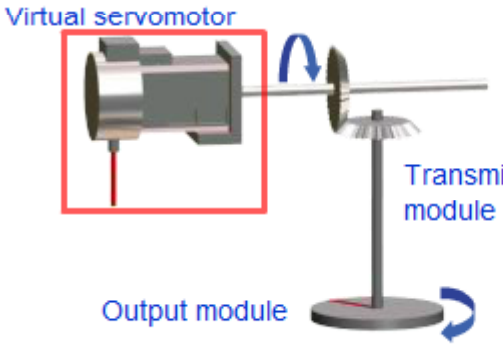
Mechanical module		Function	Refer to
Appearance	Name		
	Virtual servomotor	Used when driving the virtual axis of the mechanical system program by input pulse from the servo program and the JOG operation.	13.3.1
	Synchronous encoder	Used when driving the virtual axis by input pulses from an external synchronous encoder.	13.3.2

13.3.1 Virtual servomotor

The virtual servomotor is used when the virtual axis is driven by the servo program and the JOG operation.
When the virtual servomotor starts, it tramsmits pulses to the virtual axis according to the start condition (command speed and travel value).

Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample system.



Parameter item	Sample value
Virtual axis	1
Command in-position range	100[PLS]
Operation mode at error occurrence	Continue
Upper stroke limit value	0[PLS]
Lower stroke limit value	0[PLS]
JOG Operation-time Parameter	
Parameter block No.	2
JOG speed limit value	15000[PLS/s]

<Setting details>

Set the axis number specified by the servo program in the virtual mode.

<Setting range>

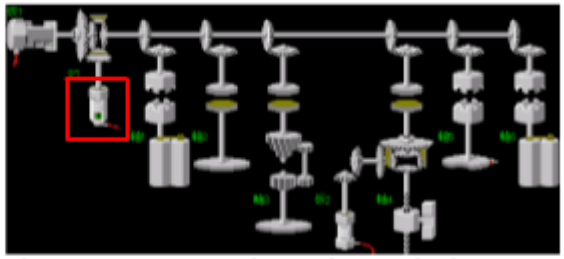
When using Q173DCPU: 1 to 32 When using Q172DCPU: 1 to 8

<Setting example>

Set this parameter item to "1" because the sample system uses the virtual axis 1.

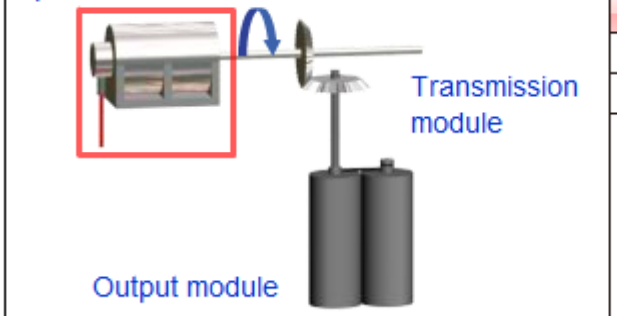
13.3.2 Synchronous encoder

A synchronous encoder is used when driving the virtual axis by the input pulses from an external source.
* Q172DEX or Q173DPX is required to use the synchronous encoder.



* The parameter values shown below are used for the sample system.

Click each parameter item in the table to see its explanation.



Parameter item	Sample value
Synchronous encoder number	1
Using the existing encoder	No
Error-time operation mode	Continue

<Setting details>

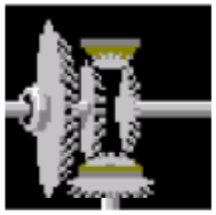
Set the synchronous encoder number defined on the system setting window.

<Setting range>

<Setting example>

13.4 Transmission Module

A transmission module transmits pulses from the drive module to the output module.
The following four types of transmission modules are available.

Mechanical module		Function	Refer to
Appearance	Name		
	Gear	Used to change the rotation ratio or direction for the travel value (pulse) input from the drive module.	13.4.1
	Clutch	Used to transmit the rotation of the drive module to the output module and separate it from the output module.	13.4.2
	Speed change gear	Used to change the speed of the output module during operation.	13.4.3
	Differential gear	Used to shift the output module phase or to adjust the operation start position.	13.4.4

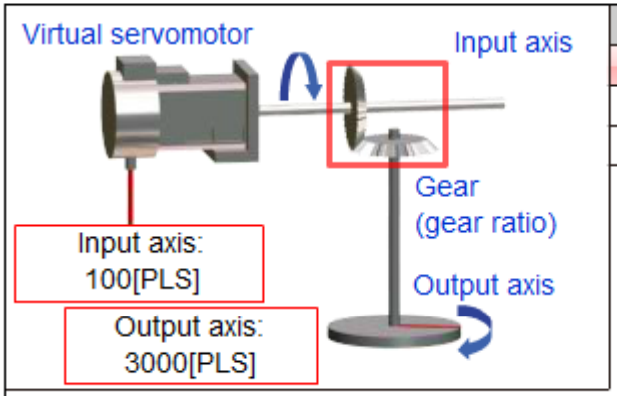
13.4.1 Gear

The gears are used to transmit the number of pulses, obtained by multiplying the number of pulses from the input axis by the gear ratio, to the output axis.
The gear ratio is calculated by dividing "Gear ratio input axis side tooth count" by "Gear ratio output axis side tooth count".

Number of output axis pulses = (Number of input axis pulses) × (Gear ratio) [PLS]

Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample system.



Parameter item	Sample value
Gear ratio input axis side tooth count	30
Gear ratio output axis side tooth count	1
Rotation direction	Forward

<Setting details>

Set the gear input axis side tooth count.

<Setting range>

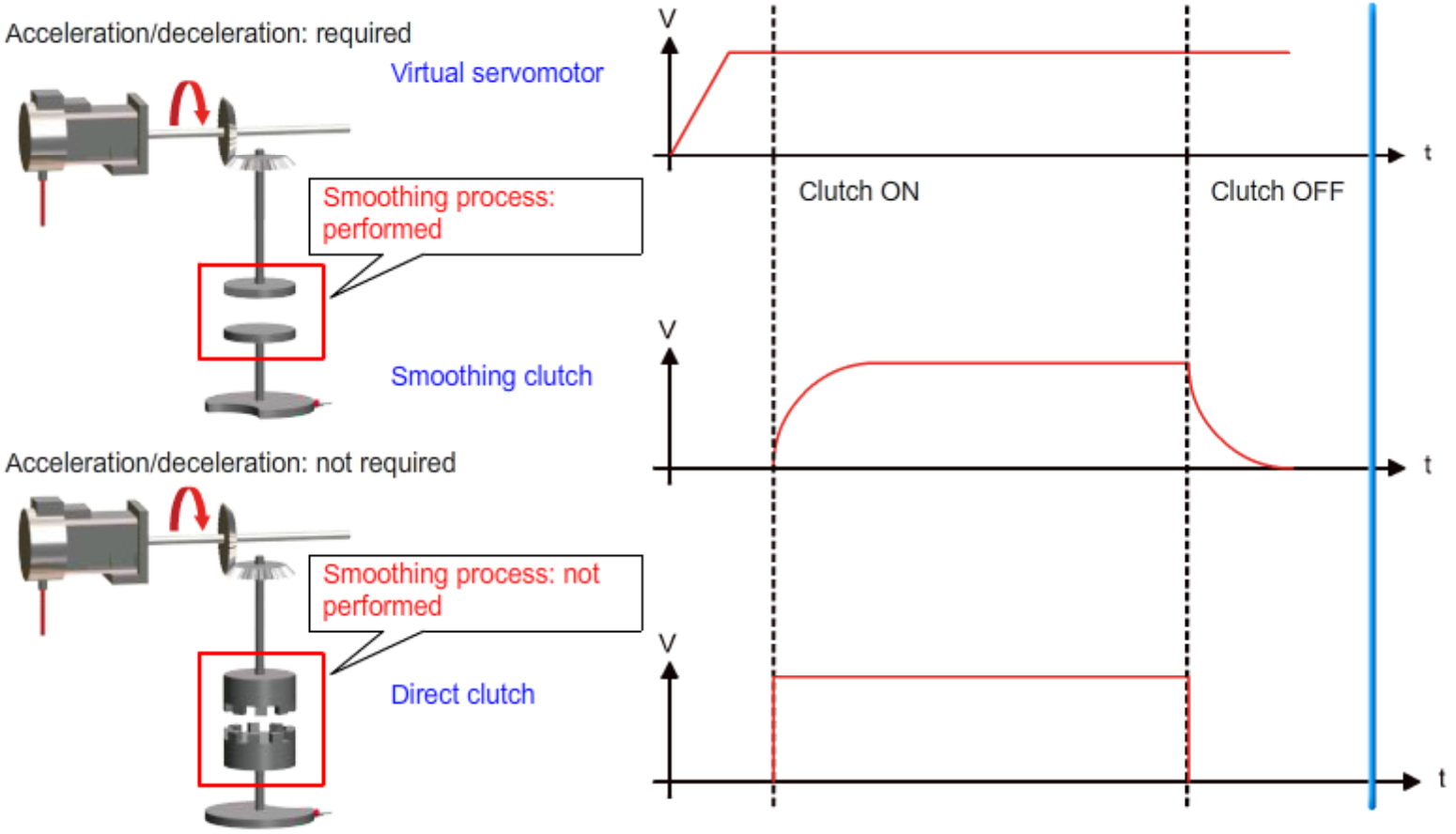
1 to 65535

<Setting example>

Set this parameter to "30" because the axis 4 of the sample system multiplies the number of input pulses from the virtual servomotor by 30.

13.4.2 Clutch

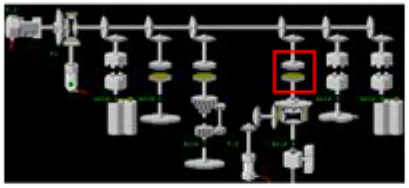
A clutch transmits the command pulses from the input axis to the output module and cut them, and is used to control start and stop operations of the servomotor.
The two types of clutches, smoothing and direct clutches, are available. Either of them is used depending on whether or not acceleration/deceleration is required.



13.4.2 Clutch

The clutch has the five different modes as below.

Operation mode	Description
ON/OFF mode	The clutch turns on when the clutch ON/OFF command device switches from OFF to ON. The clutch turns off when the clutch ON/OFF command device switches from ON to OFF.
Address mode	The clutch turns on when the clutch ON/OFF command device is ON and the clutch ON address is reached. The clutch turns off when the clutch ON/OFF command device is OFF and the clutch OFF address is reached.
Address mode 2	While the clutch ON/OFF command device is ON, the clutch turns on and off according to the clutch ON/OFF address. The clutch turns off when the clutch ON/OFF command device switches from ON to OFF.
One-shot mode	When the clutch ON/OFF command device switches from OFF to ON, the clutch turns on after moving for a specified travel amount, and then it turns off after moving for a specified travel amount.
External input mode	This mode is used only for the axis set the incremental synchronous encoder (manual pulse generator)as the drive module.The clutch turns on/off according to the clutch ON/OFF command device and external input (TREN signal: Synchronous encoder start signal).

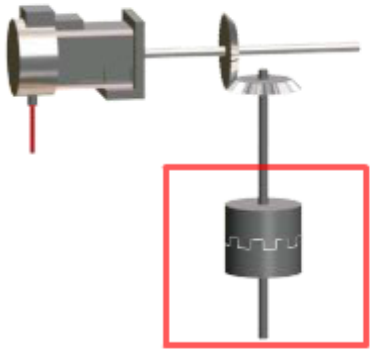


Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample

Parameter item	Sample value
Clutch ON/OFF command device	M7004
Clutch status device	M7014

13.4.2 Clutch



Direct clutch

Parameter item	Sample value
Clutch ON/OFF command device	M7004
Clutch status device	M7014
Clutch type	Smoothing clutch
Smoothing clutch method	Time-constant system
Smoothing time constant	30[ms]
Slippage setting device	
Slippage in-position range setting device	
Slippage system	Exponential function
Smoothing clutch complete signal device	
Operation mode	ON/OFF mode, address mode and one-shot
Mode setting device	D7040
ON address setting device	D7042
OFF address setting device	D7044
Address mode clutch control system	Current value within 1

<Setting details>

Specify the device for clutch on/off command.

<Setting range>

X0000 to X1FFF
Y0000 to Y1FFF
M0 to M8191 (*1)
F0 to F2047

13.4.2 Clutch

U3E0G10000.0 to U3E0G17167.F (*2)
U3E1G10000.0 to U3E1G17167.F (*2)
Label and structure name registered as bit device

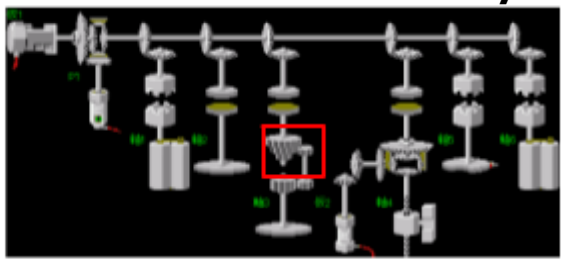
(*1) The device area of the virtual servomotor axis status and command signal not used in mechanical system program be used by the user.
(*2) The available multiple CPU sharing device range varies depending on the multiple CPU high speed transmission area setting.

<Setting example>

Set this parameter to "M7004" for the sample system.

13.4.3 Speed change gear

A speed change gear is used to change the rotation speed and travel value for the output module during operation.
The speed transmitted to output axis is calculated by multiplying the speed at input axis by a speed change ratio set to the speed change ratio setting device.

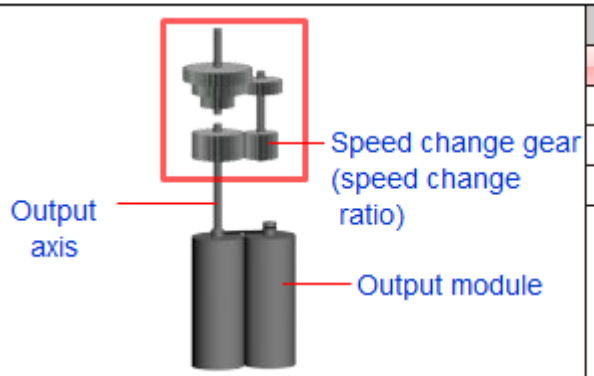


$$\text{Output axis speed} = (\text{Input axis speed}) \times \frac{(\text{Speed change ratio})^{*}}{1000} \quad [\text{PLS/s}]$$

* 0 to 65535

Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample system.



Parameter item	Sample value
Speed change ratio upper limit value	65535
Speed change ratio lower limit value	1
Speed change ratio setting device	D7036
Smoothing time constant	0[ms]

<Setting details>

Set the upper limit of the speed change ratio.
When the value from the speed change ratio setting device exceeds this limit, the speed change gear is controlled by the limit value.

<Setting range>

Set this value by multiplying 0.00 to 655.35[%] by 100 (0 to 65535).

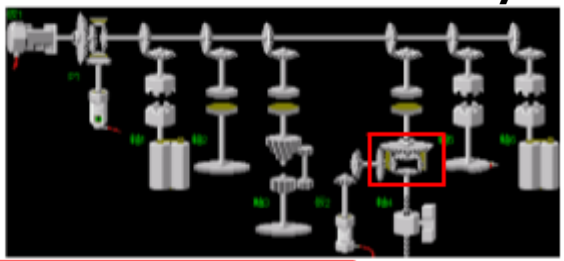
13.4.3 Speed change gear

<Setting example>

Set this parameter to "65535" for the sample system.

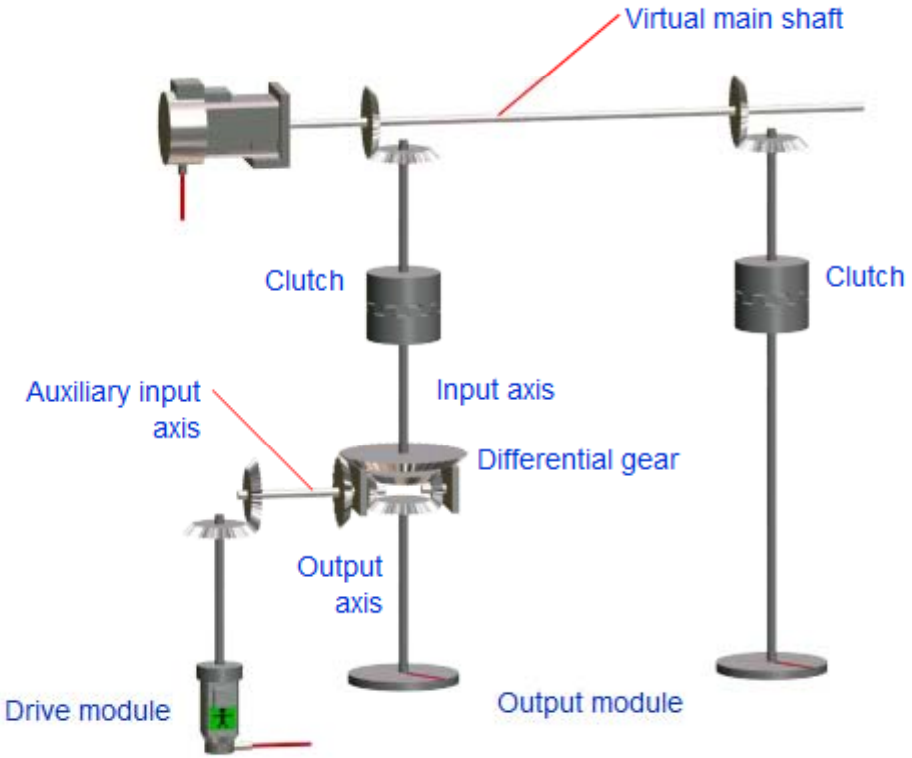
13.4.4 Differential gear

A differential gear subtracts the travel value of the auxiliary input axis from the travel value of the input axis and then transmits the result to the output axis.
The auxiliary axis of the differential gear has the rotation direction, and it is set to reverse direction by default.



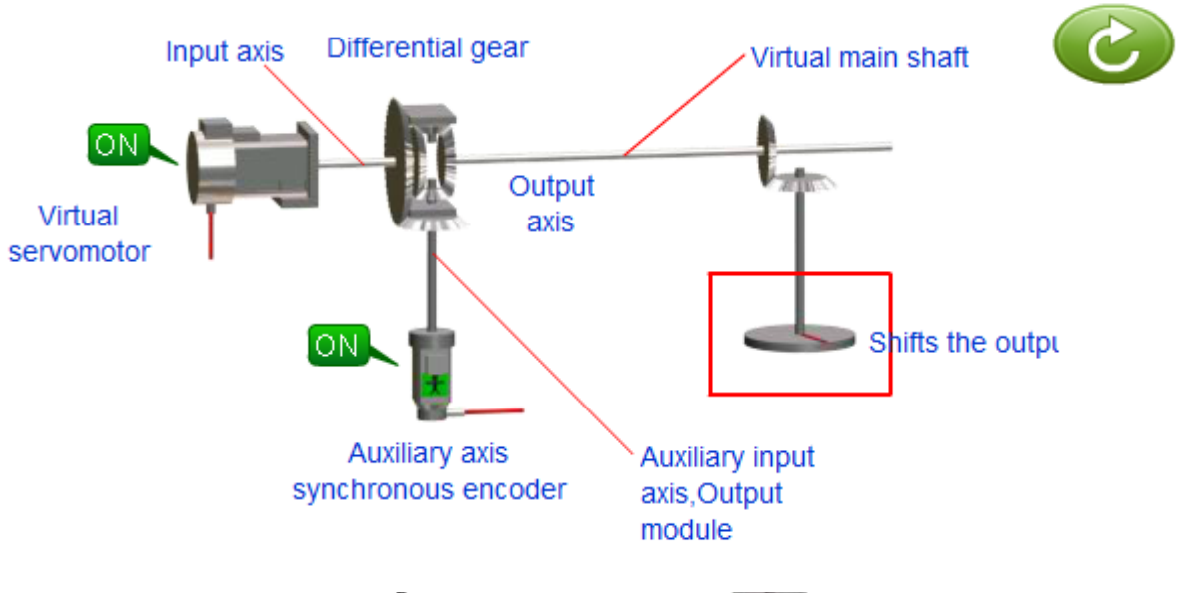
Output axis travel value = (Input axis travel value) − (Auxiliary input axis travel value) [PLS/s]

(1) When shifting the output module phase or adjusting the operation start position



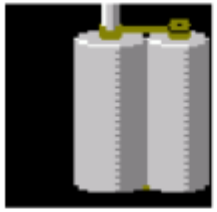
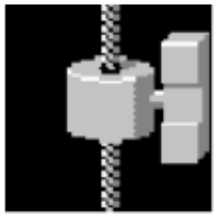
13.4.4 Differential gear

(2) When connected to virtual main shaft



13.5 Output Module

An output module controls machines. There are four types of output modules listed as below.

Mechanical module		Function	Refer to
Appearance	Name		
	Roller	Used to control the speed of a machine connected to the servomotor.	13.5.1
	Ball screw	Used to linearly move a machine connected to the servomotor.	13.5.2
	Rotary table	Used to rotationally move a machine connected to the servomotor.	13.5.3
	Cam	Used to move a machine connected to the servomotor according to a defined cam pattern.	13.5.4

13.5.1 Roller

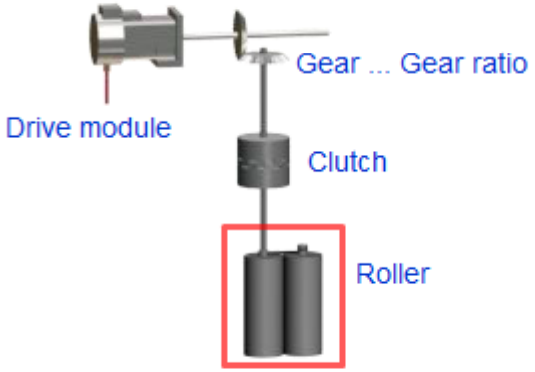
A roller is used in the following cases:
- To continuously operate a machine connected to the servomotor
- To use a system which does not require position control

The roller is controlled by the speed and the travel value calculated as below.

Roller speed = (Drive module speed [PLS/s]) x (Gear ratio) x (Speed change ratio) [PLS/s]
Roller travel value = (Drive travel value [PLS]) x (Gear ratio) x (Speed change ratio) [PLS]

Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample system.



	Sample value
Output axis No.	1
Comment	
Roller diameter	95493.0[μm]
Number of pulses per revolution	262144[PLS]
Travel value per pulse	1.1[μm]
Permissible droop pulse value	6553500[PLS]
Converted value	7499888.2[μm]
Speed limit value	1800000.00[mm/min]
Unit of output	mm
Torque limit	300%
Phase compensation	Not set

<Setting details>

Specify the axis number defined on the system setting screen.

<Setting range>

When using Q173DCPU: 1 to 32 When using Q172DCPU: 1 to 8

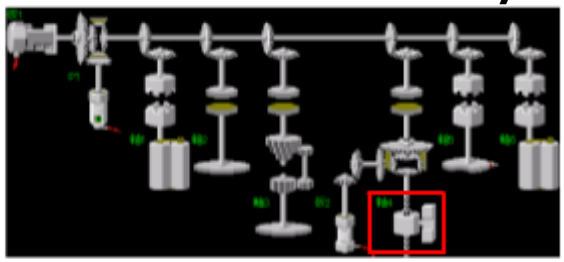
13.5.1 Roller

<Setting example>

Set this parameter to "1" because the sample system uses No. 1.

13.5.2 Ball screw

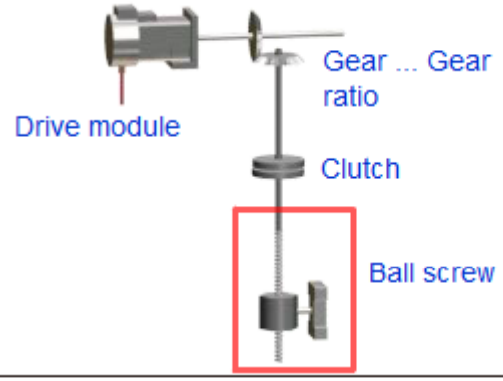
A ball screw is used to linearly move a machine connected to the servomotor. The ball screw is controlled at the speed calculated by multiplying the speed and travel value from the drive module by the gear ratio from the transfer module, and the resulting travel value is output.



Ball screw speed = (Drive module speed [PLS/s]) x (Gear ratio) x [PLS/s]
Ball screw travel value = (Drive travel value [PLS]) x (Gear ratio) [PLS]

Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample system.



Parameter item	Sample value
Output axis No.	4
Comment	
Ball screw pitch	10000.0[µm]
Number of pulses per revolution	262144[PLS]
Travel value per pulse	0.0[µm]
Permissible droop pulse value	6553500[PLS]
Converted value	249996.1[µm]
Speed limit value	60000.00[mm/min]
Unit of output	mm
Torque limit	300%
Upper stroke limit value	214748364.7[µm]
Lower stroke limit value	-214748364.8[µm]
Phase compensation	Not set

<Setting details>

Specify the axis number defined on the system setting screen.

<Setting range>

13.5.2 Ball screw

<Setting range>

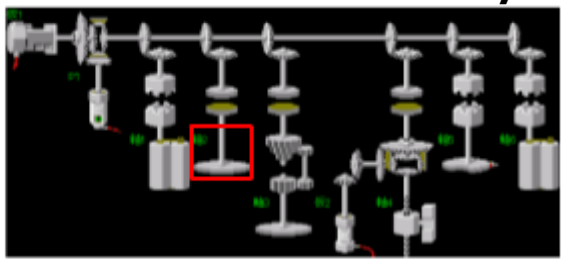
When using Q173DCPU: 1 to 32 When using Q172DCPU: 1 to 8

<Setting example>

Set this parameter to "4" because the sample system uses No. 4.

13.5.3 Rotary table

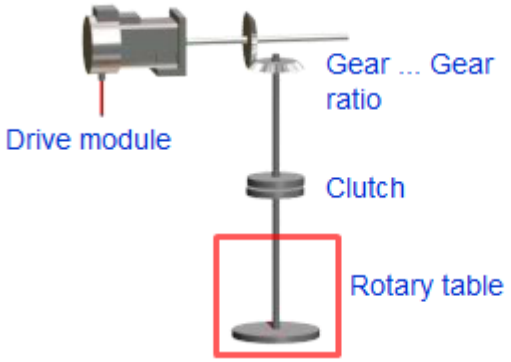
The rotary table is controlled by the speed and the travel value calculated as below.



Rotary table speed = (Drive module speed [PLS/s]) x (Gear ratio) x [PLS/s]
Rotary table travel value = (Drive travel value) x (Gear ratio) [PLS]

Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample system.



Parameter item	Sample value
Output axis No.	2
Comment	
Number of pulses per revolution	26214[PLS]
Travel value per pulse	0.01373[deree]
Permissible droop pulse value	6553500[PLS]
Converted value	90000.00000[degree]
Speed limit value	1080000.000
Torque limit	300%
Upper stroke limit value	0.00000[degree]
Lower stroke limit value	0.00000[degree]
Current value within 1 virtual axis revolution storage	
Main shaft side	D7020
Auxiliary input axis side	
Phase compensation	Not set

<Setting details>

Specify the axis number defined on the system setting screen.

13.5.3 Rotary table

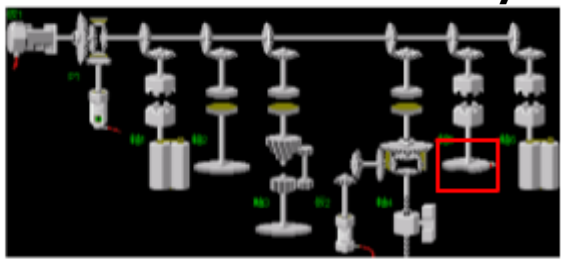
<Setting range>

When using Q173DCPU: 1 to 32 When using Q172DCPU: 1 to 8

<Setting example>

Set this parameter to "2" because the sample system uses No. 2.

13.5.4 Cam



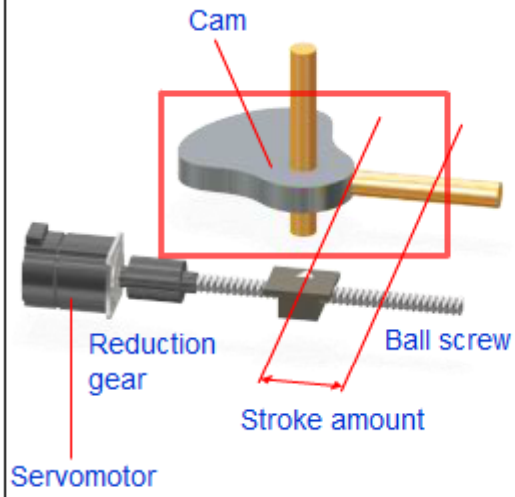
A cam is used to move a machine connected to the servomotor according to a defined cam pattern.
The cam makes one revolution with the number of pulses per one cam axis revolution.

For an axis with the cam specified as the output module, the ball screw can also be used to perform the same operation as the cam does, as animated below.
The following two types of data are required to use the cam:

- Cam data (refer to Chapter 14 for details.)
- Output module parameters

Click each parameter item in the table to see its explanation.

* The parameter values shown below are used for the sample system.



Parameter item	Sample value
Output axis No.	5
Comment	
Cam number setting device	D7056
Number of pulses per revolution	2621440[PLS]
Permissible droop pulse value	6553500[PLS]
Stroke amount setting device	D7058
Lower stroke limit value storage device	D7060
Cam or ball screw switching device	
Unit of output	mm
Torque limit	300%
Current value within 1 virtual axis revolution storage device	
Main shaft side	D7062
Auxiliary input axis side	
Phase compensation	Not set

<Setting details>

Specify the axis number defined on the system setting screen.

13.5.4 Cam

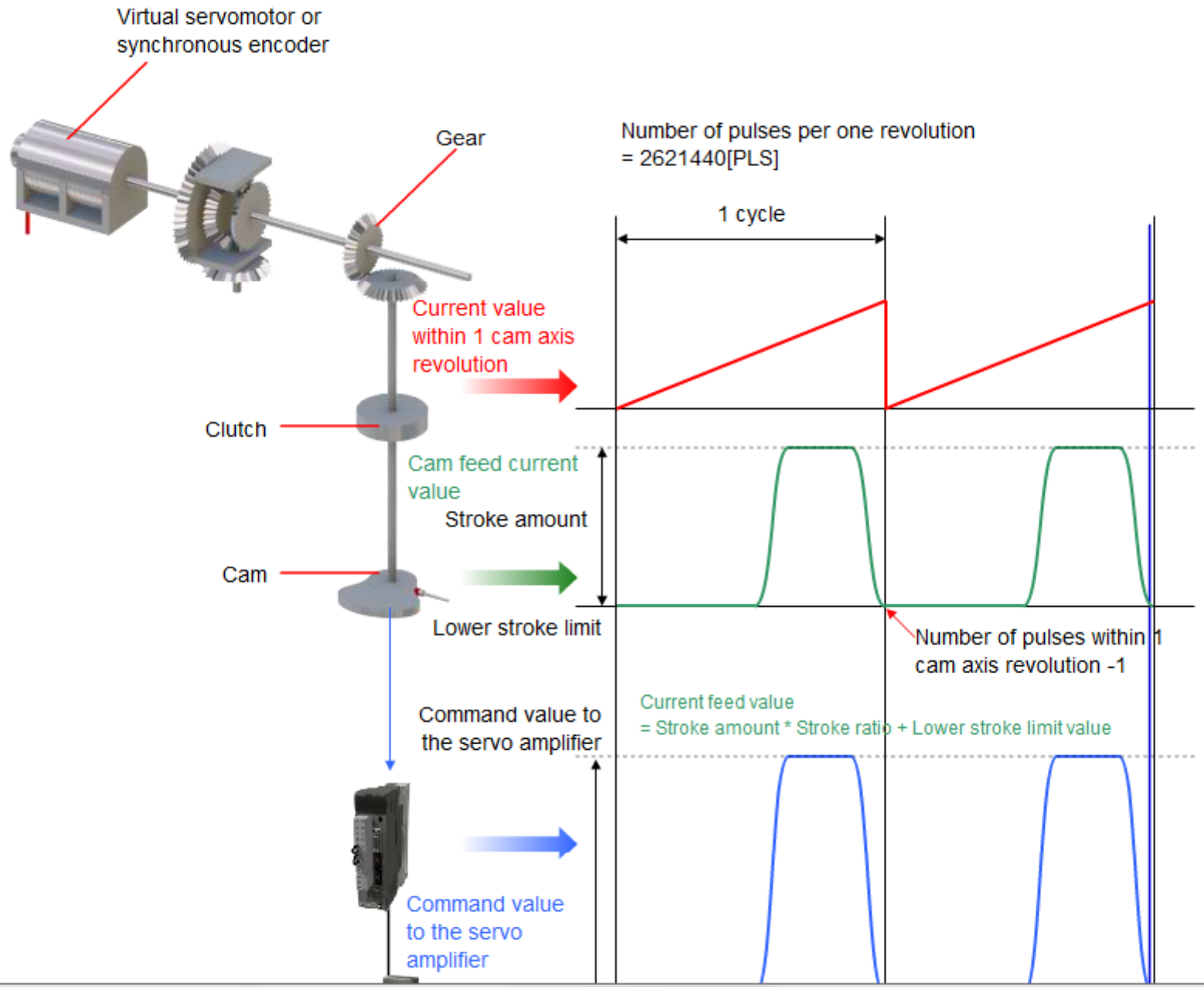
<Setting range>

When using Q173DCPU: 1 to 32 When using Q172DCPU: 1 to 8

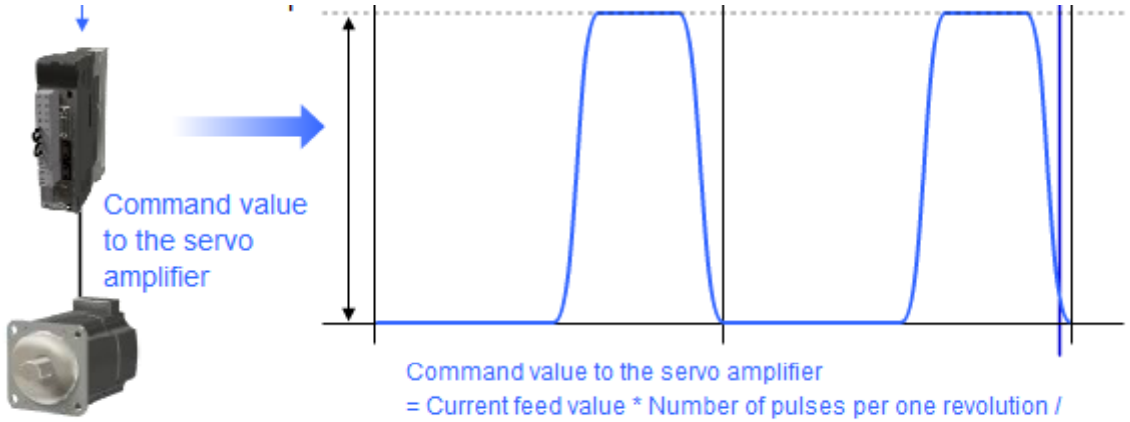
<Setting example>

Set this parameter to "5" because the sample system uses No. 5.

13.5.4 Cam


Virtual servomotor or synchronous encoder
Gear
Number of pulses per one revolution = 2621440[PLS]
1 cycle
Current value within 1 cam axis revolution
Clutch
Cam feed current value
Stroke amount
Cam
Lower stroke limit
Number of pulses within 1 cam axis revolution -1
Command value to the servo amplifier
Current feed value
= Stroke amount * Stroke ratio + Lower stroke limit value
Command value to the servo amplifier

13.5.4 Cam



Command value to the servo amplifier
= Current feed value * Number of pulses per one revolution / travel value per revolution

13.6 Summary

In this chapter, you have learned:

- Mechanical module connection diagram
- Mechanical system program
- Mechanical module
- Drive module
- Transmission module
- Output module

Important points

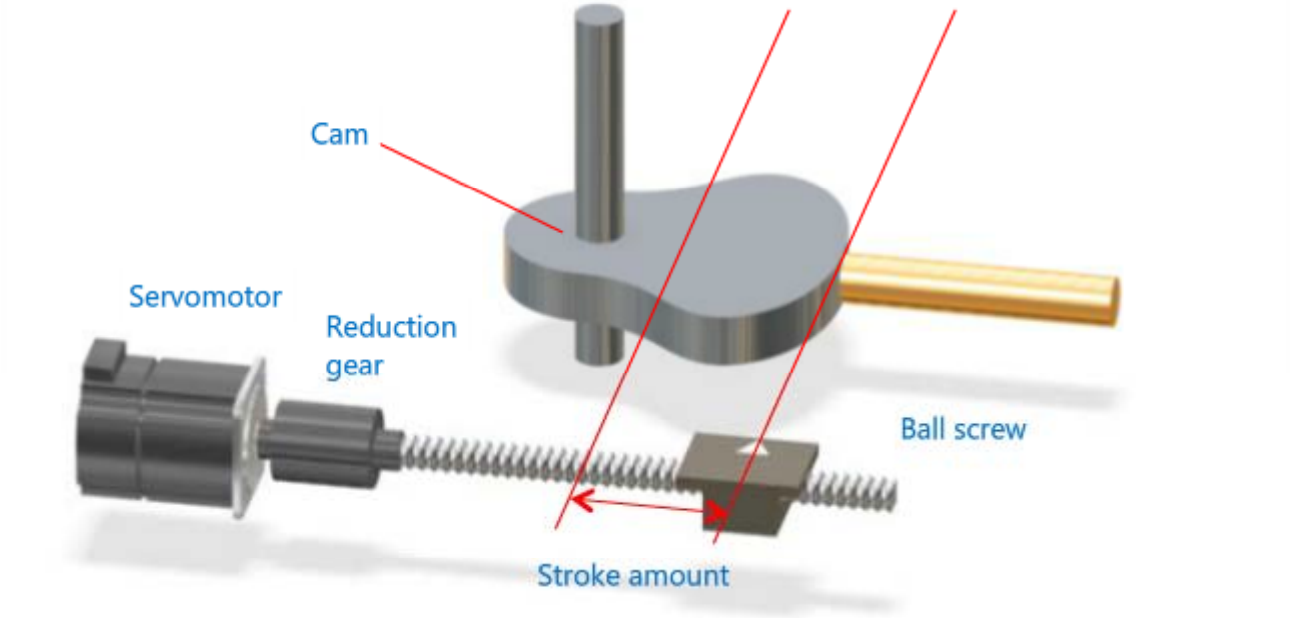
The contents you learned in this chapter are listed below.

Mechanical module connection diagram	A virtual system diagram with the mechanical modules arranged properly
Mechanical system program	A program that performs synchronization control by software in the same way as by hardware
Mechanical module	A functional module illustrated in the mechanical module connection diagram
Drive module	The driving power source of the virtual axes (virtual main shaft and virtual auxiliary input axis)
Transmission module	transmits pulses from the drive module to the output module.
Output module	The travel value of the servomotor is controlled by the command pulse from the output module.

Chapter 14 CAM DATA CREATION

In this chapter, you will learn how to create cam data.
Cam data is used by the cam, an output module of the mechanical module.
The items to be set for creating cam data are listed below.

Items to be set	Initial value	Setting range
Cam No.	-	Refer to the next section.
Resolution	256	256, 512,1024, 2048
Stroke amount switching position	0	0 to (resolution -1)
Operation mode	Two-way cam mode	• Two-way cam mode • Feed cam mode
Cam data table	0	0 ~ 32767



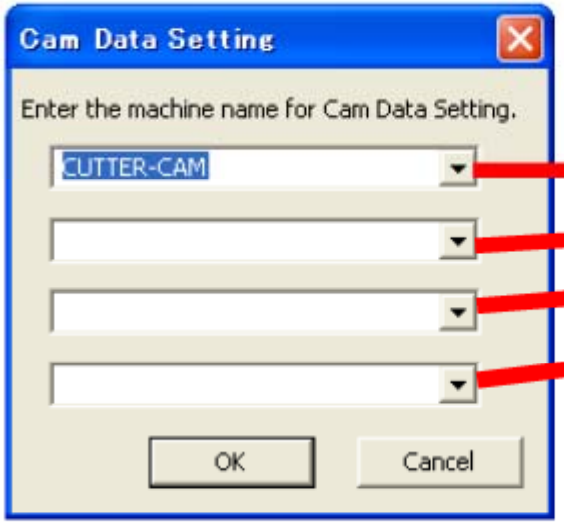
14.1 Cam No.

The cam number is the number assigned to the created cam data.

Assign a number from 1 to 64 for each machine name.

The cam data number is determined according to the order in which the machine names are registered during conversion by the mechanical system program, and is used with an offset value as shown below.

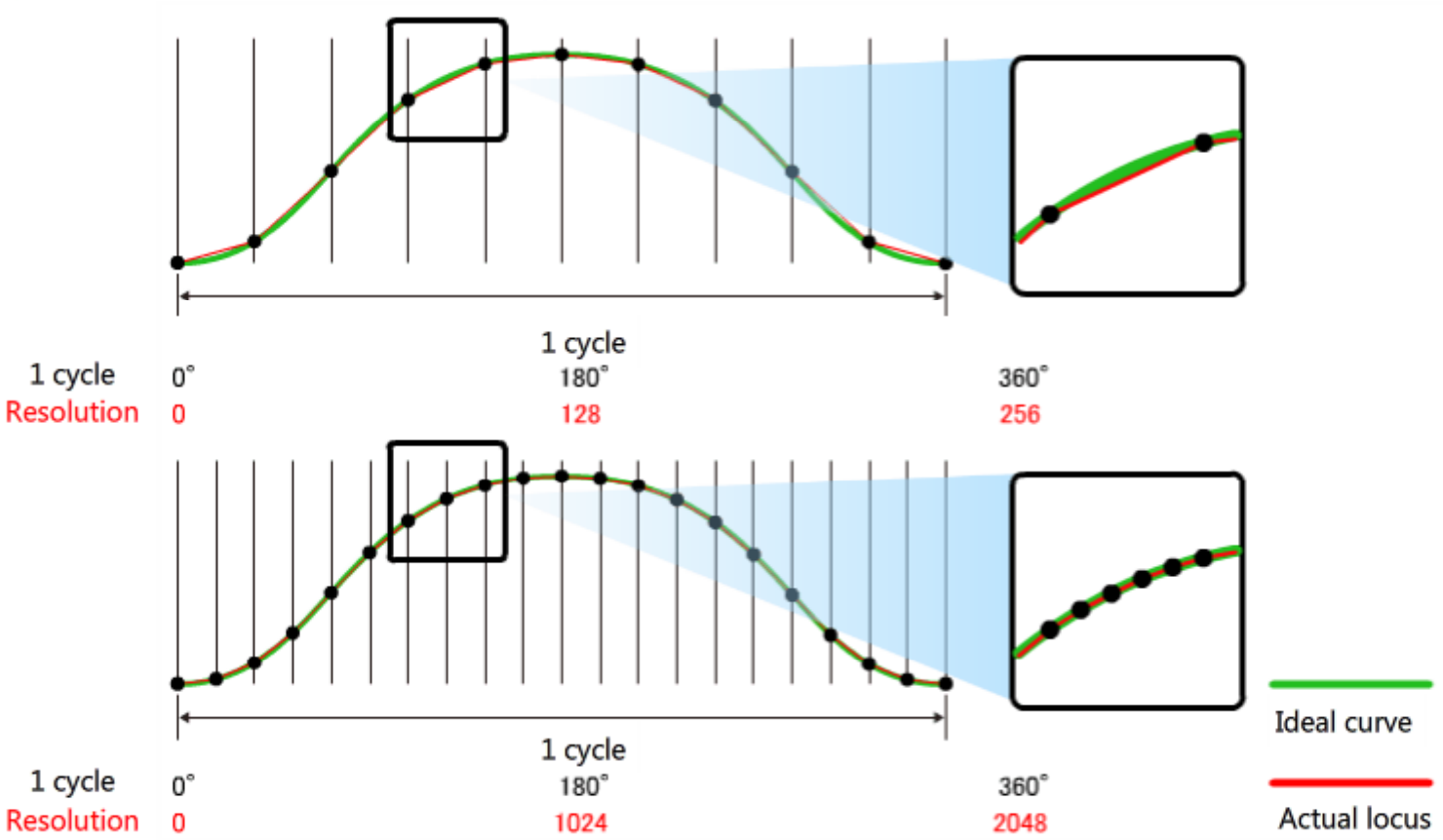
When setting the cam number of cam data used for the cam number setting device in the motion SFC program, use the number with this offset value.



Order of machine names	Cam No. setting
1	1 ~ 26
2	101 ~ 164
3	201 ~ 264
4	301 ~ 364

14.2 Resolution

Resolution is the number of segments into which a cam curve for a single cycle is divided for control.
A higher resolution acquires more sampling data to allow for control closer to the cam curve.



The following conditions shall be satisfied to make sure that all the points data of resolution are output.

- Number of pulses per cam revolution (Nc) >= Resolution
- Time required per cam revolution >= Operation cycle × Resolution

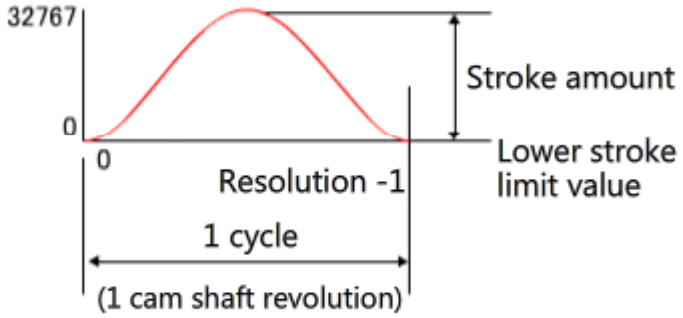
14.3 Operation Modes

Two-way cam mode and feed cam mode are available for control cam data.

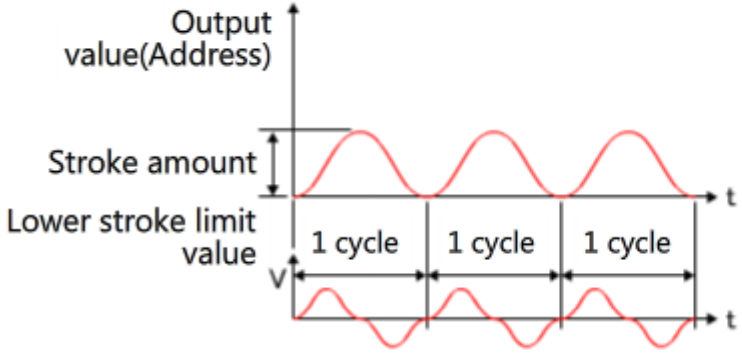
Two-way cam mode

A two-way operation is repeated within the range of the stroke amount.

Cam pattern



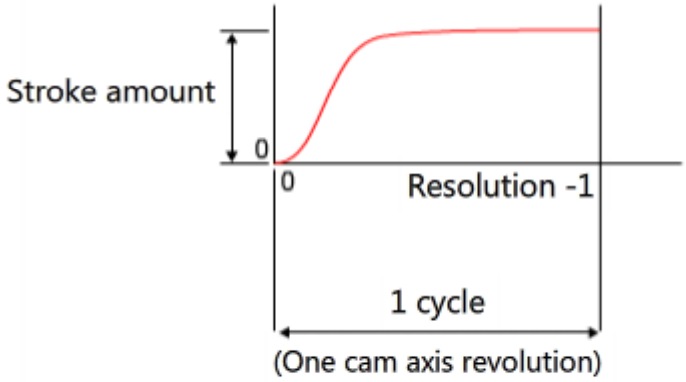
Sample operation



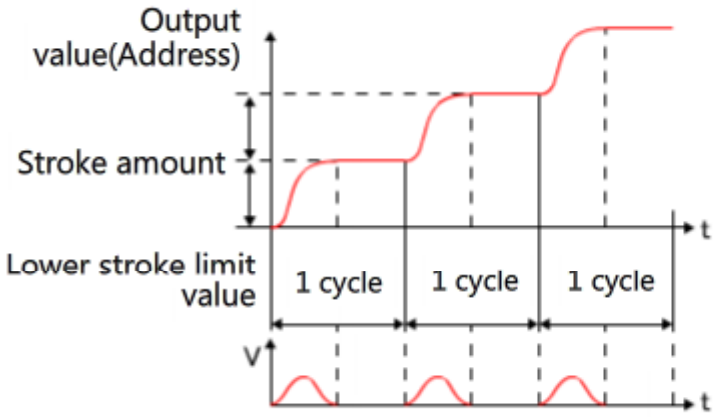
Feed cam mode

Feeds for the specified stroke amount in a single cycle in a single direction for positioning starting from the lower stroke limit value.

Cam pattern



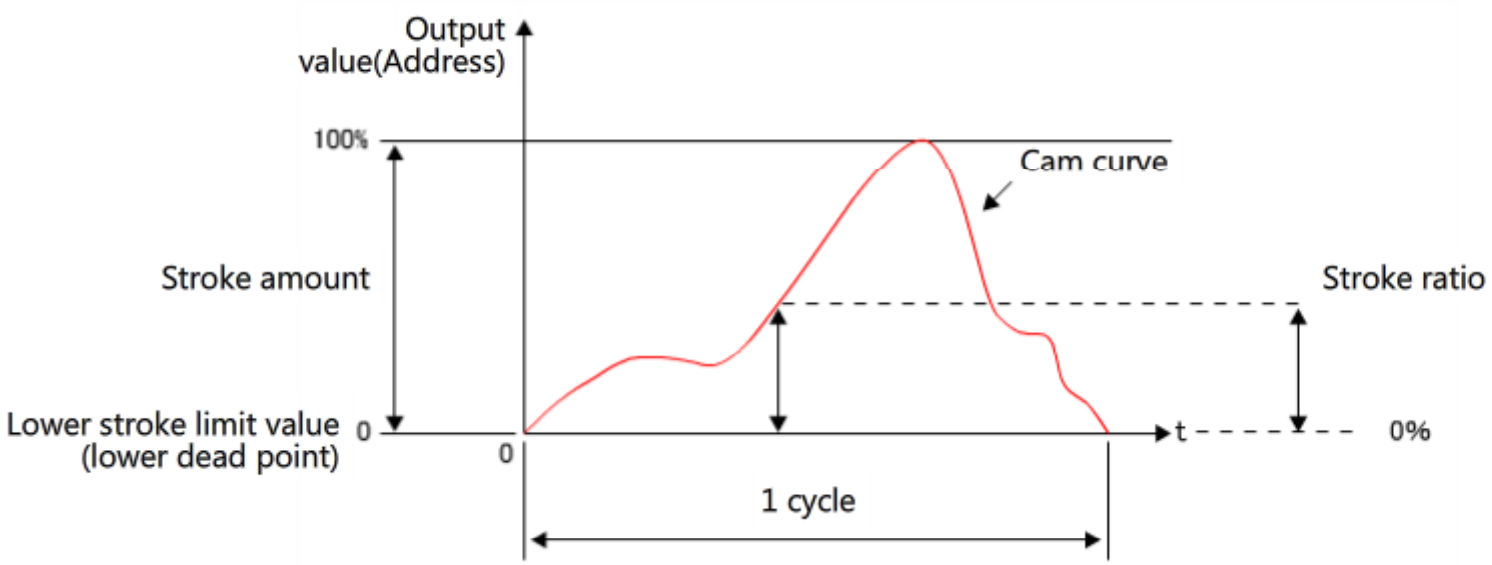
Sample operation



14.4 Cam Data Table

The cam data table defines the stroke ratio for each point of the defined resolution.
The stroke ratio is the value represented with the maximum value of the cam curve as 100%.

MT Developer2 automatically generates the cam data table when the cam curve is created.



Based on the current value within one cam axis revolution, a value calculated using the stroke ratio in the cam data table is output.

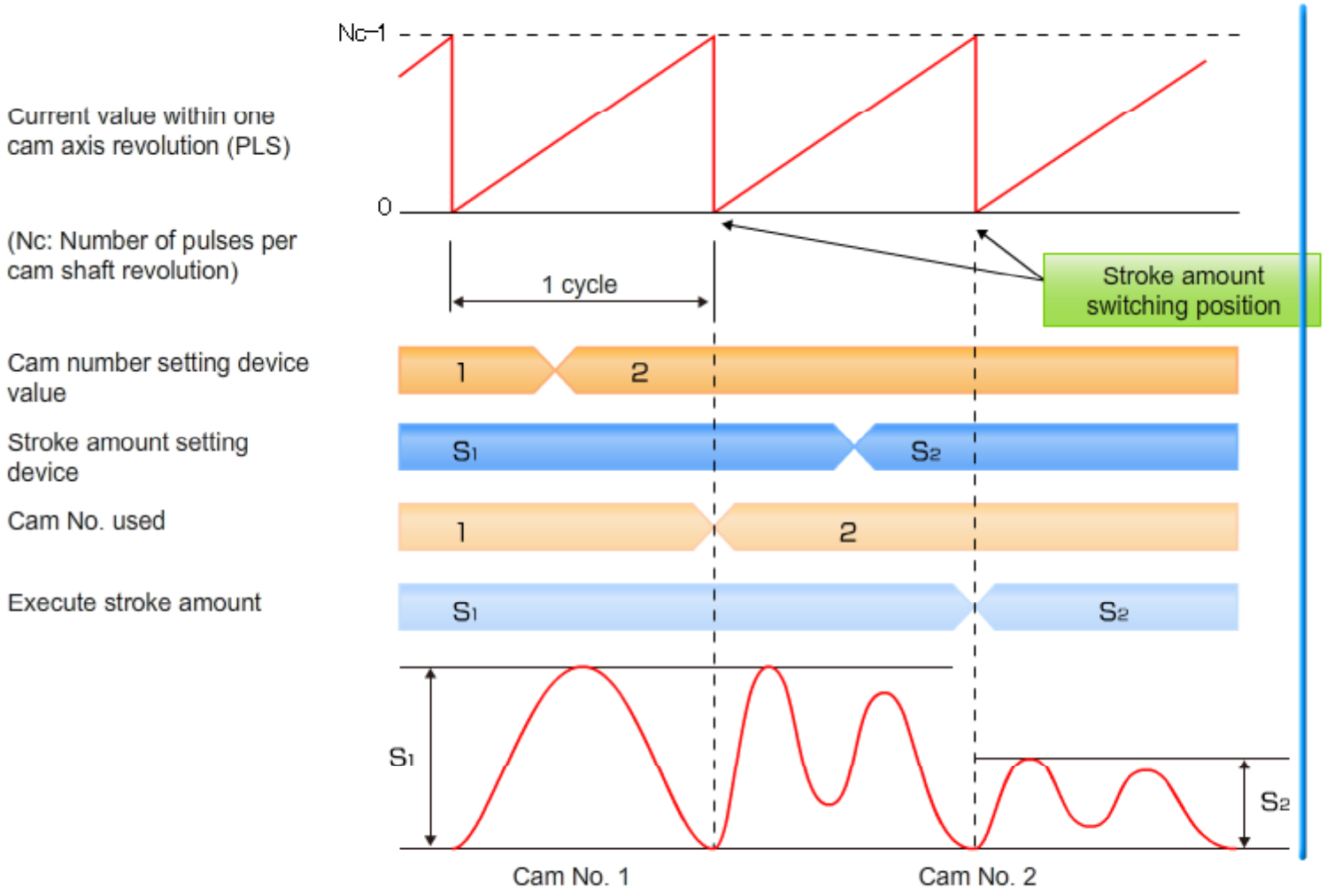
Current feed value = Lower stroke limit value + Stroke amount × Stroke ratio

14.5 Stroke Amount Switching Position

This setting is used to switch the cam number and stroke amount during operation.

When the specified switching position [0 to (resolution -1)] is passed, if the stroke amount and cam number are correct, the program switches to the specified cam number and stroke amount.

(Example) When the stroke amount switching position is set to 0, cam No. 1 and No. 2, and stroke amounts S1 and S2 are switched as shown below.11



14.6 Summary

In this chapter, you have learned:

- Cam data
- Cam No.
- Resolution
- Stroke amount switching position
- Operation mode
- Cam data table

Important points

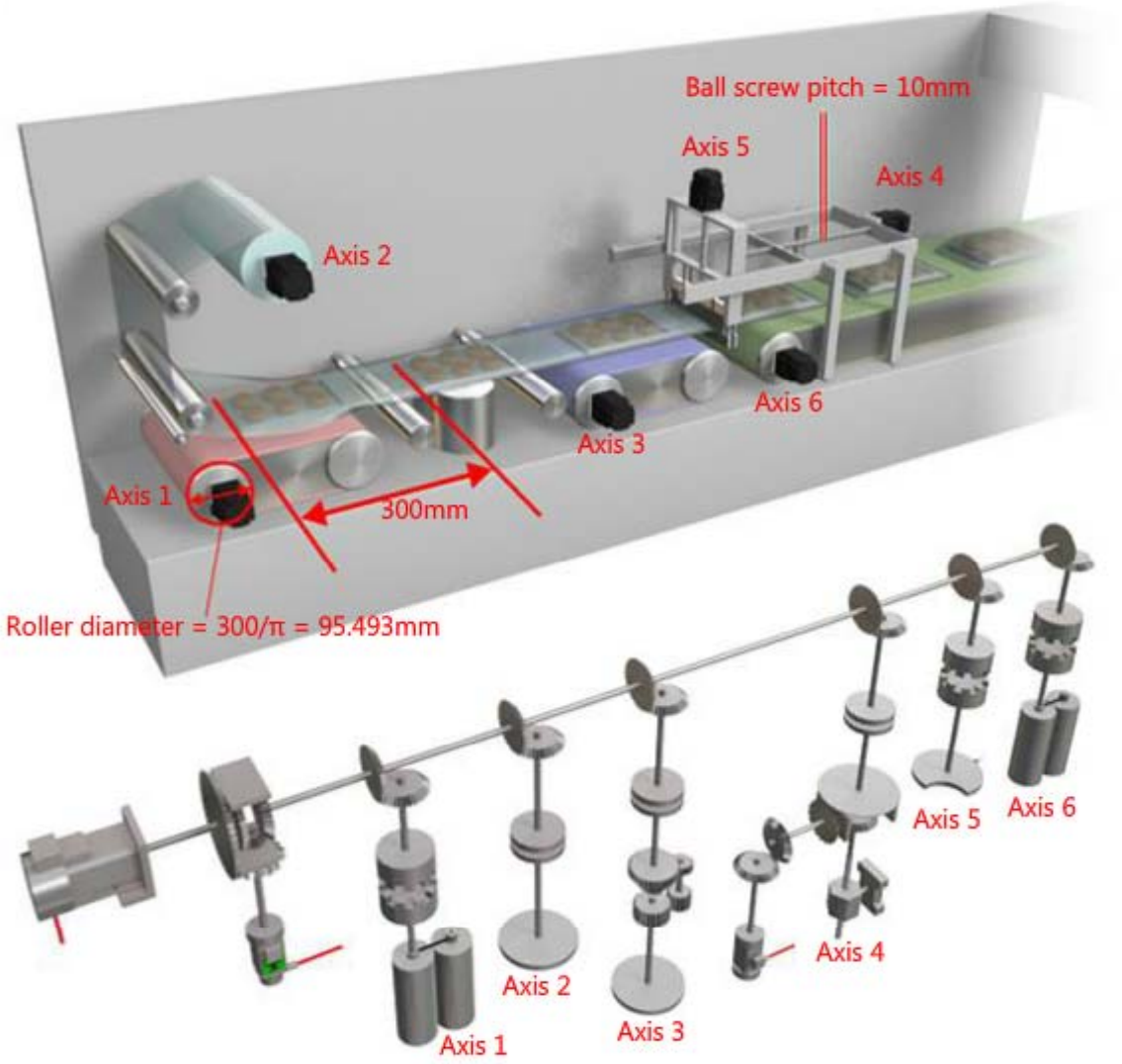
The contents you learned in this chapter are listed below.

Cam data	Settings used for the cam of the mechanical module.
Cam No.	Number assigned to the cam data.
Resolution	Number of segments into which a cam curve for a single cycle is divided for control.
Stroke amount switching position	Setting used to switch the cam number and stroke amount during operation.
Operation mode	Two-way cam mode and feed cam mode are available for control cam data.
Cam data table	Setting of the stroke ratio for each point of defined resolution.

Chapter 15 Exercise

In this chapter, you will learn about the creation of the mechanical system program and cam data, and also about monitoring the program operation.

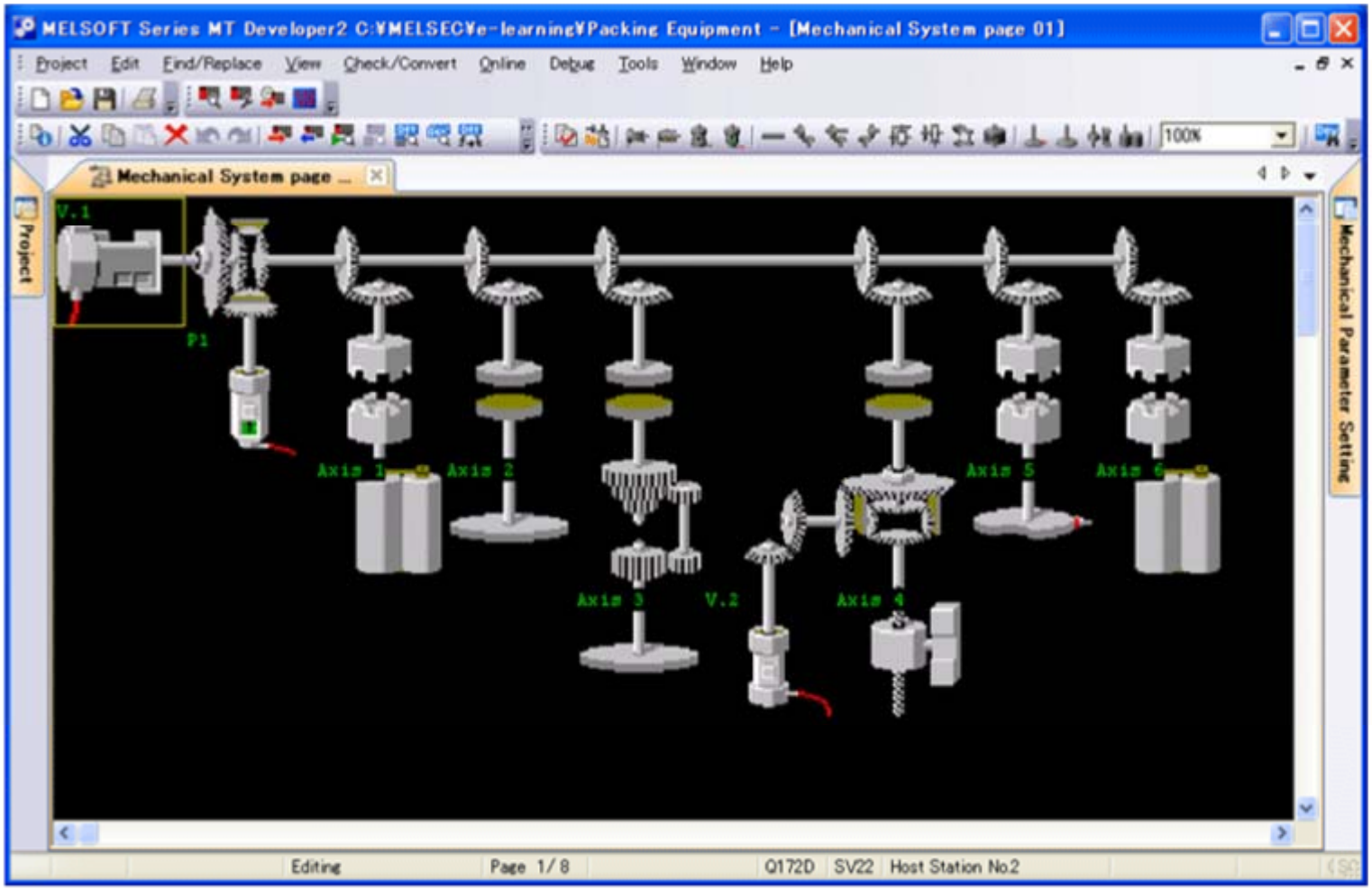
The sample system handles the packaging machine of the system used in the "SERVO MOTION CONTROLLER BASICS (HARDWARE)" course and the "SERVO MOTION CONTROLLER BASICS (REAL MODE: SFC)" course.



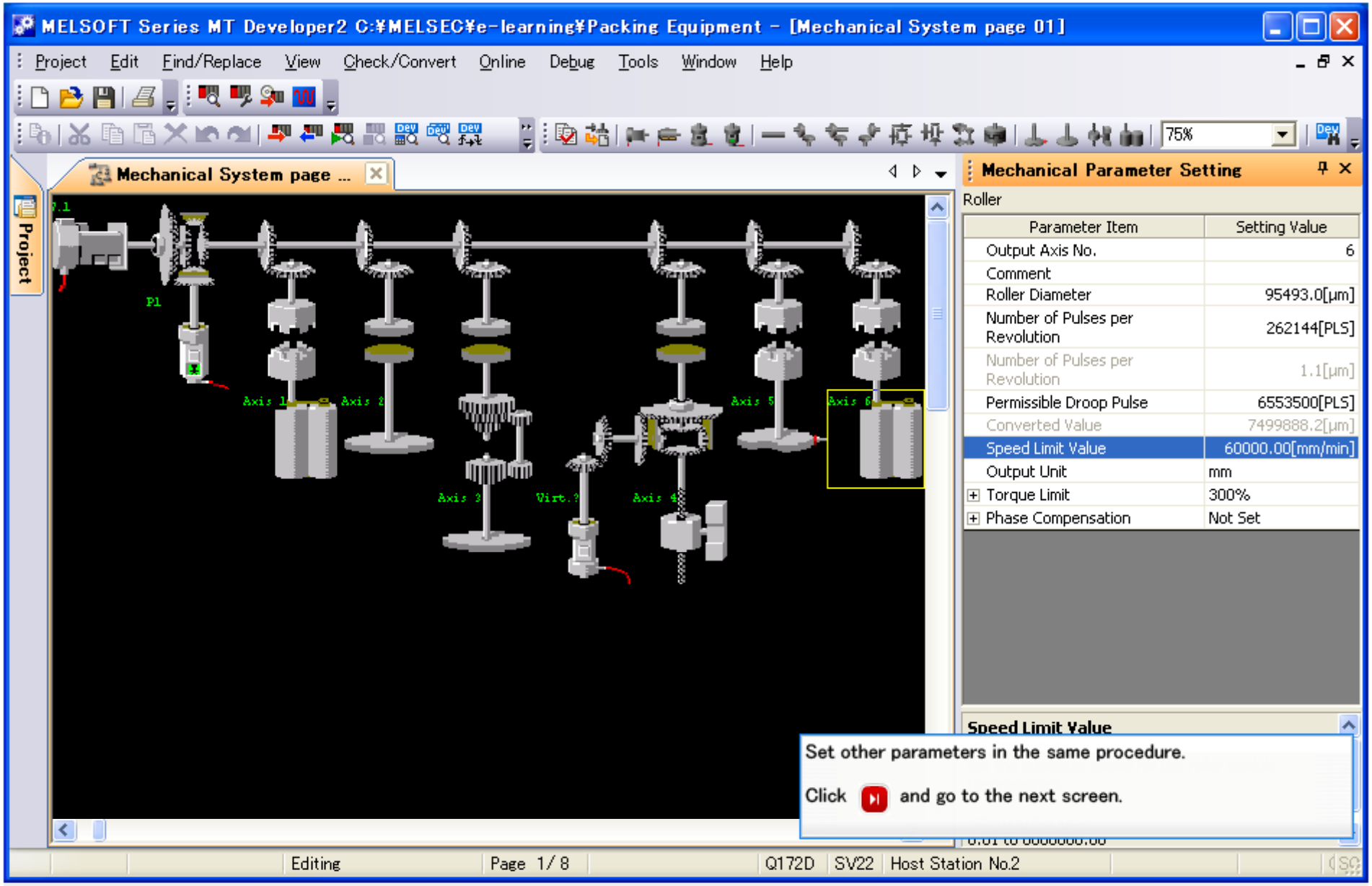
15.1 Mechanical System Program

Learn how to create the mechanical system program using the system for the exercise.

Let's set a system configuration in the next screen.



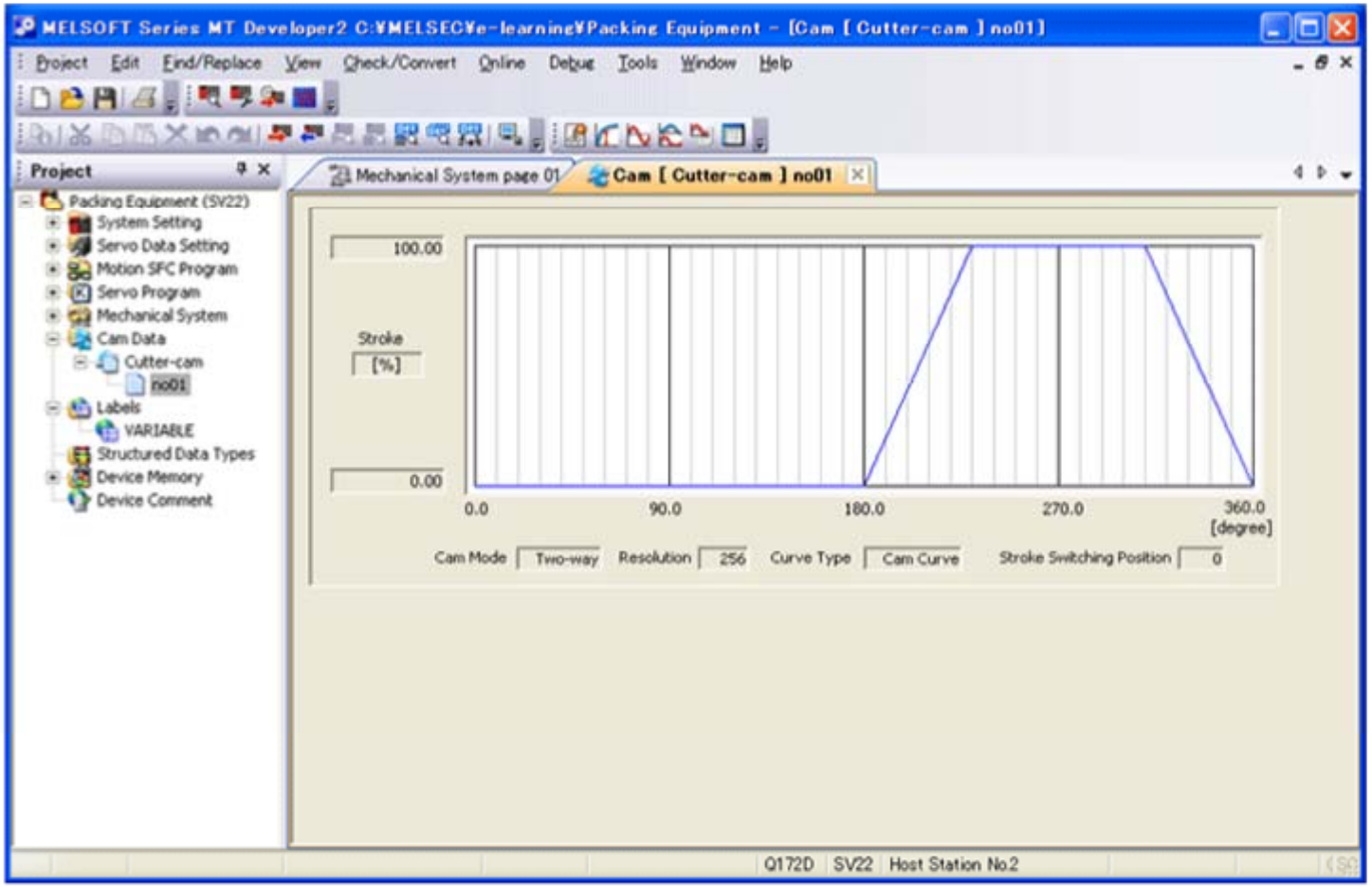
15.1 Mechanical System Program

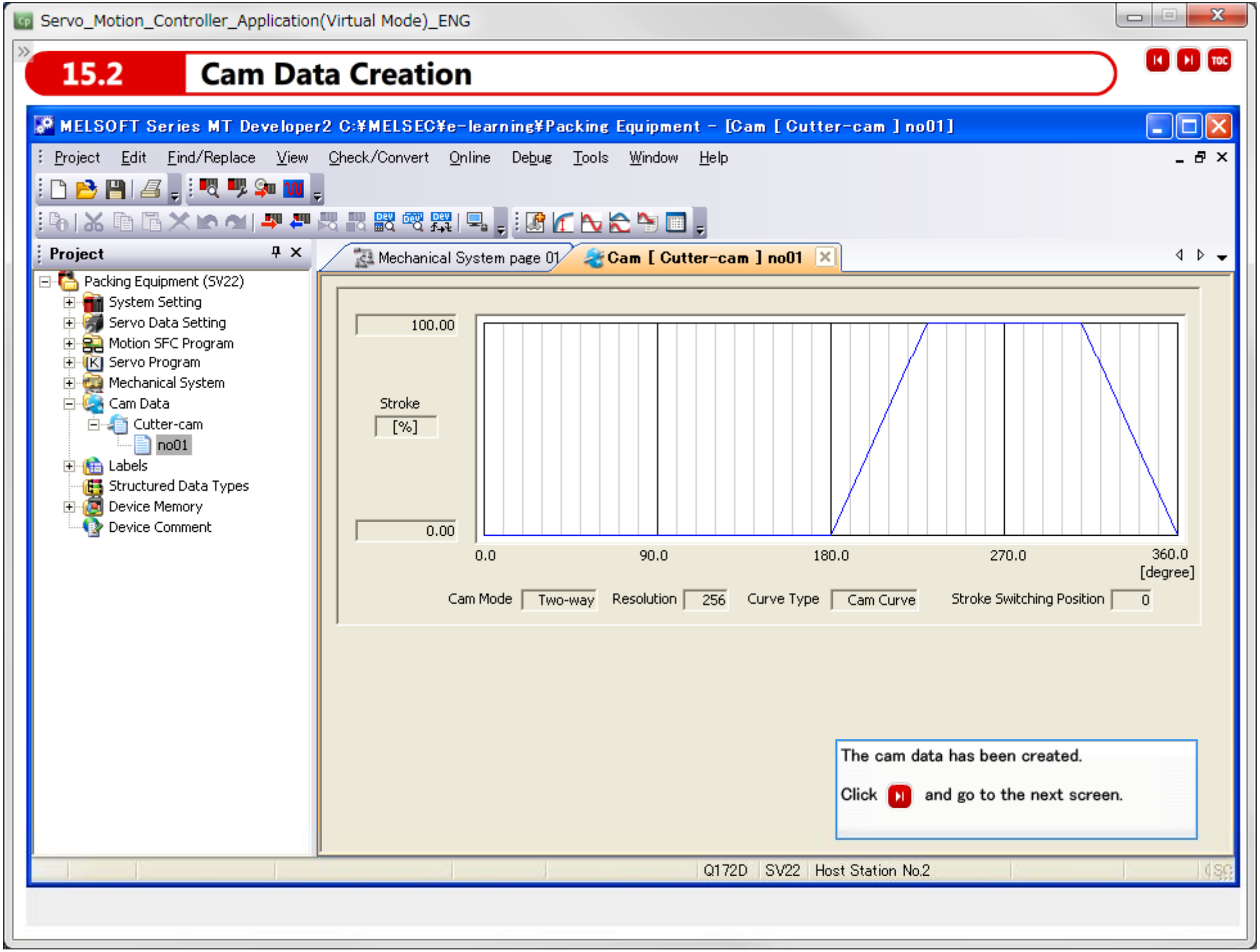


15.2 Cam Data Creation

Now we learn how to create cam data using the cam of the mechanical system program created in the section 15.1.2.

Create the cam data in the next page using the actual window.



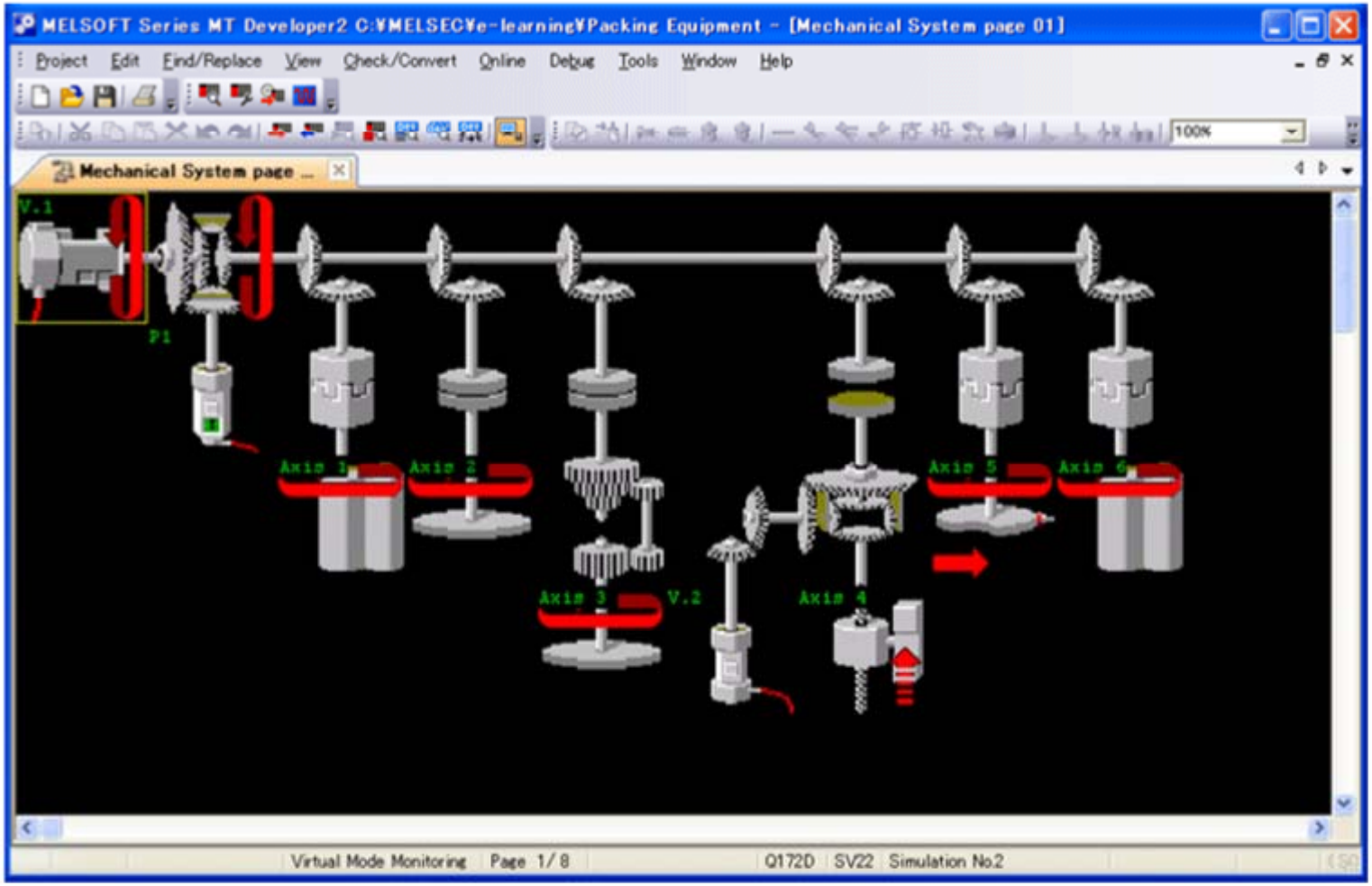

Servo_Motion_Controller_Application(Virtual Mode)_ENG
15.2
Cam Data Creation
MELSOFT Series MT Developer2 C:¥MELSEC¥e-learning¥Packing Equipment - [Cam [Cutter-cam] no01]
Project Edit Find/Replace View Check/Convert Online Debug Tools Window Help
Project
Packing Equipment (SV22)
System Setting
Servo Data Setting
Motion SFC Program
Servo Program
Mechanical System
Cam Data
Cutter-cam
no01
Labels
Structured Data Types
Device Memory
Device Comment
Mechanical System page 01
Cam [Cutter-cam] no01
100.00
Stroke
[%]
0.00
0.0
90.0
180.0
270.0
360.0
[degree]
Cam Mode
Two-way
Resolution
256
Curve Type
Cam Curve
Stroke Switching Position
0
The cam data has been created.
Click and go to the next screen.
Q172D
SV22
Host Station No.2

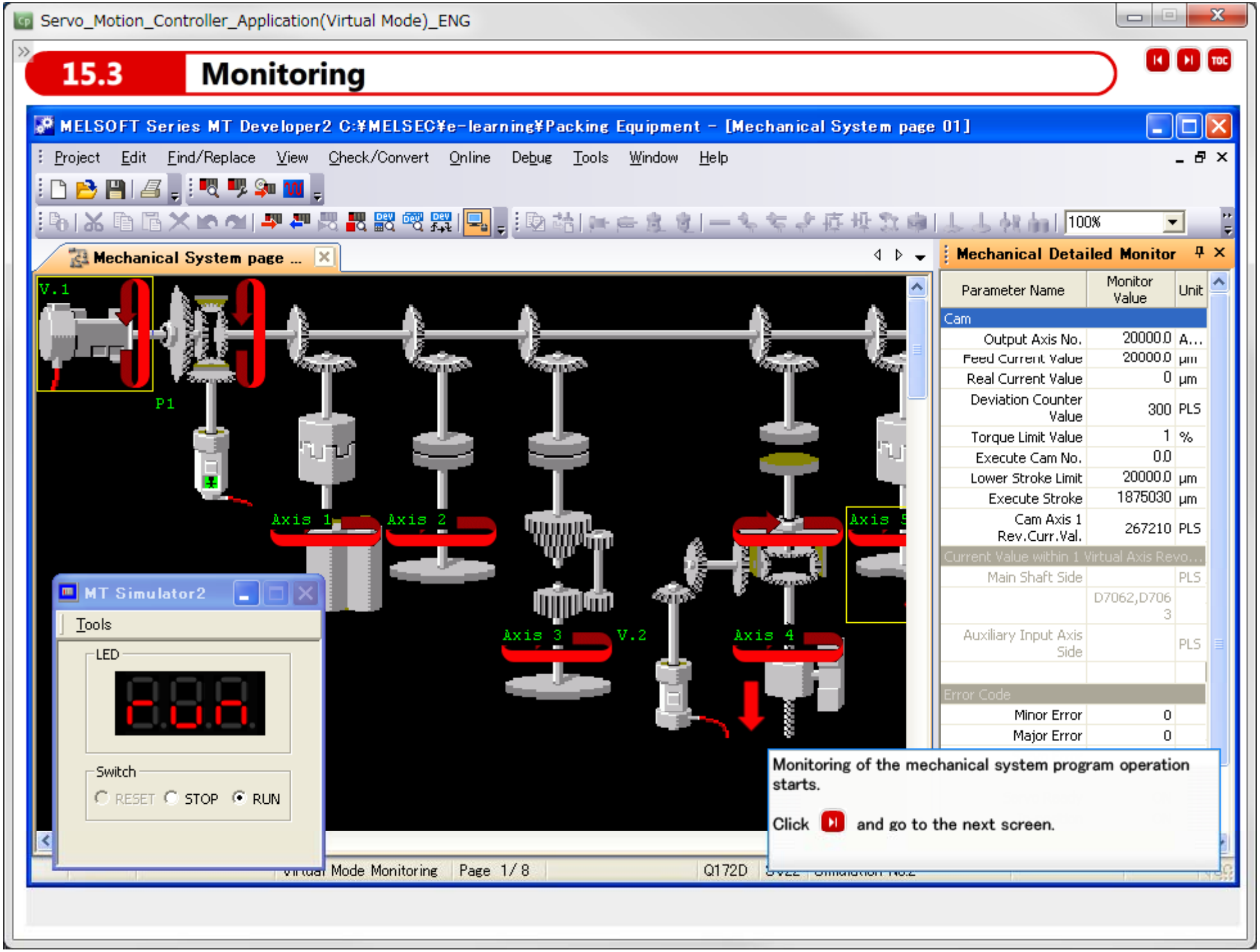
15.3 Monitoring

You can monitor operation of the created mechanical system program.

Monitor the program in the next page using MT Simulator2.

MT Simulator2: This tool allows for various monitoring tasks including motion SFC program monitoring without connecting to an actual system by starting simulation from MT Developer2.




Servo_Motion_Controller_Application(Virtual Mode)_ENG
15.3
Monitoring
MELSOFT Series MT Developer2 C:¥MELSEC¥e-learning¥Packing Equipment - [Mechanical System page 01]
Project Edit Find/Replace View Check/Convert Online Debug Tools Window Help
100%
Mechanical System page ...
V.1
P1
Axis 1
Axis 2
Axis 3
V.2
Axis 4
MT Simulator2
Tools
LED
Switch
RESET STOP RUN
Mechanical Detailed Monitor
Parameter Name
Monitor Value
Unit
Cam
Output Axis No.
Feed Current Value
Real Current Value
Deviation Counter Value
Torque Limit Value
Execute Cam No.
Lower Stroke Limit
Execute Stroke
Cam Axis 1 Rev.Curr.Val.
Current Value within 1 Virtual Axis Revo...
Main Shaft Side
D7062,D7063
Auxiliary Input Axis Side
Error Code
Minor Error
Major Error
Monitoring of the mechanical system program operation starts.
Click and go to the next screen.
Page 1/8
Q172D

15.4 Summary

In this chapter, you have learned:

- Mechanical system program creation
- Cam data creation
- Monitoring

Important points

The contents you learned in this chapter are listed below.

Mechanical system program creation	Arrange and configure the mechanical modules to configure a system.
Cam data creation	Create a necessary cam curve in accordance with control details.
Monitoring	You can check the virtual mode operation via simulation.

Chapter 16 APPLICATION

In this chapter, you will learn the following as applications of the virtual mode in the motion controller.
* You can also use the limit switch output function and digital oscilloscope in the real mode, as well as in the virtual mode.

- Limit switch output function
- Clutch operation mode (Address mode)
- Digital oscilloscope

16.1 Limit Switch Output Function

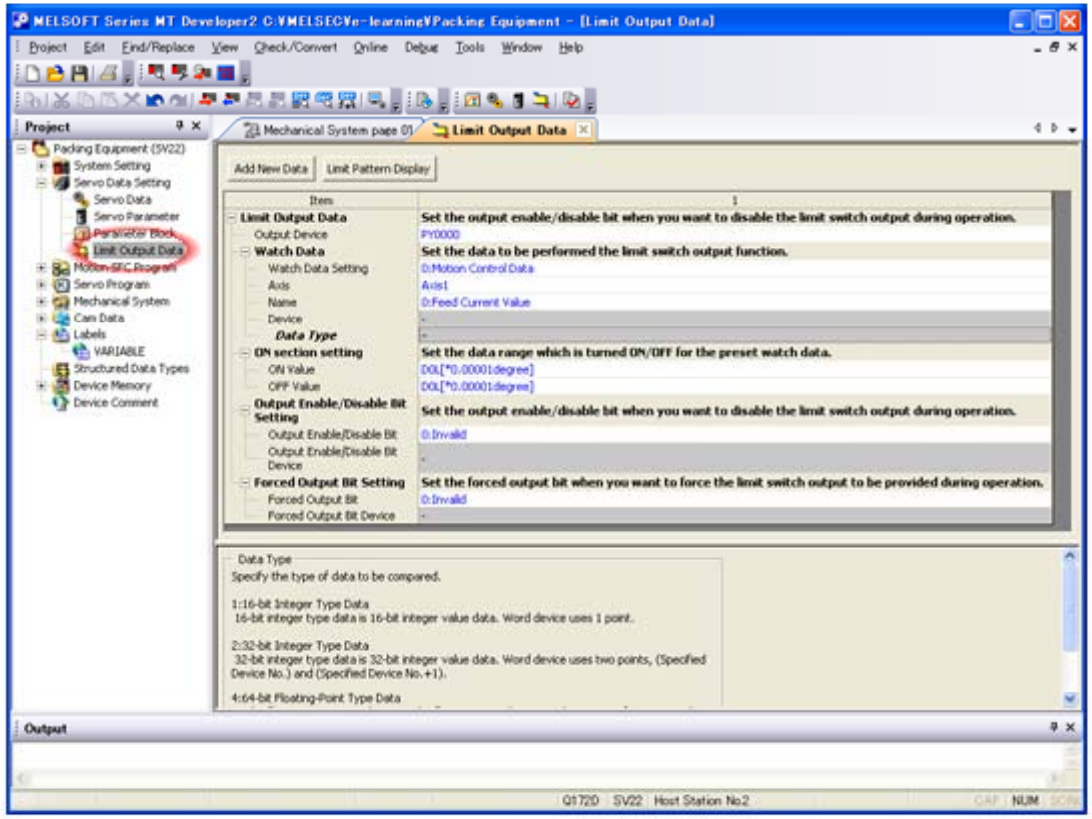
The limit switch output function uses the motion control data or arbitrary word device data as watch data and turns on the output device while the watch data is within the ON output block defined by the ON and OFF values.
Settings can be made by selecting [Servo Data Setting] -> [Limit Output Data] in the project window.

Advantages of using the limit switch output function

- The cost can be reduced because the sensor switch and related hardware are not necessary.
- Switch cabling is not necessary.
- Position data can be monitored accurately.

Application

- Used for monitoring the rotary cutter address
- Used for the marking switch



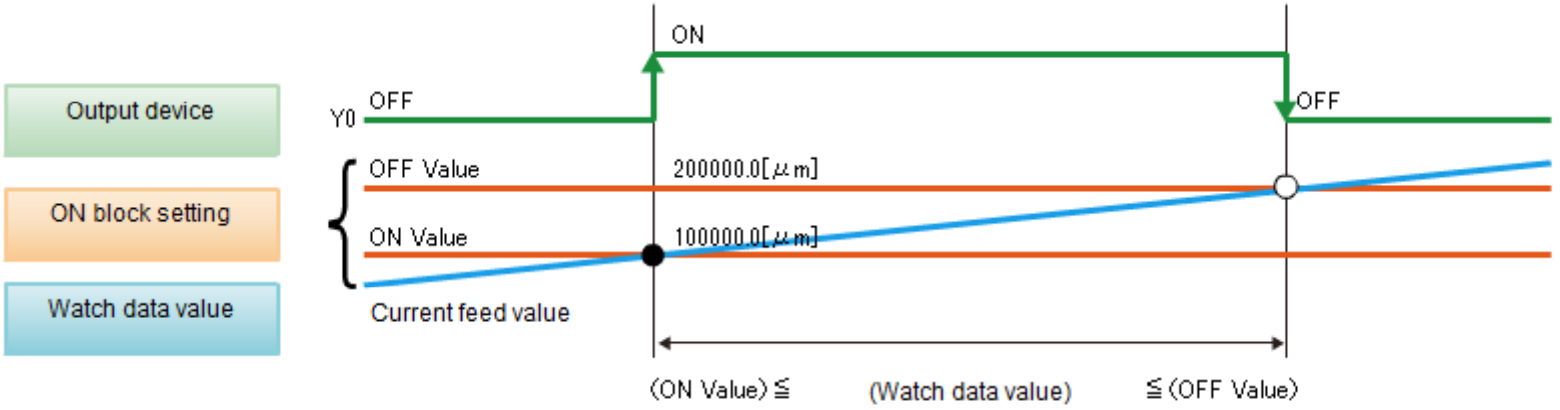
16.1.1 Operation of the limit switch output function

Limit switch output control is enabled during PCPU Ready Complete flag (SM500: ON) by turning on the PLC ready flag (M2000) from off.
All points are disabled when the PCPU Ready Complete flag (SM500) is turned off by turning off the PLC READY flag (M2000) from on.
The limit switch output can be enabled or disabled individually for each point by setting the enable/disable output bit.
By setting the forced output bit, the limit switch output can be turned on for each point.

When (ON value) < (OFF value)

100000.0 [μm] ≦ Current feed value < 200000.0 [μm]

Y0 turns on when the current feed value is 100[mm] or higher and lower than 200[mm].



Parameter item	Sample value
Limit output data	
Output device	Y0000
Watch data	
Watch data specification	0: Motion control data
Axis	Axis 1
Name	0: Current feed value
ON block setting	
ON Value	K100000.0[μm]

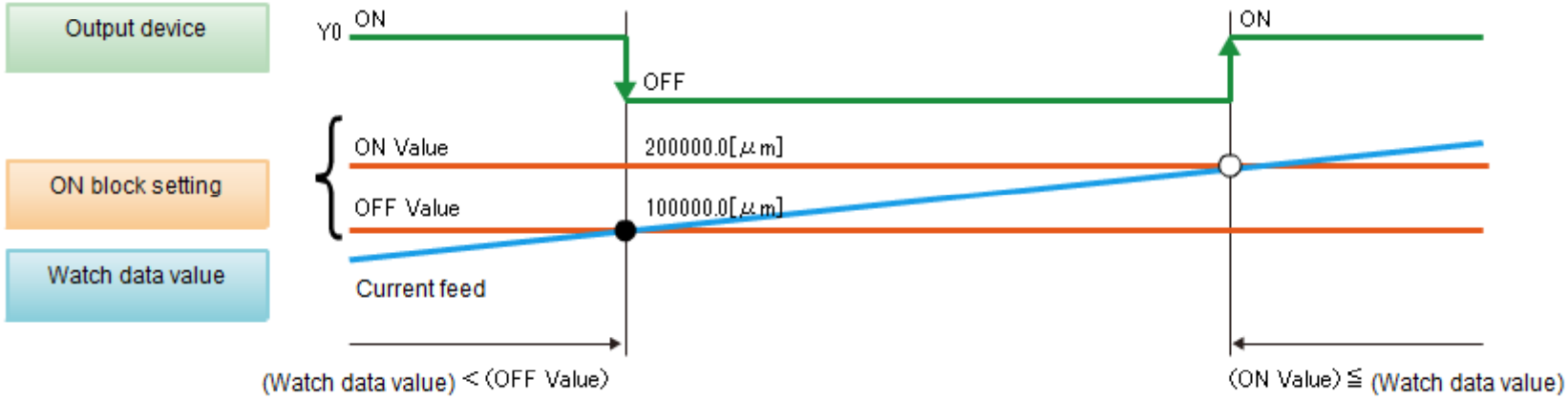
16.1.1 Operation of the limit switch output function

ON Value	K100000.0L[μm]
OFF Value	K200000.0L[μm]
Enable/disable output bit setting	
Enable/disable output bit	0: Invalid
Forced output bit setting	
Forced output bit	0: Invalid

When (ON value) > (OFF value)

Current feed value ≦ 100000.0[μm],
200000.0[μm] < Current feed value

Y0 turns on when the current feed value is 100[mm] or lower or higher than 200[mm].



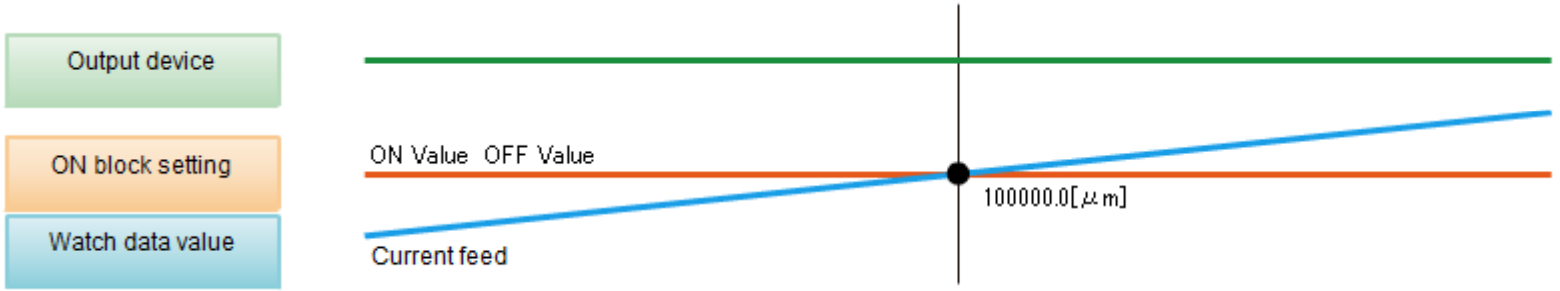
16.1.1 Operation of the limit switch output function

Parameter item	Sample value
Limit output data	
Output device	Y0000
Watch data	
Watch data specification	0: Motion control data
Axis	Axis 1
Name	0: Current feed value
ON block setting	
ON Value	K200000.0L[μm]
OFF Value	K100000.0L[μm]
Enable/disable output bit setting	
Enable/disable output bit	0: Invalid
Forced output bit setting	
Forced output bit	0: Invalid

When (ON value) = (OFF value)

Current feed value = 100000.0[μm]

Y0 is constantly turned off regardless of the current feed value.



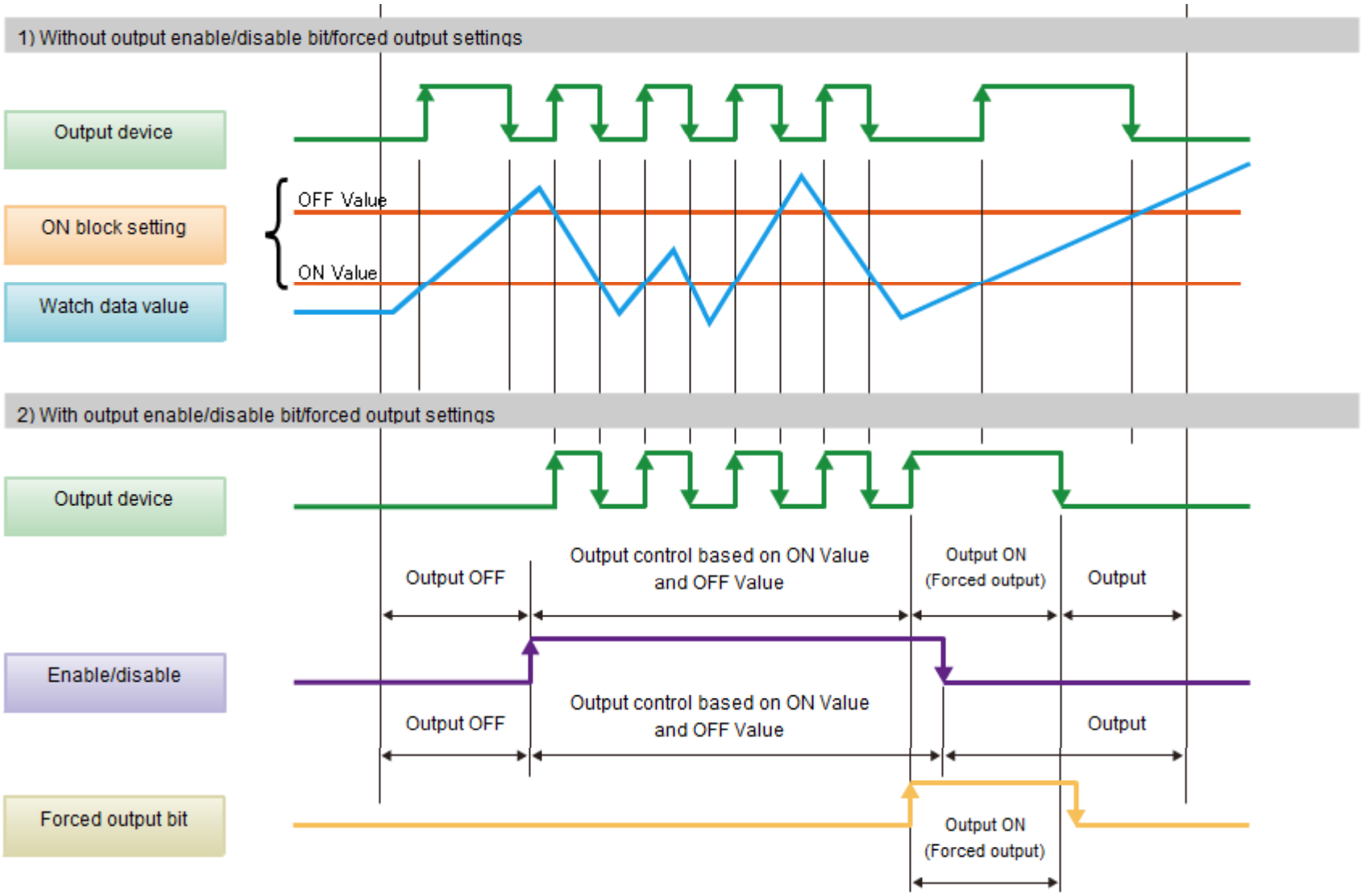
16.1.1 Operation of the limit switch output function

Parameter item	Sample value
Limit output data	
Output device	Y0000
Watch data	
Watch data specification	0: Motion control data
Axis	Axis 1
Name	0: Current feed value
ON block setting	
ON Value	K100000.0L[μm]
OFF Value	K100000.0L[μm]
Enable/disable output bit setting	
Enable/disable output bit	0: Invalid
Forced output bit setting	
Forced output bit	0: Invalid

Logical sum of output results

When the multiple watch data,ON region, output enable/disable bit and forced output bit are set to the same output device, the logical add of output results of the settings is output.

16.1.1 Operation of the limit switch output function



16.1.2 Limit output setting data

The limit output setting data items to be set for the limit switch output function are listed below.
Up to 32 limit output setting data can be created.

Item		Setting range	Description
Output device		Bit device (X, Y, M, B, U□ \ G)	This device outputs the ON/OFF signals for the set watch data.
Watch data		Motion control data, Word device (D, W, #, U□ \ G) (16-bit integer, 32-bit integer, 64-bit floating-point)	Target data for the limit switch output function
ON block	ON Value	Word device (D, W, #, U□ \ G), constant (K, H)	The output device is turned on within this block for the watch data.
	OFF Value		
Enable/disable output bit		Bit device (X, Y, M, B, F, SM, U□ \ G), None: Invalid (default)	The limit switch output is turned off regardless of the watch data value while the setting device is turned off.
Forced output bit		Bit device (X, Y, M, B, F, SM, U□ \ G), None: Invalid (default)	The limit switch output is turned on regardless of the watch data value while the setting device is turned on.

16.2 Address mode clutch

The address mode clutch provides modes to turn on/off the clutch depending on the current address value of the virtual axis (input axis).
Address mode and address mode 2 are available depending on the clutch operation method.
(Refer to the section 13.4.2 for the clutch.)

Advantage of address mode

- Suitable for the clutch of a device requiring high precision
- Suitable for a device repeatedly turning on/off the clutch

Application

- Clutch used with the axis for the running cutter of the sample system (axis repeatedly turning on/off the clutch)

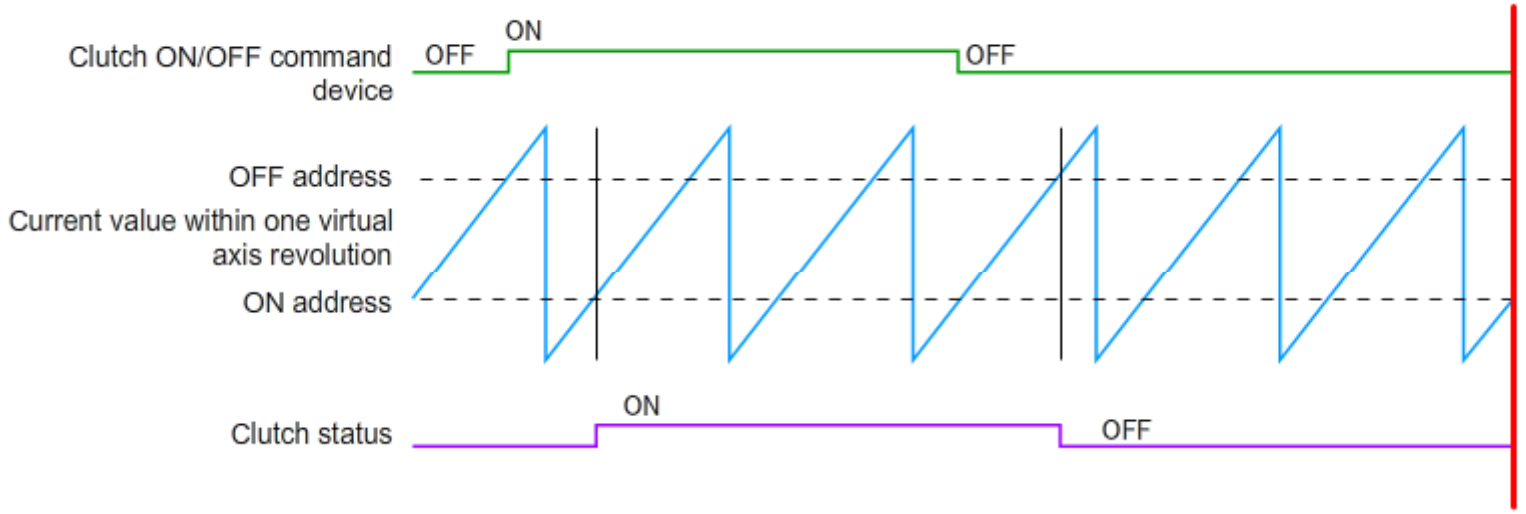
Operation mode	Clutch operation
Address mode	The clutch turns on when the clutch ON/OFF command device is ON and the clutch ON address is reached. The clutch turns on when the clutch ON/OFF command device is OFF and the clutch OFF address is reached.
Address mode 2	While the clutch ON/OFF command device is ON, the clutch turns on and off according to the clutch ON/OFF address. The clutch turns off when the clutch ON/OFF command device switches from ON to OFF.

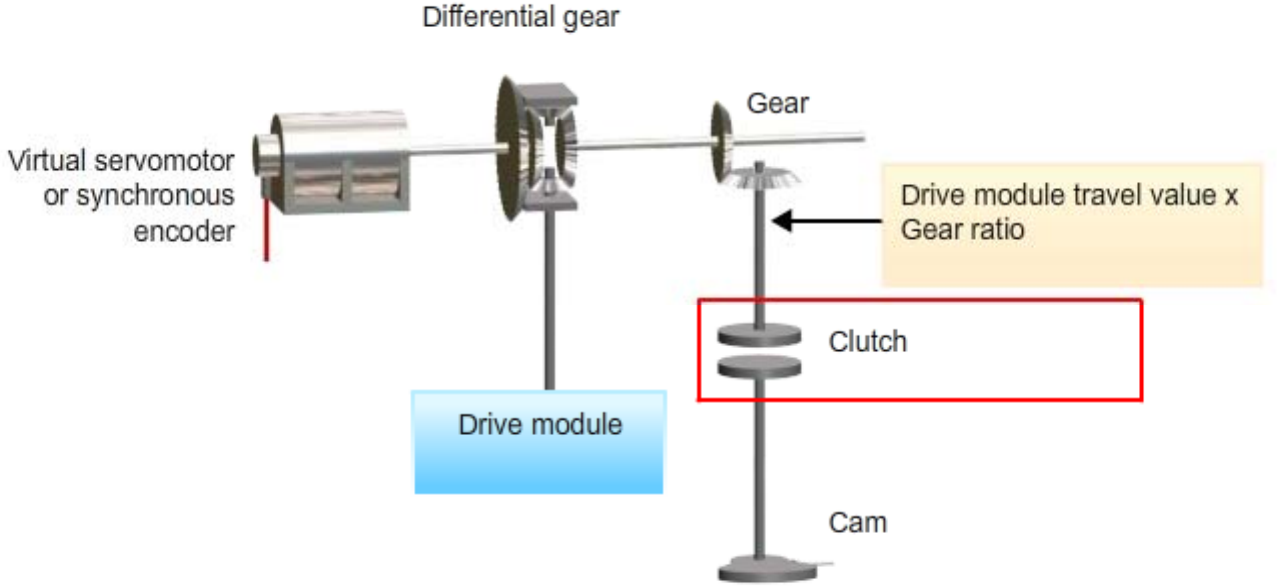
The value of the clutch ON/OFF address setting device is the current value of the virtual axis or the current value within one virtual axis revolution, depending on the output module.

Ball screw or roller	Differential gear
• Current value of virtual axis When the differential gear is connected to the main shaft, the current value of the main shaft is after the differential gear	• Current value within one virtual axis revolution (Drive module travel value x Gear ratio % NC) %: Multiplication and division operator, NC: Number of pulses per one cam axis revolution

16.2.1 Address mode

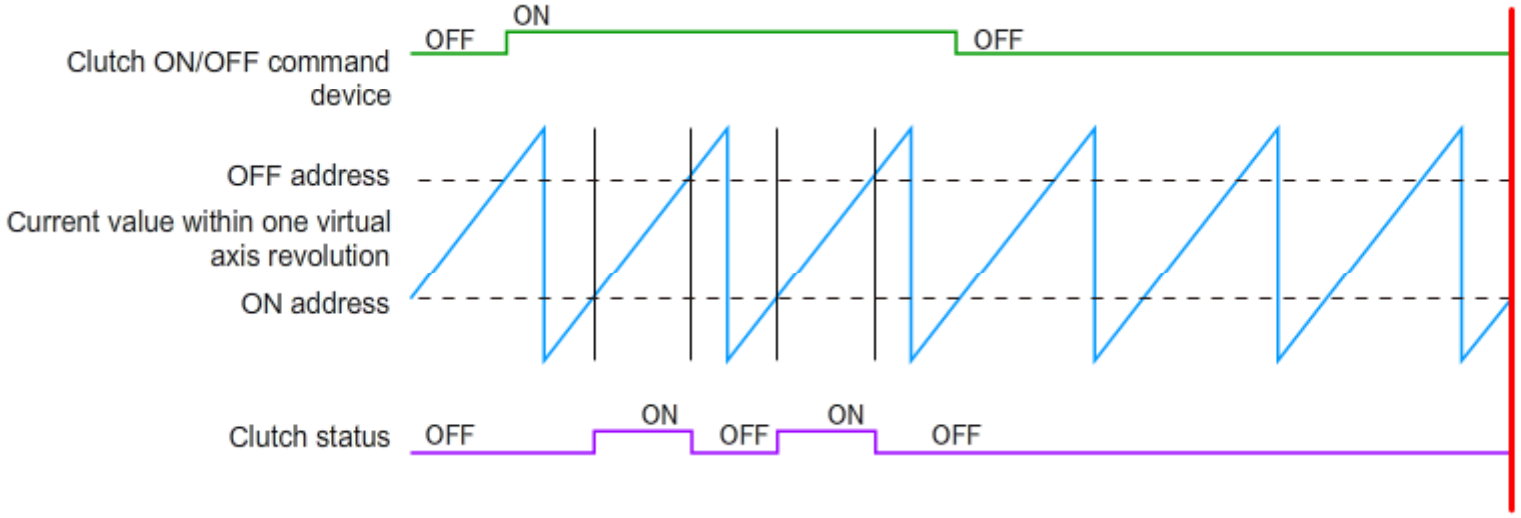
An example of the address mode operation is shown below.
This example uses the cam as the output module.

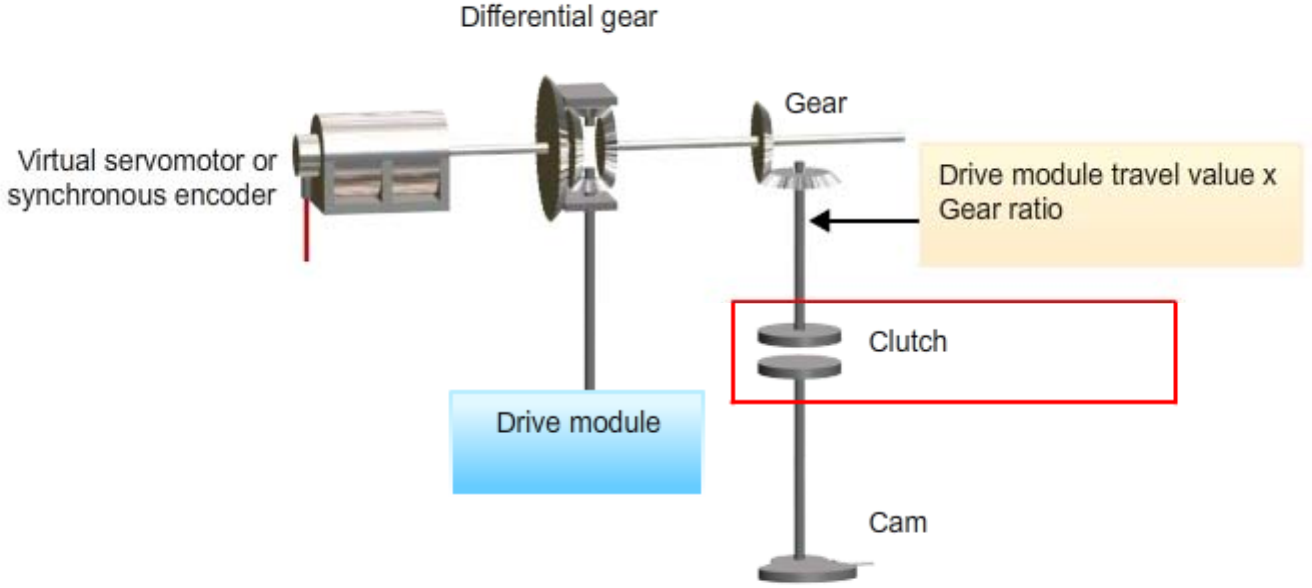




16.2.2 Address mode 2

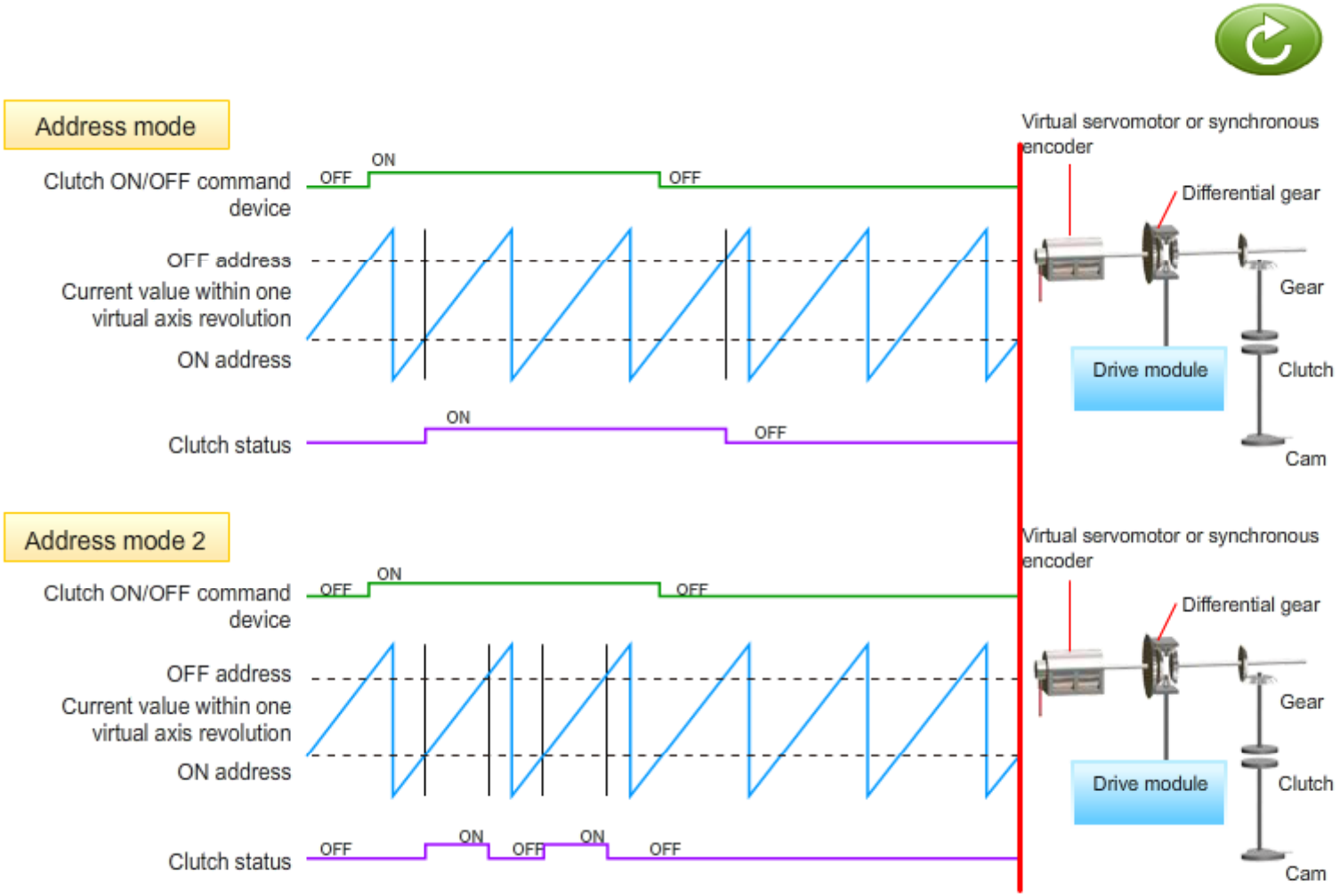
An example of the address mode 2 operation is shown below.
This example uses the cam as the output module.





16.2.3 Comparison between address mode and address mode 2

The figure below compares the address mode and address mode 2.

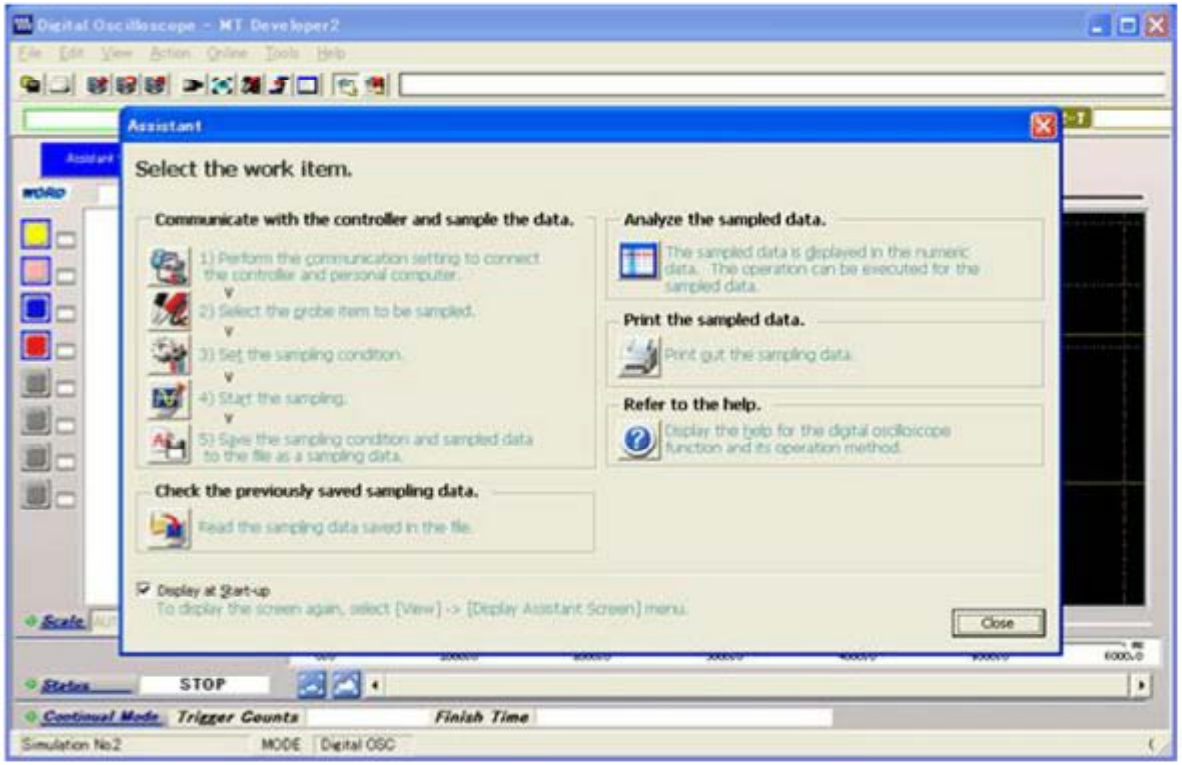


16.3 Digital Oscilloscope

The digital oscilloscope emulates the oscilloscope functionality on software and is used to adjust and analyze the status of the motion controller system.

This function allows for using the oscilloscope functionality without preparing a physical oscilloscope.

It is ideal for analysis upon startup of a system or during the occurrence of a failure because it displays the control status of the motion system by waveforms.

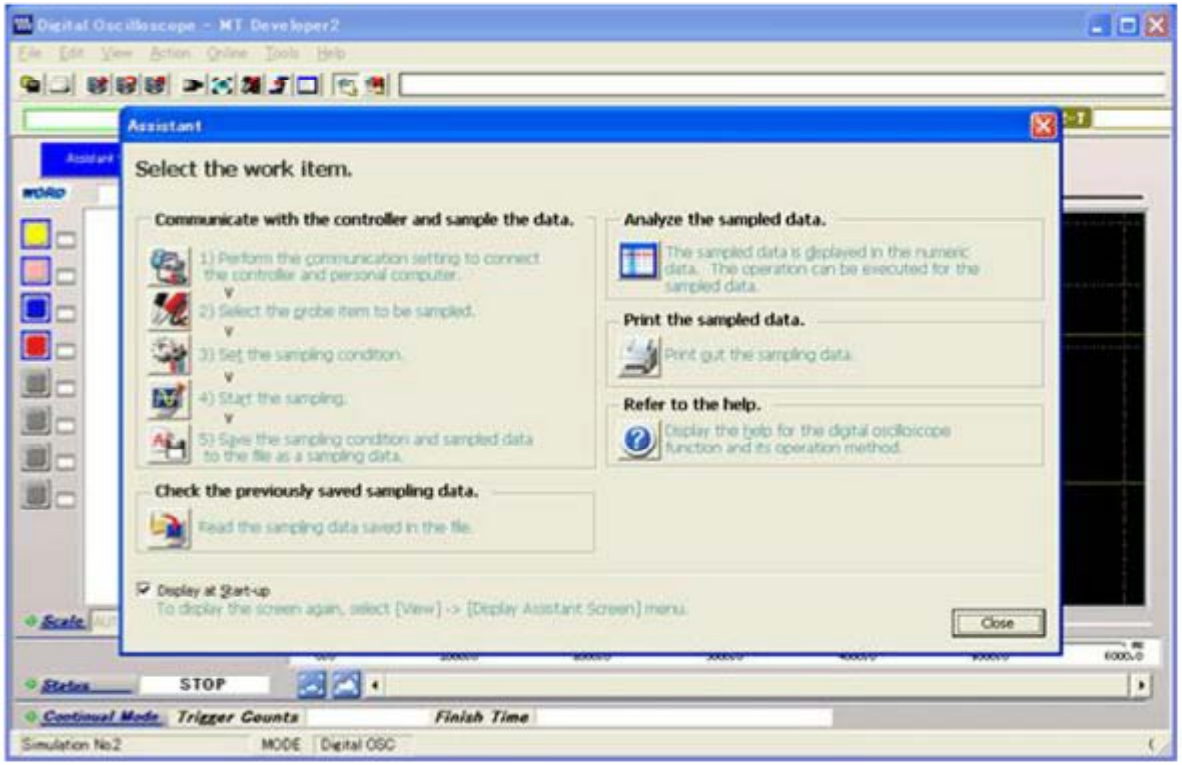


16.3.1 How to use the digital oscilloscope

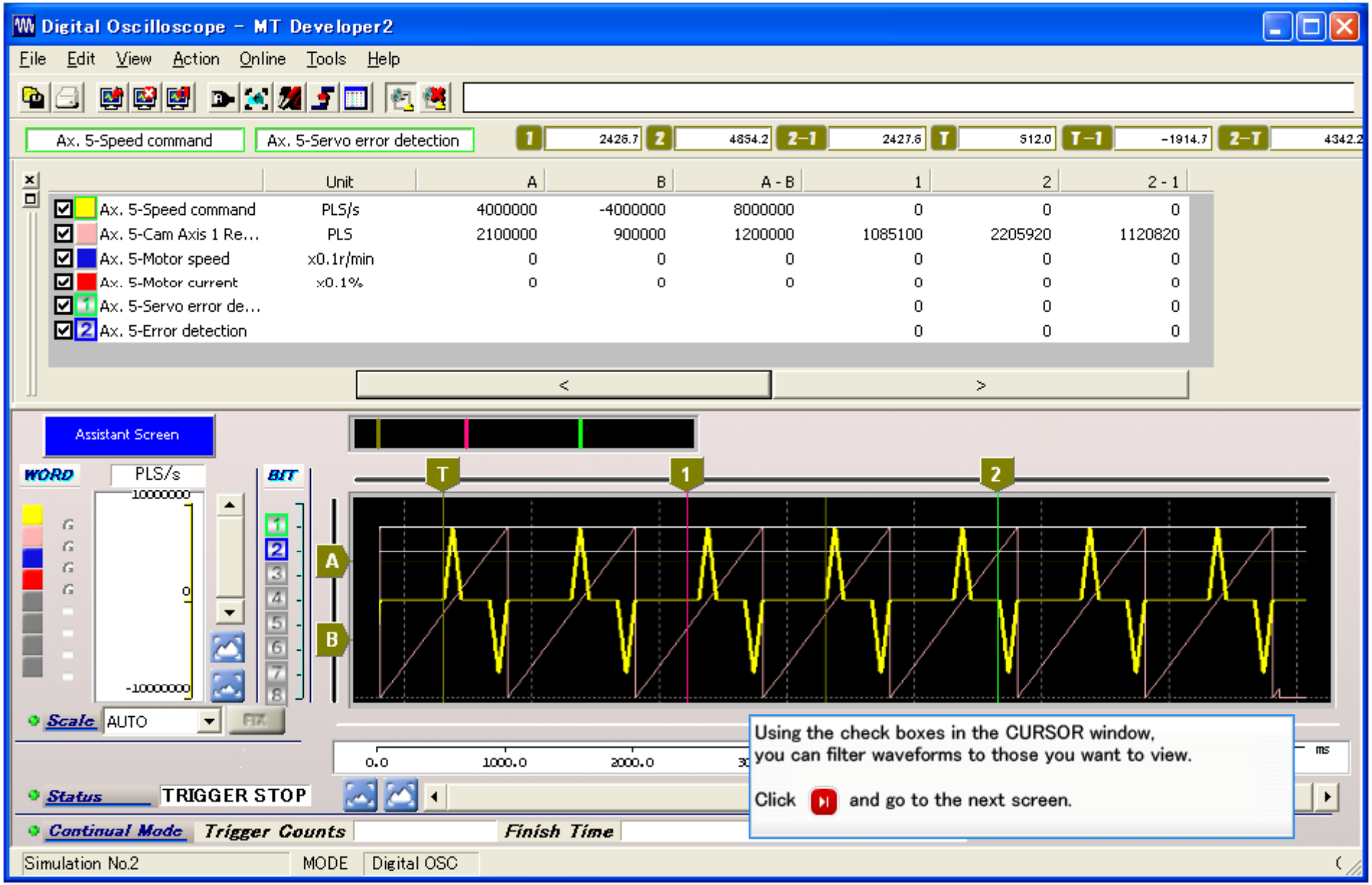
The digital oscilloscope is a function of MT Developer2.
Now we confirm how to use the digital oscilloscope.

Go to the next page.

You will configure the digital oscilloscope using MT Developer2.
(You can simulate the software.)



16.3.1 How to use the digital oscilloscope



16.4 Summary

In this chapter, you have learned:

- Limit switch output function
- Clutch operation mode (Address mode)
- Digital oscilloscope

Important points

The contents you learned in this chapter are listed below.

Limit switch output function	This function turns on the output device while the watch data value is within the ON output block.
Clutch operation mode (Address mode)	This mode turns on/off the clutch according to the current value of the virtual axis or the current value within one virtual axis revolution.
Digital oscilloscope	This software emulates a physical oscilloscope.

Test Final Test

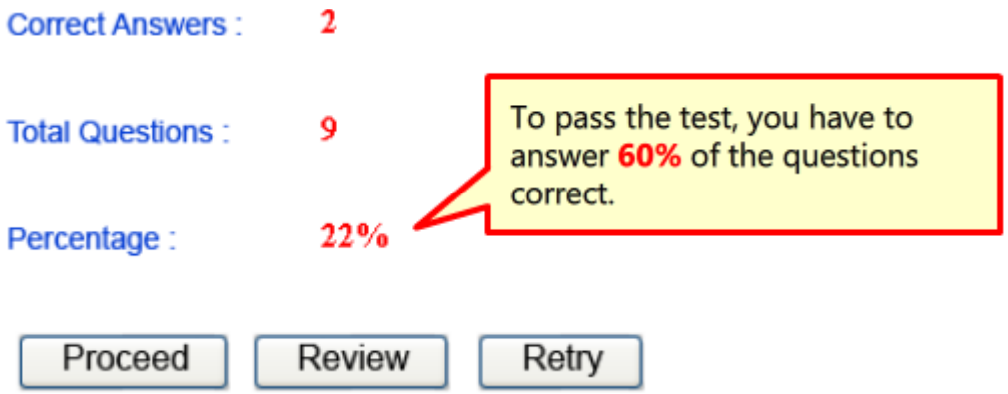
Now that you have completed all of the lessons of the MOTION CONTROLLER Application (Virtual Mode) Course, you are ready to take the final test.
If you are unclear on any of the topics covered, please take this opportunity to review those topics.
There are a total of 10 questions (32 items) in this Final 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.



- 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.

Test Final Test 1

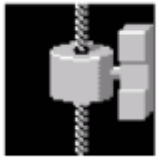
Select the motion OS software that supports the virtual mode.

- ○ Conveyor assembly use (SV13)
- ○ Automatic machinery use (SV22)
- ○ Machine tool peripheral use (SV43)

Answer Back

Test Final Test 2

Select the functions of the configuration components (such as step, transition) used in a motion SFC program.

Mechanical module		Function description
Appearance	Name	
		Used to drive the mechanical system program's virtual axis by servo program or JOG operation.
		Used to adjust the rotation ratio and direction according to the travel value (pulse) input from the drive module.
		Used to change the speed of the output module during operation.
		Used to carry out linear positioning control of the machine connected to the servomotor.

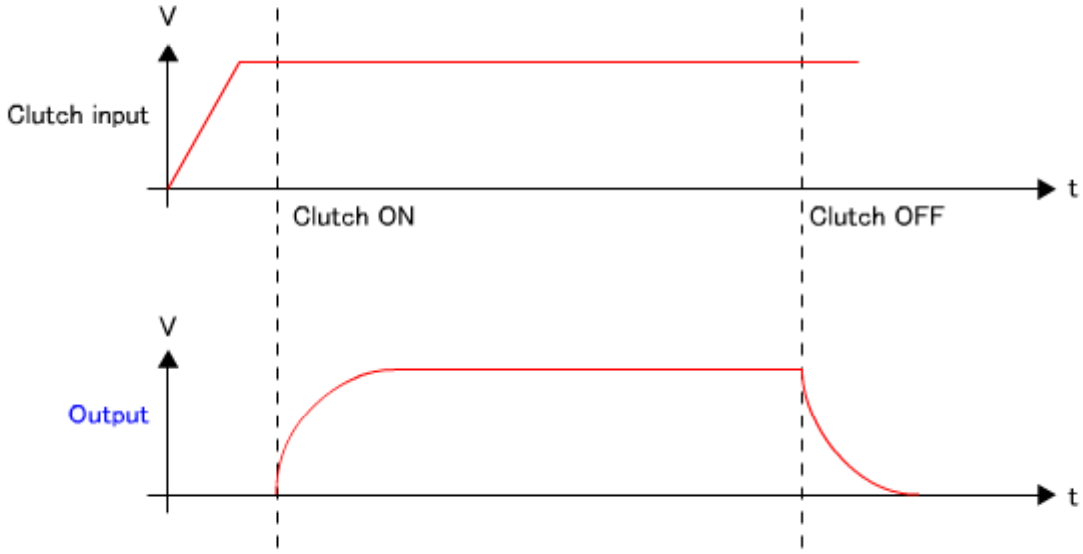
Name

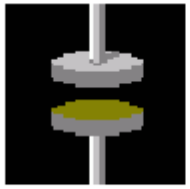
1. Virtual servomotor
2. Synchronous encoder
3. Gear
4. Clutch
5. Speed change gear
6. Roller
7. Ball screw
8. Cam

Answer Back

Test Final Test 3

The graphs below shows the relationship between clutch input and output. Select the clutch suitable for this type of control.





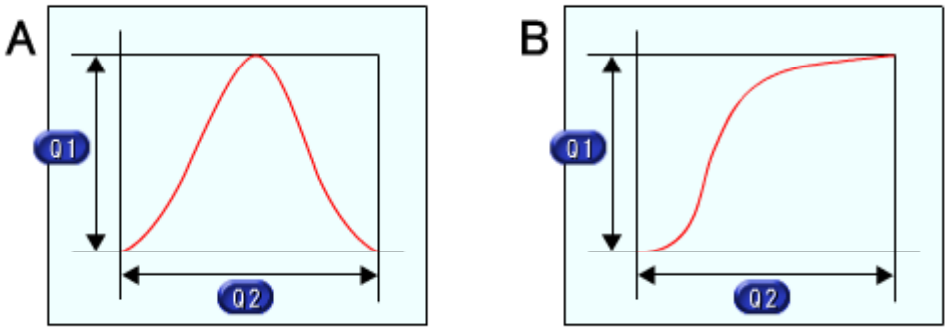
○ Smoothing clutch

○ Direct clutch

Answer Back

Test Final Test 4

Select the 3 processes which should be executed before the positioning control when designing a motion SFC program.



- A cam patterns are indicated in the above graphs. Select the correct term to fill Q1 and Q2 in the graph.

Q1 --Select-- Q2 --Select--

- Select the correct cam pattern set in the feed cam mode from the above graph A and B.

Q3

Answer Back

Test Final Test 5

Answer the questions below.

● Select the correct term to fill Q1to Q4 in the following descriptions from 1 to 7 in the lower box.

Present feed value = Lower stroke limit value + [Q1] * Stroke ratio

The number of pulses required to rotate the cam through one cycle is [Q2]

[Q3] is the setting determines the number of index divisions in one cycle.

[Q4] and stroke amount are set, and turn a REAL/VIRTUAL mode switching request flag (M2043) ON.

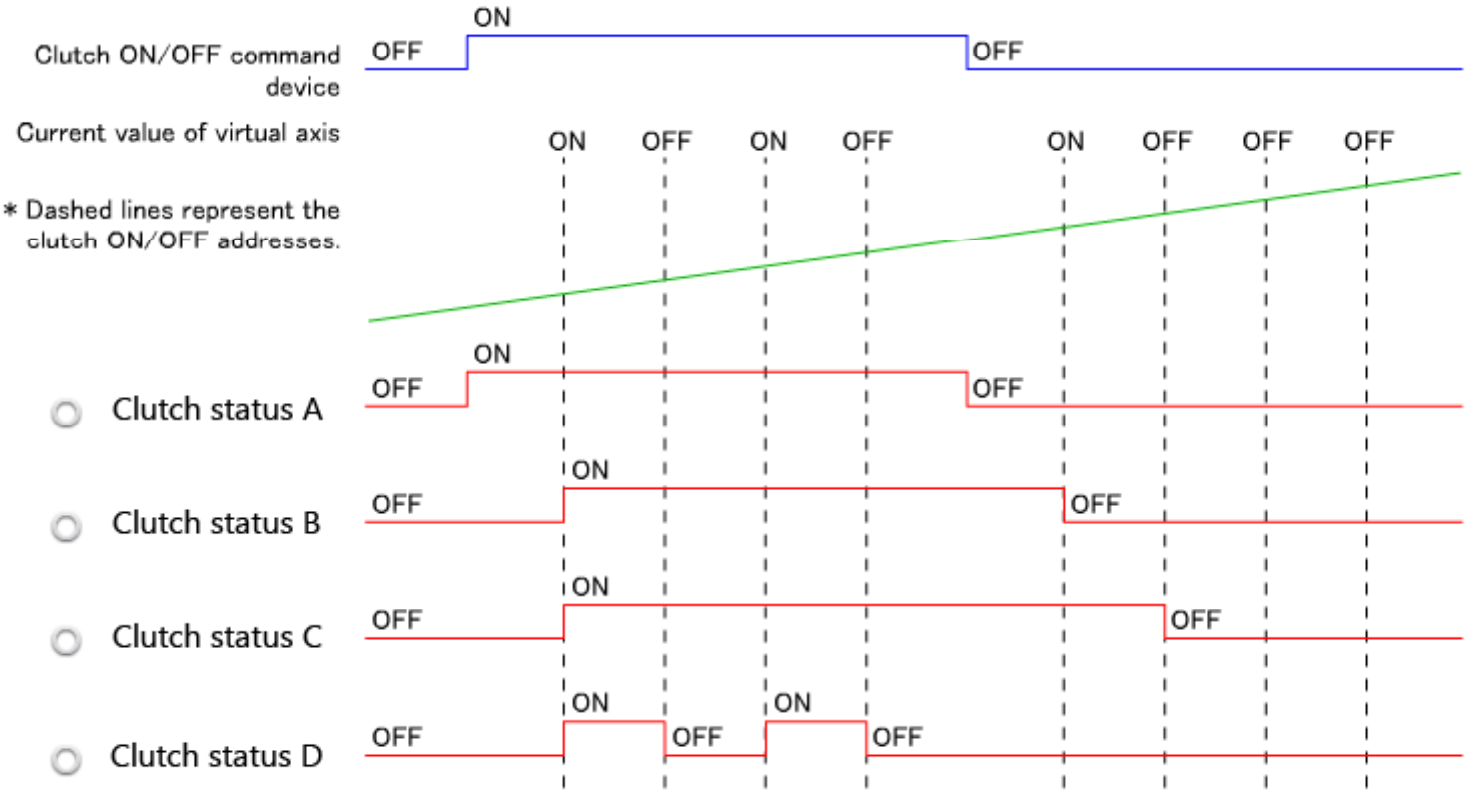
Terms

1. Stroke amount
2. Number of pulses per cam shaft revolution
3. Cam resolution
4. Stroke ratio
5. Cam No.
6. Operation mode
7. Feed cam mode

Answer Back

Test Final Test 6

When the address mode 2 is set to the address mode clutch, select the correct clutch status with the following clutch ON/OFF command device, virtual axis present value, and the clutch ON/OFF address.



Answer Back

Servo_Motion_Controller_Application(Virtual Mode)_ENG

Test Score

You have completed the Final Test. You results area as follows.
To end the Final Test, proceed to the next page.

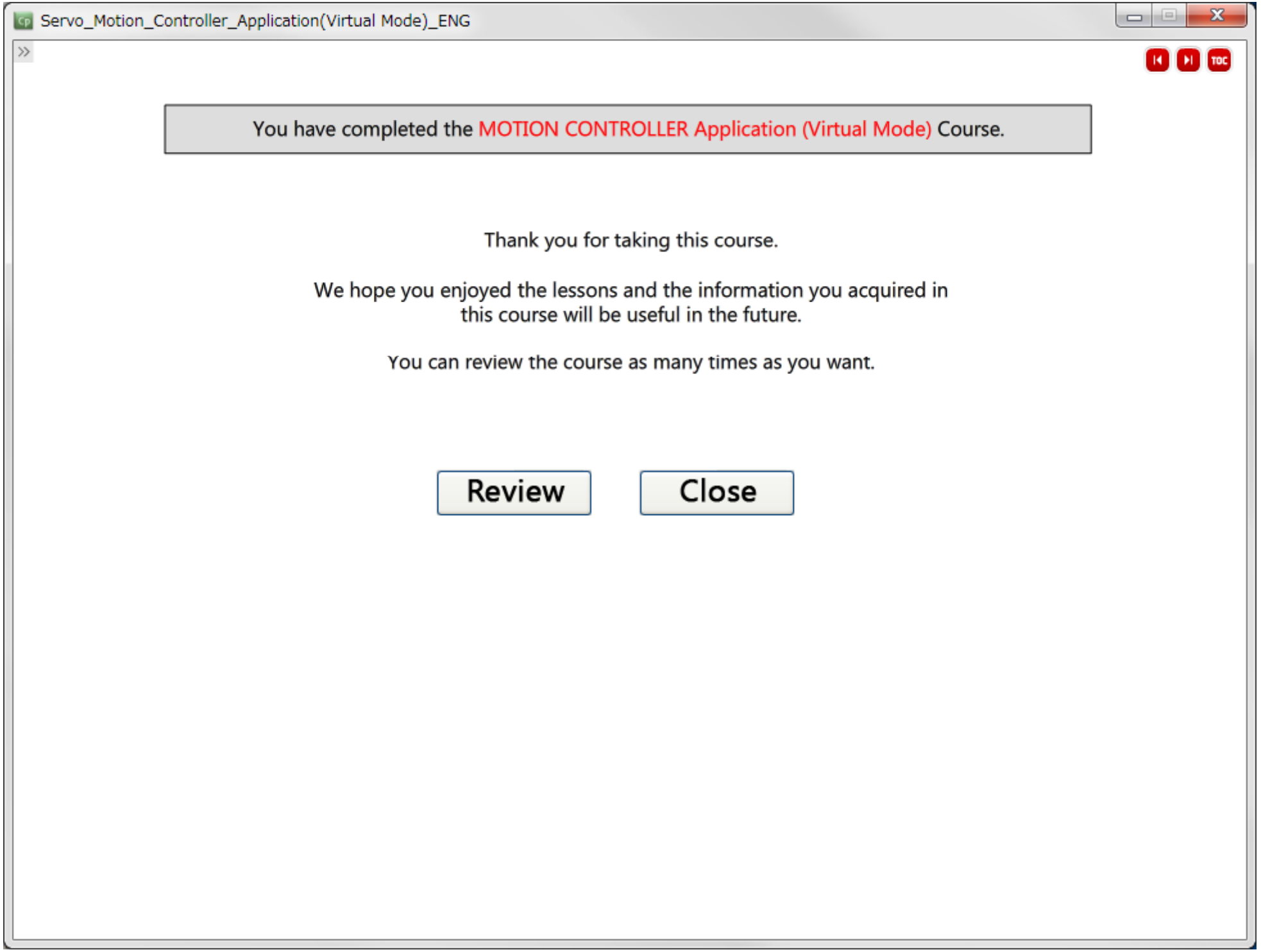
Correct answers : 0

Total questions : 6

Percentage : 0%

Proceed | Review | Retry

You failed the test.


Servo_Motion_Controller_Application(Virtual Mode)_ENG
TOC
You have completed the MOTION CONTROLLER Application (Virtual Mode) 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