HITACHI PROGRAMMABLE AUTOMATION CONTROLLER

HX Series

APPLICATION MANUAL (Motion)

(SERVICE MANUAL)

NJI-650A(X)

○ Warranty period and coverage

The warranty period is the shorter period either 18 months from the date of manufacture or 12 months from the date of installation.

However within the warranty period, the warranty will be void if the fault is due to;

(1) Incorrect use as directed in this manual and the application manual.

(2) Malfunction or failure of external other devices than this unit.

(3) Attempted repair by unauthorized personnel.

(4) Natural disasters.

The warranty is for the PLC only, any damage caused to third party equipment by malfunction of the PLC is not covered by the warranty.

○ Repair

Any examination or repair after the warranty period is not covered. And within the warranty period any repair and examination which results in information showing the fault was caused by any of the items mentioned above, the repair and examination cost are not covered. If you have any questions regarding the warranty please contact with your supplier or the local Hitachi Distributor. (Depending on failure part, examination might be impossible.)

○ Ordering parts or asking questions

When contacting us for repair, ordering parts or inquiring about other items, please have the following details ready before contacting the place of purchase.

(1) Model

(2) Manufacturing number (MFG.NO.)

(3) Details of the malfunction

○ Reader of this manual

This manual is described for the following person.

・Person considering the introduction of PLC
・PLC system engineer
・Person handling PLC
・Manager after installing PLC

Safety Precautions

Read this manual and related documents thoroughly before installing, operating, performing preventive maintenance or performing inspection, and be sure to use the unit correctly. Use this product after acquiring adequate knowledge of the unit, all safety information, and all cautionary information. Also, make sure this manual enters the possession of the chief person in charge of safety maintenance.

Safety caution items are classifies as “Danger” and “Caution” in this document.

DANGER : Cases where if handled incorrectly a dangerous circumstance may be created, resulting in possible death or severe injury.

CAUTION : Cases where if handled incorrectly a dangerous circumstance may be created, resulting in possible minor to medium injury to the body, or only mechanical damage

However, depending on the circumstances, items marked with CAUTION may result in major accidents.

In any case, they both contain important information, so please follow them closely.

Icons for prohibited items and required items are shown blow:

: Indicates prohibited items (items that may not be performed). For example, when open flames are prohibited, is shown.

: Indicates required items (items that must be performed). For example, when grounding must be performed, is shown.

1. Installation

⚠ CAUTION
• Use this product in an environment as described in the catalog and this document. If this product is used in an environment subject to high temperature, high humidity, excessive dust, corrosive gases, vibration or shock, it may result in electric shock, fire or malfunction. • Perform installation according to this manual. If installation is not performed adequately, it may result in dropping, malfunction or an operational error in the unit. • Do not allow foreign objects such as wire chips to enter the unit. They may become the cause of fire, malfunction or failure.

2. Wiring

REQUIRED

- Always perform grounding (FE terminal).
  If grounding is not performed, there is a risk of electric shocks and malfunctions.

⚠ CAUTION

- Connect power supply that meets rating.
  If a power supply that does not meet rating is connected, fire may be caused.
- The wiring operation should be performed by qualified personnel.
  If wiring is performed incorrectly, it may result in fire, damage, or electric shock.

3. Precautions before using

DANGER

- Do not touch the terminals while the power is on.
  There is a risk of electric shock.
- Structure the emergency stop circuit, interlock circuit, etc. outside the programmable controller (hereinafter referred to as PLC).
  Damage to the equipment or accidents may occur due to failure of the PLC.
  However, do not interlock the unit to external load via relay drive power supply of the relay output module.

⚠ CAUTION

- When performing program change, forced output, RUN, STOP, etc., while the unit is running, be sure to verify safety.
  Damage to the equipment or accidents may occur due to operation error.
- Supply power according to the power–up order.
  Damage to the equipment or accidents may occur due to malfunctions.

⚠ CAUTION

DO NOT CONNECT EH-PSD/HX-PSD DIRECTLY TO LINE VOLTAGE. LINE VOLTAGE MUST BE SUPPLIED BY A SUITABLE, APPROVED ISOLATING TRANSFORMER HAVING SHORT CIRCUIT CAPACITY NOT EXCEEDING 150VA MAXIMUM.

4. Preventive maintenance

DANGER
• Do not connect the battery (+) and (-) in reverse. Do not charge, disassemble, heat, place in fire, or short circuit the battery. There is a risk of explosion or fire.

PROHIBITED
• Do not disassemble or modify the unit. Electric shock, malfunction or failure may result.

CAUTION
• Turn off the power supply before removing or attaching module/unit. Electric shock, malfunction or failure may result.

Revision History

No.	Description of revision	Date of revision	Manual number
1	The first edition	2018.1	NJI-650(X)
2	CNC model added. Chapter layout revised.	2018.9	NJI-650A(X)

Table of Contents

MEMO

Chapter 1 Introduction of SoftMotion

1.1 Features

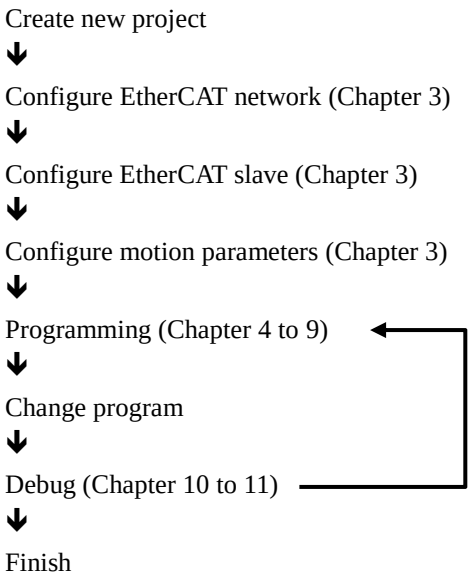
The HX-series CPU module (hereinafter called HX-CPU) supports SoftMotion functionality with built-in Ethernet port configured as EtherCAT master. Variety of motion controls such as single axis positioning, synchronous control with electronic cam, speed control, torque control can be performed. The commands for motion control are basically standard function blocks defined by PLCopen®*.

EtherCAT slaves of servo drives supporting CiA402 drive profile can be operated easily without users considering status word, control word, mode register and other mapping parameters.

* PLCopen is a worldwide association to standardize global standard IEC61131-3. Motion control library, safety, XML specification and other standard not defined in IEC61131-3 are defined by PLCopen.

1.2 Steps to Set Up

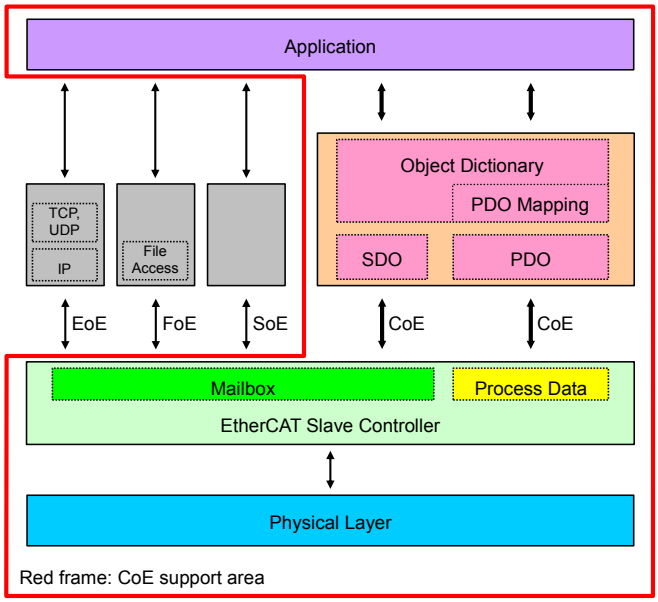
The following steps are required for motion control.



1.3 EtherCAT Communication

1.3.1 EtherCAT Communication Architecture

HX-CPU SoftMotion is to access slave devices in EtherCAT network. Communication protocol for motion control is CAN application protocol over EtherCAT (CoE), and supported profile is IEC61800-7 (CiA402). EtherCAT architecture is shown in the block diagram below.



CoE support area

1.3.2 CoE Profile

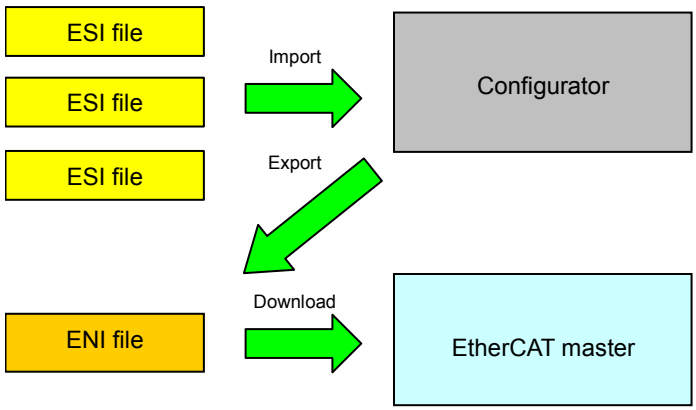
2 types of communication are defined in CoE. The one is PDO (process data object) and the other is SDO (service data object). PDO is cyclic communication to object dictionary which can be mapped as PDO. SDO is non-cyclic message communication to whole the object dictionary.

PDO: From application view point, data is accessed in cyclic as variables (I/O) mapped in PDO mapping table.

SDO: From application view point, data is accessed by special function block in user program or by startup parameters (as initial values).

1.3.3 ESI File

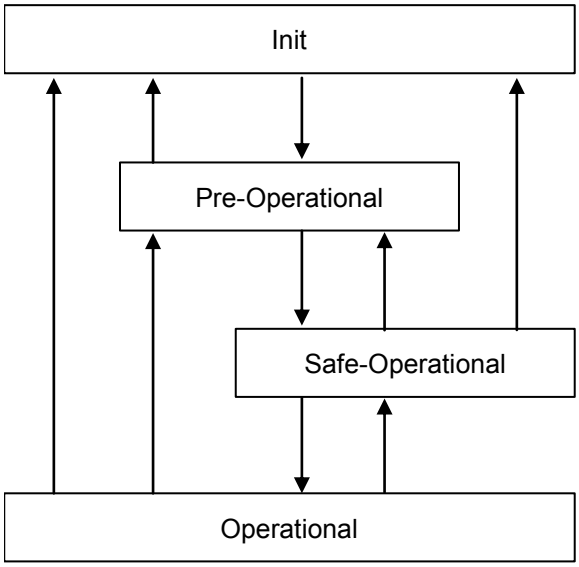
Vendor name, device group, PDO mapping, sync manager and other parameters of the EtherCAT® slave are defined in ESI (EtherCAT Slave Information). When ESI file is installed in configurator (HX-CODESYS), ENI file having network information is created, which will be downloaded to the EtherCAT master.



ESI file

1.3.4 EtherCAT State Machine

EtherCAT slaves follow ESM (EtherCAT State Machine), which is controlled by an EtherCAT master. Availability of PDO and SDO are defined according to ESM.



State transitions

Available communication

Status	Description	SDO	PDO
Init	Under initialization of communication. No service is available.	-	-
Pre-Operational	Only SDO is available. After initialization completed, the state goes to pre-operational mode.	✓	-
Safe-Operational	Besides SDO communication, input of PDO communication is available. If an error is found in operational mode, the state goes to safe-operational mode.	✓	✓ (input only)
Operational	Normal communication state. Input and output of PDO communication are available.	✓	✓

1.3.5 Differences Between Motion and CNC Motion

The following table shows the main differences between motion and CNC motion features.

Category			Motion (HX-CP1S08M)	CNC Motion (HX-CP1H16M)
PLCopen	PLCopen FB part 1 & 2 (&3*)		●	●
	PLCopen FB part 4		-	●
Operation	Multi-axis control		●	●
	Linear/circular interpolation		-	●
	Coordinated control	Master/slave	●	●
		Axis group	-	●
	Robot control		-	●
Programming	IEC language		●	●
	G-code		-	●
	Cam editor		●	●
	CNC editor		-	●
Library name	SM3_Basic		●	●
	SM3_CNC		-	●
	SM3_Robotics		-	●

* PLCopen FB Part 3 is users guidelines.

Chapter 2 Precautions

If DC (Distributed Clock) is enabled, be sure to follow the instructions below. DC is a function to compensate hardware delay by sharing system clock between a master and all slaves. If slaves do not receive data from master within specified time, slaves stop operation with DC error.

2.1 Project Settings

Be sure to set the following parameters according to your system configuration.

2.1.1 DC Cycle Time

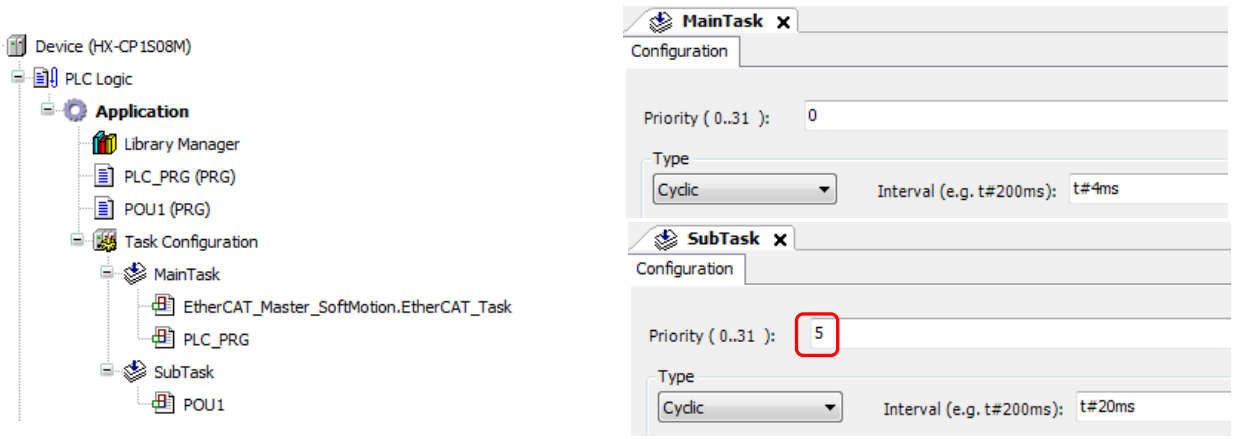
Set appropriate DC cycle time. The table below shows recommended cycle time according to the number of axes, however these values are based on the minimum conditions (small user program without additional communication load such as Modbus). Set appropriate cycle time according to your system configurations.

The number of axes	DC cycle time
1 to 4	2ms
5 to 8	4ms
9 or more	8ms

2.1.2 Priority of Task

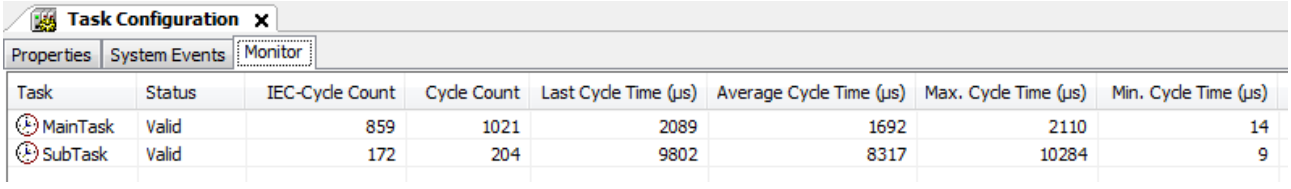
Be sure to set 0 for the EtherCAT task (EtherCAT_Master_SoftMotion.EtherCAT.Task). If the EtherCAT master device is added, it will be allocated under MainTask (priority 0) automatically. If 2 or more tasks exist, it will be allocated under the task located at the top. POU handling motion control should be executed by the EtherCAT task.

Other programs than motion control and time consuming programs should be separated from motion control and executed by lower priority task than MainTask. Set priority 5 or lower (5 to 31) to this task. In the figure below, SubTask with priority 5 is added and POU1 is assigned.



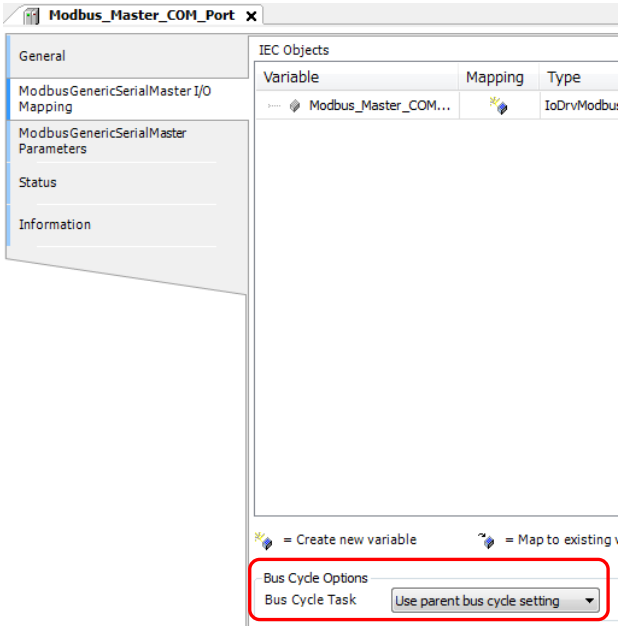
Task Cycle Time

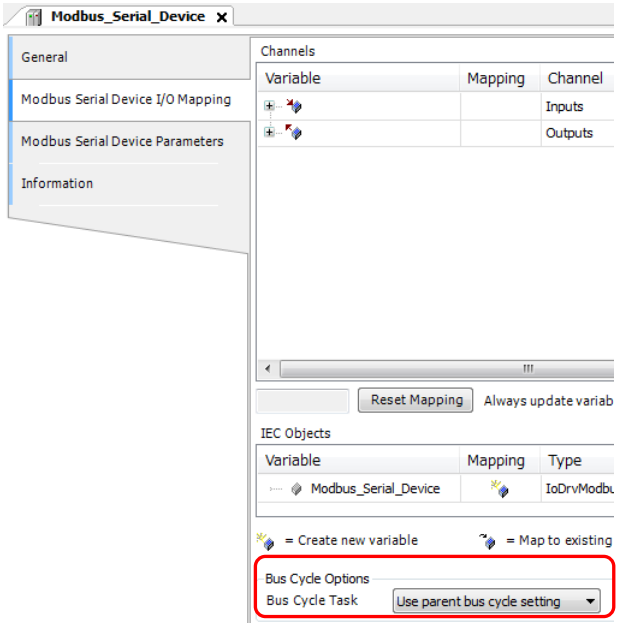
Actual cycle time of each task can be monitored in [Task Configuration]. Double-click [Task Configuration] in device tree and choose [Monitor] tab.



CAUTION

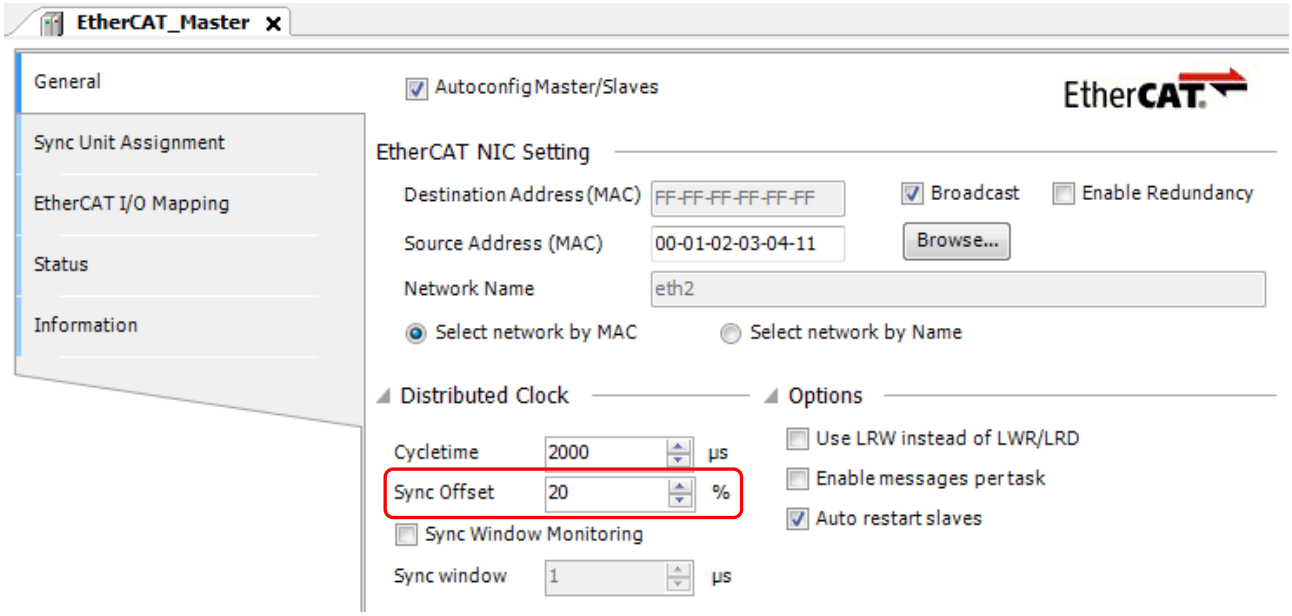
If you use Modbus-RTU master or slave, be sure to set priority 5 or lower (5 to 31) to the bus cycle task. If priority 0 to 4 is set, motors might stop due to DC synchronization lost. In addition, set 10ms or more to the cycle time (interval), otherwise it may be delayed to receive responses from slaves.
The bus cycle task for Modbus-RTU master and slave are defined as follows. If [Use parent bus cycle setting] is chosen, the shortest cycle task is taken.





2.1.3 Sync Offset

Allowable jitter of EtherCAT frame for DC synchronization can be set in Sync Offset. Default value is 20%. If DC synchronization fails by big jitter, set greater value up to 50%.

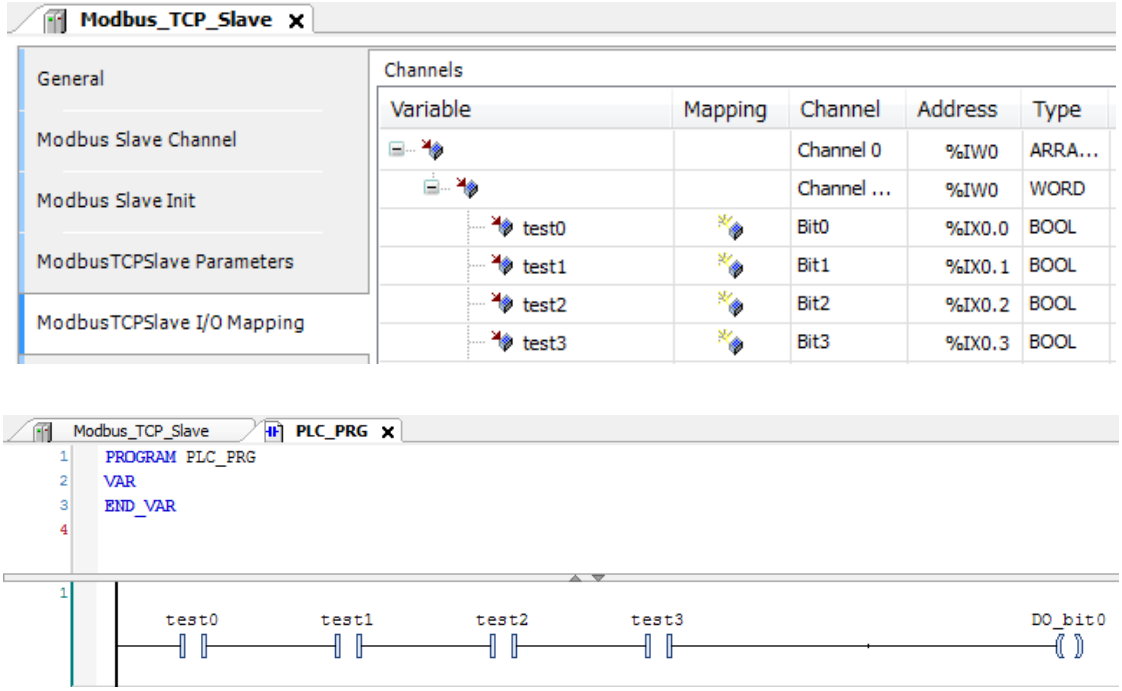


2.1.4 I/O Mapping

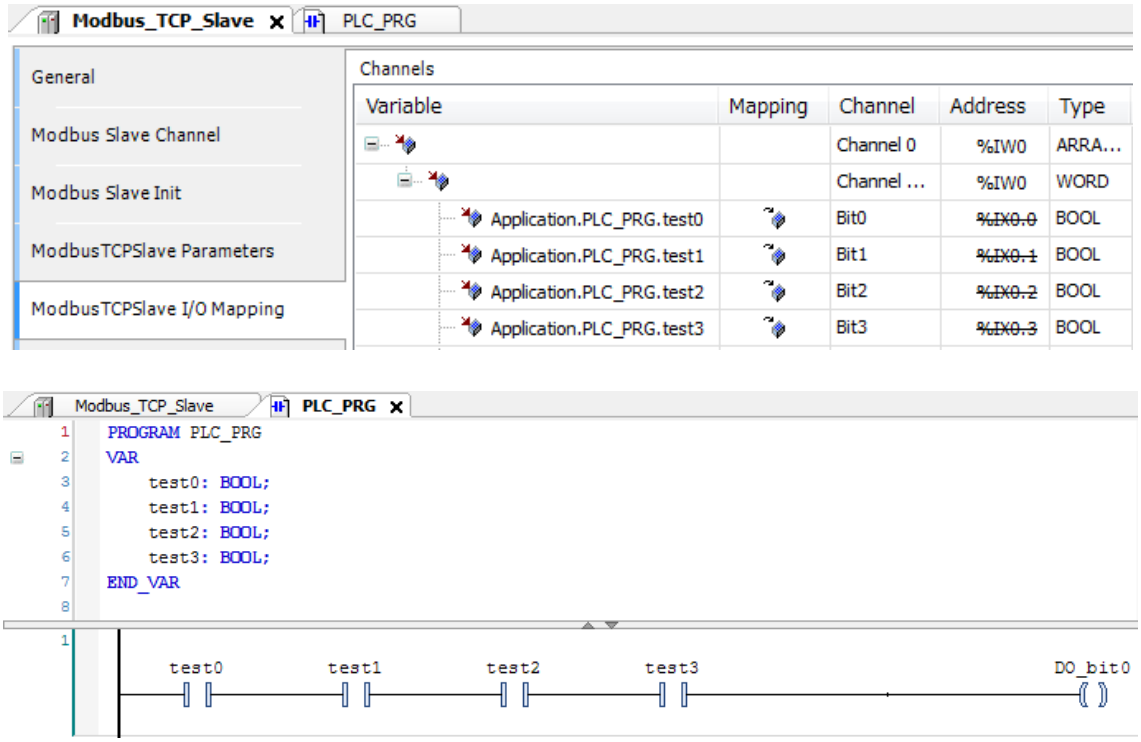
There are 2 different mappings available to access external I/O and Modbus I/O. The one is that variables are directly mapped in mapping table and used in POUs. The other is that variables are declared in POU or GVL and referred from mapping table.

The secondary mentioned mapping could give extra CPU load when online change, which can lead to DC synchronous failure. If this mapping is necessary, do not map more than 200 variables to be referred. If variables over 200 are to be mapped, use direct mapping.

(1) Direct mapping



(2) Declaration in POU/GVL and referred from mapping table



2.2 Restrictions of Function

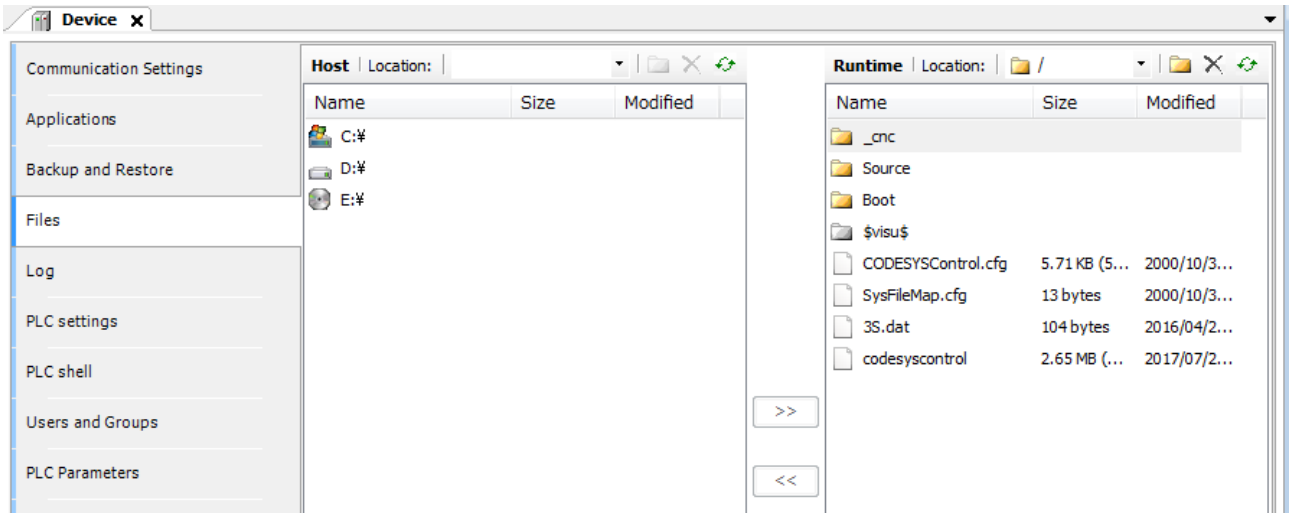
Do not use functions below while PLC is in RUN status, otherwise DC synchronous could fail.

2.2.1 FTP Server

Since FTP server could have heavy load on communication process of CPU, do not use it when PLC is in RUN status. If it is necessary to use while CPU running, use it only when drives are stopping.

2.2.2 File Transfer

Since file transfer function in [Device]-[File] could have heavy load on communication process of CPU, do not use it when PLC is in RUN status. If it is necessary to use while CPU running, use it only when drives are stopping.

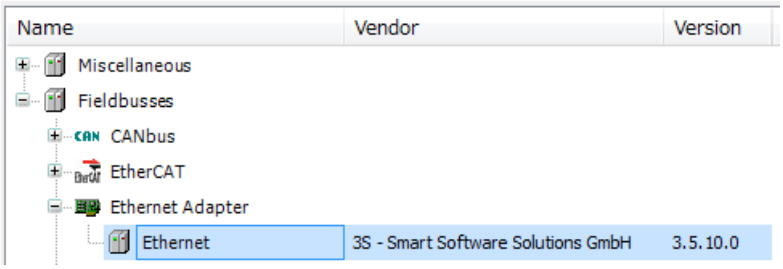


2.3 Restrictions of Configuration

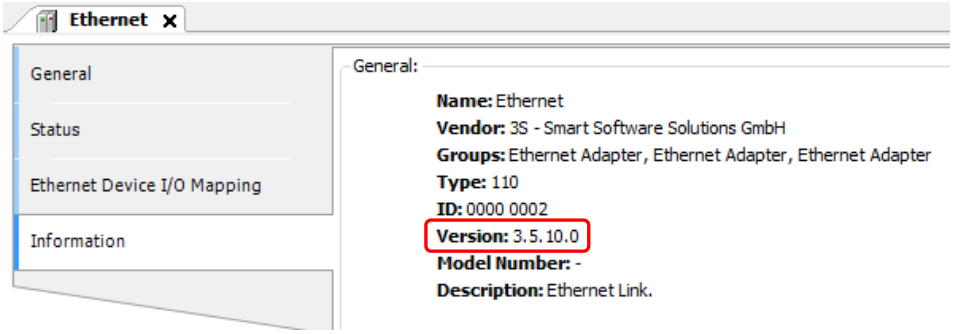
Follow the instruction below, otherwise DC synchronous could fail.

2.3.1 Modbus-TCP Master / Slave

Be sure to use an Ethernet Adapter version 3.5.10.0 or newer. The Ethernet Adapter is required when using Modbus-TCP master or slave.

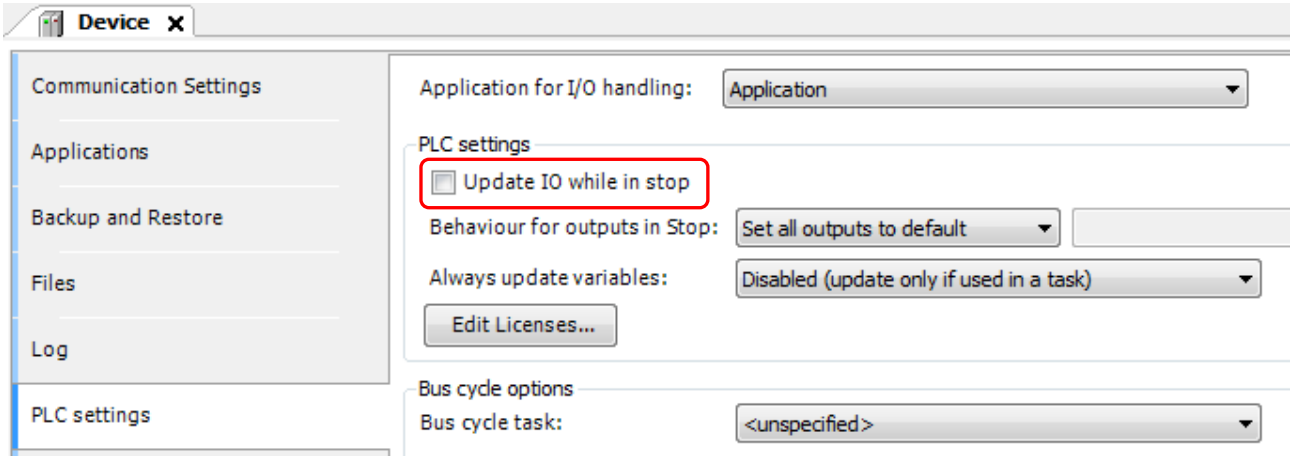


Device version can be seen in [Information] tab.



2.3.2 PLC Settings (Update IO while in stop)

Update IO while in stop of HX-CP1S08M and HX-CP1H16M is disabled as default.



CAUTION

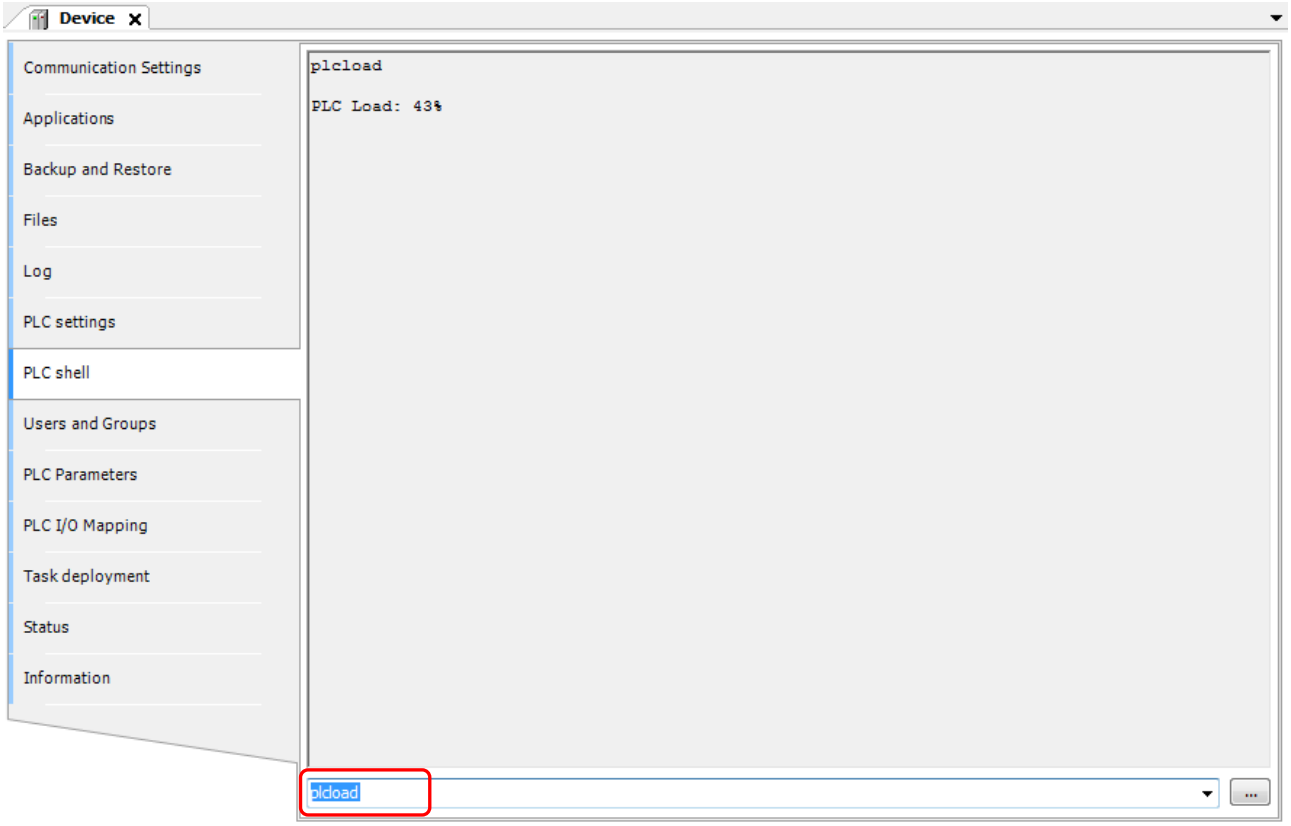
Do not enable this parameter, otherwise drives could move rapidly when reset operation (Reset warm, Reset cold, Reset origin) because target position is reset at that time. If this parameter is to be enabled, be sure to check carefully how drives react on reset operation when the current position is not 0.

2.4 CPU Load

If CPU load exceeds 80%, CPU stops with processor overload exception (error code 25). Check the CPU load as follows and make your application program so as not to exceed 80%.

2.4.1 PLC Shell

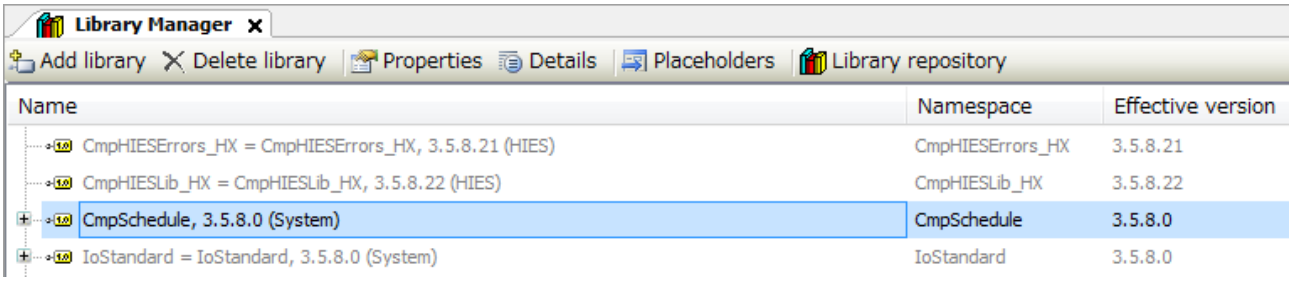
CPU load can be checked manually with PLC shell function of HX-CODESYS. Double-click [Device], choose [PLC shell], type ‘plcload’ in the field at the bottom, and hit [Enter] key. The current CPU load is shown.



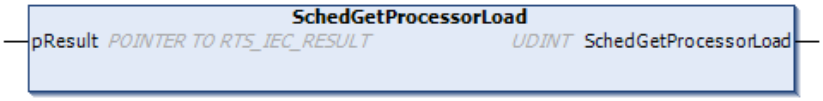
2.4.2 CmpSchedule Library

CPU load can be taken with a special function in your application program. This could be used for warning of CPU load.

(1) Add CmpSchedule library.

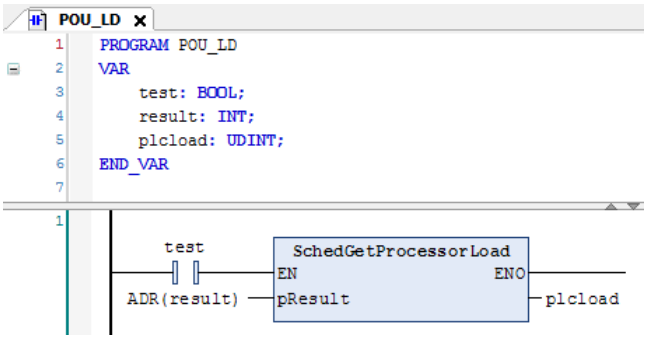


(2) CPU load is taken by output of FUNCTION SchedGetProcessorLoad.

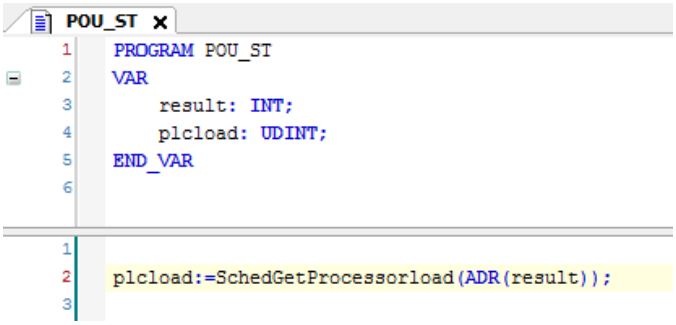


Sample program

FBD/LD



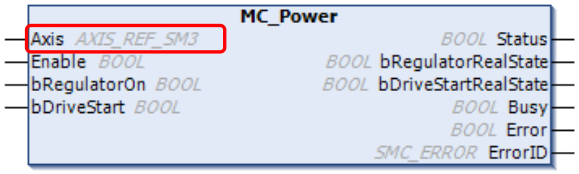
ST



2.5 Other Tips

2.5.1 Data Type of Axis

Data type of axis used in motion FBs is AXIS_REF_SM3 (FB).



The data of AXIS_REF_SM3 members can be monitored however, only variables mapped in PDO can be updated basically. For example, actual position fActPosition is updated in realtime, but actual jerk fActJerk is always 0.

MC_MoveRelative_0	MC_MoveRelative				
Axis	REFERENCE TO AXI...				Reference to axis
wAxisStructID	WORD	65042			
nAxisState	SMC_AXIS_STATE	standstill			State of the axis according to the ``PLCopen..
bRegulatorOn	BOOL	TRUE			Parameter number: 1010
bDriveStart	BOOL	TRUE			Parameter number: 1011
bCommunication	BOOL	TRUE			| ``TRUE``: Communication OK
wCommunicationState	WORD	100			Parameter number: 1013
uiDriveInterfaceError	UINT	0			| Drive interface error number
fSetPosition	LREAL	110.0000152587...			Parameter number: 1100, 1
fActPosition	LREAL	110.0000152587...			Parameter number: 1101
fSetJerk	LREAL	0			Parameter number: 1140
fActJerk	LREAL	0			Parameter number: 1141

2.5.2 Jerk

Jerk is the rate of change of acceleration.

The relation of position, velocity, acceleration and jerk are shown as follows.

The rate of change of position	=	Velocity
The rate of change of velocity	=	Acceleration
The rate of change of acceleration	=	Jerk

Position —Derivative→ Velocity —Derivative→ Acceleration —Derivative→ Jerk

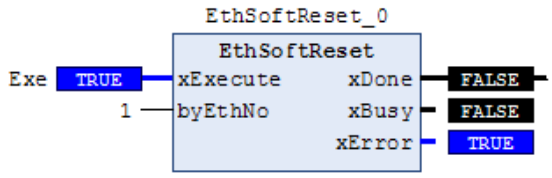
2.5.3 EthSoftReset Command

Function block EthSoftReset in CmpHIESLib_HX library is to reset Ethernet port.

EthSoftReset is to reset a designated Ethernet port in hardware level. If Ethernet port does not work due to hardware reasons, it could restore by executing this function block.

Motion type HX-CPU (HX-CP1S08M) and CNC motion type HX-CPU (HX-CP1H16M) do not support this function block because this FB may affect motion control even if designated port is different from motion control. If executed, xError output will be activated as follows.

Just in case a port is out of control, try to restore by reset warm or power rebooting (CPU stops by reset warm).

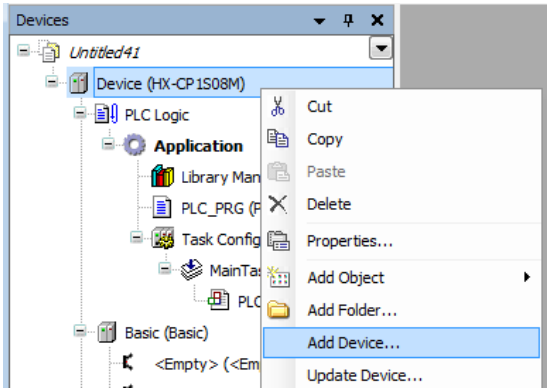


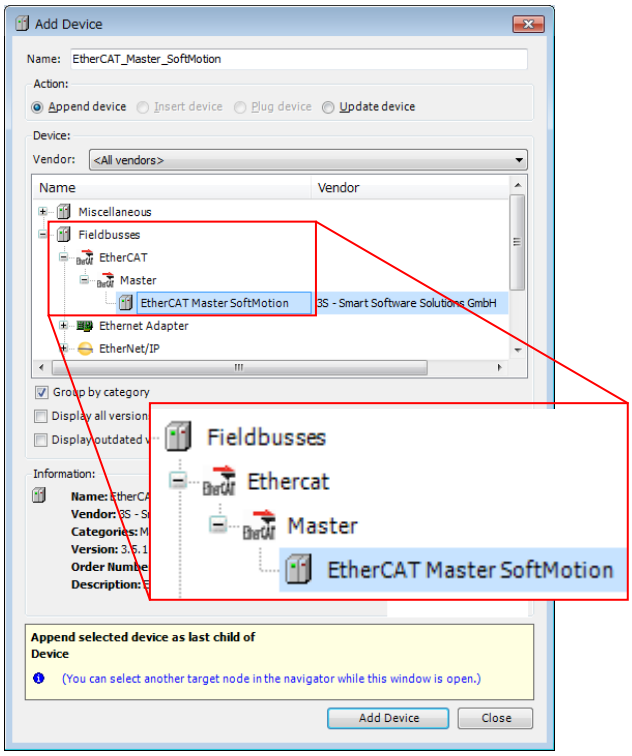
Chapter 3 Configuration of EtherCAT and Motion Axis

3.1 EtherCAT Network

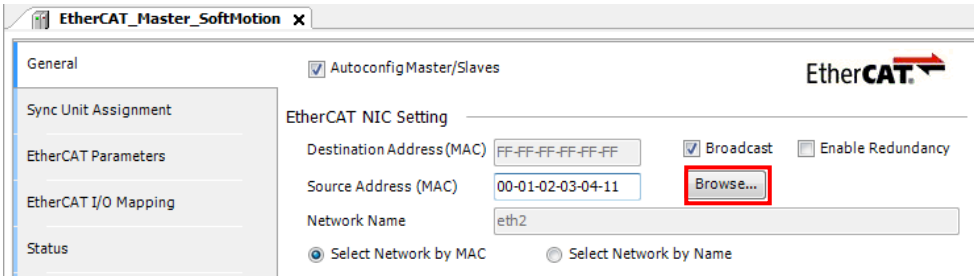
3.1.1 EtherCAT Master

Right-click on [Device] and choose [Add Device...].
[Add Device] window appears.
Click [EtherCAT Master SoftMotion] and
[Add Device] button.

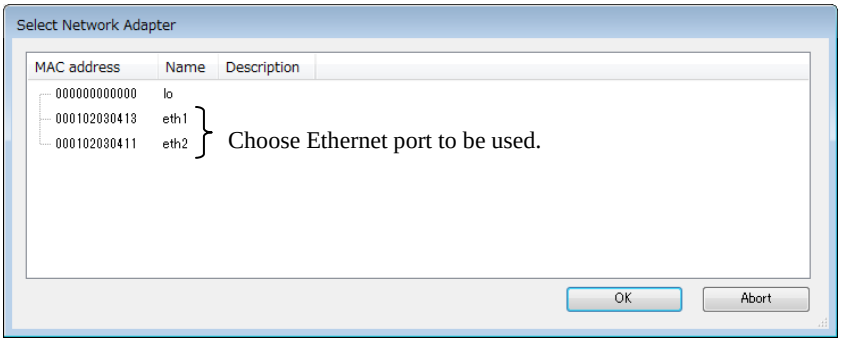




Double click [EtherCAT_Master_SoftMotion (EtherCAT Master SoftMotion)] to configure Ethernet port. After communication between PC and HX-CPU configured, click [Browse...] button and choose Ethernet port for the EtherCAT master.



* [Enable Redundancy] is not supported.

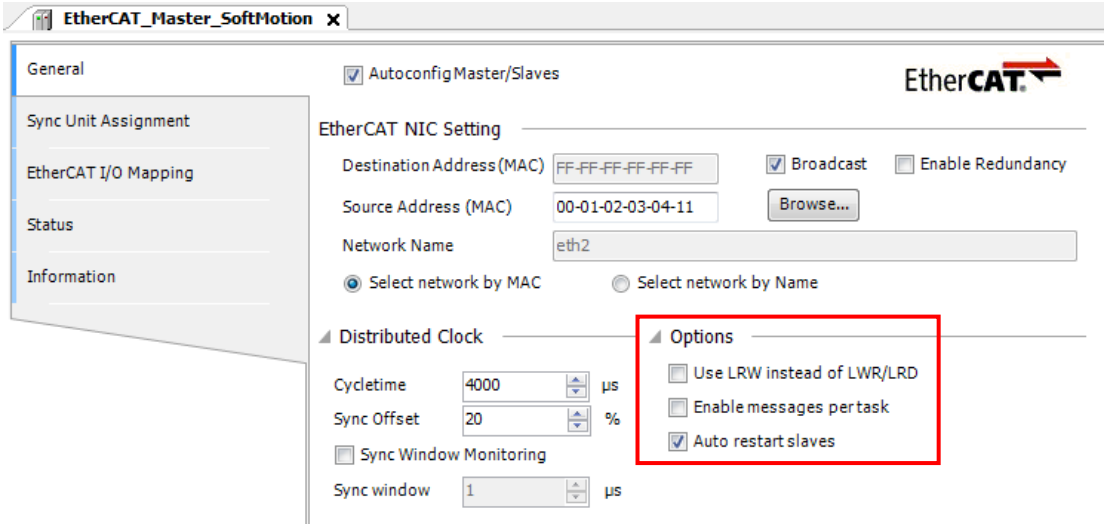


* Be sure to use [eth1] or [eth2] for EtherCAT master.

NOTE

Only one EtherCAT master can be configured per CPU module. If two or more EtherCAT master devices are configured, performance of EtherCAT may be degraded or DC synchronization may be lost.

Click ▷ mark at [Options] to open optional setting parameters.



Use LRW instead of LWR/LRD

Disable: Read command (LRD) and write command (LWR) are used.

Enable: Read/write command (LRW) is used.

If LRW is used, communication efficiency is higher since the packet length is shorter. Be noted some of slave devices may not support LRW command (this information is written in ESI file).

If this parameter is enabled and FMMU (Fieldbus memory management unit) of slave is customized, it is possible to communicate directly between slaves without master control. FMMU setting appears in each slave device by disabling [AutoconfigMaster/Slaves] then enabling [Show generic device configuration views] in [Tool] - [Options] - [Device editor]. Customizing FMMU is for experts only. You don't have to enable this parameter because direct communication between slaves is not used in normal operation with function block.

Enable messages per task

Enable: Variables in PDO mapping are updated by the task of POU instead of EtherCAT task. (e.g. Even if the EtherCAT master is assigned to 4ms task, variable is transferred every 20ms cycle because the POU including this variable is assigned to 20ms task.)

Disable: Variables in PDO mapping are updated by EtherCAT task.

Auto restart slaves

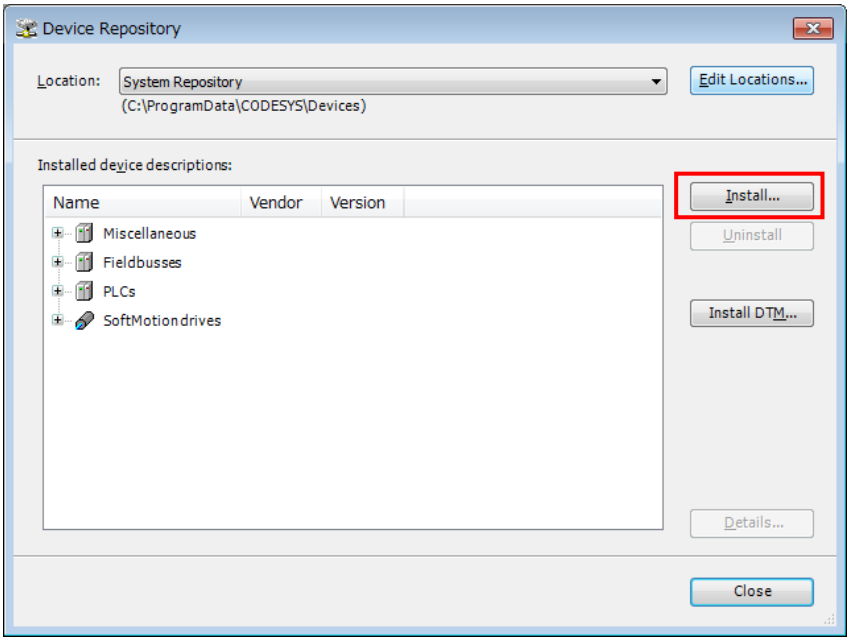
Enable: If communication stops due to cable disconnection or other temporary reasons, communication restarts automatically.

Disable: Once communication stops, it does not restart.

3.1.2 Installation of ESI File

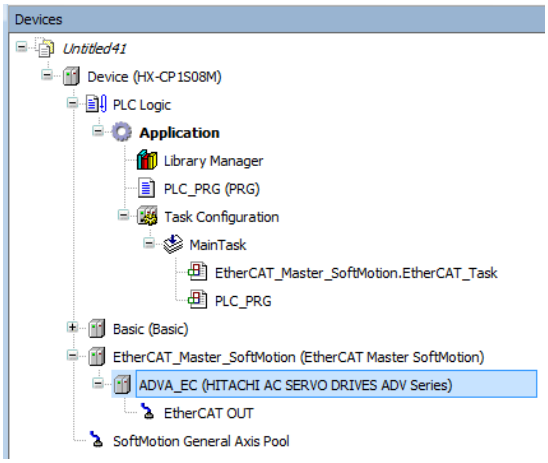
Install the ESI file (EtherCAT Slave Information file) of your EtherCAT slave devices on HX-CODESYS. This installation is required once per PC for every slave device. If you installed before, it is not necessary to install for every new project. The ESI file is provided by slave's vendor.

Choose [Tools]-[Device repository] and click [Install] button. Then new dialog appears to choose file. Click [Open] to install the ESI file.



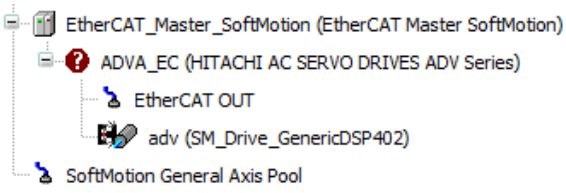
3.1.3 Slave Device

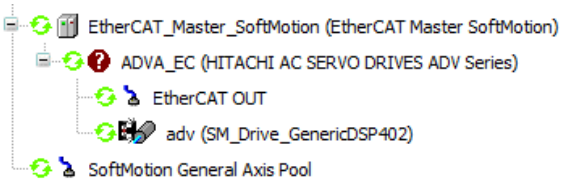
Right-click on [EtherCAT_Master_SoftMotion] and choose [Add Devices...]. Devices of the ESI file installed before are listed in [Add Devices] window. Choose slave devices and click [Add Device] button.



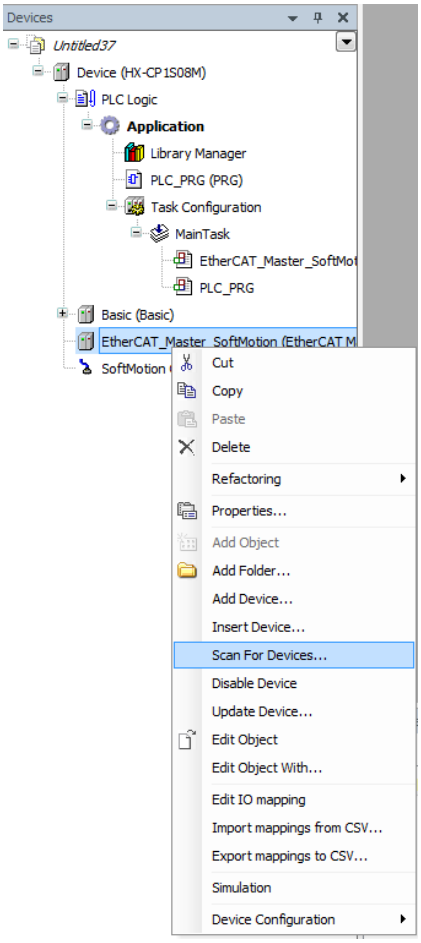
NOTE

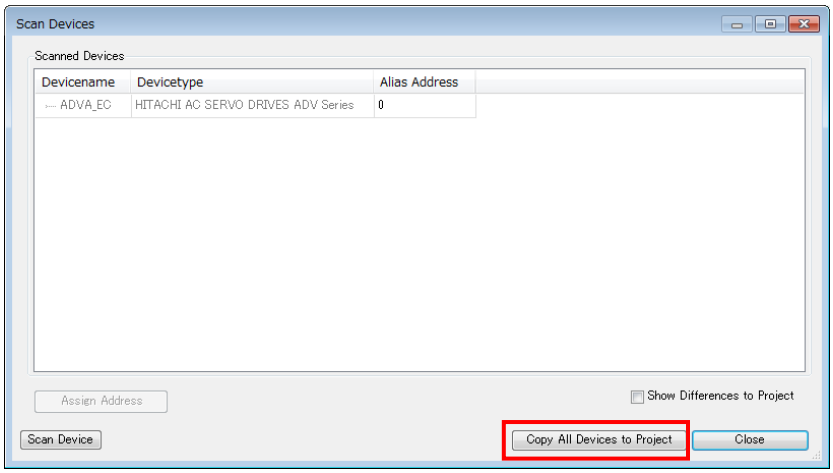
In case right ESI file is configured in the project and the ESI file is not registered in device repository (e.g. project file is opened in another PC than originally created), [?] sign is indicated at the icon as follows however, operation of PLC is no problem because information of ESI file is saved in the project file.



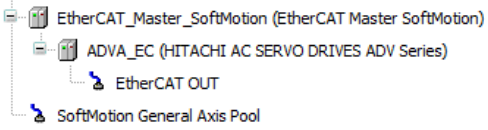


If slave devices are connected to EtherCAT network, configuration data can be read out from the network. This must be done in offline (logout) after online (login) once. Righ-click on [EtherCAT_Master_SoftMotion], choose [Scan for Devices...] and click [Copy All Devices to Project]. Then connected devices will be configured under [EtherCAT Master SoftMotion].



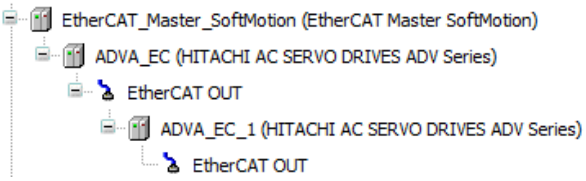


If ESI file for connected slave is not installed, correct device name is not read out properly. In that case, obtain right ESI file from the slave vendor and install it in [Tools]-[Device Repository].



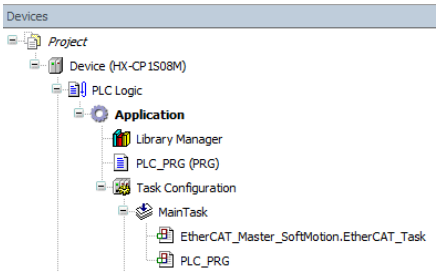
NOTE

If [Scan For Devices] is executed for two or more drives, they will be configured like a tree as the figure below. In this case, SoftMotion axis (SoftMotion CiA402 Axis: refer to section 3.2 Configuration of SoftMotion Axis) cannot be added except for the drive at the bottom. If you use 2 or more drives, configure manually instead of Scan For Devices.

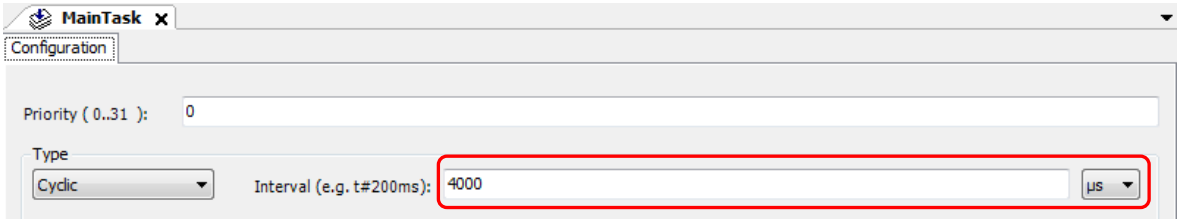


3.1.4 EtherCAT Task Cycle

If the EtherCAT Master Softmotion is added, an object to execute the EtherCAT master will be automatically created under the task located to the top. Double click the task having [EtherCAT_Master_SoftMotion.EtherCAT_Task] (MainTask in case of the picture below) to open configuration window.

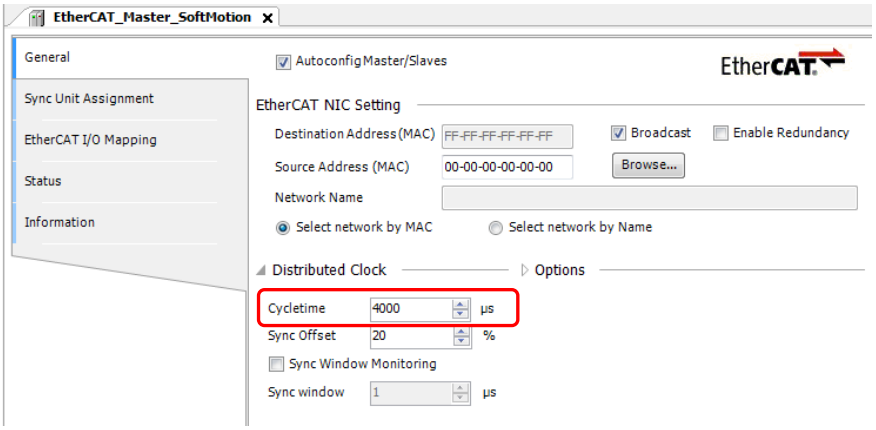


Be sure to set the same cycle time as the cycle time of Distributed Clock to this task.



3.1.5 EtherCAT Distributed Clock (Master)

Distributed Clock, one of the features of EtherCAT, is used in motion control for synchronization between master and slaves in general. The type and enabling/disabling are configured in each slave device however, cycle time is set in master. Double click on [EtherCAT_Master_SoftMotion] and set the cycle time in [General] tab.

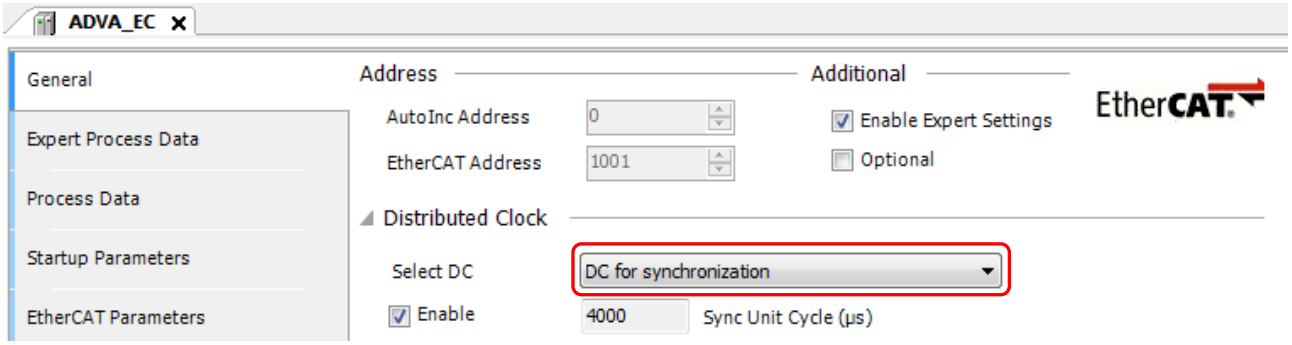


NOTE

- Allowable cycle time of Distributed Clock are 250µs / 500µs / 1ms / 2ms / 4ms / 8ms in general however, it is recommended to use 1 to 8ms for HX-CPU, otherwise drives do not work properly.
- Depending on the number of axes, DC synchronization could be lost. As a reference, set 2ms for 4 axes, and 4ms for 8 axes at minimum.
- If you change DC cycle time of EtherCAT, task cycle time of [EtherCAT_Master_SoftMotion.EtherCAT_Task] is automatically changed. But if you change the task cycle at first, DC cycle time of EtherCAT is not changed.
- If you add the EtherCAT master device, the task cycle of EtherCAT_Master_SoftMotion.EtherCAT_Task is automatically changed to 4000µs.

3.1.6 EtherCAT Distributed Clock (Slave)

Double click on a slave device and configure DC types. The contents of this drop-down menu are different in drives because this information is described in ESI file. Refer to the instruction manual of drives for further information.



3.1.7 Node Address

Two types of addresses, auto increment address and station alias, are available in EtherCAT. The default setting of HX-CODESYS is auto increment address.

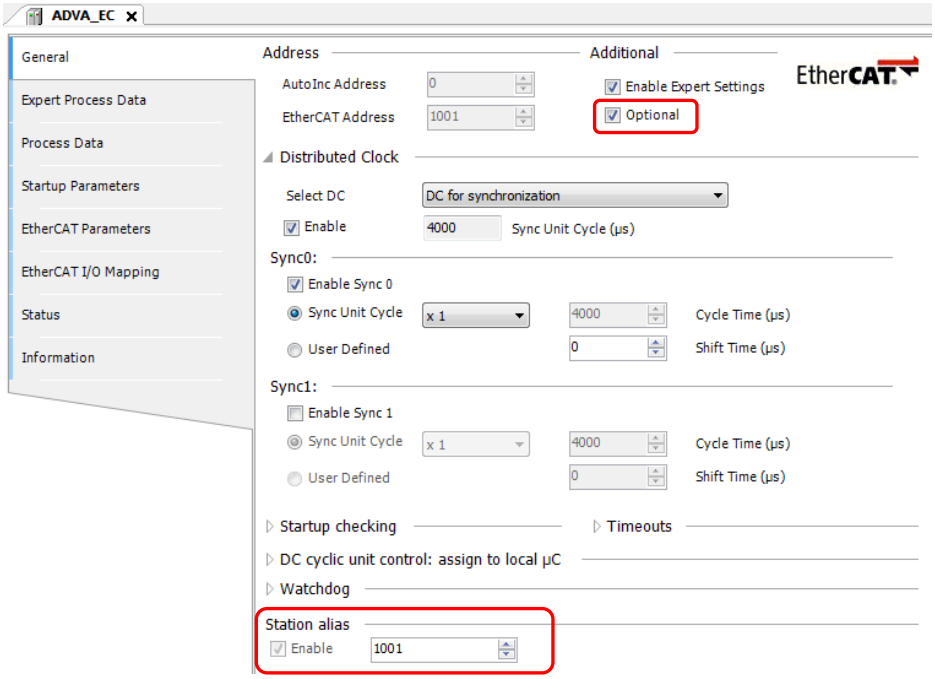
Auto Increment address

Station address is automatically assigned by a master according to physical location in the network. You don't have to set addresses on slave devices.

Station Alias

Each slave has unique address. Since this address is independent from position, you don't have to modify application program if you change EtherCAT cable routing.

Enable [Optional] at [Additional] and set [Station alias] according to the slave address.

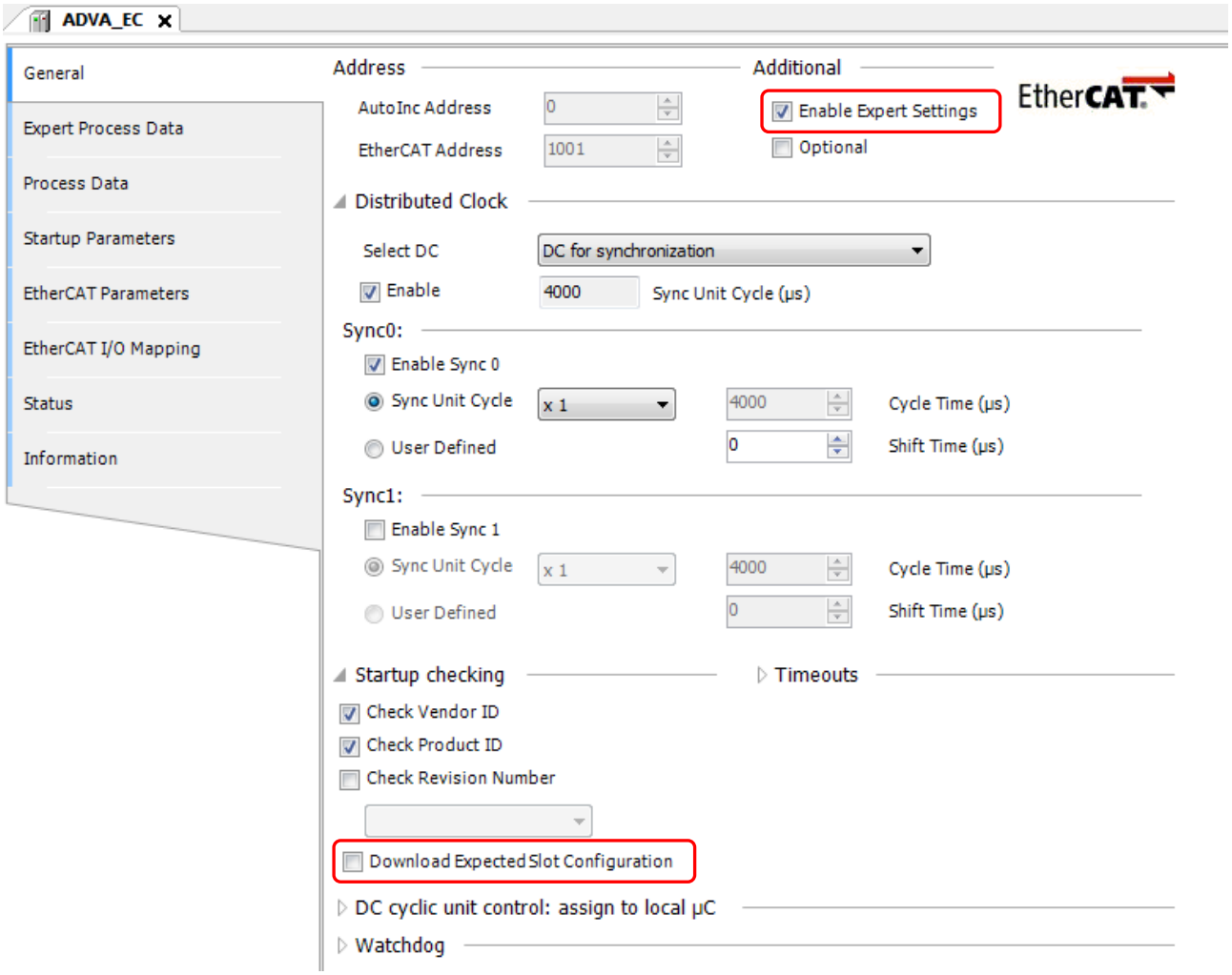


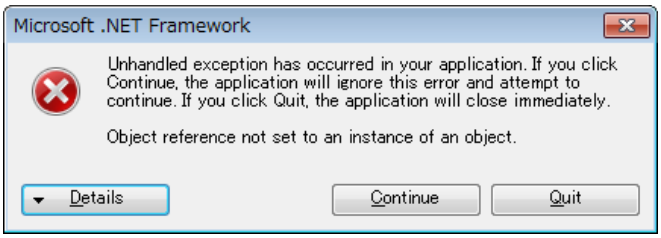
NOTE

If the station alias is enabled, [Auto restart slaves] does not work properly. If you need to enable [Auto restart slaves], use AutoInc address.

3.1.8 Additional Settings

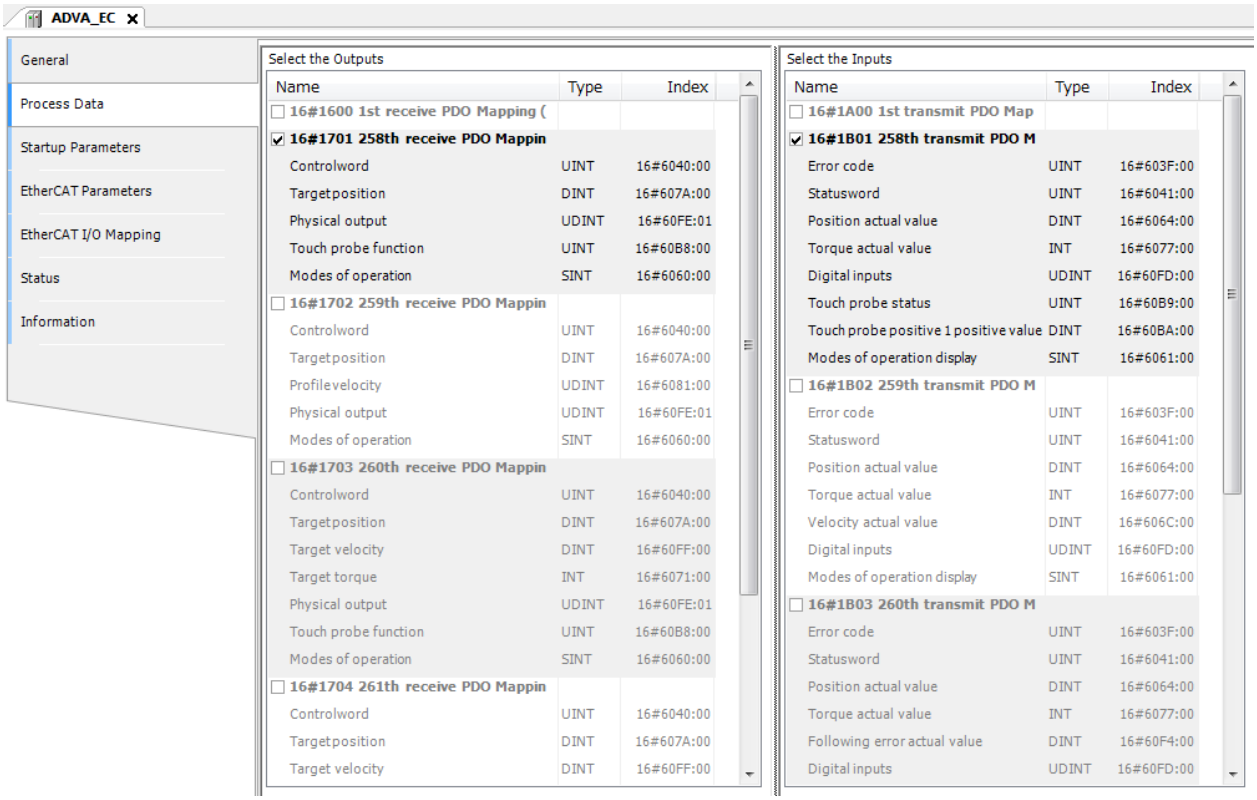
If [Enable Expert Settings] in [Additional] is activated, [Startup checking], [Timeouts] and other expert settings appear. If [Download Expected Slot Configuration] in [Startup checking] is activated, an error message might appear depending on drives. Do not activate this parameter because it is about MDP (Modular Device Profile), which is not used in standard drives.





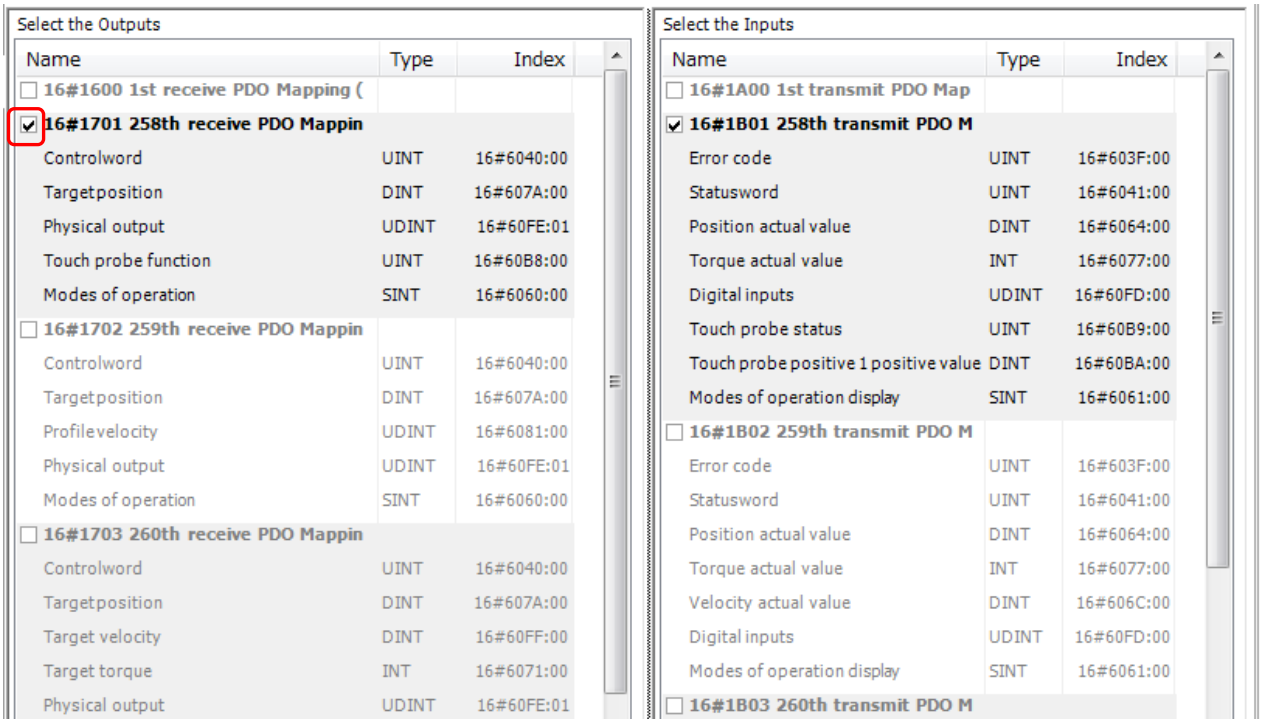
3.1.9 Process Data Object

In EtherCAT communication, the data called Process Data Object (PDO) is cyclically read and written. The data structure of PDO is defined in ESI file and can be configurable by users. Please refer to instruction manual of slave devices for further information.

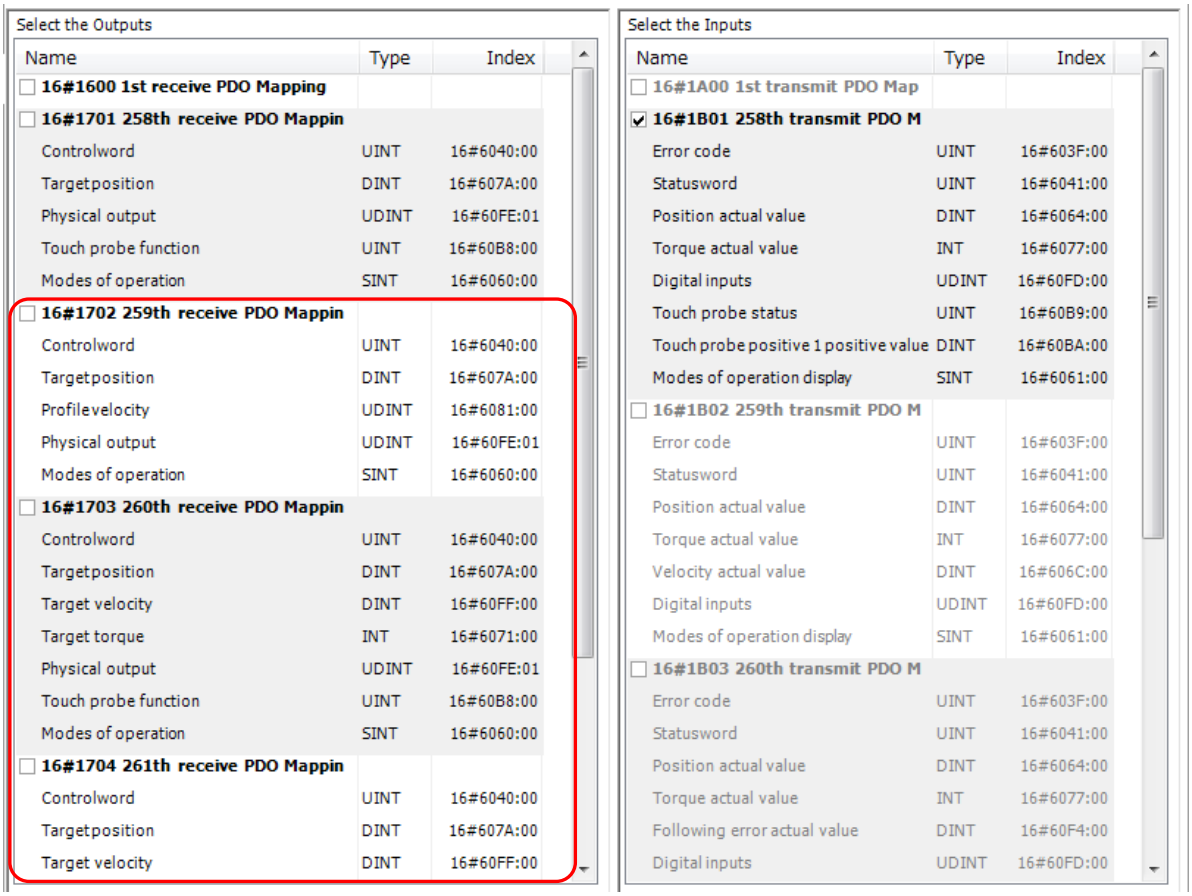


How to change PDO mapping

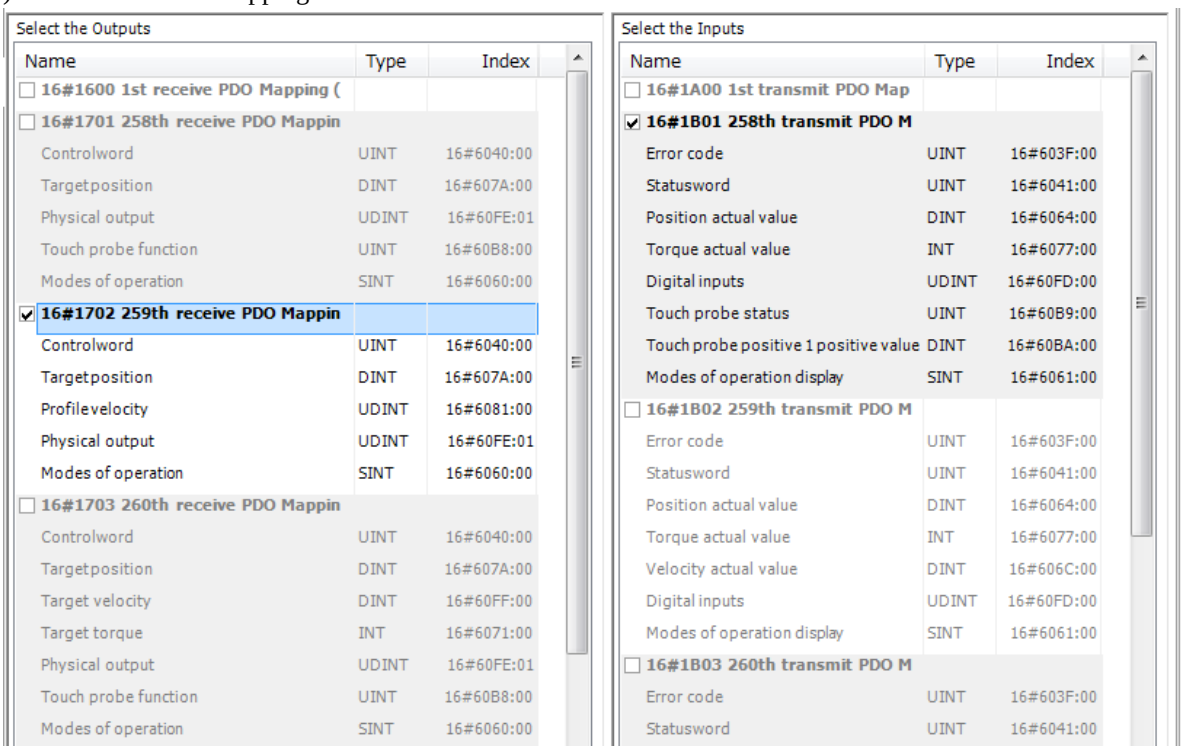
(1) Deactivate the PDO mapping currently activated.



(2) The other PDO mappings are highlighted (ready to be chosen).



(3) Choose new PDO mapping.



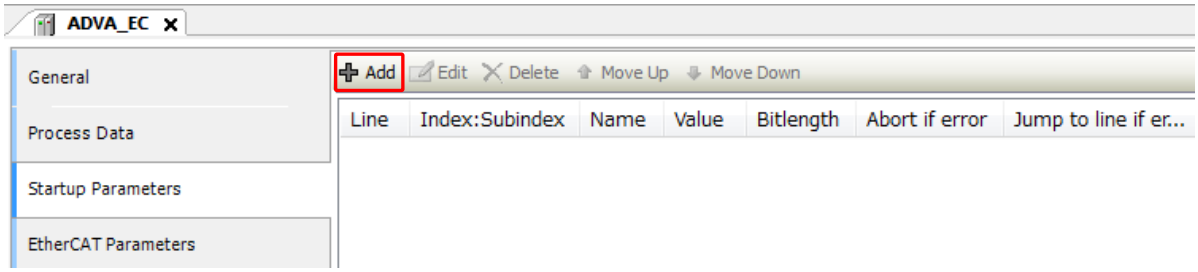
PDO mapping is seen at [EtherCAT I/O Mapping] tab. Put variable names on this mapping and create application program same as standard I/Os.

3.1.10 Startup Parameters

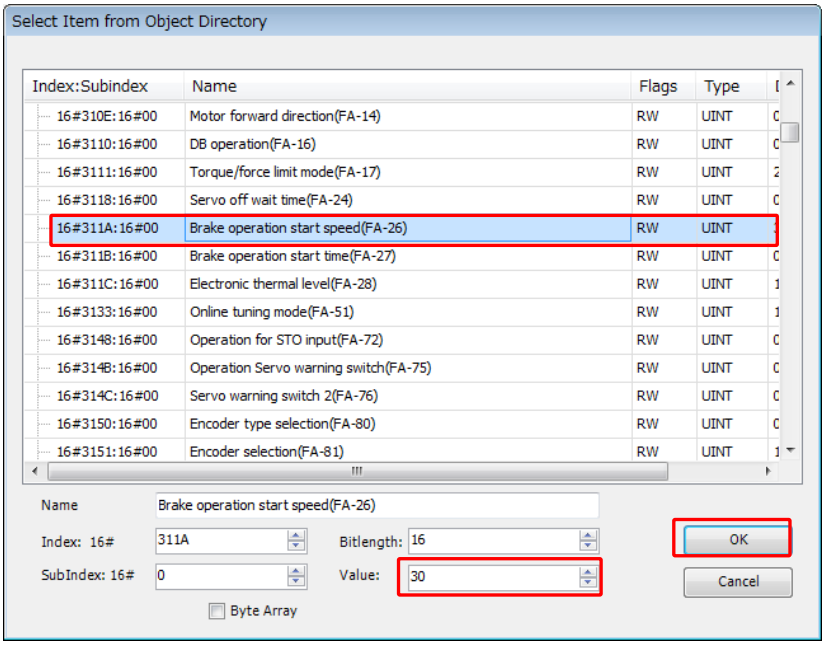
Initial value of SDO (service data object) can be set in [Startup parameter] tab. These values are set at starting of PLC. SDO can be read and written by dedicated function blocks in application program.

How to set Startup Parameters?

(1) Click [Add] in [Startup Parameters] tab.

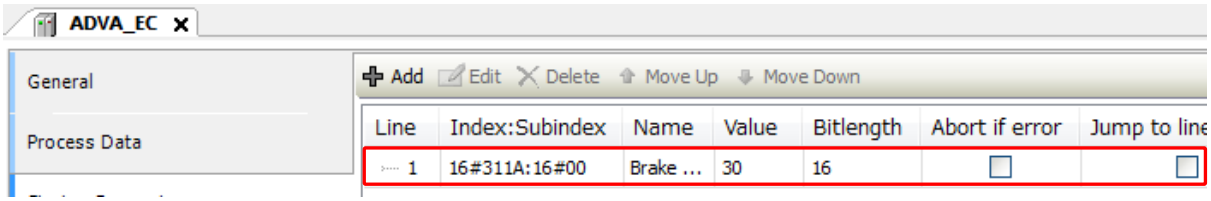


(2) Choose a parameter, enter a value and click [OK].



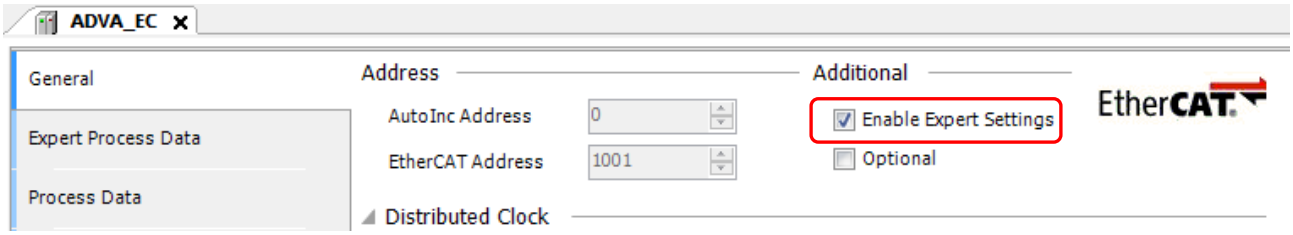
The contents of SDO parameters (object dictionary) depend on slave device. Refer to instruction manual of slave device for further information.

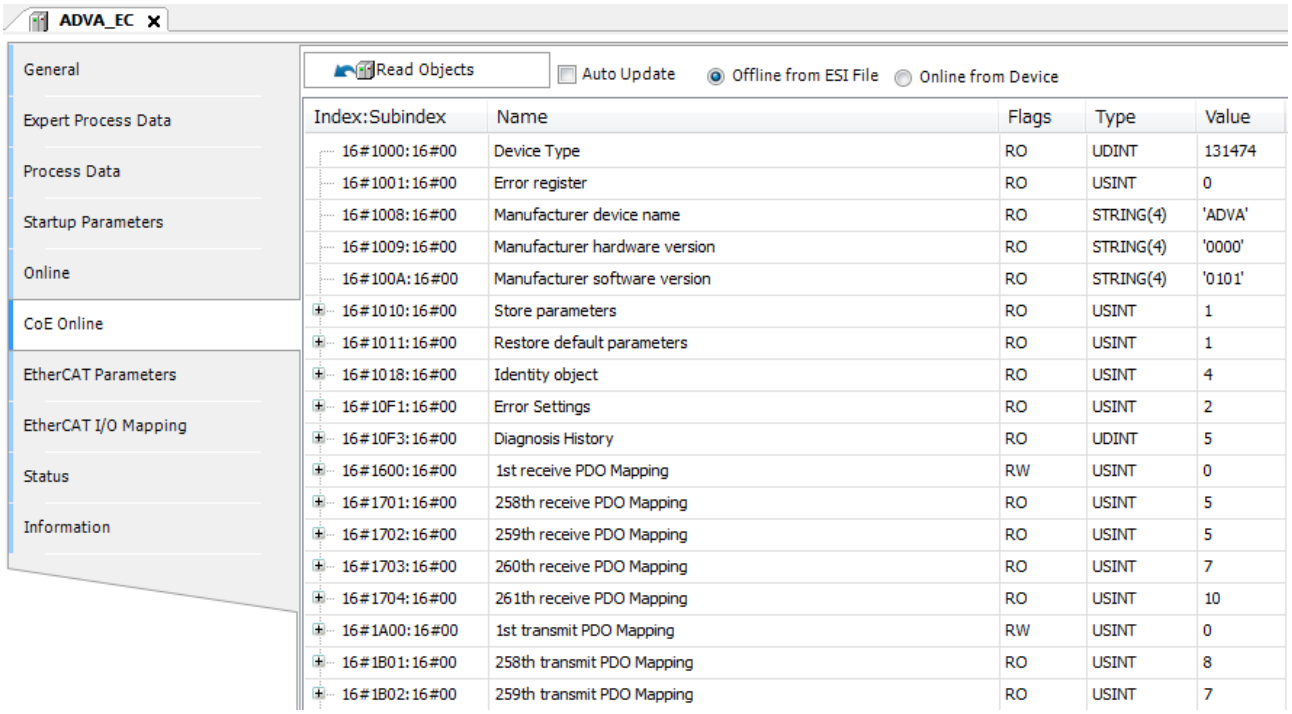
(3) Startup parameter is added in the list.



3.1.11 Read/Write Object Dictionary

If [Enable Expert Settings] in [Additional] is activated, [CoE Online] tab appears and values of object dictionary can be read and written in this window.





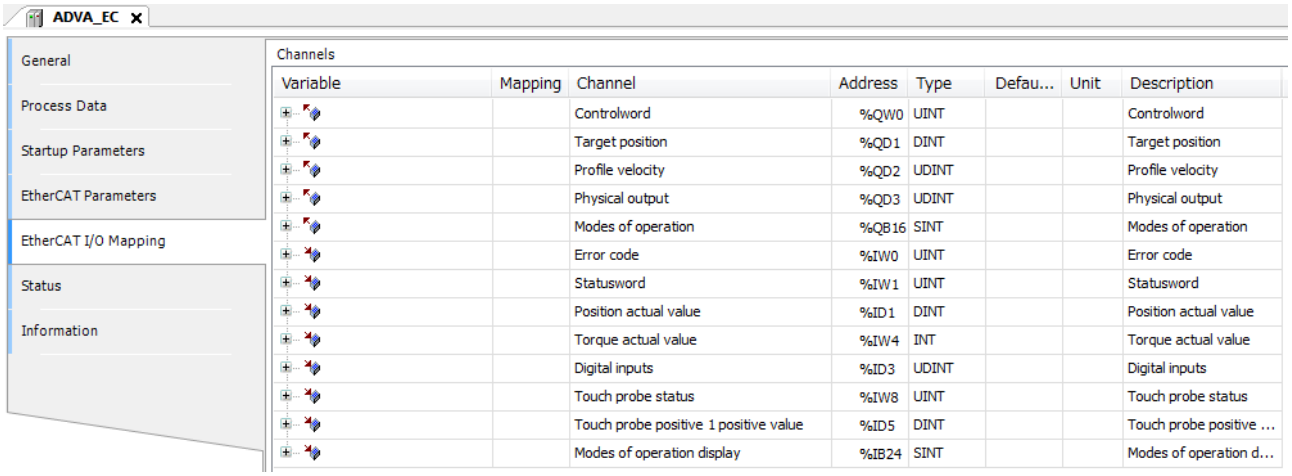
Index:Subindex	Name	Flags	Type	Value
16#1000:16#00	Device Type	RO	UDINT	131474
16#1001:16#00	Error register	RO	USINT	0
16#1008:16#00	Manufacturer device name	RO	STRING(4)	'ADVA'
16#1009:16#00	Manufacturer hardware version	RO	STRING(4)	'0000'
16#100A:16#00	Manufacturer software version	RO	STRING(4)	'0101'
16#1010:16#00	Store parameters	RO	USINT	1
16#1011:16#00	Restore default parameters	RO	USINT	1
16#1018:16#00	Identity object	RO	USINT	4
16#10F1:16#00	Error Settings	RO	USINT	2
16#10F3:16#00	Diagnosis History	RO	UDINT	5
16#1600:16#00	1st receive PDO Mapping	RW	USINT	0
16#1701:16#00	258th receive PDO Mapping	RO	USINT	5
16#1702:16#00	259th receive PDO Mapping	RO	USINT	5
16#1703:16#00	260th receive PDO Mapping	RO	USINT	7
16#1704:16#00	261th receive PDO Mapping	RO	USINT	10
16#1A00:16#00	1st transmit PDO Mapping	RW	USINT	0
16#1B01:16#00	258th transmit PDO Mapping	RO	USINT	8
16#1B02:16#00	259th transmit PDO Mapping	RO	USINT	7

NOTE

Negative value cannot be set in CoE Online window. If you need to write negative value, use Startup Parameters or dedicated function blocks (ETC_CO_SdoWrite, etc.).

3.1.12 Programming

I/O mapping of slave device is shown in [EtherCAT I/O Mapping] tab. Put variable names on this mapping and create application program same as standard I/Os.



Variable	Mapping	Channel	Address	Type	Defau...	Unit	Description
		Controlword	%QW0	UINT			Controlword
		Target position	%QD1	DINT			Target position
		Profile velocity	%QD2	UDINT			Profile velocity
		Physical output	%QD3	UDINT			Physical output
		Modes of operation	%QB16	SINT			Modes of operation
		Error code	%IW0	UINT			Error code
		Statusword	%IW1	UINT			Statusword
		Position actual value	%ID1	DINT			Position actual value
		Torque actual value	%IW4	INT			Torque actual value
		Digital inputs	%ID3	UDINT			Digital inputs
		Touch probe status	%IW8	UINT			Touch probe status
		Touch probe positive 1 positive value	%ID5	DINT			Touch probe positive ...
		Modes of operation display	%IB24	SINT			Modes of operation d...

In case of motion axis, state machine of CiA402 drive profile is controlled by dedicated function blocks. You don't have to create a program to control state machine by using Controlword, Statusword, Modes of operation and Modes of operation display. (variable field can be left as empty)

NOTE

- When PLC is powered up with RUN switch position in RUN, I/O refresh of the EtherCAT slaves starts about a few second after I/O refresh of standard I/O started because of configuration between the EtherCAT master and all slaves. If this delay is not accepted, use a special bit register 'EtherCAT_Master.xConfigFinished', which turns on when EtherCAT configuration is finished. The codes below are sample program in ST language.
- Since EtherCAT communication is handled by EtherCAT_Master task, I/O refresh cycle of the EtherCAT slave is delayed one cycle at maximum compared to I/O refresh cycle of external I/O in basic and expansion bases.

Sample program

Use same instance of EtherCAT master SoftMotion.

```
IF EtherCAT_Master_SoftMotion.xConfigFinished=FALSE THEN
    RETURN;
END_IF
```

Programs under END_IF are not executed while this bit is FALSE.

3.1.13 Wiring

(1) Cable

Use category 5 or higher STP (Shielded Twisted Pair) cable.

(2) Network switch

Standard network switch is not allowed to use in EtherCAT network. If necessary, use dedicated EtherCAT hub such as CU1128 sold by Beckhoff.

NOTE

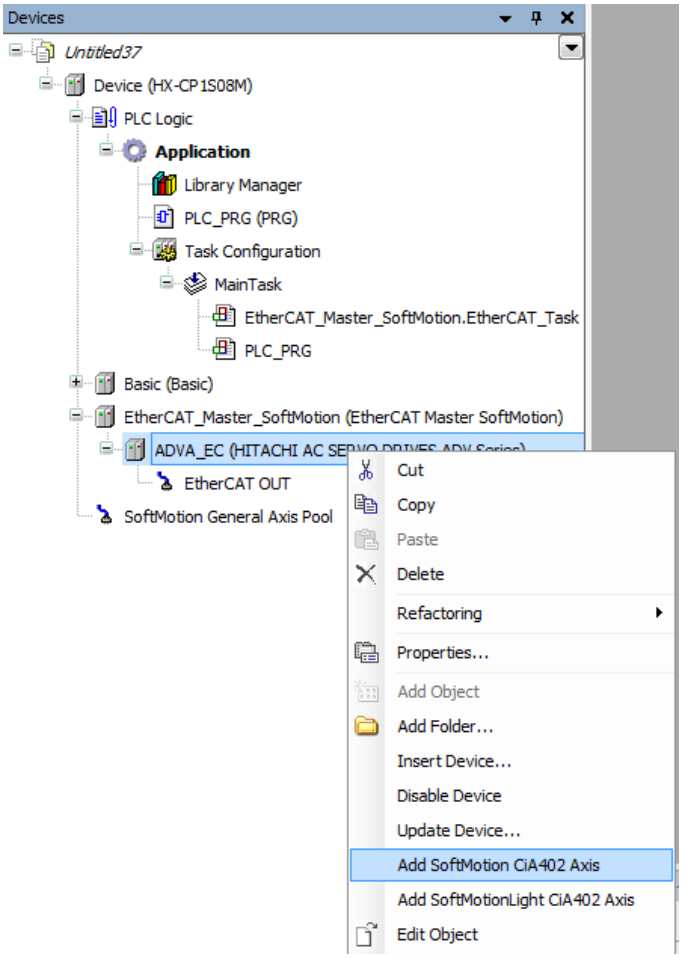
When the port is used for the EtherCAT master, do not use this port for other Ethernet based communication such as gateway (communication with HX-CODESYS or HMI), Modbus-TCP or global network variable list, otherwise EtherCAT communication performance may be limited.

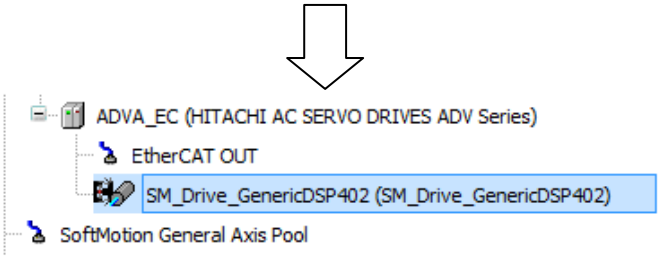
3.2 Configuration of SoftMotion Axis

3.2.1 Adding SoftMotion Axis

Add SoftMotion axis to EtherCAT slave drives, so as to use motion control libraries.

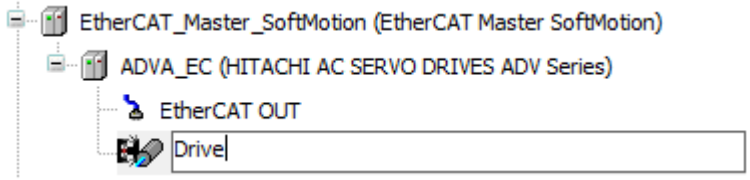
Right click on slave drive and choose [Add SoftMotion CiA402 Axis].



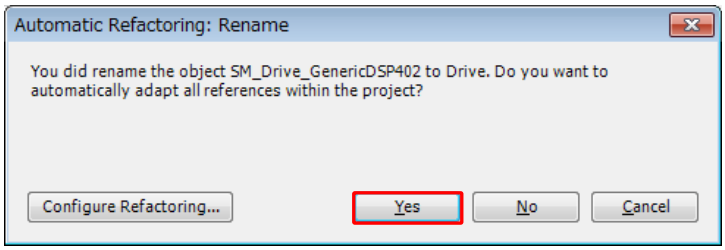


3.2.2 Renaming SoftMotion Axis

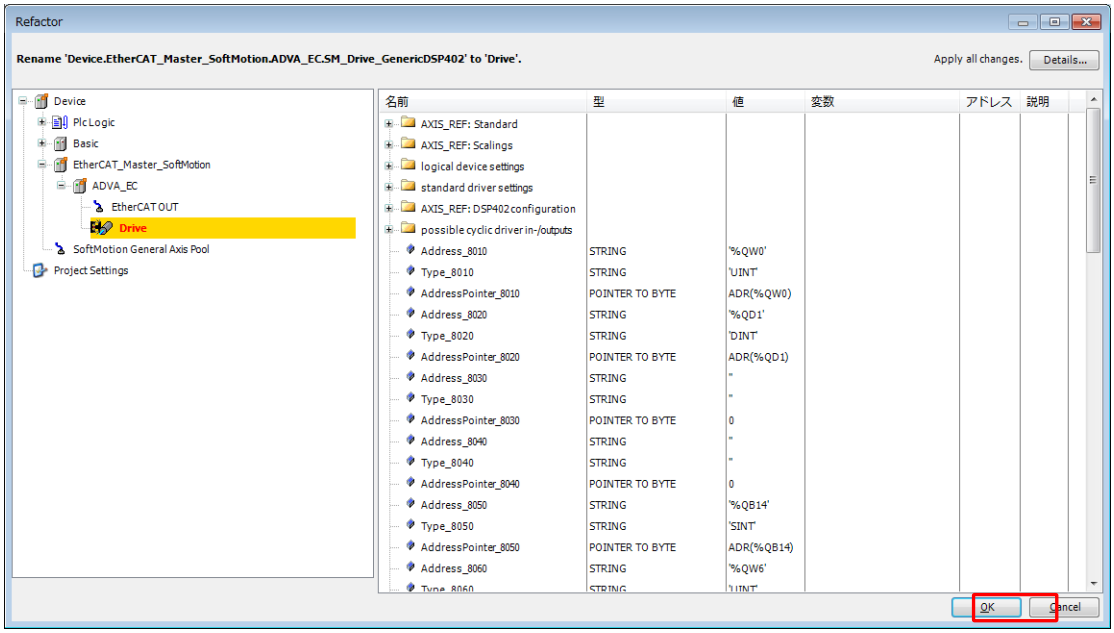
The name of SoftMotion axis can be renamed by single clicking or right-mouse clicking menu [Refactoring] on SoftMotion axis. Since this name is used as an instance of axis (AXIS_REF_SM3) in all the motion function blocks, shorter name would be easy to handle.



If the instance name is changed, a dialog appears to adapt automatically all references. Click [Yes] to proceed.

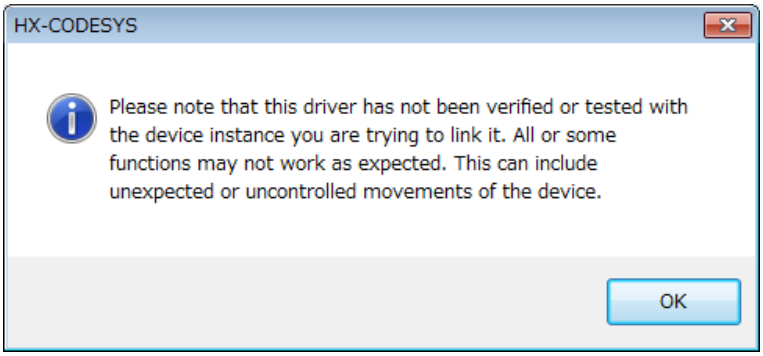


Then reference list appears. Click [OK] to proceed.



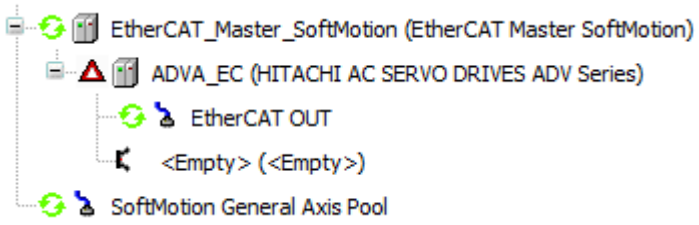
NOTE

If certified drive by 3S is used, the special SoftMotion axis for the drive is automatically added. If the other uncertified drive is used, you must add a generic SoftMotion axis manually. In that case, the dialog below appears. Read the message and click [OK].



NOTE

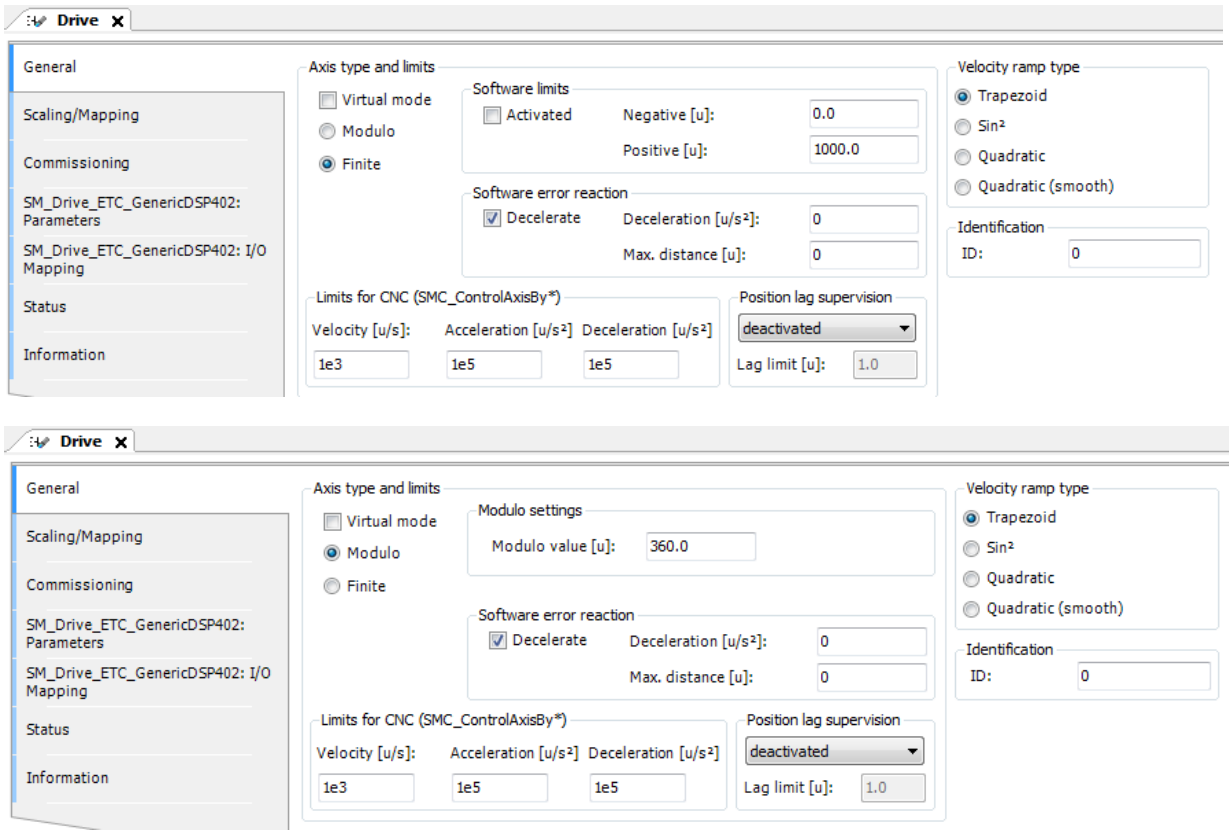
If you delete a SoftMotion axis, slave status is failed (red triangle icon) because <Empty> slot is remained. If a SoftMotion axis is to be deleted, delete the slave device and add again.



3.2.3 Configuration of SoftMotion Axis

Double click SoftMotion axis to open configuration parameters.

[General]

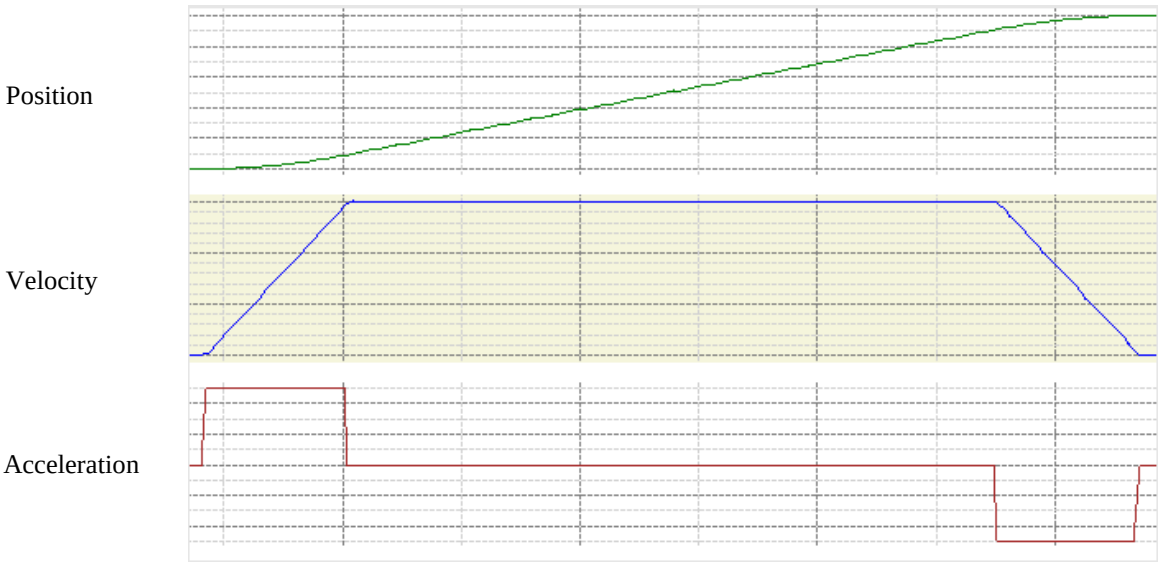


No.	Name	Description	Default
1	Axis type and limits	Virtual mode: The drive will be replaced by a simulation similar to a virtual drive device.	Disabled
		Modulo: The drive turns endlessly without limiting the traversing range (e.g. belt drive) Finite: The drive has a fixed work area (e.g. linear drive)	Finite
2	Software limits	Activate the option if you want to limit the position values.	Disabled
3	Modulo settings	The maximum value of the position value (unit: u). If the current position value exceeds the modulo value, the position value goes back to 0. It is possible to set a larger value than modulo value, but the maximum value of the current position data read out from drive is this modulo value.	360.0
4	Software error reaction	Drive decelerates with specified deceleration when the position exceeds the software limits.	Enabled
5	Limits for CNC	Define limit values for velocity, acceleration and deceleration. The limits are used by the library named SMC_ControlAxisBy* to detect jumps.	1e3, 1e5, 1e5
6	Position lag supervision	Define the reaction of the system after detection a lag error.	deactivated
7	Velocity ramp type	The velocity ramp type defines the velocity profile for the velocity generating one-axis and the master/slave-modules. Trapezoid: Trapezoid velocity profile (with constant acceleration in each section). Sin^2: A velocity profile as defined as sin^2 function (with constant acceleration curve). Quadratic: Acceleration profile in trapezoidal form with jerk limitation. Quadratic (smooth): Like Quadratic but generates a jerk profile without jumps.	Trapezoid
8	Identification	ID: Integer identifier. Should be unique for each drive. For example, this identifier is used in the PLC log in order to identify the drive when an error occurs.	0

Velocity ramp type

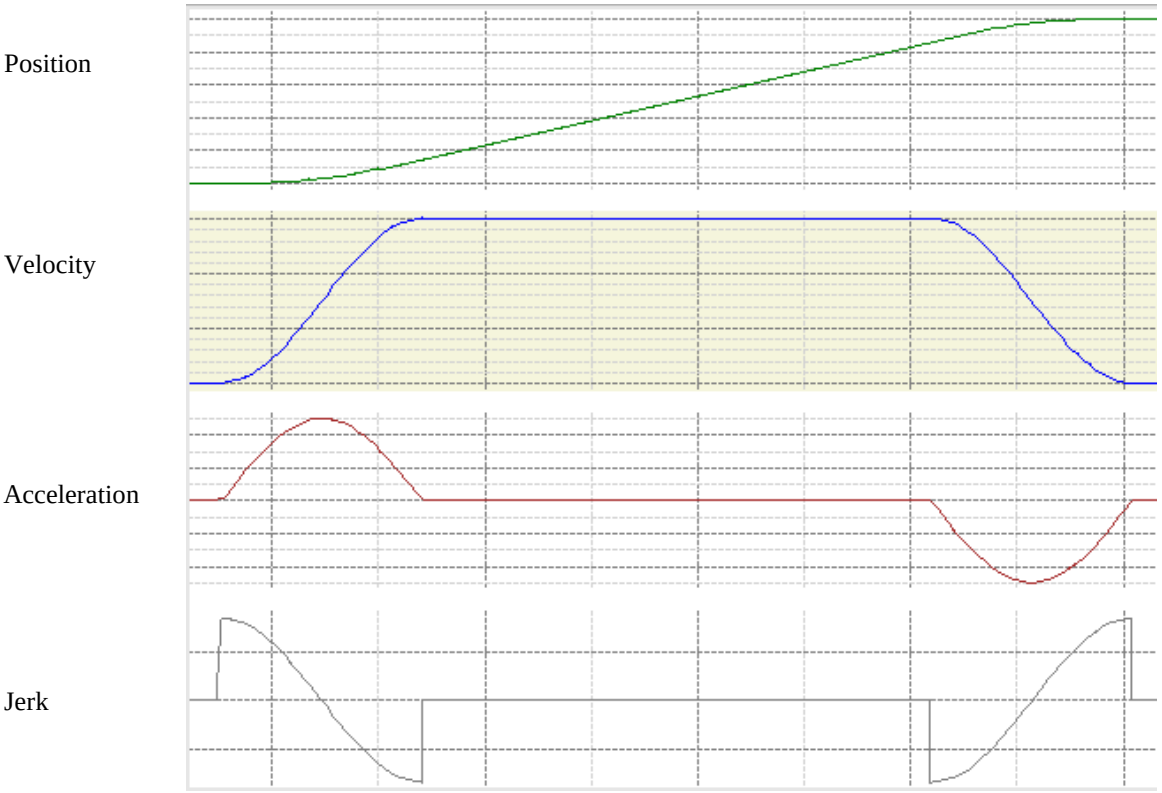
Trapezoid

Velocity profile is linear since acceleration is constant.



Sin^2

A velocity profile as defined by the sin^2 function (with constant acceleration curve).

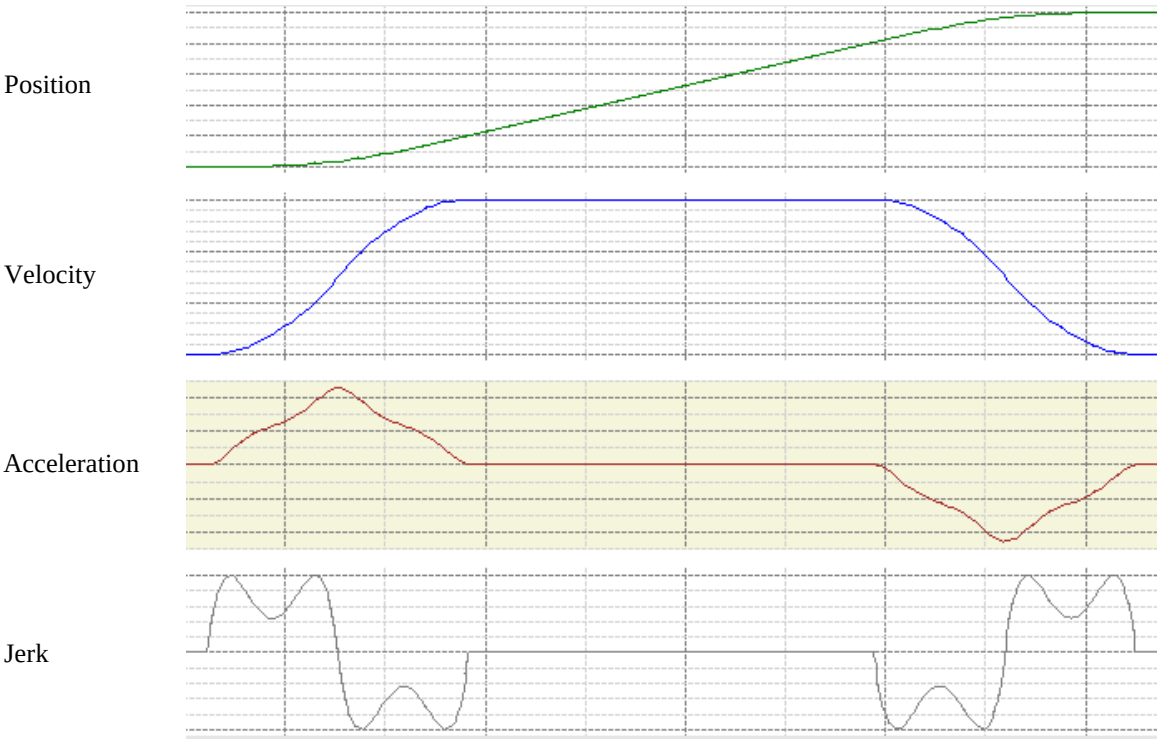


Quadratic

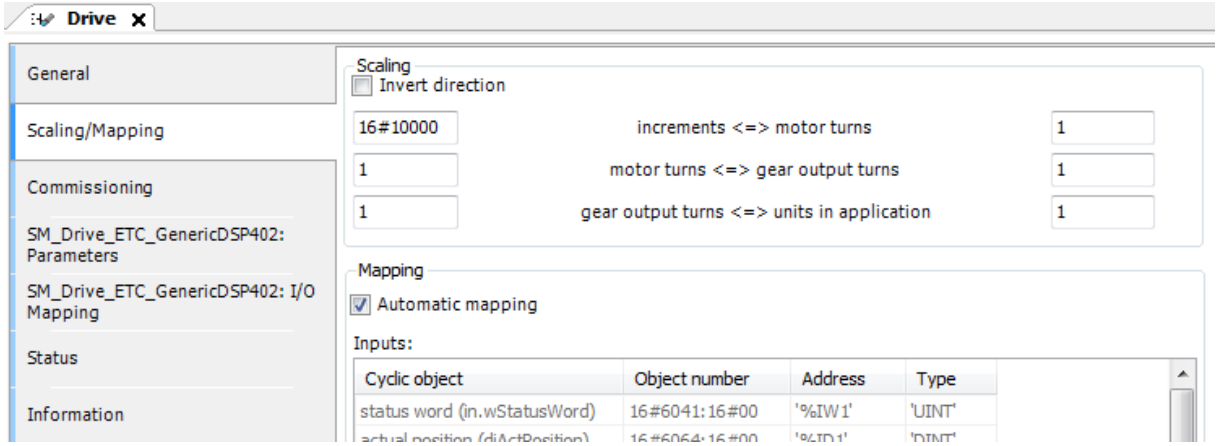
Acceleration profile in trapezoidal form with jerk limitation.

Quadratic (smooth)

Like Quadratic but generates a jerk profile without jump.



[Scaling/Mapping]

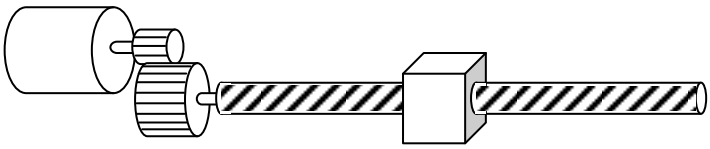


No.	Name	Description
1	Invert direction	The direction of rotation is reversed. The motor receives the specified values with inversed signs.
2	Increments < = > motor turns	Number of increments that correspond to a given number of motor rotations. You can see the parameter in the Configuration tab of the device editor. e.g. 17-bit encoder increments :16#20000, motor turns:1 e.g. 20-bit encoder increments :16#100000, motor turns:1
3	Motor turns < = > gear output turns	Number of motor rotations that correspond to a given number of gear output rotations. e.g. motor 3 turns = gear 1 turn motor turns :3, gear output turns:1
4	Gear output turns < = > units in application	Number of gear output rotations that correspond to a unit in the application. e.g. gear 1 turn = 1mm movement with ball screw gear output turns :1, units in application:1 e.g. gear 1 turn = 0.1mm movement with ball screw gear output turns :10, units in application:1
5	Automatic mapping	IEC parameters that affect the drive are automatically mapped to the corresponding inputs and outputs of the device.

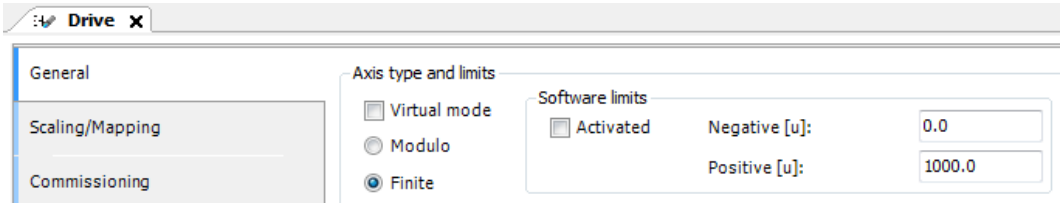
Example 1

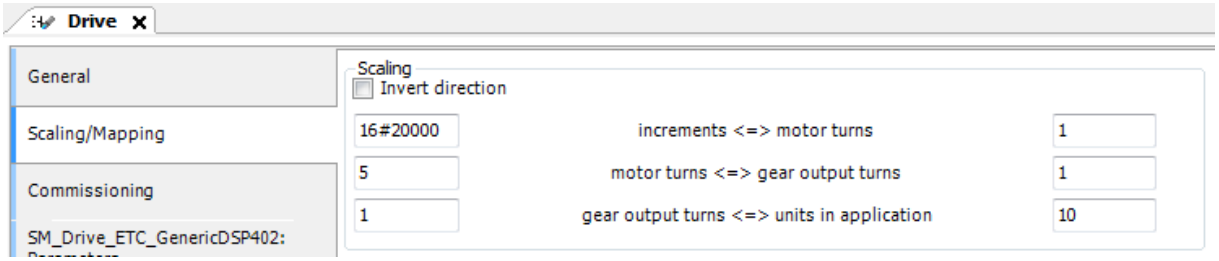
Servo motor
17-bit encoder
131,072 pulses/turn

Ball screw pitch: 10mm
(10mm / turn)



Gear reduction ratio: 1/5
(motor 5 turns = gear 1 turn)

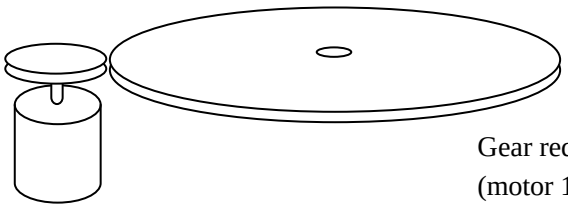




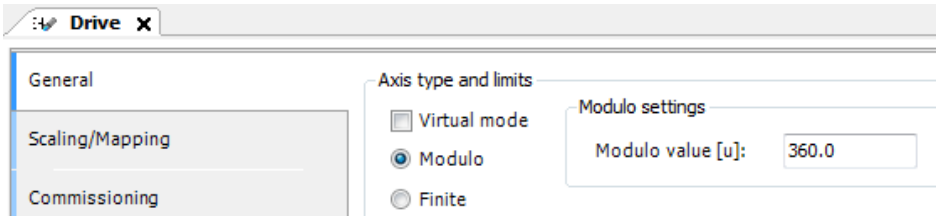
In this case, if you set 10 units for distance, motor rotates 5 turns, and consequently the table of ball screw moves 10mm. (10 units equals to 10 mm)

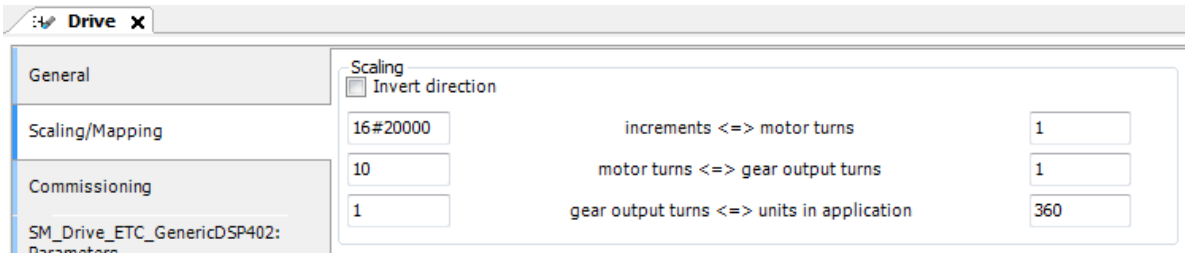
Example 2

Servo motor
17-bit encoder
131,072 pulses/turn



Gear reduction ratio: 1/10
(motor 10 turns = gear 1 turn)

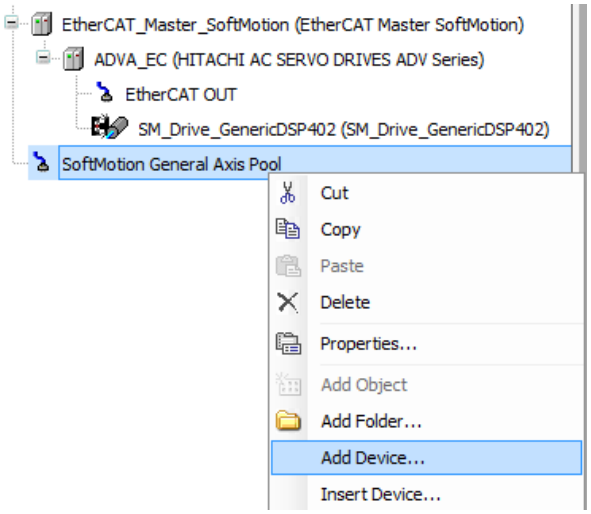


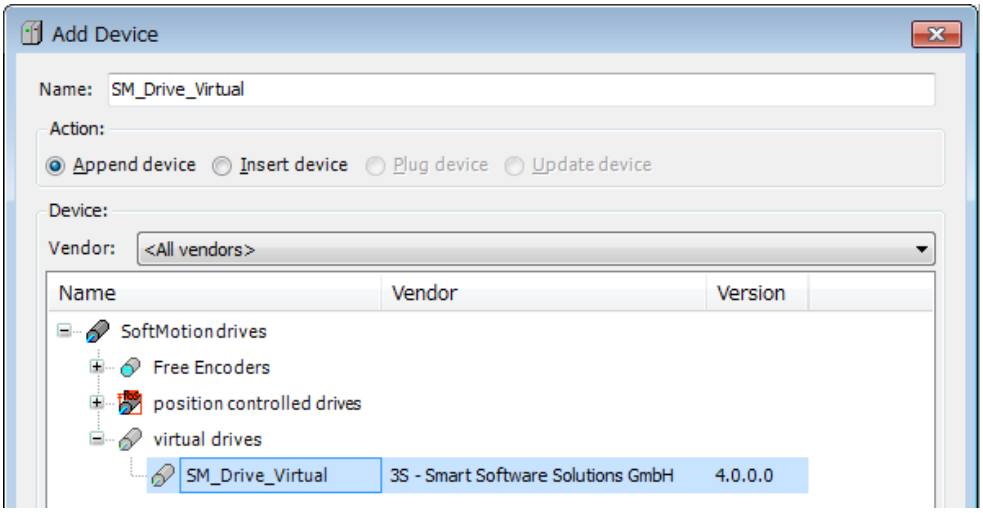


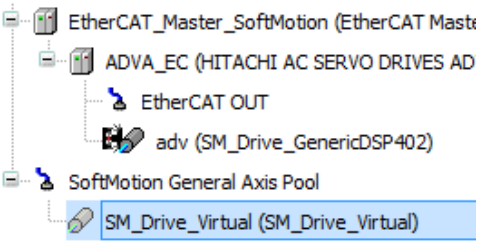
In this case, if you set 360 units for distance, motor rotates 10 turns, and consequently the turn table rotates 1 turn (360 degrees). (360 units equals to 360 degrees)

3.2.4 Virtual Axis

Virtual drives are simulated drives in software. If a virtual axis is configured as a master axis and real axes are configured as slaves, synchronous motion control can be easily realized by controlling the master axis with using cam and gear functions. Right-click on [SoftMotion General Axis Pool] and choose [Add Device...]. Then [Add Device] window appears. Click [SM_Drive_Virtual].







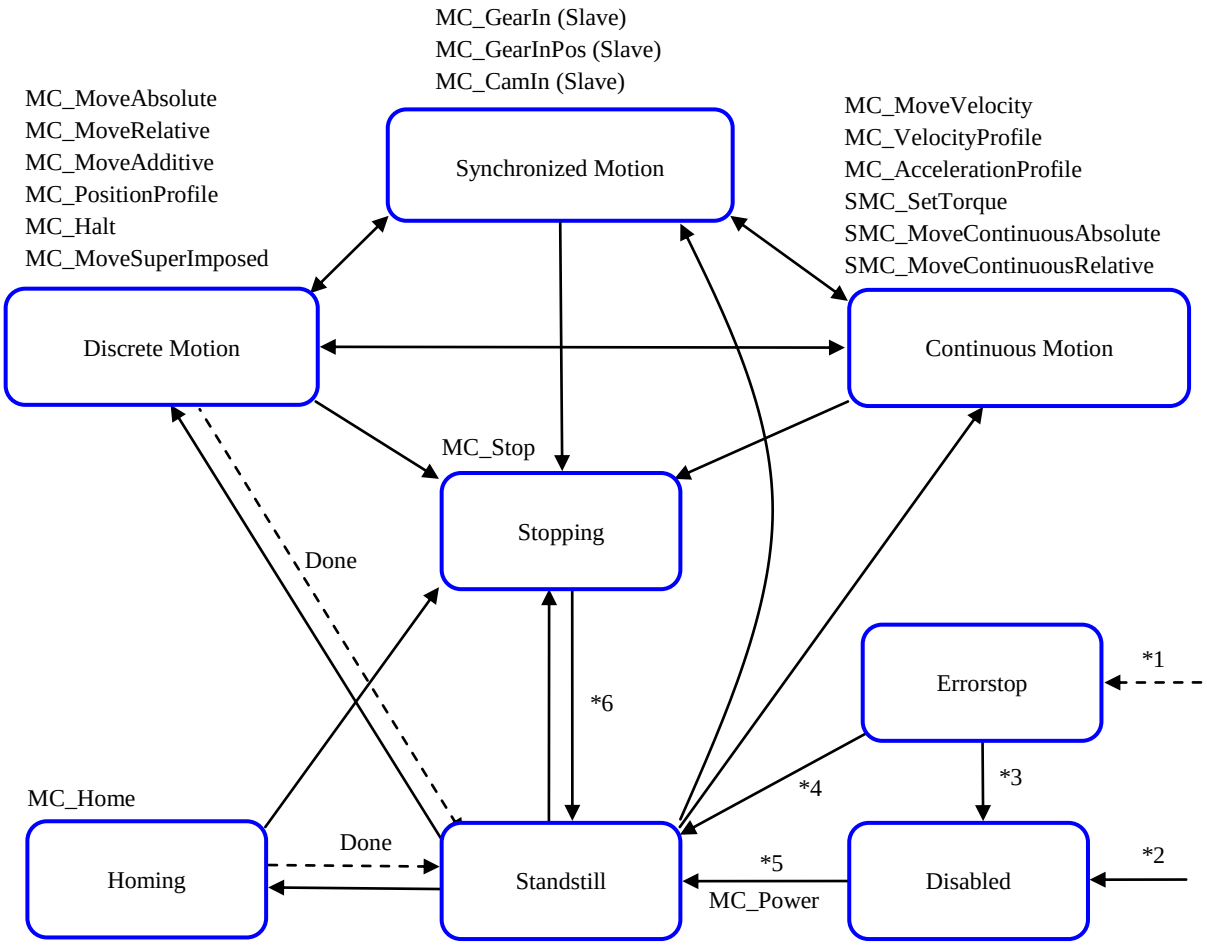
If this 'SM_Drive_Virtual', which can be renamed, is set to axis input (AXIS_REF_SM3) of motion function blocks, virtual drive can be controlled as same as real drives.

MEMO

Chapter 4 Manual Operation

4.1 State Diagram

The following diagram normatively defines the behavior of the axis at a high level when multiple motion control function blocks are simultaneously activated. The axis is always in one of the defined states. Arrows within the state diagram show the possible state transitions between the states. State transitions due to an issued command are shown by full arrows. Dashed arrows are used for state transitions that occur when a command of an axis corresponding motion state are listed above the states. These motion commands may also be issued when the axis is already in the according motion state.



*1 From any state. An error in the axis occurred.

*2 From any state. MC_Power.Enable=TRUE AND MC_Power.bRegulatorOn=FALSE and there is no error in the axis.

*3 MC_Reset AND MC_Power.Status=FALSE

*4 MC_Reset AND MC_Power.Status=TRUE AND MC_Power.Enable=TRUE AND MC_Power.bRegulatorOn=TRUE AND AND MC_Power.bDriveStart=TRUE AND MC_Power.Status=TRUE

*5 MC_Power.Enable=TRUE AND MC_Power.bRegulatorOn=TRUE AND MC_Power.bDriveStart=TRUE AND MC_Power.Status=TRUE

*6 MC_Stop.Done=TRUE AND MC_Stop.Execute=FALSE

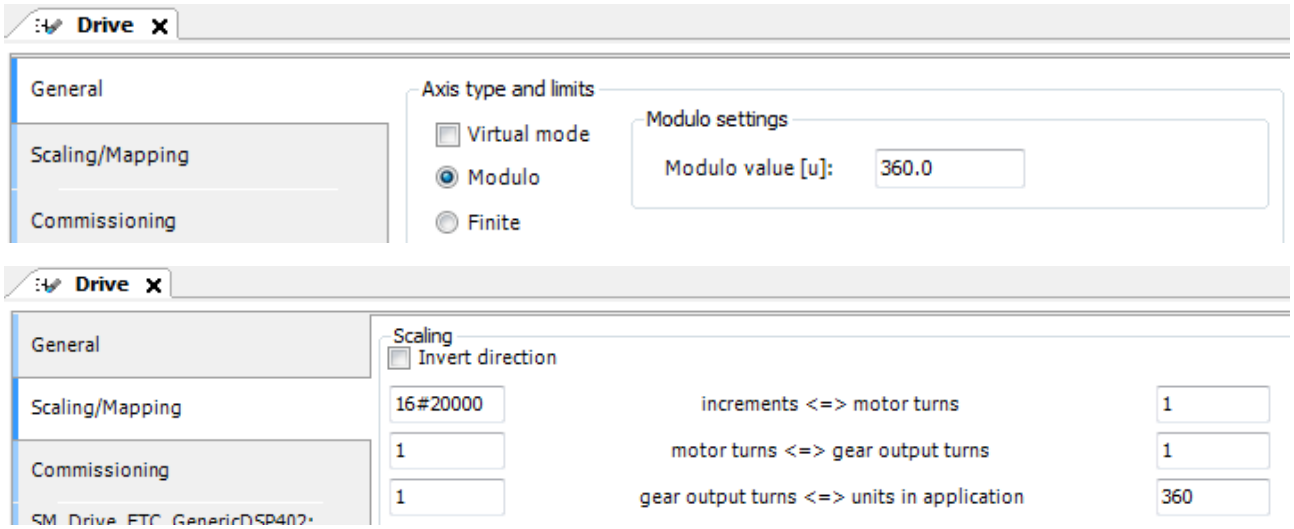
NOTE

The state behavior is different from the diagram defined by PLCopen for some function blocks.

- After MC_PositionProfile done, the state is in [Discrete Motion] instead of [Standstill].
- While MC_VelocityProfile and MC_AccelerationProfile, the state is [Discrete Motion] instead of [Continuous Motion].

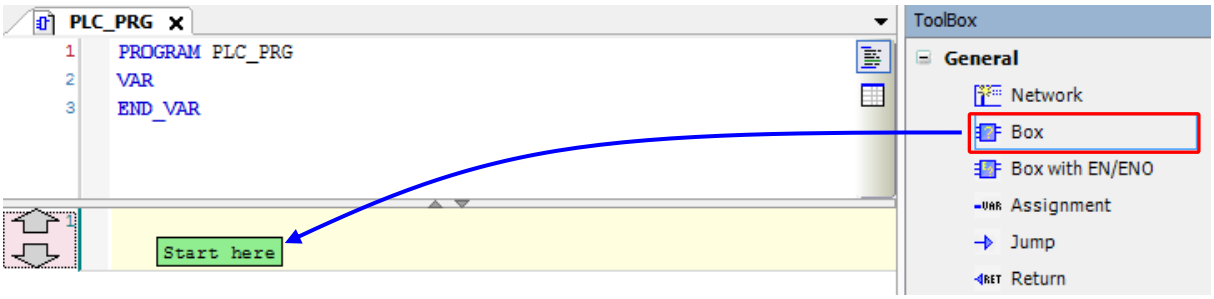
4.2 Servo-On

In this chapter, it's described about how to configure and program with the HX-CPU and the servo drives. Configure parameters according to your drives. (In this sample, 17-bit encoder (resolution 131,072 = #20000) is used.

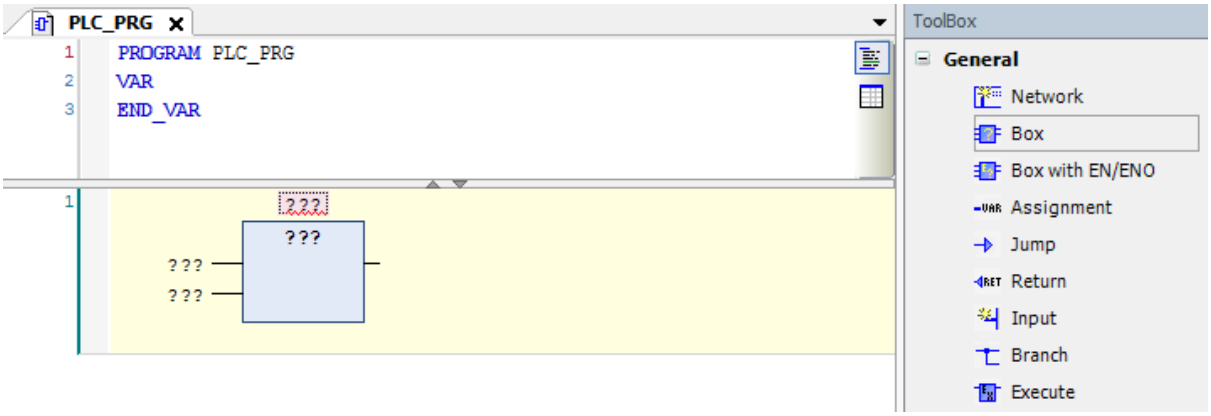


The servo drive is activated (energized) by the command MC_Power.

(1) Drag the [Box] to Start here and release it.



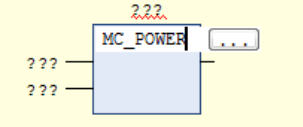
Then an undefined function block is created.



(2) Specify the function block by either of the following ways.

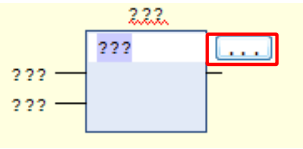
Direct typing

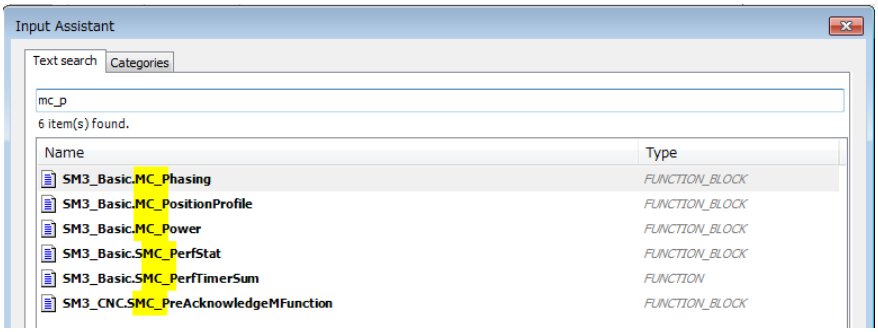
Type ‘MC_Power’ at ‘???’ in the function block and hit [Enter] key.



Search in Input Assistant

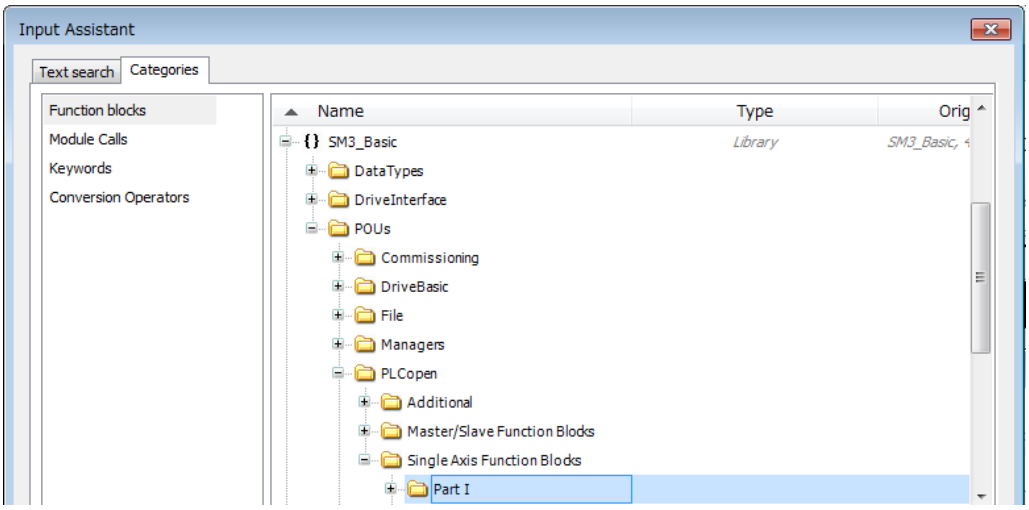
Click [...] and search ‘mc_power’ at [Text search] tab.



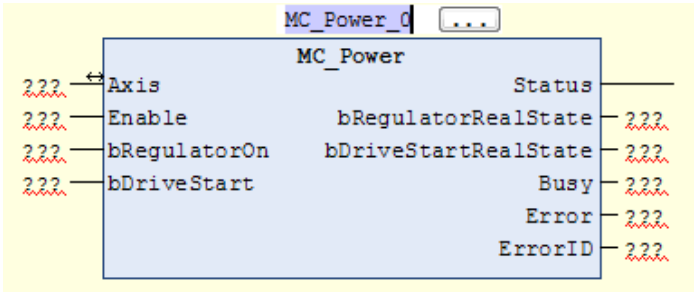


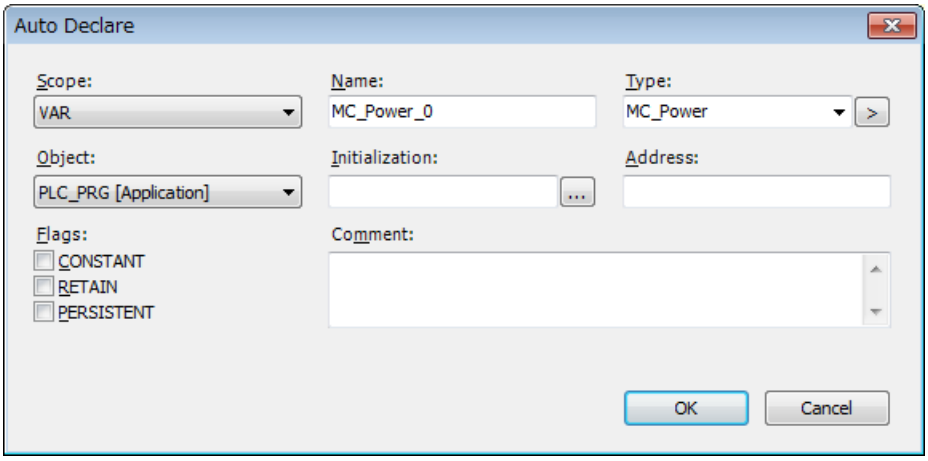
Choose in Input Assistant

Click [...] and choose ‘MC_Power’ under SM3_Basic library in [Categories] tab.

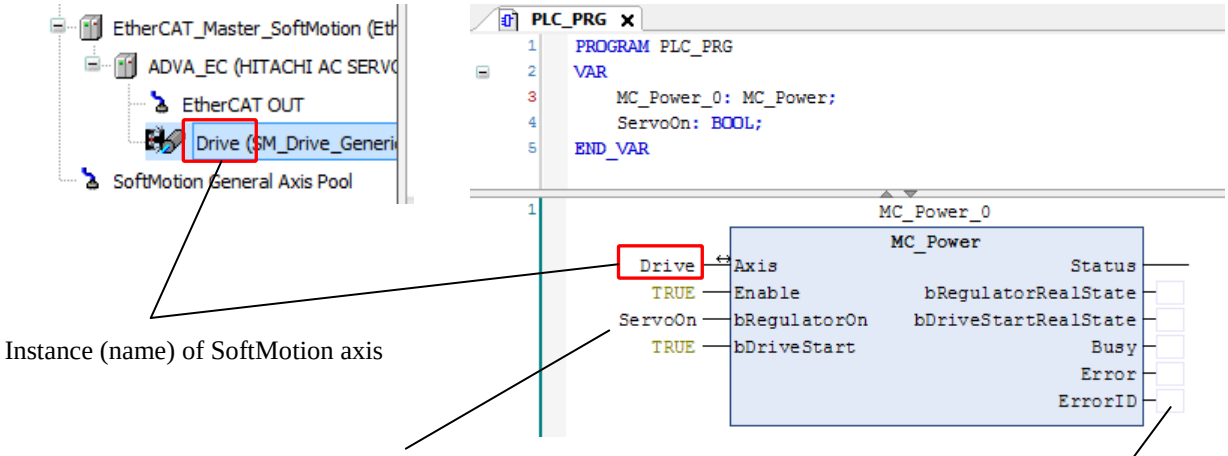


(3) New instance ‘MC_Power_0’ is automatically assigned. Hit [Enter] key to open Auto Declare dialog. Click [OK] or hit [Enter] key to close the dialog.





(4) Set inputs and outputs



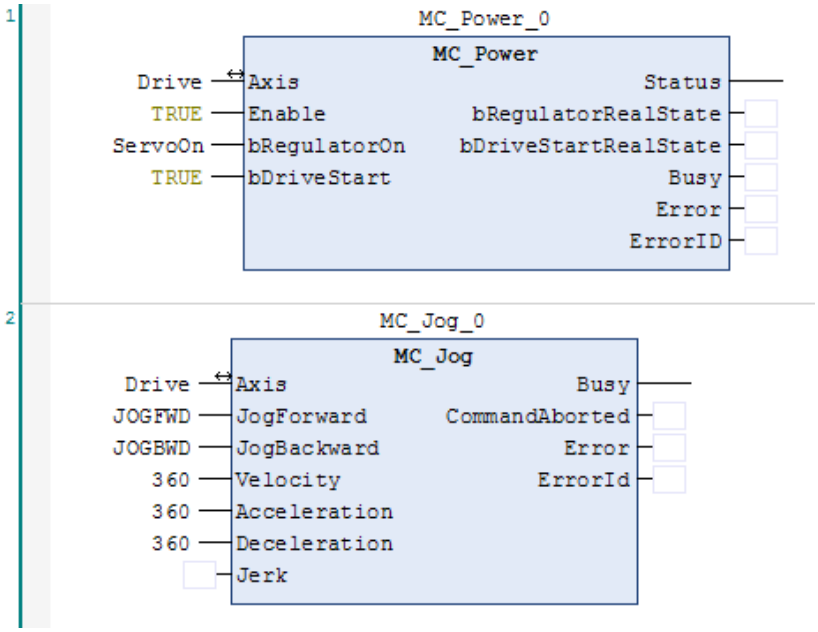
Instance (name) of SoftMotion axis

ServoOn is new boolean variable.
TRUE: Servo-ON (activated)
FALSE: Servo-OFF (deactivated)

Outputs can be opened, but
‘???’ must be deleted.

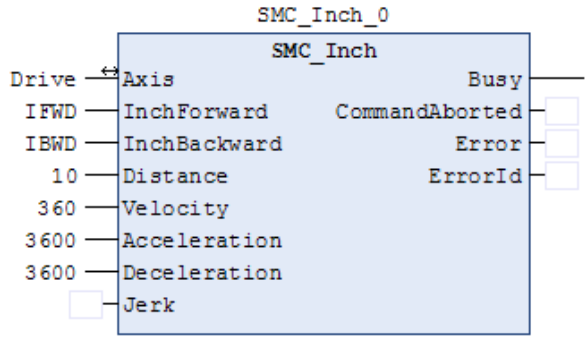
4.3 Jogging

Add MC_Power and MC_Jog as same like the last section and put inputs and outputs as the sample below.
After servo-ON by setting TRUE to servoOn input, the motor rotates in forward direction with velocity 360 [u/s] and acceleration 360 [u/s^2] while JOGFWD input is TRUE. If JOGBWD is TRUE, the motor rotates in backward direction. If the both JOGFWD and JOGBWD are TRUE, motor stops.



4.4 Inching

While IFWD input is TRUE, the motor rotates in forward direction with distance 10 [u], velocity 360 [u/s] and acceleration 3600 [u/s^2]. While IBWD input is TRUE, the motor rotates in backward direction with same distance, velocity and acceleration. If the both IFWD and IBWD are TRUE, motor stops.

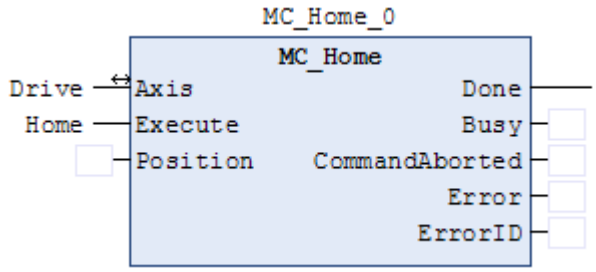


MEMO

Chapter 5 Single-Axis Control

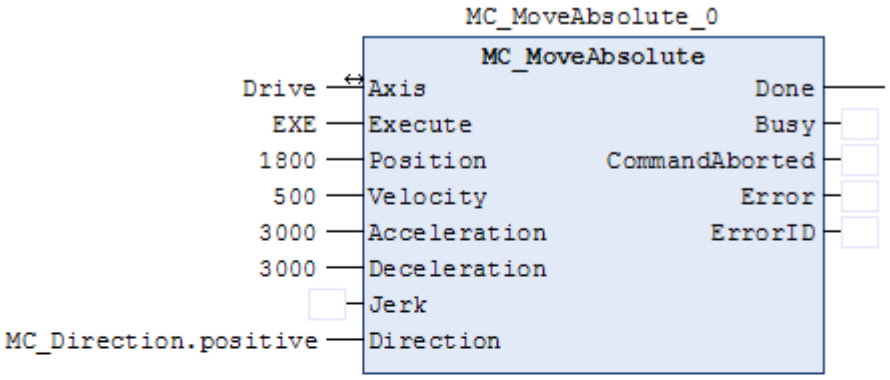
5.1 Homing

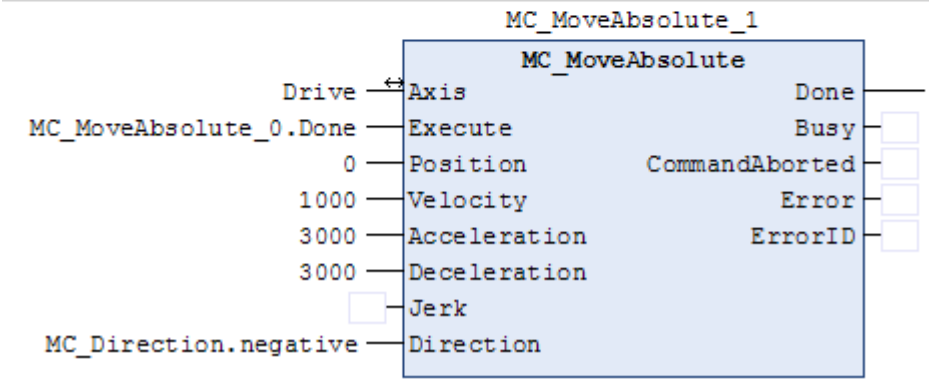
If this function block is executed, the axis performs homing according to the homing method, velocity, acceleration and other parameters configured in the drive. Those parameters can be set by startup parameters or mailbox (function block such as ETC_CO_SdoWrite, etc.) or special configuration software provided by drive's vendor.



5.2 Position Control

A sample program is introduced about MC_MoveAbsolute with absolute position.
When EXE input is TRUE, the axis goes to position 1800 [u] with velocity 500 [u/s] and acceleration 3000 [u/s^2].
As soon as arrived, the axis goes back to position 0 [u] with velocity 1000 [u/s] and acceleration 3000 [u/s^2].





Direction in modulo

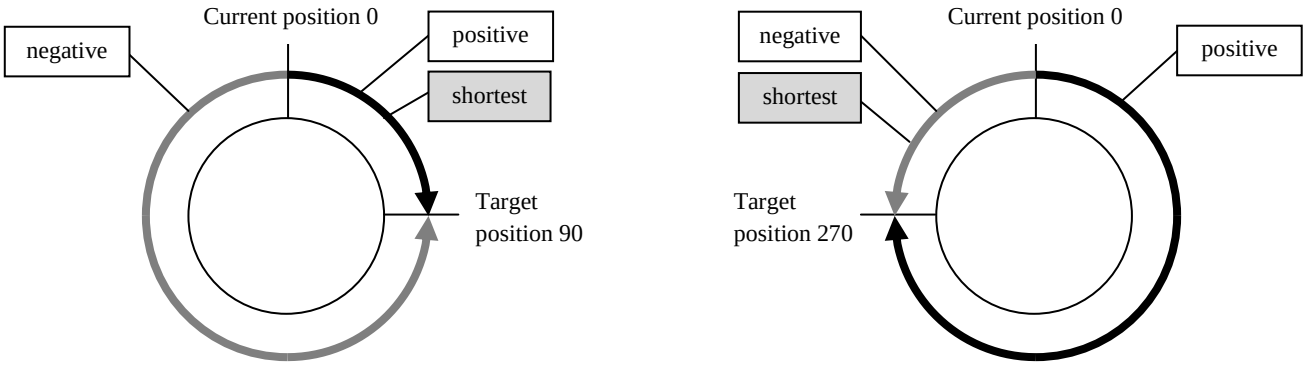
If direction is specified as shortest or fastest, actual direction is determined according to the current position, gear reduction ratio and modulo value.

Example

Modulo value : 360

Scaling : shown as follows

16#20000	increments <=> motor turns	1
1	motor turns <=> gear output turns	1
1	gear output turns <=> units in application	360



Name	value	Description
MC_Direction.fastest	3	Selects the direction automatically to reach the target position as fast as possible timewise. (only modulo axes)
MC_Direction.current	2	Keeps the current direction (only modulo axes)
MC_Direction.positive	1	Moves in positive direction
MC_Direction.shortest	0	Selects the direction according to the shortest distance (only modulo axes)
MC_Direction.negative	-1	Moves in negative direction

The following function blocks are available for position control. Refer to chapter 9 for further information.

Function Block	Name
MC_MoveAbsolute	Moves to a specified absolute position.
MC_MoveRelative	Moves to a specified relative position.
MC_MoveAdditive	Specifies relative distance additional to the most recent commanded position.
MC_MoveSuperImposed	Specifies relative distance additional to an existing motion.
SMC_MoveContinuousAbsolute	Moves to a specified absolute position ending with the specified velocity.
SMC_MoveContinuousRelative	Moves to a specified relative position ending with the specified velocity.
MC_PositionProfile	Moves according to time-position locked motion profile.

5.3 Velocity Control

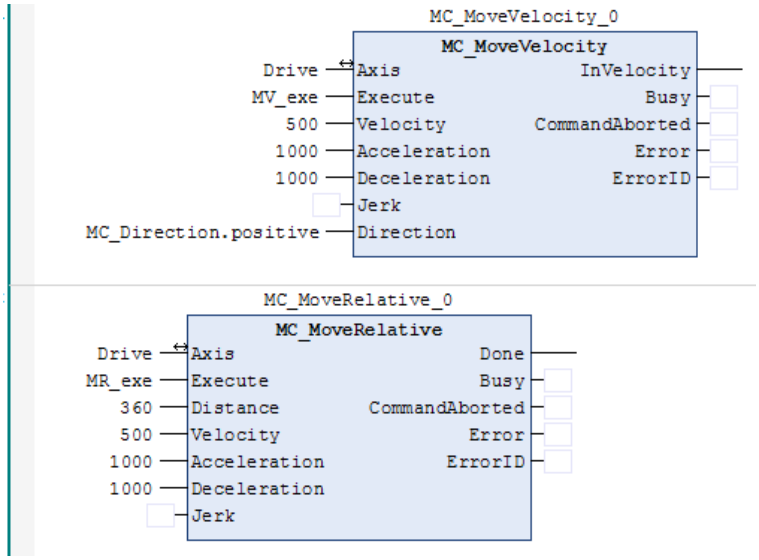
Velocity control is to specify velocity, acceleration, deceleration and jerk without specifying target position. The function block for velocity control is MC_MoveVelocity.

Change velocity

Velocity, acceleration, deceleration and direction can be changed while movement. In order to apply new parameters, rising edge must be input to [Execute] input. Alternatively another instance of MC_MoveVelocity can be executed. In that case, originally executed MC_MoveVelocity is aborted, which results in CommandAborted output TRUE.

Velocity Control ➔ Switching to Position Control

It is possible to switch from velocity control to position control while movement. If MV_exe is TRUE, the axis rotates with constant velocity 500 [u/s]. If MC_MoveRelative is executed while the axis is in constant movement, the axis moves, decelerates and stops with specified distance 360 [u] and deceleration 1000 [u/s^2]. MC_MoveVelocity is aborted with CommandAborted output TRUE.



5.4 Stop

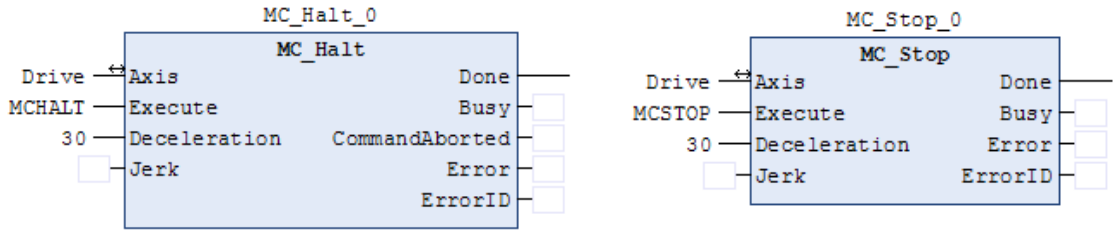
The usage of MC_Halt and MC_Stop are to decelerate and stop motion for both, but there are some differences as follows.

MC_Halt

MC_Halt is used to stop the axis under normal operation conditions. Even the axis is in deceleration by MC_Halt command, the next command can be issued and effective.

MC_Stop

MC_Stop is primarily intended for emergency stop functionality or exceptional situations. As long as 'Execute' input is TRUE, the axis remains in the state 'Stopping' and may not be executing any other motion command. If Execute input is FALSE, the axis goes to 'Standstill' status.

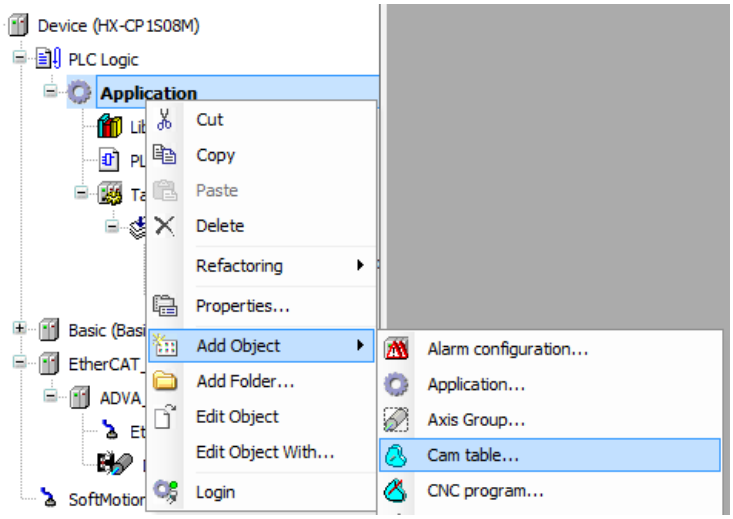


Chapter 6 Multi-Axis Control

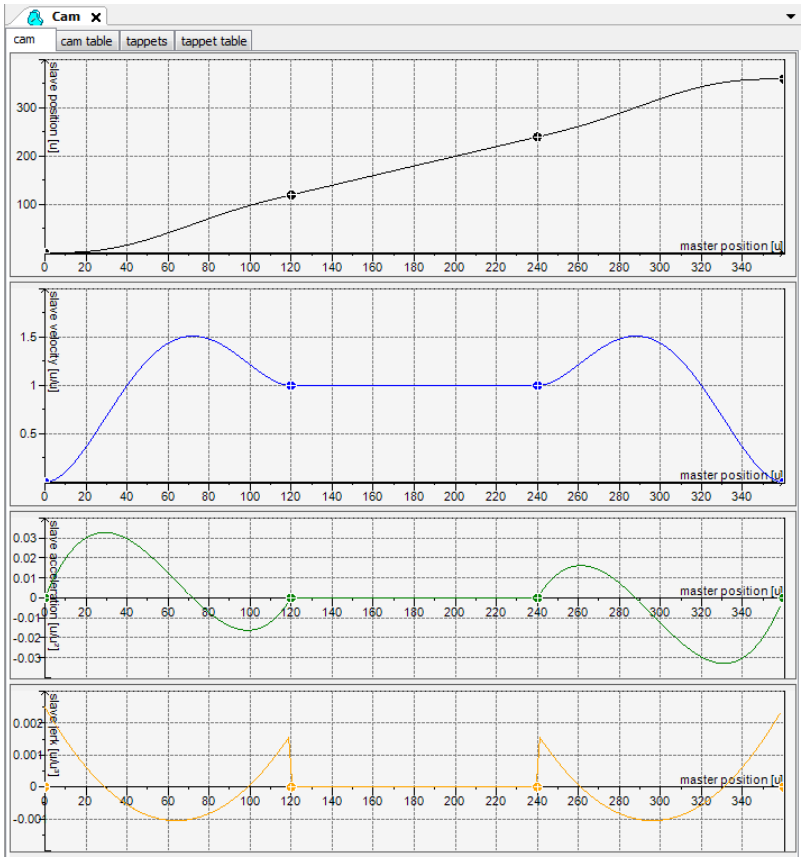
6.1 Cam Synchronization

6.1.1 Cam Table Definition

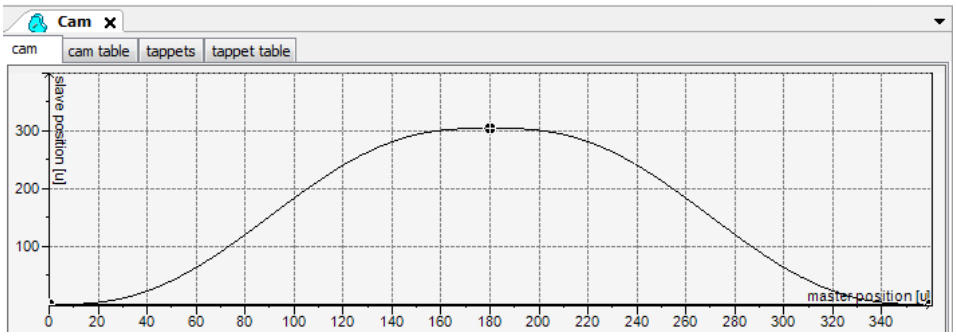
Right click on [Application] and choose [Add Object]-[Cam table...].



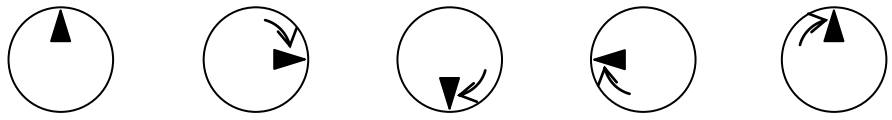
New cam table is created. The horizontal axis is the position of the master, and the vertical axes are position, velocity, acceleration and jerk of the slave for each. Graphic editor can be edited directly with mouse dragging. In addition, it is possible to specify with numeric data in [cam table] tab. Graphic data and numeric data are related dynamically.



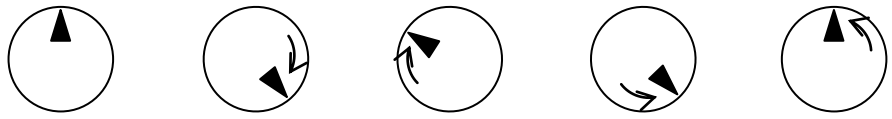
For example, in case the cam profile below is defined, master and slave axis rotate as follows.



Master

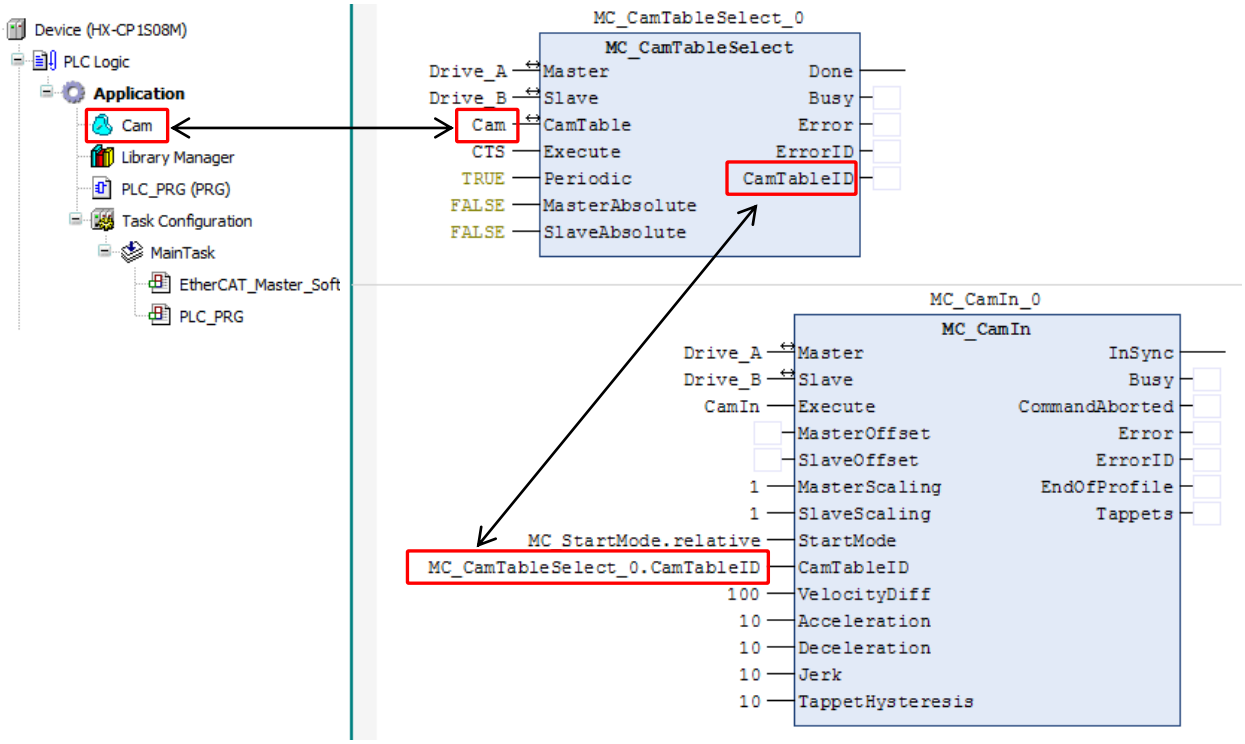


Slave



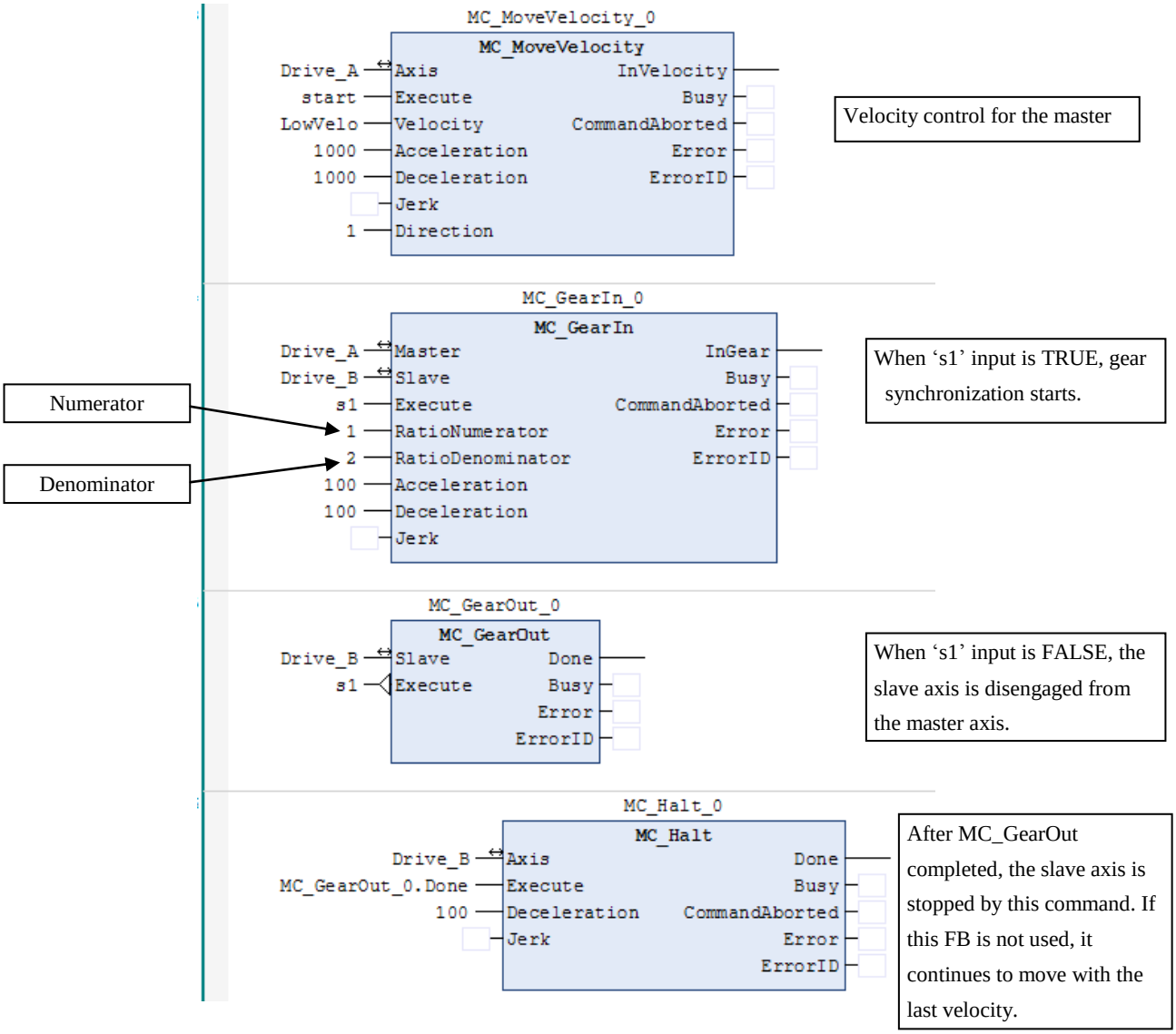
6.1.2 Sample Program

The minimum configuration for cam is shown as follows. ‘CamTable’ input of MC_CamTableSelect must be same name as cam table’s name under the device tree. Connect ‘CamTableID’ output of MC_CamTableSelect to ‘CamTableID’ input of MC_CamIn.



6.2 Gear Synchronization

A sample program of gearing is shown as below. When ‘s1’ input is TRUE, the slave axis (Drive_B) rotates according to the master axis (Drive_A) with gear ratio [2:1]. If ‘s1’ input is FALSE, the slave axis stops.



The following function blocks are available for synchronous control. Refer to chapter 9 for further information.

Function Block	Description
MC_CamIn	Engages the CAM.
MC_CamOut	Disengages the slave axis from the master axis.
MC_CamTableSelect	Selects the CAM table.
MC_GearIn	Commands a ratio between the velocity of the slave and master axis.
MC_GearInPos	Commands a ratio between the position of the slave and master axes from the synchronization point onwards.
MC_GearOut	Disengages the slave axis from the master axis.
MC_Phasing	Creates an phase shift in the master position of a slave axis.

MEMO

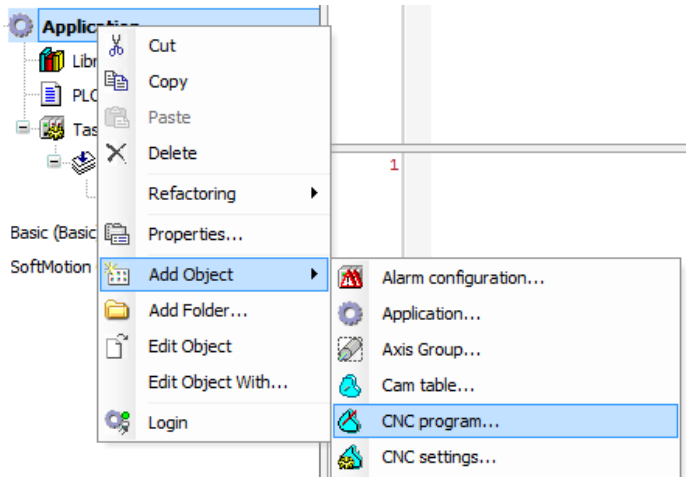
Chapter 7 CNC Control

The features described in this chapter are supported by CNC motion type (HX-CP1H16M) only.
Be noted that motion type (HX-CP1S08M) does not support CNC features.

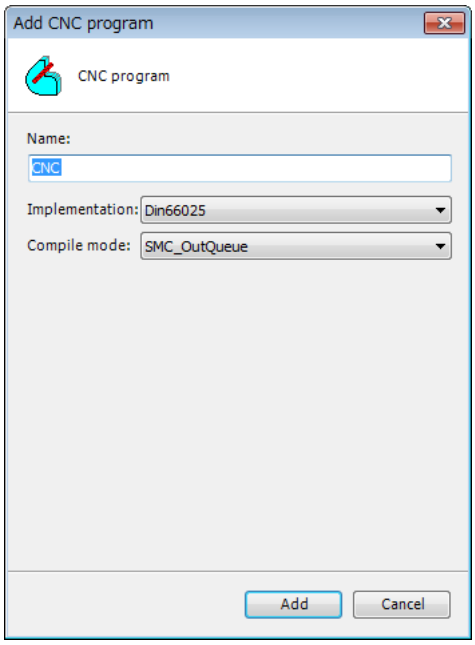
7.1 CNC Editor

7.1.1 Configuration of CNC Editor

Right-click on [Application] and choose [Add Object]-[CNC program...].

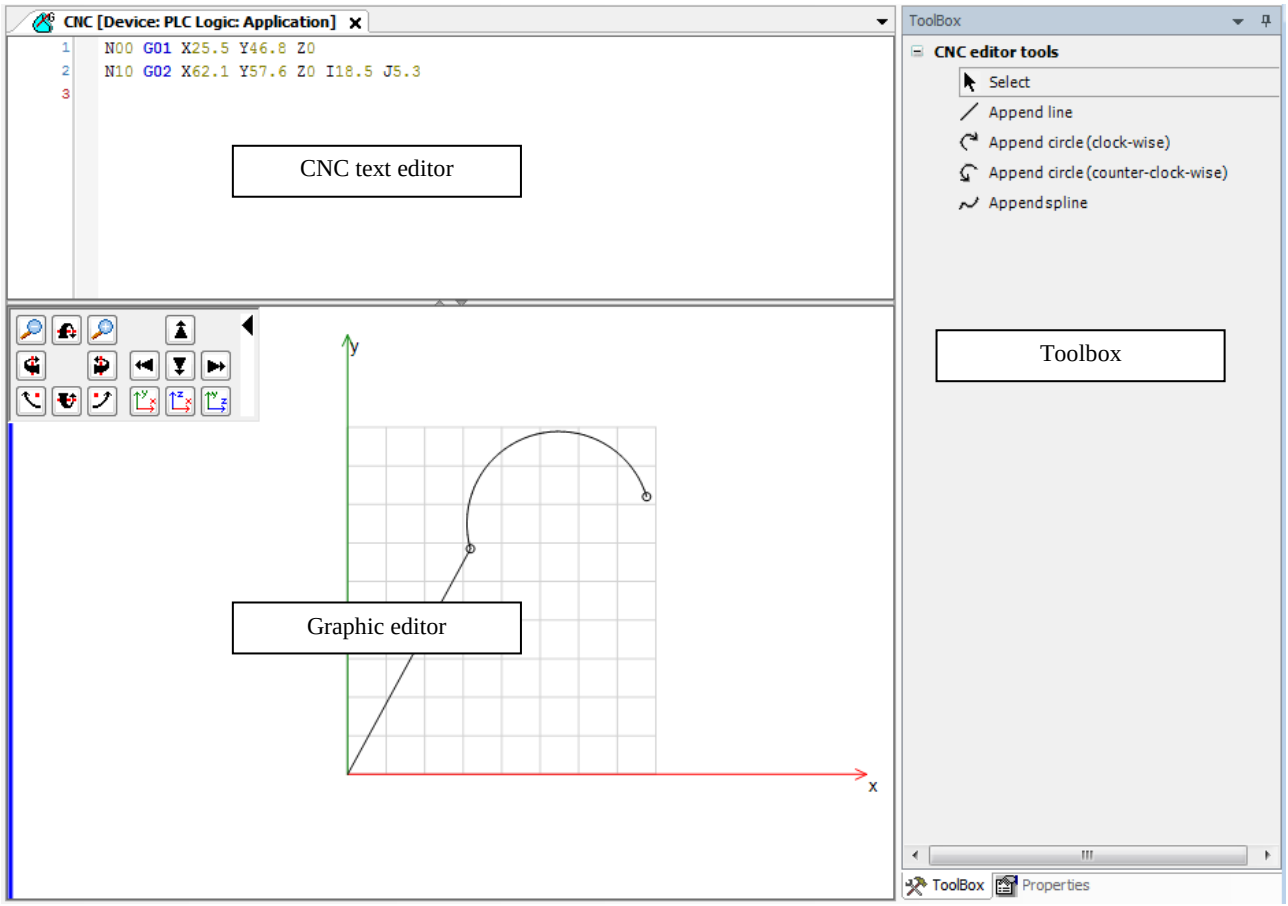


CNC editor dialog appears. Choose [Implementation] and [Compile mode] and click [Add] button.



Item	Options	Description
Implementation	Din66025	The path elements are programmed with CNC text editor according to Din66025 (G-code)
	Table	The path elements are listed in a table.
Compile mode	SMC_OutQueue	SMC_OutQueue type data
	SMC_CNC_REF	SMC_CNC_REF type data (Select if you want program variables)
	File	Select this if you want a file to be creaeted out of the G-code.

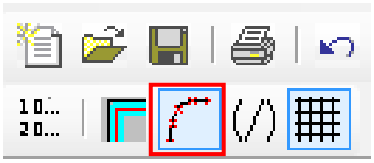
The CNC editor consisits of the text editor for G-code in the upper part and the graphic editor in the lower part as shown below. If you enter G-code program in the text editor, path elements are displayed accordingly in the graphic editor. If you draw path elements in the graphic editor, G-code program is displayed in the text editor.

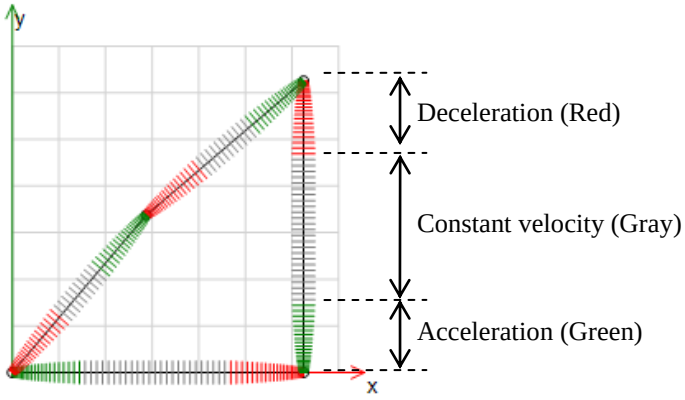


7.1.2 CNC Editor Features

Acceleration and deceleration

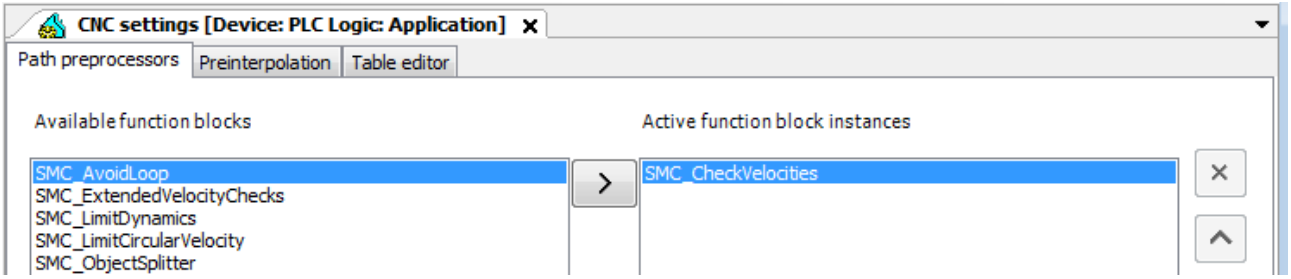
Choose [CNC]-[Show Interpolation Points] or click  icon to display velocity status.

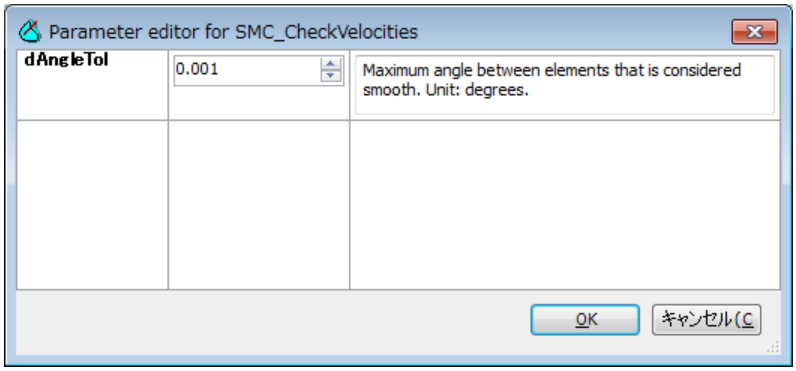




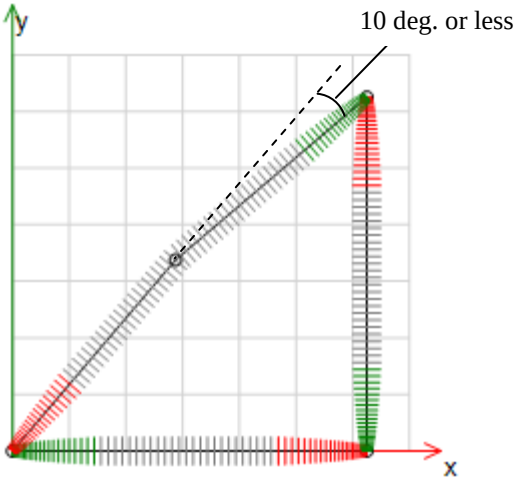
Angle tolerance

Normally an object stops at end of element. If you set angle torelance, an object does not stop at the angle under the torelance value. Double-click on [CNC settings] or right-mouse click on [CNC settings] and choose [Edit Object], then double-click on [SMC_CheckVelocities]. Set a value to dAngleTol.



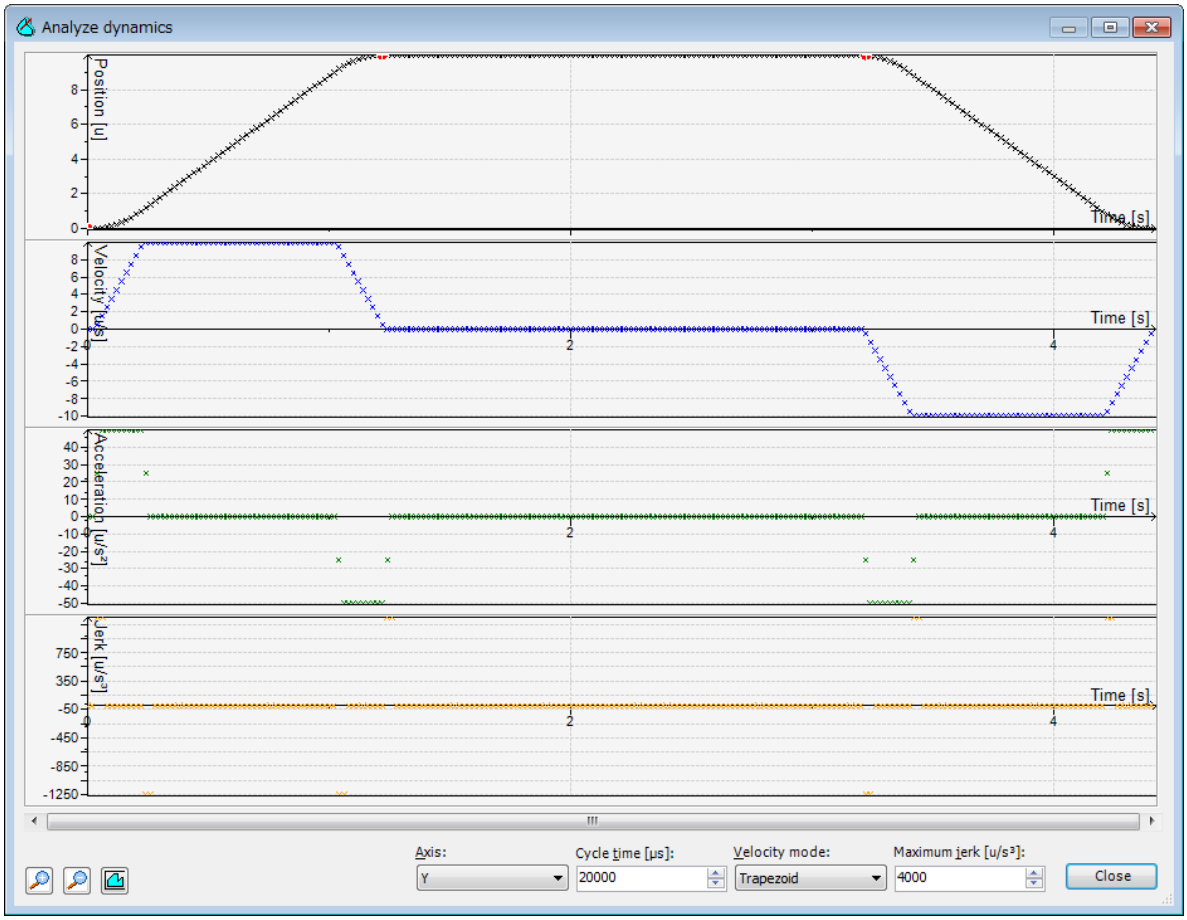


The figure right shows that dAngleTol is 10 degrees.



Analyze Dynamics

Choose [CNC]-[Analyze Dynamics] to show the dynamics of the path. Position, velocity, acceleration, deceleration and jerk of each axis are displayed as below.



7.2 G-code

7.2.1 G-code List

Code	Description
G0	Direct movement without tool contact, positioning
G1	Linear (straight) movement with tool contact
G2	Circle (-segment) clockwise
G3	Circle (-segment) counterclockwise
G4	Delay time
G5	Point of a 2D cardinal spline
G6	Parabola
G8	Ellipse (-segment) clockwise
G9	Ellipse (-segment) counterclockwise
G10	Point of a 3D cardinal spline
G15	Switch to 2D
G16	Switch to 3D by activating 3D mode with normal vector I/J/K to the plane
G17	Switch to 3D by activating 3D mode in X/Y plane
G18	Switch to 3D by activating 3D mode in Z/X plane
G19	Switch to 3D by activating 3D mode in Y/Z plane
G20	Conditional jump to L, if K<>0
G36	Write value D to variable O
G37	Increment variable O by value D
G38	Activate the extended preprocessor functions
G39	Deactivate the extended preprocessor functions
G40	End of the tool radius correction
G41	Start the tool radius correction to the left of the workpiece
G42	Start the tool radius correction to the right of the workpiece
G50	End of round path/smooth path function
G51	Start the smooth path function (SMC_SmoothPath)
G52	Start the round path function (SMC_RoundPath)
G53	End the shift coordinate function
G54	Set offset of all following coordinates to the specified position
G55	Add the specified position to the current offset
G56	Set the offset such that the current position equals the specified position
G60	End of the avoid-loop function (SMC_AvoidLoop)
G61	Start of the avoid-loop function (SMC_AvoidLoop)
G70	End of the smoothing of additional axis (See SMC_SmoothAddAxes)
G71	Start of the smoothing of additional axis (See SMC_SmoothAddAxes)

Code	Description
G75	Time synchronization with interpolator
G90	Start interpreting the following coordinate values for X/Y/Z/A/B/C/P/Q/U/V/W) as absolute values.
G91	Start interpreting the following coordinate values for X/Y/Z/A/B/C/P/Q/U/V/W) as relative to the current position.
G92	Positioning by jump
G98	The axis midpoints (I/J/K) are interpreted as absolute values.
G99	The axis midpoints (I/J/K) are interpreted as values relative to the start position.

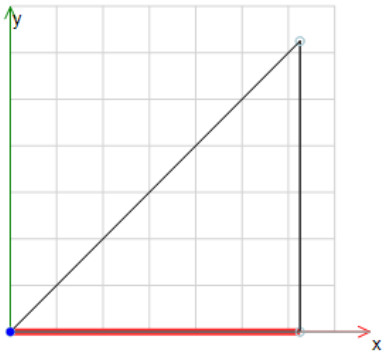
7.2.2 G-code Parameters

Parameter	Description	Remarks
X, Y, Z	X,Y,Z-coordinate of the target position	
A, B, C, P, Q, U, V, W	Target position of the additional axis	
D	Tool radius	G1-3, 5, 6, 8, 9, 10
	Variable value	G36-G37
	Tool radius for compensation	G40-G42
	Tool distance for angle rounding	G50-G52
E	Max. path acceleration/deceleration	Value < 0 : deceleration
EF	Path acceleration/deceleration for G0 movements	
F	Velocity	
FF	Velocity of a G0 movement only for the positioning command in this sentence.	
H L/O	Switch point for H-function	
I, J	Circle/ellipse midpoint or parabola vertex	Circle, Ellipse
K	Direction of the primary ellipse axis	Ellipse
	dT1 parameter value for M function	SMC_GetMParameters
L	Jump target	G20
	dT2 parameter value for M function	SMC_GetMParameters
M	M function	Eg. M5
O	Variable value	G36-G37
	Data structure for the parameter for an M function	
R	Circle radius	Circle
	Length ratio of the elliptical secondary/primary axis	Ellipse
S	S profile	
T	Aperture angle in degree	Circle
	Time in second	Delay time

7.2.3 G-code Sample Program

(1) Linear interpolation

```
N000 F100 E200 E-200      Velocity: 100, Acc.: 200, Dec. :200
N010 G01 X100 Y0          Move to (100, 0)
N020 G01 X100 Y100        Move to (100, 100)
N030 G01 X0 Y0            Move to (0, 0)
```

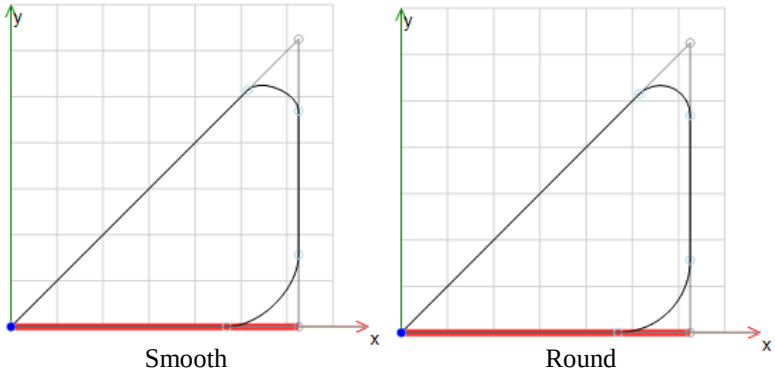


(2) Linear interpolation (smooth)

```
N000 G51 D25 F100 E200 E-200
N010 G01 X100 Y0
N020 G01 X100 Y100
N030 G01 X0 Y0
N040 G50
```

(3) Linear interpolation (round)

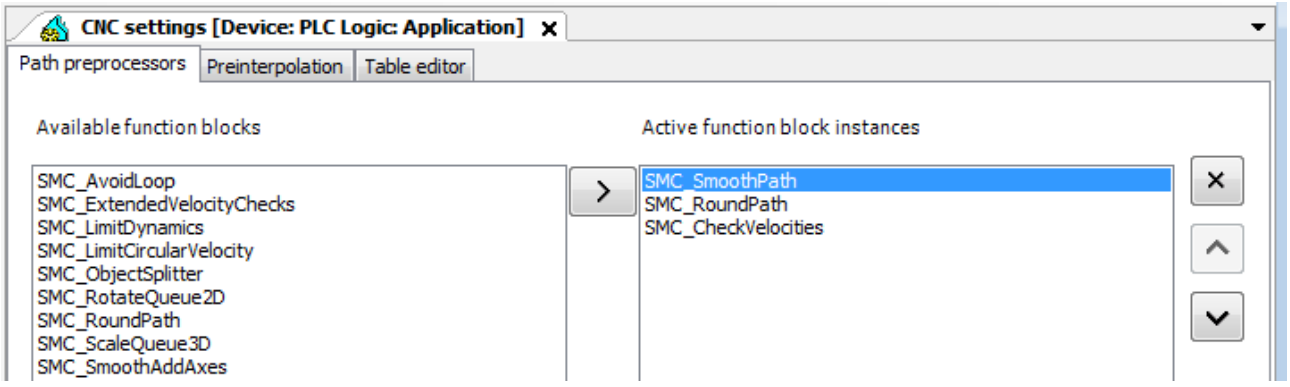
```
N000 G52 D25 F100 E200 E-200
N010 G01 X100 Y0
N020 G01 X100 Y100
N030 G01 X0 Y0
N040 G50
```



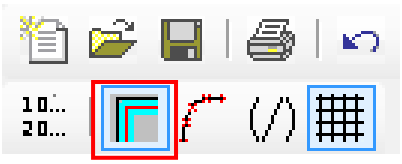
Smooth Round

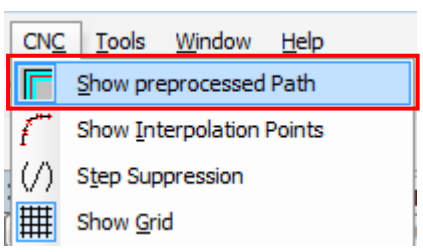
NOTE

When G51 is used, add SMC_SmoothPath to the Active function block instances.
When G52 is used, add SMC_RoundPath to the Active function block instances.



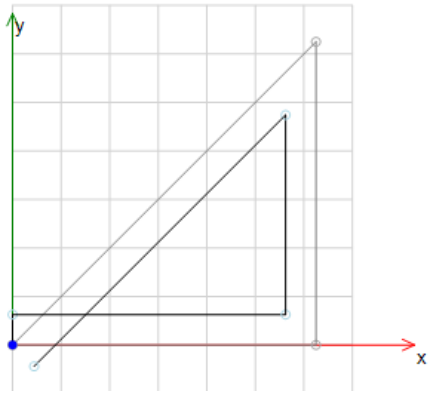
Activate [Show preprocessed Path] to display the path with smooth/round applied.





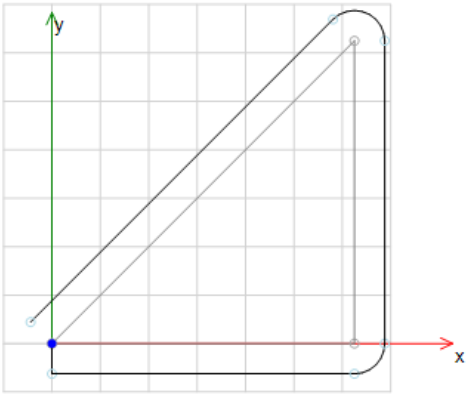
(4) Linear interpolation with tool radius correction (left)

```
N000 F100 E200 E-200
N010 G41 D10
N020 G00 X0 Y0
N030 G01 X100 Y0
N040 G01 X100 Y100
N050 G01 X0 Y0
N060 G40
```



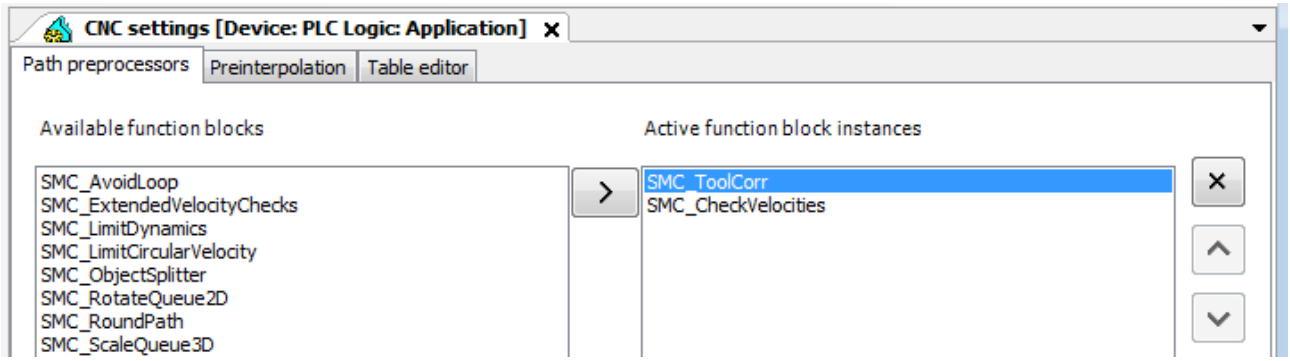
(5) Linear interpolation with tool radius correction (right)

```
N000 F100 E200 E-200
N010 G42 D10
N020 G00 X0 Y0
N030 G01 X100 Y0
N040 G01 X100 Y100
N050 G01 X0 Y0
N060 G40
```



NOTE

When G41 or G42 is used, add SMC_ToolCorr to the Active function block instances.

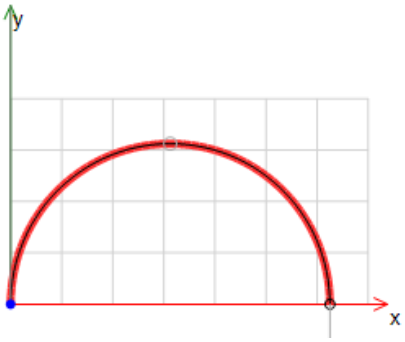


(6) Circlar interpolation

Target position and radius

```
N000 F100 E200 E-200
N010 G02 X100 Y0 R50
```

From (0, 0) to (100, 0) with radius 50



Target position and center

```
N000 F100 E200 E-200
N010 G02 X100 Y0 I50 J0
```

From (0, 0) to (100, 0) with center (50, 0)

Center and aperture angle

```
N000 F100 E200 E-200
N010 G02 I50 J0 T180
```

Center (50, 0) with aperture angle 180

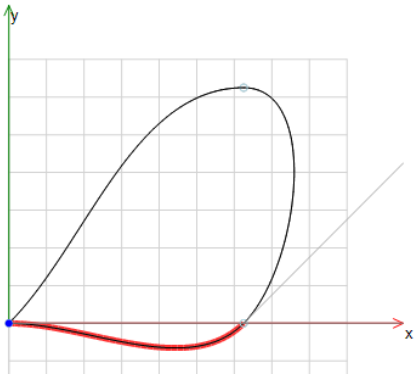
(7) Delay time

```
N000 G04 T1
```

1 second delay

(8) 2.5D spline

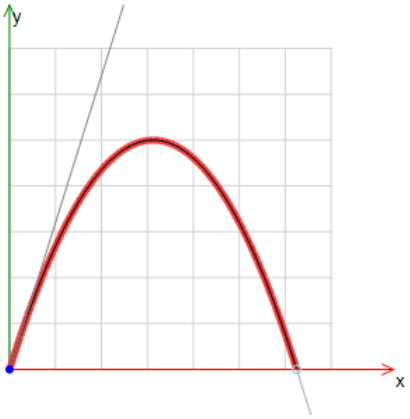
```
N000 F100 E200 E-200
N010 G05 X100 Y0
N020 G05 X100 Y100
N030 G05 X0 Y0
```



(9) Parabola

```
N000 F100 E200 E-200
N010 G06 X100 Y0 I50 J80
```

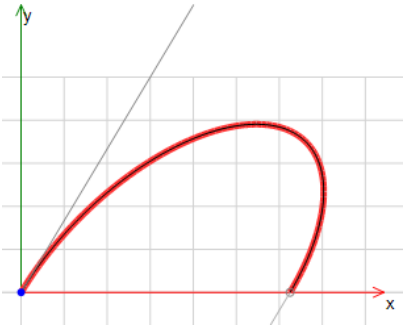
From (0, 0) to (100, 0) with vertex (50, 80)



(10) Ellipse

```
N000 F100 E200 E-200
N010 G08 X100 Y0 I50 J0 K45 R0.5
```

From (0, 0) to (100, 0) with center (50, 0), angle 45, ratio 0.5

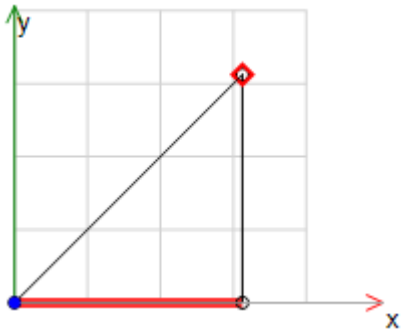


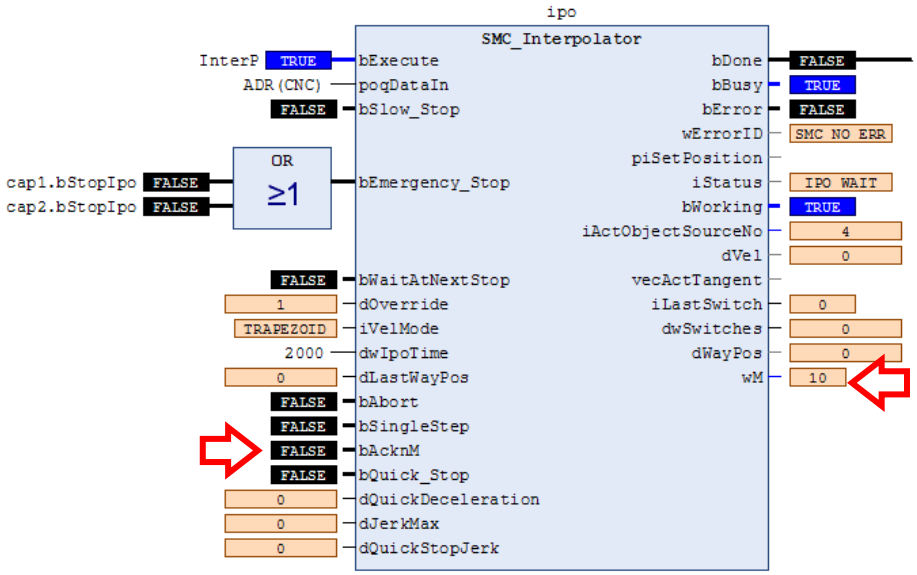
7.2.4 G-code M Function

M function makes the movement stop and restart.

With below sample codes, it stops at ◇ sign (100, 100) and at the same time value 10 is set to wM output of SMC_Interpolator. Set TRUE to bAcknM input of SMC_Interpolator to restart.

```
N000 F100 E100 E-100
N010 G01 X100 Y0 Z0
N030 G01 X100 Y100 Z0
N040 M10
N050 G01 X0 Y0 Z0
```

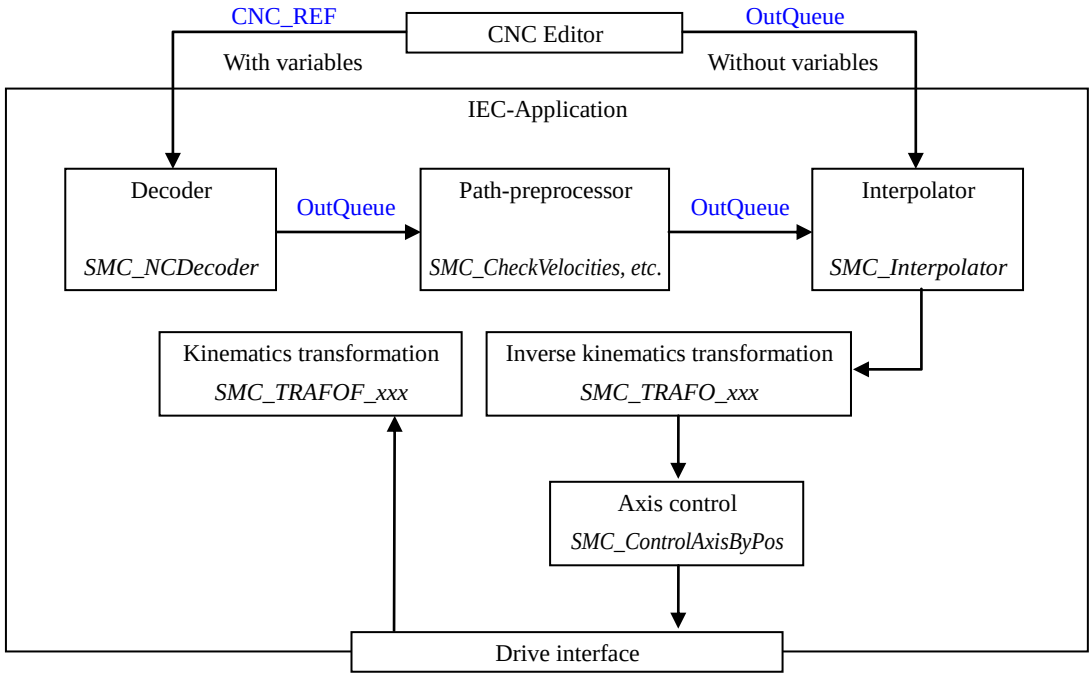




7.3 CNC Programming

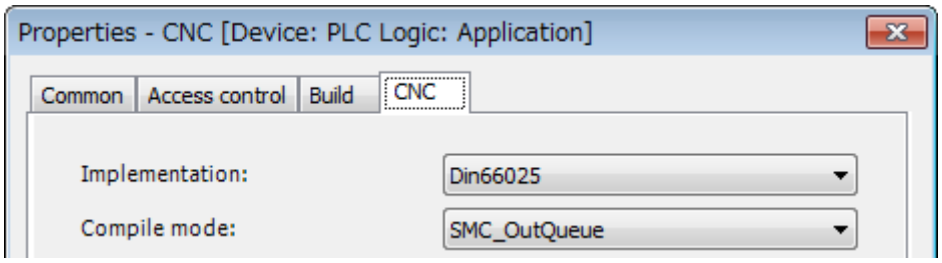
7.3.1 Overview

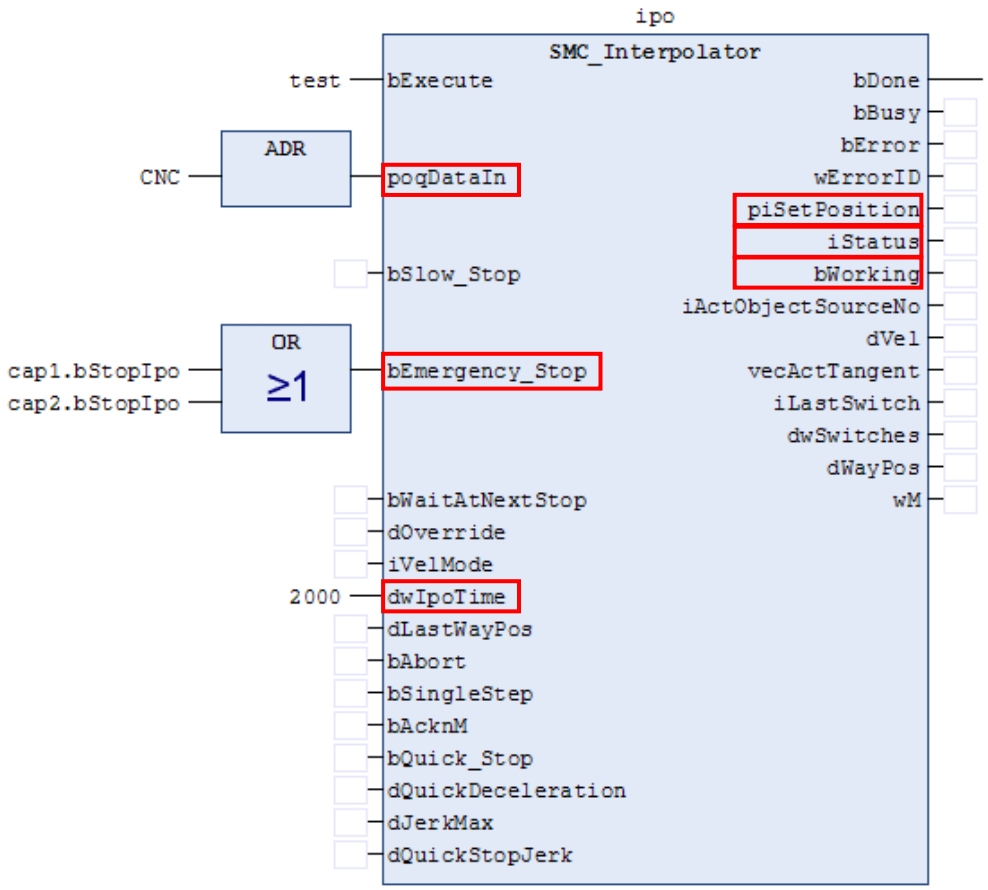
The basic flow of CNC programming is shown below.



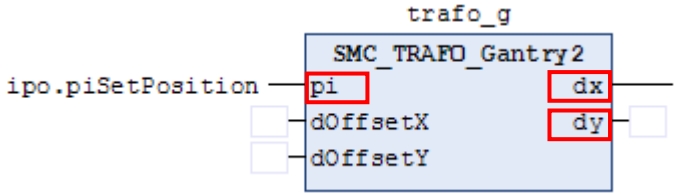
7.3.2 Programming (without variable)

(1) Set [SMC_OutQueue] to the compile mode of CNC and connect CNC data via ADR function to [poqDataIn] input of SMC_Interpolator. Be sure to set EtherCAT cycle time to [dwIpoTime] input in μs unit.
Connect [bStopIpo] output of each axis to [bEmergency_Stop] input with OR function.

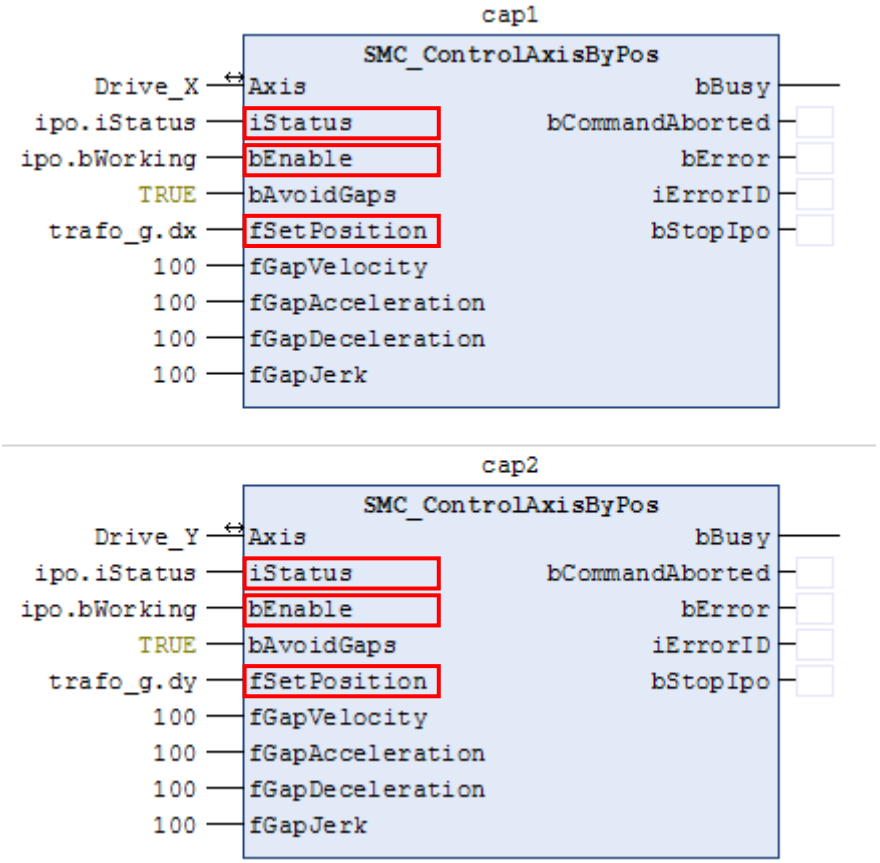




(2) Connect [piSetPosition] output of SMC_Interpolator to [pi] input of SMC_TRAFO function block, which must be selected according to kinematics of your system.

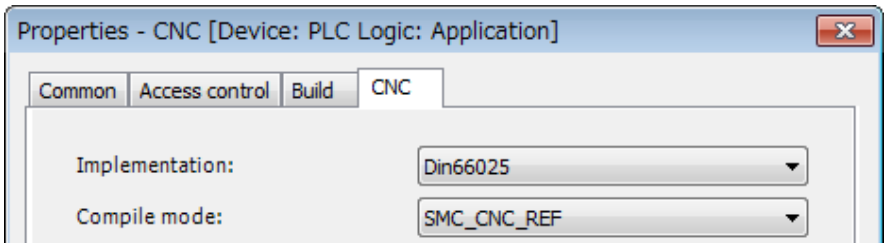


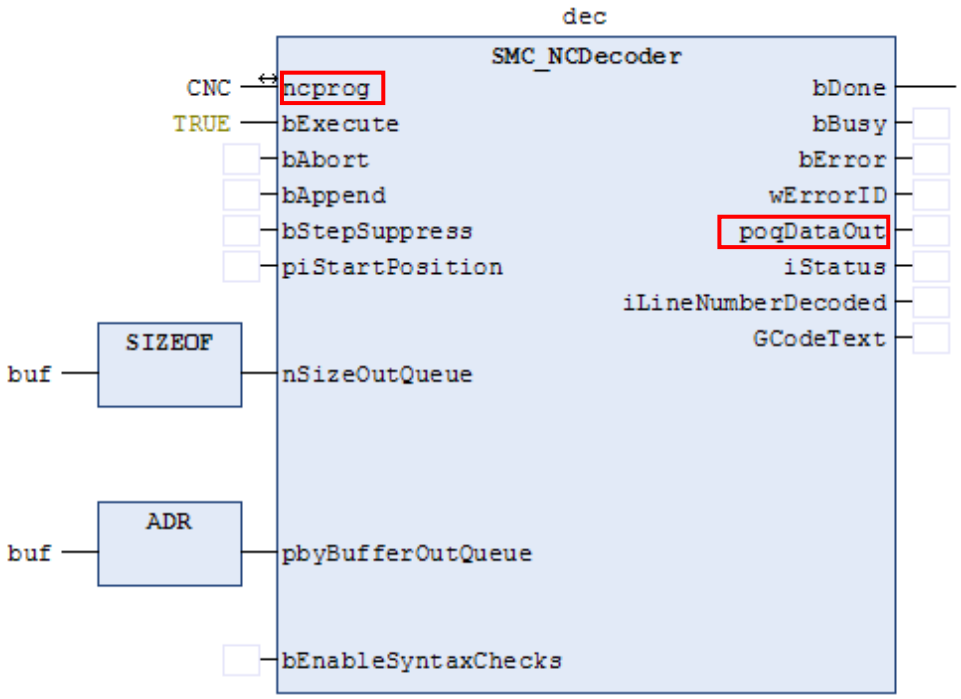
(3) Connect [dx] and [dy] output of SMC_TRAFO function block to [fSetPosition] input of SMC_ControlAxisByPos.



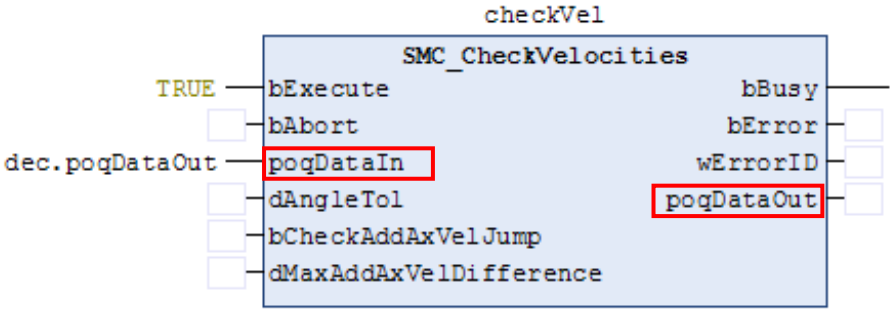
7.3.3 Programming (with variable)

(1) Set [SMC_CNC_REF] to the compile mode of CNC and connect CNC data to [ncprog] input of SMC_NCDecoder.

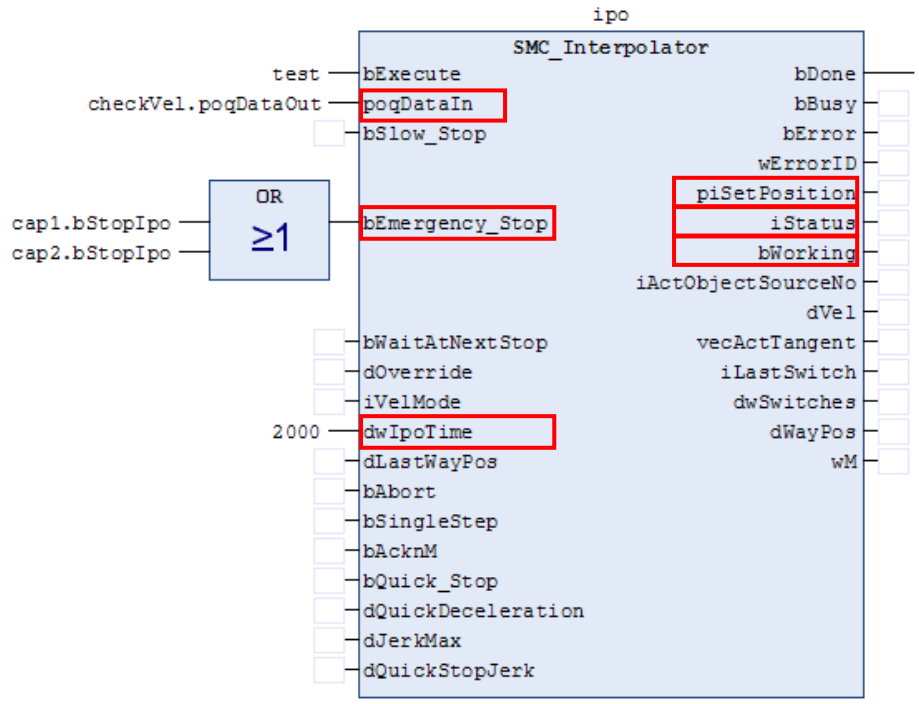




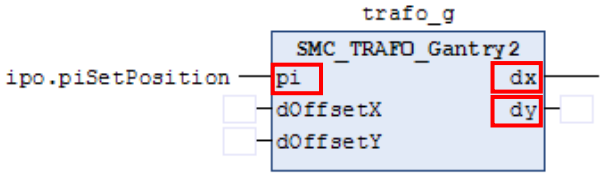
(2) Connect [poqDataOut] output of SMC_NCDecoder to [poqDataIn] input of SMC_CheckVelocities.



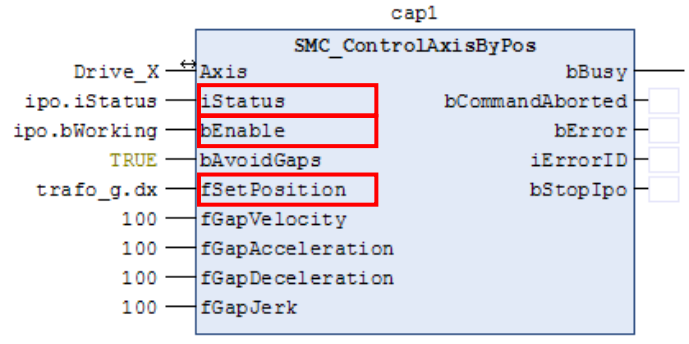
(3) Connect [poqDataout] output of SMC_CheckVelocities to [poqDataIn] input of SMC_Interpolator.
Be sure to set EtherCAT cycle time to [dwIpoTime] input in μs unit.
Connect [bStopIpo] output of each axis to [bEmergency_Stop] input with OR function.

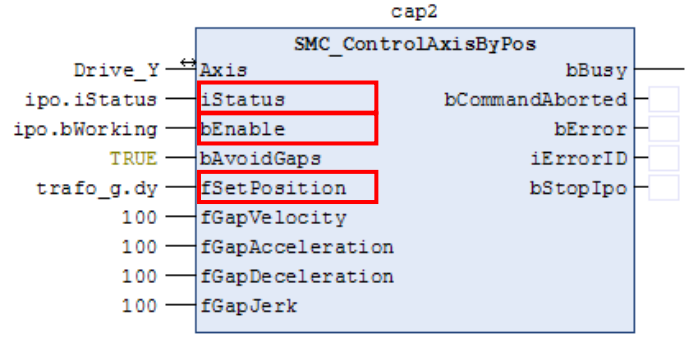


(4) Same as the previous section, Connect [piSetPosition] output of SMC_Interpolator to [pi] input of SMC_TRAFO function block, which must be selected according to kinematics of your system.



(5) Connect [dx] and [dy] output of SMC_TRAFO function block to [fSetPosition] input of SMC_ControlAxisByPos.





MEMO

Chapter 8 Robotics

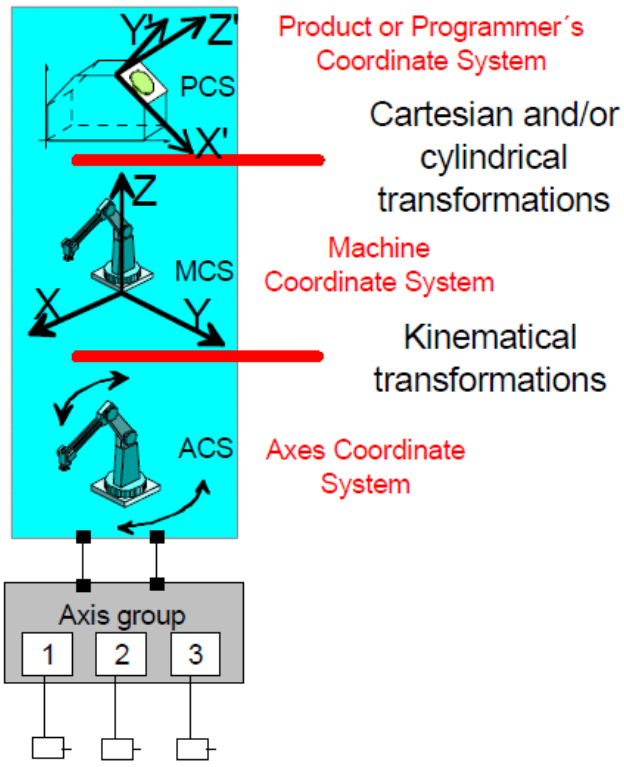
The features described in this chapter are supported by CNC motion type (HX-CP1H16M) only.
Be noted that motion type (HX-CP1S08M) does not support robotics features.

8.1 Overview

8.1.1 Coordinate System

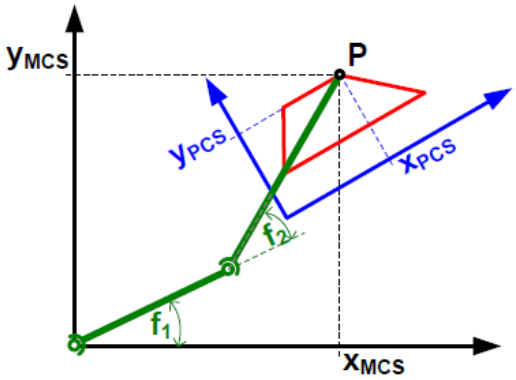
Coordinate system used in Robotics control are defined as follows.

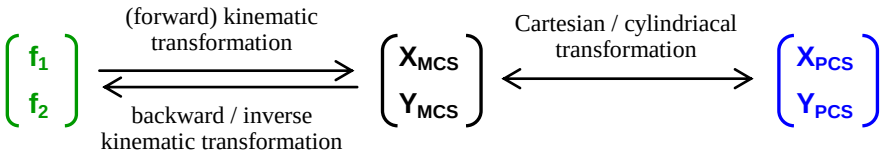
Short name	Name	Description
ACS	Axes Coordinate System	The system of coordinates related to the physical motors and the single movements caused by the single drive.
MCS	Machine Coordinate System	The system of coordinates that is related to the machine. A Cartesian coordinate system with the origin in a fixed position relative to the machine (the origin is defined during the machine setup). Sometimes called “World Coordinate System” or “Base Coordinate System”. (Note: with Cartesian build machines, MCS is a Cartesian Coordinate system and may be identical to ACS, or mapped via a trivial transformation). The coordinate system from the physical multiple axes ACS is linked to the MCS via a kinematic transformation (forward and backward conversion). The MCS represents an imaginable space with up to 6 dimensions.
PCS	Product Coordinate System Program Coordinate System	The coordinate system of the product can be called PCS – Product Coordinate System (or “Program Coordinate System” in CNC world, or Programmers Coordinate System). The PCS is based on the MCS typically by shifting and maybe rotating the MCS. The Zero point of the PCS is related to the product and can be changed during runtime by the program. The real work piece can have a rotation or shift to the MCS coordinate system or even might be moving relative to the MCS coordinate system. By specifying a trajectory in PCS one is able to describe the trajectory independent from the machine situation. To map these two worlds (MCS to PCS and vice versa), a cartesian or cylindrical transformation is normally done.



8.1.2 Coordinate System Example

The example below demonstrates how a point P, which is situated on a 2D workpiece (red trapezoid), can be described equivalent in PCS (blue), MCS (black) and ACS (green). Point P could be specified by referring to PCS resulting in the position $P_{PCS} = (x_{PCS}, y_{PCS})$. Given the shift and orientation of PCS relative to MCS, point P equivalently could be specified by $P_{MCS} = (x_{MCS}, y_{MCS})$. Assuming a SCARA robot with two rotary axes point P also could be described by the angles of the axes $P_{ACS} = (\varphi 1, \varphi 2)$.

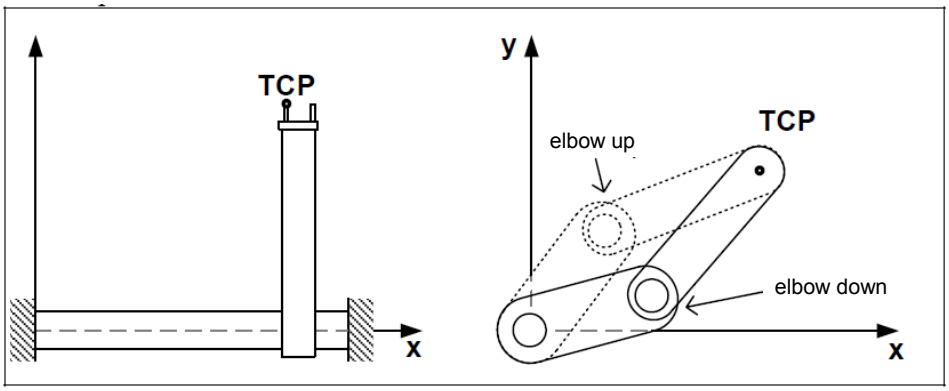




8.1.3 Kinematic Transformation

Axes are connected via mechanical links providing movements of the 'Tool Center Point', TCP in space. TCP is a distinguished point of the machine, sometimes also called 'Point of Interest', POI, or 'effector'. The physical assembly of the axes and therefore the position of the TCP in MCS is described by a so called kinematic transformation. The kinematic transformation connects ACS to MCS (forward conversion). By applying the kinematic transformation on a position related to ACS, this position can be transformed into a position in MCS. The other way round, applying the inverse kinematic transformation, a position related to MCS can be transformed into a position in ACS (backward conversion).

With simple cartesian machine constructions, in which axes are directly oriented in X-, Y-, and Z-directions of MCS, the kinematic transformation can easily be specified. One just has to define which axis is in the X-direction, which in Y, and which in the Z-direction. In the simplest case ACS is identically to MCS and one needn't distinguish between both. But in praxis there are many non-cartesian structures, like SCARA robots or Tripods, where the kinematic transformation is more complex.



Above example demonstrates how a position in space could be reached by a cartesian handling or a SCARA. Whereas the positions of the linear axes are more or less identical to the coordinates of the position in MCS, the positions of the axes of the SCARA are not that easy to calculate. Additionally there are two possible solutions of the backward kinematic transformation, different configurations of the machine: elbow down and elbow up.

8.1.4 Movements

Basically there are two types of movements which have to be distinguished.

(1) PTP (Point-to-Point)

With this type the essence is to reach the commanded position as fast as possible. This can be achieved by moving each axis on the shortest way from its starting position to its target position. Usually this kind of movement is the fastest way to reach a new commanded position, because at any time at least one axis moving at it's dynamic limit. The path and the path velocity of the TCP are not important. They are determined by the process of the positions of the axes and the kinematic transformation of the machine. Therefore this kind of movement is applicable for handlings and whenever the path of the TCP is not crucial. It is recommended that all axes will arrive at the commanded position at the same point in time (synchronized).

The applicable Function Blocks as specified herein are:

- MC_MoveDirectAbsolute
- MC_MoveDirectRelative

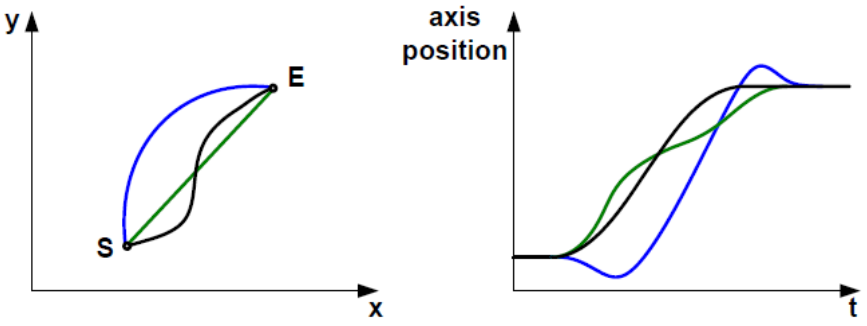
(2) CP (Cartesian Path)

CP movements cause the TCP to move along a defined path in Cartesian space. A path can be (a set of) a straight line, a circular movement, or a spline function. The path via which the new commanded position is reached is important. For example, this is essential if a workpiece is being processed. Further, the path velocity of the TCP can be controlled directly. Contrary to joint interpolated movements the process of the position of each axis is determined by the desired path and the inverse kinematic transformation.

The applicable Function Blocks as specified herein are:

- MC_MoveLinearAbsolute
- MC_MoveLinearRelative
- MC_MoveCircularAbsolute
- MC_MoveCircularRelative

The figure below illustrates the difference between different types of movement by means of a theoretical machine. (black: MC_MoveDirect, green: MC_MoveLinear, blue: MC_MoveCircular)



8.1.5 Buffer Mode (Blending)

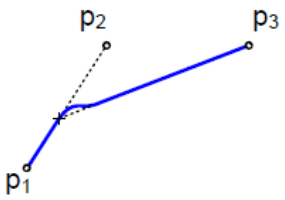
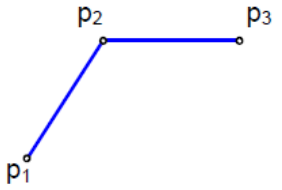
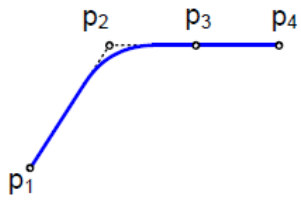
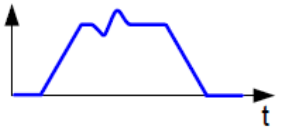
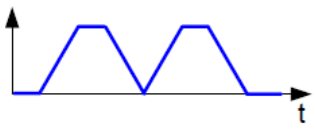
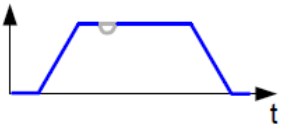
A fundamental part of interpolated motion control is blending of (buffered) consecutive motion commands on an axis group. Without blending the TCP of an axis group moves towards the commanded position, decelerates and comes to standstill exactly at the commanded position. In many applications a different behaviour of the TCP is desired and one wants to concatenate movements without stopping.

Reasons for this are:

- Reduction of the process cycle time (e.g. pick and place)
- Generate a smoother movement in order to reduce the mechanical stress
- Some applications demand a constant Velocity of the TCP (e.g. applying glue, painting, welding, etc.)

All this can be achieved by different types of blending. Common to all types of blending is a modification of the original path, resulting in a smooth trajectory without corners. There are 3 types of buffer mode.

Aborting : Current motion is aborted and new FB starts immediately.
Buffered without blending : New FB starts after current motion has been finished.
Blending : Velocity is blended during transition period.

	Aborting	Buffered without blending	Blending
Trajectory of TCP			
Speed of TCP			

Details of ENUM MC_BUFFER_MODE are shown below.

No.	MC_BUFFER_MODE	Description
0	Aborting	Start FB immediately
1	Buffered	Start FB after the currently last motion in queue has finished.
2	BlendingLow	The velocity is blended with the lowest velocity of both FBs.
3	BlendingPrevious	The velocity is blended with the velocity of the first FBs.
4	BlendingNext	The velocity is blended with the velocity of the second FBs.
5	BlendingHigh	The velocity is blended with the highest velocity of both FBs.

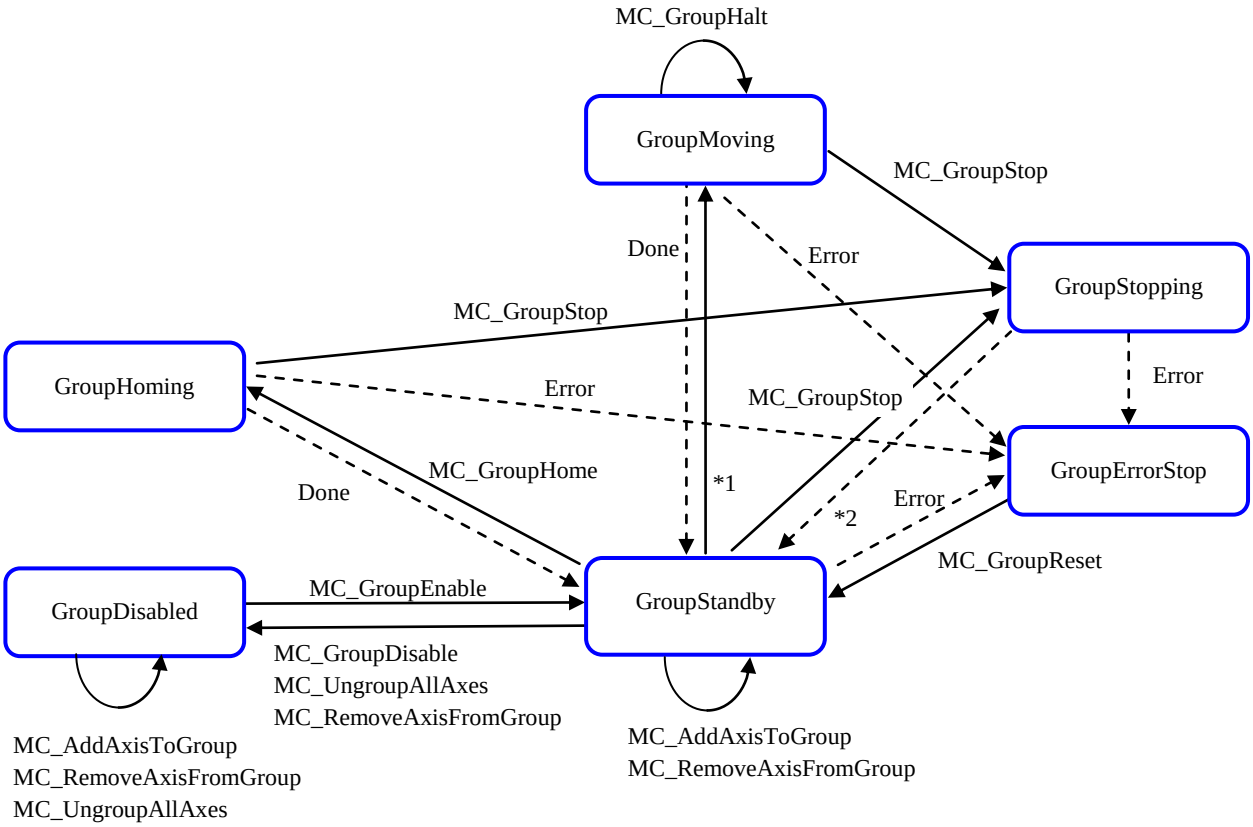
Details of ENUM MC_TRANSITION_MODE are shown below.

No.	MC_TRANSITION_MODE	Description
0	TMNone	No blending
1	TMStartVelocity	Velocity based blending
2	TMCornerDistance	Distance based blending

8.2 Axis Group

8.2.1 State Diagram

The state diagram of axis group is shown below. The state diagram reflects the state of the group and the issued FBs. Continuous lines are commanded transitions. Dotted lines are automatic transitions.

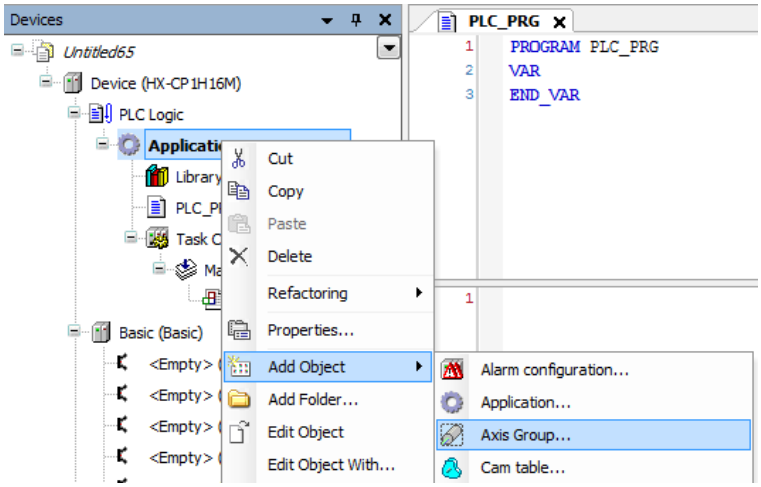


*1 Applicable for all non-administrative (moving) function blocks.

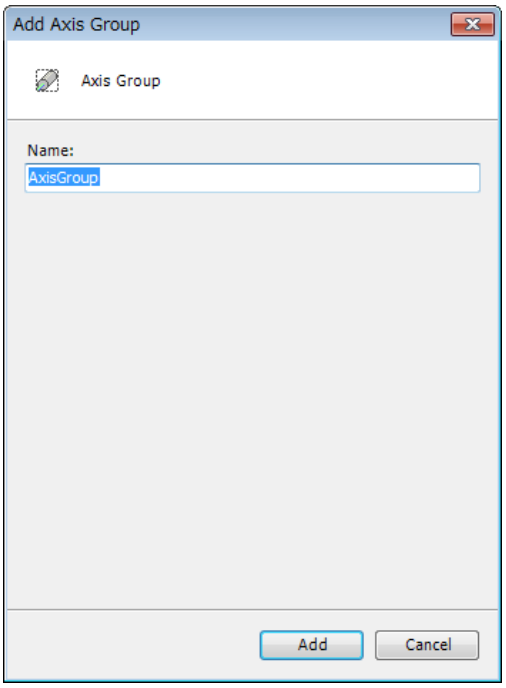
*2 MC_GroupStop.done = TRUE AND MC_GroupStop.execute = FALSE

8.2.2 Add Axis Group

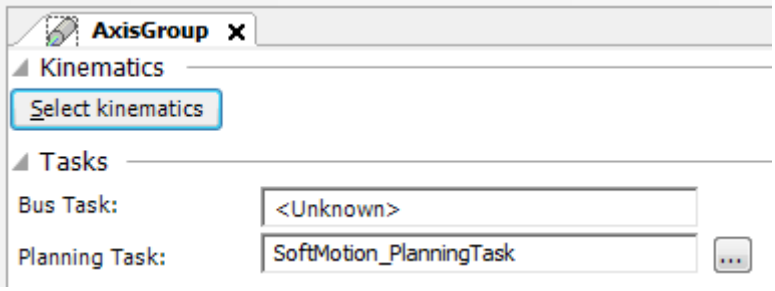
Right-click on [Application] and choose [Add Object]-[Axis Group...].



Axis Group dialog appears. Click [Add] button.

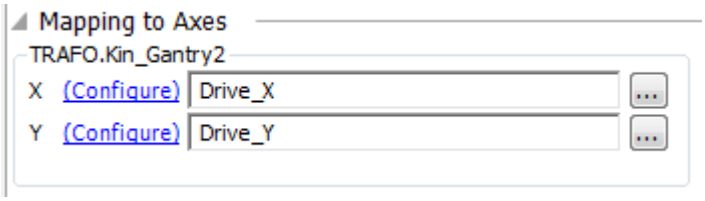


Click [Select kinematics] and choose kinematics according to your system.



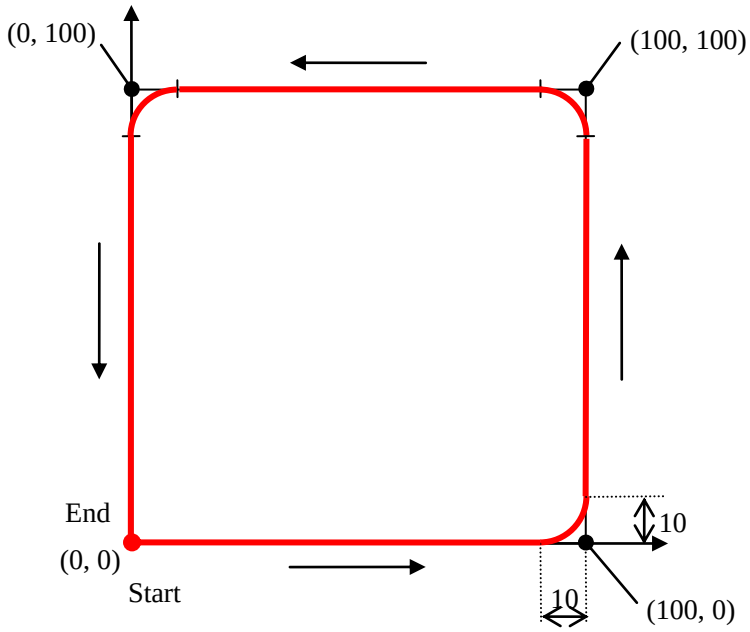
Kinematics	Description
TRAFO.Kin_CAxis	Transformation FB for a C-axis. The TCP will only turned around the Z axis.
TRAFO.Kin_CAxis_Tool	Transformation FB for a C-axis. The TCP will only turned around the Z axis and be moved in direction of the new x axis.
TRAFO.Kin_Tool	Transformation FB for a constant translation. The TCP will be shifted about a constant position vector (dToolx, dToolY, dToolZ). The orientation of the tool is not be changed with respect to the base (position) kinematics.
TRAFO.Kin_Wrist2	Transformation FB for a 2-axis inline wrist, where a0 rotates around the Z axis and a1 around the new Y axis.
TRAFO.Kin_Wrist3	Transformation FB for a 3-axis inline wrist, where a0 rotates around the Z axis, a1 around the new Y axis, and a2 around the new Z axis. The tool points in direction of the negative Z axis of the TCP coordinate system.
TRAFO.Kin_Gantry2	Transformation FB for a 2-axis gantry.
TRAFO.Kin_Gantry3	Transformation FB for a 3-axis gantry.
TRAFO.Kin_HGantry2	Transformation FB for a 2-axis H gantry.
TRAFO.Kin_HGantry3	Transformation FB for a 3-axis H gantry.
TRAFO.Kin_TGantry2	Transformation FB for a 2-axis T gantry.
TRAFO.Kin_Bipod_Rotary	Transformation FB for bipod kinematics.
TRAFO.Kin_Tripod_Linear	Transformation FB for tripod kinematics with linear axes.
TRAFO.Kin_Tripod_Rotary	Transformation FB for tripod kinematics with rotary axes.
TRAFO.Kin_Polar	Transformation FB for polar kinematics.
TRAFO.Kin_Scara2_Z	Transformation FB for SCARA2 kinematics with an additional axis.
TRAFO.Kin_5Axes	Transformation FB for 5-axis-gantries. This is possible way how a coupled kinematic can be realized based on existing kinematics.
TRAFO.Kin_Scara3_Z	Transformation FB for SCARA3 kinematics with an additional axis.
TRAFO.Kin_4AxesPalletizer	Transformation FB for a 4-axis palletizer.
TRAFO.Kin_ArticulatedRobot_6DOF	Transformation FB for a 6-axis articulated robot.

Configure the drives according to the kinematics.



8.3 Robotics Programming

The following sample program is to demonstrate TCP moving along the red colored trajectory.



Variable definitions

```
VAR
        state: INT;
        ServoOn: BOOL;
        grs: MC_GroupReadStatus;
        gp: SMC_GroupPower;
        mh1: MC_Home;
        mh2: MC_Home;
        gre: MC_GroupEnable;
        mla1: MC_MoveLinearAbsolute;
        mla2: MC_MoveLinearAbsolute;
        mla3: MC_MoveLinearAbsolute;
        mla4: MC_MoveLinearAbsolute;
END_VAR
```

Program

```
grs(AxisGroup:=AxisGroup, Enable:=TRUE); // MC_GroupReadStatus

CASE state OF
0:      // SMC_GroupPower
        gp(AxisGroup:=AxisGroup, Enable:=TRUE, bRegulatorOn:=ServoOn, bDriveStart:=TRUE);
        IF gp.Status THEN
                state:=state+1;
        END_IF
```

```
1:    // MC_Home & MC_GroupEnable
          mh1(Axis:=Drive_X, Execute:=TRUE, Position:=0);
          mh2(Axis:=Drive_Y, Execute:=TRUE, Position:=0);
          IF mh1.Done=TRUE AND mh2.Done=TRUE THEN
              gre(AxisGroup:=AxisGroup, Execute:=TRUE);
              state:=state+1;
          END_IF

2:    // MC_MoveLinearAbsolute : path 1 from (0,0) to (100,0)
      IF gre.Done THEN  // GroupEnable done
          mla1.Position.c.X:=100;  // Target position X=100
          mla1.Position.c.Y:=0;    // Target position Y=0
          mla1.Velocity:=100;      // Velocity 100
          mla1.Acceleration:=100;  // Acceleration 100
          mla1.Deceleration:=100;  // Deceleration 100
          mla1.Jerk:=100;          // Jerk 100
          mla1.CoordSystem:=SMC_COORD_SYSTEM.MCS;
          mla1.BufferMode:=MC_BUFFER_MODE.Aborting;
          mla1(AxisGroup:=AxisGroup, Execute:=TRUE);
          state:=state+1;
      END_IF

3:    // MC_MoveLinearAbsolute : path 2 from (100,0) to (100,100)
      IF mla1.CommandAccepted THEN
          mla2.Position.c.X:=100;    // Target position X=100
          mla2.Position.c.Y:=100;    // Target position Y=100
          mla2.Velocity:=100;
          mla2.Acceleration:=100;
          mla2.Deceleration:=100;
          mla2.Jerk:=100;
          mla2.CoordSystem:=SMC_COORD_SYSTEM.MCS;
          mla2.BufferMode:=MC_BUFFER_MODE.BlendingLow;
          mla2.TransitionMode:=MC_TRANSITION_MODE.TMCornerDistance;
          mla2.TransitionParameter[0]:=10;   // Blending with radius 10
          mla2(AxisGroup:=AxisGroup, Execute:=TRUE);
          state:=state+1;
      END_IF

4:    // MC_MoveLinearAbsolute : path 3 from (100,100) to (0,100)
      IF mla2.CommandAccepted THEN
          mla3.Position.c.X:=0;     // Target position X=0
          mla3.Position.c.Y:=100;    // Target position Y=100
          mla3.Velocity:=100;
          mla3.Acceleration:=100;
          mla3.Deceleration:=100;
          mla3.Jerk:=100;
          mla3.CoordSystem:=SMC_COORD_SYSTEM.MCS;
          mla3.BufferMode:=MC_BUFFER_MODE.BlendingLow;
          mla3.TransitionMode:=MC_TRANSITION_MODE.TMCornerDistance;
          mla3.TransitionParameter[0]:=10;   // Blending with radius 10
          mla3(AxisGroup:=AxisGroup, Execute:=TRUE);
          state:=state+1;
      END_IF
```

```
5:      // MC_MoveLinearAbsolute : path 4 from (0,100) to (0,0)
        IF mla3.CommandAccepted THEN
                mla4.Position.c.X:=0;    // Target position X=0
                mla4.Position.c.Y:=0;    // Target position Y=0
                mla4.Velocity:=100;
                mla4.Acceleration:=100;
                mla4.Deceleration:=100;
                mla4.Jerk:=100;
                mla4.CoordSystem:=SMC_COORD_SYSTEM.MCS;
                mla4.BufferMode:=MC_BUFFER_MODE.BlendingLow;
                mla4.TransitionMode:=MC_TRANSITION_MODE.TMCornerDistance;
                mla4.TransitionParameter[0]:=10;   // Blending with radius 10
                mla4(AxisGroup:=AxisGroup, Execute:=TRUE);
                state:=state+1;
        END_IF

6:
                mla1(AxisGroup:=AxisGroup);
                mla2(AxisGroup:=AxisGroup);
                mla3(AxisGroup:=AxisGroup);
                mla4(AxisGroup:=AxisGroup);
        IF mla4.Done THEN
                mla1(AxisGroup:=AxisGroup, Execute:=FALSE);
                mla2(AxisGroup:=AxisGroup, Execute:=FALSE);
                mla3(AxisGroup:=AxisGroup, Execute:=FALSE);
                mla4(AxisGroup:=AxisGroup, Execute:=FALSE);
                state:=state+1;
        END_IF

7:
        CycleDone:=TRUE;

END_CASE
```

Chapter 9 Function Blocks for Motion Control

This chapter describes the specifications of frequently used function blocks. Refer to Appendix 2 in this manual or online help of HX-CODESYS for the information about other function blocks.

9.1 Function Blocks for Motion Control

9.1.1 Libraries for Motion Control

The function blocks for motion control are included in the libraries as shown below.

Library name	Function blocks	Prefix	Supported CPU	
			Motion type (HX-CP1S08M)	CNC motion type (HX-CP1H16M)
SM3_Basic	PLCopen 1 Single-axis	MC_***	●	●
	PLCopen 2 Single-axis		●	●
	PLCopen 1, 2 Multi-axis		●	●
	PLCopen 3 Single-axis		●	●
	Others	SMC_***	●	●
SM3_CNC	CNC	SMC_***	-	●
SM3_Robotics	PLCopen 4 Coordinated motion (administrative)	MC_***	-	●
	PLCopen 4 Coordinated motion (moving)		-	●

Function blocks with prefix “MC” conform with PLCopen.

9.1.2 Function Block Interface

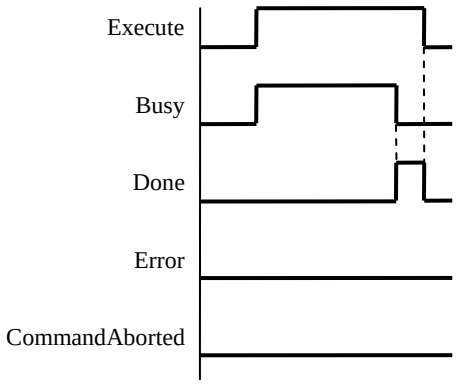
General rules of function block interface are described as follows.

Input parameters	With ‘Execute’: The parameters are used with the rising edge of the ‘Execute’ input. To modify any parameter it is necessary to change the input parameter(s) and to trigger the ‘Execute’ input again. With ‘Enable’: The parameters are used with the rising edge of the enable input and can be modified continuously.
Missing input parameters	If any parameter of a function block input is missing (“open”) then the value from the previous invocation of this instance will be used. In the first invocation the initial value is applied.
Acceleration, Deceleration and Jerk inputs	If the input ‘Acceleration’, ‘Deceleration’ or ‘Jerk’ is open, initial value (0) is applied, which causes that ‘Error’ output of the function block is TRUE. If velocity ramp type is ‘Trapezoid’ or ‘Sin^2’, ‘Jerk’ input can be open (initial value 0). However, if velocity ramp type is ‘Quadratic’ or ‘Quadratic (smooth)’, ‘Jerk’ input must not be zero, otherwise ‘Error’ output of the function block is TRUE.
Output exclusivity	With ‘Execute’: The outputs ‘Busy’, ‘Done’, ‘Error’ and ‘CommandAborted’ are mutually exclusive: only one of them can be TRUE on one FB. If ‘Execute’ is TRUE, one of these outputs has to be TRUE. With ‘Enable’: The outputs ‘Valid’ and ‘Error’ are mutually exclusive: only one of them can be TRUE on one FB.

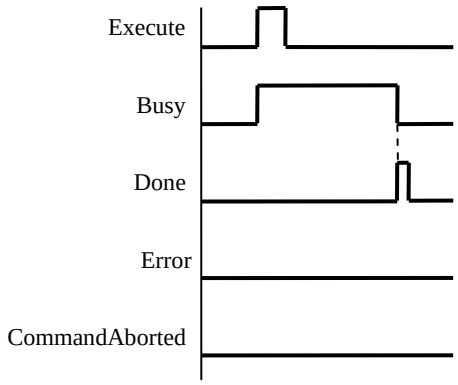
Output status	With 'Execute': The 'Done', 'Error', 'ErrorID' and 'CommandAborted' outputs are reset with the falling edge of 'Execute'. However the falling edge of 'Execute' does not stop or even influence the execution of the actual FB. It must be guaranteed that the corresponding outputs are set for at least one cycle if the situation occurs, even if execute was reset before the FB completed. If an instance of a FB receives a new execute before it finished (as a series of commands on the same instance), the FB won't return any feedback, like 'Done' or 'CommandAborted', for the previous action. With 'Enable': The 'Valid', 'Enabled', 'Busy', 'Error' and 'ErrorID' outputs are reset with the falling edge of 'Enable' as soon as possible.
Behavior of Done output	The 'Done' output is set when the commanded action has been completed successfully. With multiple Function Blocks working on the same axis in a sequence, the following applies: when one movement on an axis is interrupted with another movement on the same axis without having reached the final goal, 'Done' of the first FB will not be set.
Behavior of Busy output	With 'Execute': Every FB can have an output 'Busy', reflecting that the FB is not finished and new output values can be expected. 'Busy' is SET at the rising edge of 'Execute' and RESET when one of the outputs 'Done', 'Aborted', or 'Error' is set. With 'Enable': Every FB can have an output 'Busy', reflecting that the FB is working and new output values can be expected. 'Busy' is SET at the rising edge of 'Enable' and stays SET as long as the FB is performing any action. It is recommended that the FB should be kept in the active loop of the application program for at least as long as 'Busy' is true, because the outputs may still change.
Behavior of InVelocity, InGear, InTorque and InSync	The outputs 'InVelocity', 'InGear', 'InTorque', and 'InSync' (from now on referred to as 'Inxxx') have a different behavior than the 'Done' output. As long as the FB is Active, 'Inxxx' is SET when the set value equals the commanded value, and will be RESET when at a later time they are unequal. For example, the InVelocity output is SET when the set velocity is equal to the commanded velocity. This is similar for 'InGear', 'InTorque', and 'InSync' outputs in the applicable FBs. 'Inxxx' is updated even if 'Execute' is FALSE as long as the FB has control of the axis ('Active' and 'Busy' are SET). 'Inxxx' definition does not refer to the actual axis value, but must refer to the internal instantaneous setpoint.
Behavior of CommandAborted	'CommandAborted' is set, when a commanded motion is interrupted by another motion command. The reset-behavior of 'CommandAborted' is like that of 'Done'. When 'CommandAborted' occurs, the other output-signals such as 'InVelocity' are reset.
Enable input and Valid output	The 'Enable' input is coupled to a 'Valid' output. 'Enable' is level sensitive, and 'Valid' shows that a valid set of outputs is available at the FB. The 'Valid' output is TRUE as long as a valid output value is available and the 'Enable' input is TRUE. The relevant output value can be refreshed as long as the input 'Enable' is TRUE. If there is a FB error, the output is not valid ('Valid' set to FALSE). When the error condition disappears, the values will reappear and 'Valid' output will be set again.
Position, Distance	'Position' is a value defined within a coordinate system. 'Distance' is a relative measure related to technical units. 'Distance' is the difference between two positions.
Sign rules	The 'Velocity', 'Acceleration', 'Deceleration' and 'Jerk' are always positive values. 'Position' and 'Distance' can be both positive and negative.

The behavior of FB with ‘Execute’ input and ‘Done’ output

Without error

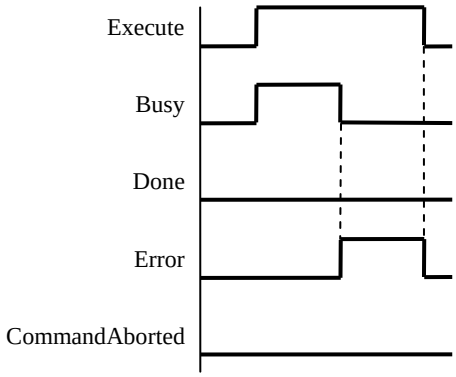


With Execute input keeping TRUE

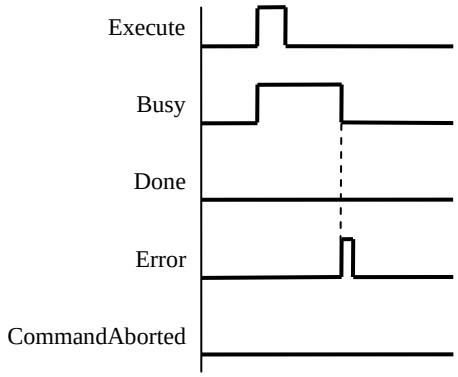


With rising edge of Execute input

With error

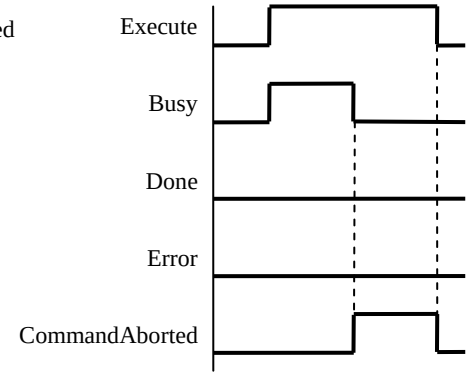


With Execute input keeping TRUE

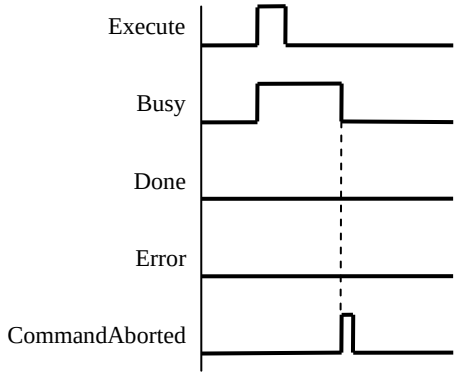


With rising edge of Execute input

Command aborted



With Execute input keeping TRUE

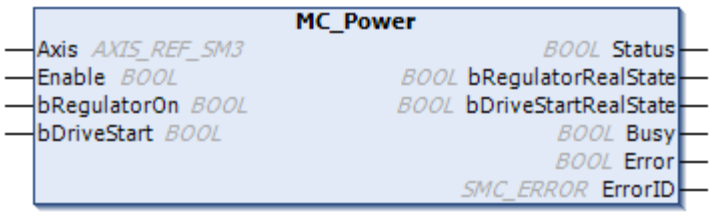


With rising edge of Execute input

9.2 PLCopen Part 1 for Single-Axis

9.2.1 MC_Power

Name	Description	Type
MC_Power	This FB controls the power stage (On or Off)	FB



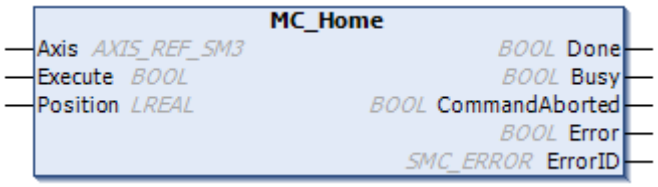
Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
	bRegulatorOn	BOOL	TRUE: Enables the power stage. FALSE: Disables the power stage.
	bDriveStart	BOOL	TRUE: Disables the quickstop mechanism. FALSE: Enables the quickstop mechanism.
OUT	Status	BOOL	TRUE: Axis is ready to move.
	bRegulatorRealState	BOOL	TRUE: The power stage has been switched on.
	bDriveStartRealState	BOOL	TRUE: Drive is not blocked by the quickstop mechanism.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

NOTE

When MC_Power is executed, there is a momentary ‘Stopping’ status (50 to 100ms) between ‘Disabled’ and ‘Standstill’, which can be seen with MC_ReadStatus. Although it is not described in the state diagram in page 4-1, this is expected behavior.

9.2.2 MC_Home

Name	Description	Type
MC_Home	This FB commands the axis to perform the search home sequence according to the drive. (controlled by the drive)	FB



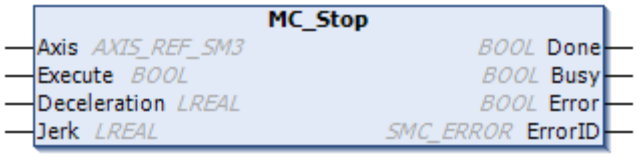
Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Position	BOOL	Absolute position when the reference signal is detected.
OUT	Done	BOOL	TRUE: Reference known and set successfully.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

NOTE

If a value other than 0 is set to ‘Position’ input, the sign of the current position might be inverted depending on drives. If inverted, set a right value with MC_SetPosition.

9.2.3 MC_Stop

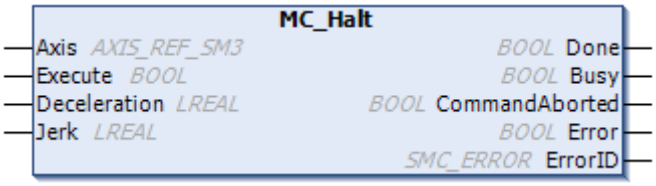
Name	Description	Type
MC_Stop	This FB commands a controlled motion stop and transfers the axis to the state 'Stopping'. It aborts any ongoing Function Block execution. While the axis is in state 'Stopping', no other FB can perform any motion on the same axis.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Deceleration	LREAL	Value of the 'deceleration' [u/s^2] (positive value)
	Jerk	LREAL	Value of the 'Jerk' [u/s^3] (positive value)
OUT	Done	BOOL	TRUE: Zero velocity reached.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.4 MC_Halt

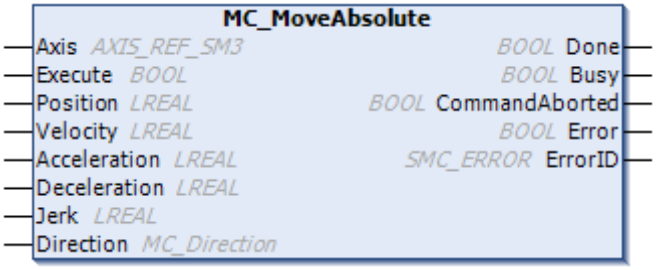
Name	Description	Type
MC_Halt	This FB commands a controlled motion stop. It is possible to set another motion command during deceleration of the axis, which will abort the MC_Halt and will be executed immediately.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Deceleration	LREAL	Value of the 'deceleration' [u/s^2] (positive value)
	Jerk	LREAL	Value of the 'Jerk' [u/s^3] (positive value)
OUT	Done	BOOL	TRUE: Zero velocity reached.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.5 MC_MoveAbsolute

Name	Description	Type
MC_MoveAbsolute	This FB commands a controlled motion to a specified absolute position.	FB



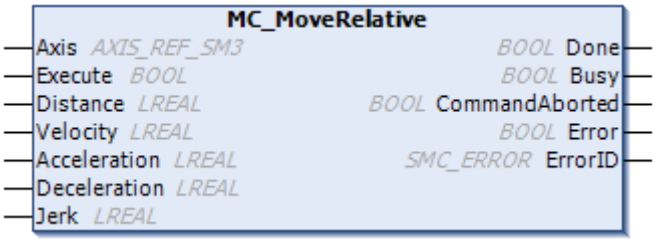
Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Position	LREAL	Target position [u] (positive or negative)
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
	Direction	MC_Direction	fastest (3), current (2), positive (1), shortest (0), negative (-1) (Refer to section 9.11 Enumeration (ENUM))
OUT	Done	BOOL	TRUE: End position has been achieved.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

MC_DIRECTION (ENUM)

Name	Value	Description
fastest	3	Selects the direction automatically in order to reach the target position as fast as possible (only modulo axes).
current	2	Keeps the current direction to reach the target (only modulo axes).
positive	1	Moves in positive direction.
shortest	0	Selects the direction according to the shortest distance (only modulo axes).
negative	-1	Moves in negative direction.

9.2.6 MC_MoveRelative

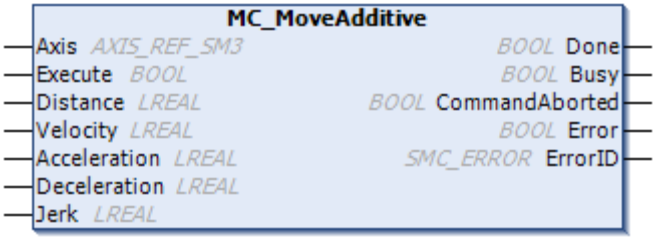
Name	Description	Type
MC_MoveRelative	This FB commands a controlled motion to a specified distance relative to the set position.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Distance	LREAL	Relative distance [u] (positive or negative)
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
OUT	Done	BOOL	TRUE: Distance has been achieved.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.7 MC_MoveAdditive

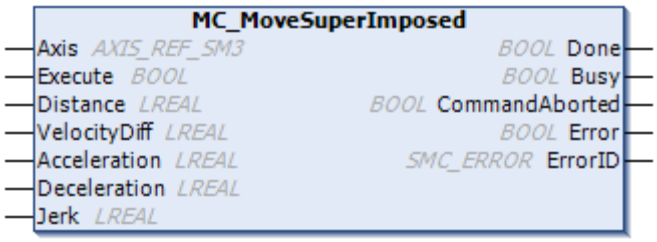
Name	Description	Type
MC_MoveAdditive	This FB commands a controlled motion of a specified relative distance additional to the most recent commanded position in the axis state 'DiscreteMotion'.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Distance	LREAL	Relative distance [u] (positive or negative)
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
OUT	Done	BOOL	TRUE: Distance has been achieved.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.8 MC_MoveSuperImposed

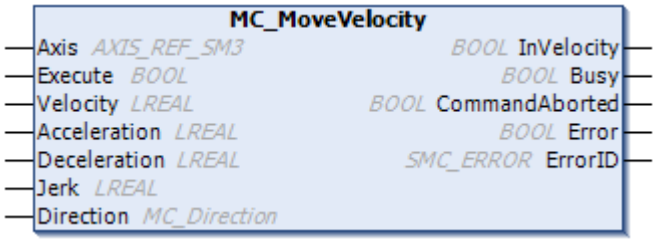
Name	Description	Type
MC_MoveSuperImposed	This FB commands a controlled motion of a specified relative distance additional to an existing motion. The existing Motion is not interrupted, but is superimposed by the additional motion.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Distance	LREAL	Additional distance that is to be superimposed [u] (positive or negative)
	VelocityDiff	LREAL	Maximum velocity difference [u/s] (positive)
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
OUT	Done	BOOL	TRUE: Distance is reached.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.9 MC_MoveVelocity

Name	Description	Type
MC_MoveVelocity	This FB commands a never ending controlled motion at a specified velocity.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
	Direction	MC_Direction	fastest (3), current (2), positive (1), shortest (0), negative (-1) (Refer to section 9.11 Enumeration (ENUM))
OUT	InVelocity	BOOL	TRUE: The set velocity has been reached for the first time.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

NOTE

This FB is used for speed control. However, the drives are controlled by position based control instead of speed based control internally. For this reason, ‘Modes of operation’ (0x6060) and Modes of operation display’ (0x6061) in the object dictionary are both ‘8’ (cyclic synchronous position mode) instead of ‘9’ (cyclic synchronous velocity mode).

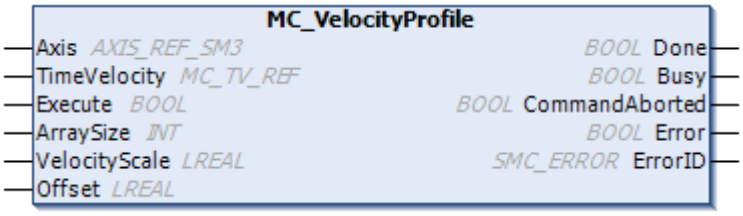
9.2.10 MC_PositionProfile

Name	Description	Type
MC_PositionProfile	This FB commands a time-position locked motion profile.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
	TimePosition	MC_TP_REF	Reference to time-position description
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	ArraySize	INT	The number of time-position profiles.
	PositionScale	LREAL	Overall position scaling factor (initial value: 1)
	Offset	LREAL	Overall offset for profile [u]
OUT	Done	BOOL	The profile has been completed.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.11 MC_VelocityProfile

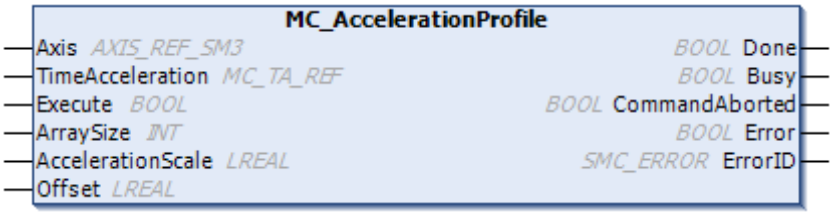
Name	Description	Type
MC_VelocityProfile	This FB commands a time-velocity locked motion profile.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
	TimeVelocity	MC_TV_REF	Reference to time-velocity description
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	ArraySize	INT	The number of time-velocity profiles.
	VelocityScale	LREAL	Overall velocity scaling factor (initial value: 1)
	Offset	LREAL	Overall offset for profile [u/s]
OUT	Done	BOOL	The profile has been completed.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.12 MC_AccelerationProfile

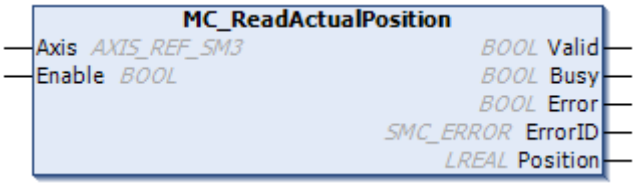
Name	Description	Type
MC_AccelerationProfile	This FB commands a time-acceleration locked motion profile.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
	TimeAcceleration	MC_TA_REF	Reference to time-acceleration description
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	ArraySize	INT	The number of time-acceleration profiles.
	AccelerationScale	LREAL	Overall acceleration scaling factor (initial value: 1)
	Offset	LREAL	Overall offset for profile [u/s^2]
OUT	Done	BOOL	The profile has been completed.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.13 MC_ReadActualPosition

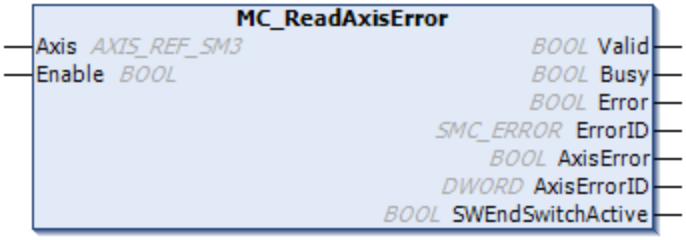
Name	Description	Type
MC_ReadActualPosition	This FB returns the actual position.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	Position	LREAL	New absolute position [u]

9.2.14 MC_ReadAxisError

Name	Description	Type
MC_ReadAxisError	This FB presents general axis errors not relating to the function blocks.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	AxisError	BOOL	TRUE: Axis error has occurred.
	AxisErrorID	DWORD	Vendor specific identification of the axis error.
	SWEndSwitchActive	BOOL	TRUE: Software limits are exceeded.

9.2.15 MC_ReadParameter

Name	Description	Type
MC_ReadParameter	This FB returns the value of a vendor specific parameter with data type LREAL.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
	ParameterNumber	DINT	Number of the parameter (see the table below)
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	Value	LREAL	Value of the parameter specified in input 'ParameterNumber'

PN	Name	Type	B/E	R/W	Description
1	CommandedPosition	REAL	B	R	Commanded position
2	SWLimitPos	REAL	E	R/W	Positive software limit switch position
3	SWLimitNeg	REAL	E	R/W	Negative software limit switch position
4	EnableLimitPos	BOOL	E	R/W	Enable positive software limit switch
5	EnableLimitNeg	BOOL	E	R/W	Enable negative software limit switch
6	EnablePosLagMonitoring	BOOL	E	R/W	Enable monitoring of position lag
7	MaxPositionLag	REAL	E	R/W	Maximal position lag
8	MaxVelocitySystem	REAL	E	R	Maximal allowed velocity of the axis in the motion system
9	MaxVelocityAppl	REAL	B	R/W	Maximal allowed velocity of the axis in the application
10	ActualVelocity	REAL	B	R	Actual velocity
11	CommandedVelocity	REAL	B	R	Commanded velocity
12	MaxAccelerationSystem	REAL	E	R	Maximal allowed acceleration of the axis in the motion system
13	MaxAccelerationAppl	REAL	E	R/W	Maximal allowed acceleration of the axis in the application
14	MaxDecelerationSystem	REAL	E	R	Maximal allowed deceleration of the axis in the motion system
15	MaxDecelerationAppl	REAL	E	R/W	Maximal allowed deceleration of the axis in the application
16	MaxJerkSystem	REAL	E	R	Maximal allowed jerk of the axis in the motion system
17	MaxJerkAppl	REAL	E	R/W	Maximal allowed jerk of the axis in the application

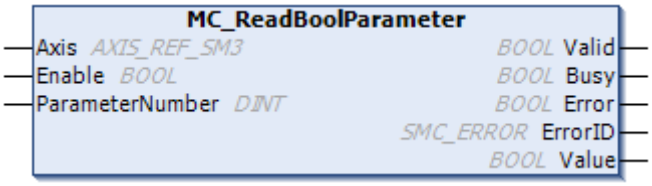
PN: Parameter Number

B: Basic E: Expanded

R: Read only R/W: Read and Write

9.2.16 MC_ReadBoolParameter

Name	Description	Type
MC_ReadBoolParameter	This FB returns the value of a vendor specific parameter with data type BOOL.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
	ParameterNumber	DINT	Number of the parameter (see section 9.2.15 MC_ReadParameter)
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	Value	BOOL	Value of the parameter specified in input 'ParameterNumber'

9.2.17 MC_WriteParameter

Name	Description	Type
MC_WriteParameter	This FB modifies the value of a vendor specific parameter with data type LREAL.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	ParameteNumber	DINT	Number of the parameter (see section 9.2.15 MC_ReadParameter)
	Value	LREAL	New value of the specified parameter
OUT	Done	BOOL	TRUE: Parameter successfully written
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

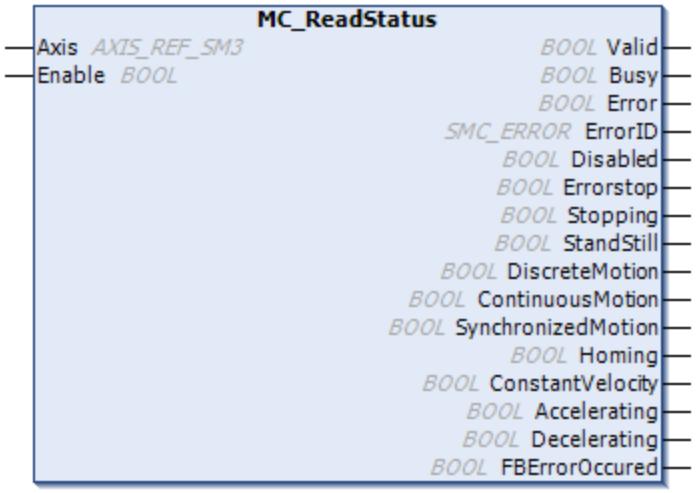
9.2.18 MC_WriteBoolParameter

Name	Description	Type
MC_WriteBoolParameter	This FB modifies the value of a vendor specific parameter with data type BOOL.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	ParameterNumber	DINT	Number of the parameter (see section 9.2.15 MC_ReadParameter)
	Value	BOOL	New value of the specified parameter
OUT	Done	BOOL	TRUE: Parameter successfully written
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.2.19 MC_ReadStatus

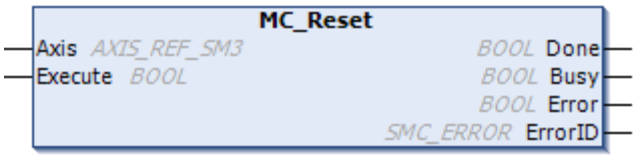
Name	Description	Type
MC_ReadStatus	This FB returns in details the status of the state diagram of the selected axis.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	Disabled	BOOL	TRUE: Disabled (see section 4.1 State diagram)
	Errorstop	BOOL	TRUE: Errorstop (see section 4.1 State diagram)
	Stopping	BOOL	TRUE: Stopping (see section 4.1 State diagram)
	StandStill	BOOL	TRUE: StandStill (see section 4.1 State diagram)
	DiscreteMotion	BOOL	TRUE: DiscreteMotion (see section 4.1 State diagram)
	ContinuousMotion	BOOL	TRUE: ContiuousMotion (see section 4.1 State diagram)
	SynchronizedMotion	BOOL	TRUE: SynchronizedMotion (see section 4.1 State diagram)
	Homing	BOOL	TRUE: Homing (see section 4.1 State diagram)
	ConstantVelocity	BOOL	TRUE: Motor moves with constant velocity.
	Accelerating	BOOL	TRUE: Motor moves with increasing velocity.
	Decelerating	BOOL	TRUE: Motor moves with decreasing velocity.
	FBErrorOccurred	BOOL	TRUE: FB error has occurred.

9.2.20 MC_Reset

Name	Description	Type
MC_Reset	This FB makes the transition from the state 'ErrorStop' to 'Standstill' or 'Disabled' by resetting all internal axis-related errors.	FB

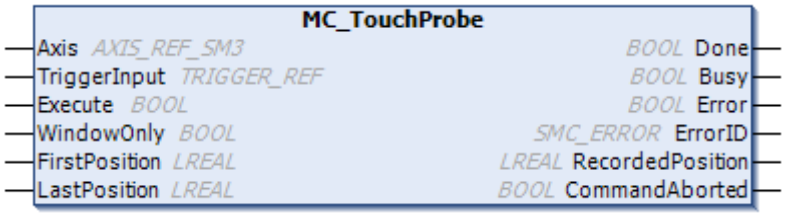


Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
OUT	Done	BOOL	TRUE: Reset has been executed.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.3 PLCopen Part 2 for Single-Axis

9.3.1 MC_TouchProbe

Name	Description	Type
MC_TouchProbe	This FB is used to record an axis position at a trigger event.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
	TriggerInput	TRIGGER_REF	Reference to trigger signal source
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	WindowOnly	BOOL	TRUE: Trigger events will be accepted only within the specified window.
	FirstPosition	LREAL	Start position from whereon (in positive direction) trigger events will be accepted [u].
	LastPosition	LREAL	End position up to which trigger events will be accepted [u].
OUT	Done	BOOL	TRUE: Trigger event has been recorded.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	RecordedPosition	LREAL	Position, where trigger event has occurred [u].
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.

9.3.2 MC_AbortTrigger

Name	Description	Type
MC_AbortTrigger	This FB is used to abort function block which are connected to trigger events.	FB

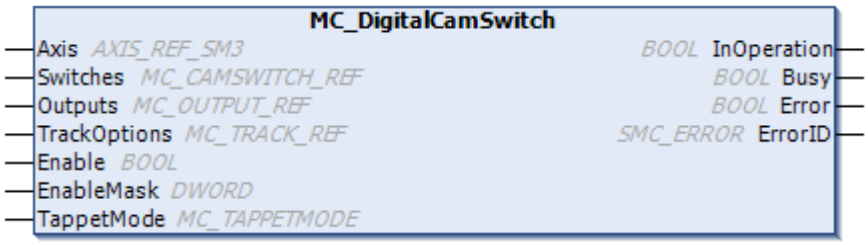
Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
	TriggerInput	TRIGGER_REF	Reference to trigger signal source
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
OUT	Done	BOOL	TRUE: Latching has been aborted successfully.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

NOTE

MC_AbortTrigger might not work depending on drives. Possible countermeasure in this case could be to set parameter directly to drives.

9.3.3 MC_DigitalCamSwitch

Name	Description	Type
MC_DigitalCamSwitch	This FB is the analogy to switches on a motor shaft: it commands a group of discrete output bits to switch in analogy to a set of mechanical cam controlled switches connected to an axis.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
	Switches	MC_CAMSWITCH_REF	Reference to switching actions
	Outputs	MC_OUTPUT_REF	Reference to signal outputs that are directly related to the referenced tracks. (`ARRAY [1..32] OF BOOL`)
	TrackOptions	MC_TRACK_REF	Reference to structure containing track related properties, e.g. the on/off compensations per output/track. (`ARRAY [1..32] OF MC_TRACK_TR`)
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
	EnableMask	DWORD	32 bits of BOOL enabling the different tracks. Least significant data is related to the lowest TrackNumber. (initial value: 16#FFFFFFFF)
	TappetMode	MC_TAPPETMODE	ENUM
OUT	InOperation	BOOL	TRUE: Commanded tracks have been enabled.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

MC_CAMSWITCH_REF (STRUCT)

Name	Type	Initial	Description
NoOfSwitches	BYTE	0	Number of switch positions
CamSwitchPtr	POINTER TO MC_CAMSWITCH_TR	0	Address of MC_CAMSWITCH_TR

MC_CAMSWITCH_TR (STRUCT)

Name	Type	Initial	Description
TrackNumber	INT		Number of the output; several position ranges per output are possible. [1..32]
FirstOnPosition	LREAL		Switch-on position of the output
LastOnPosition	LREAL		Switch-off position of the output
AxisDirection	INT		0: The output is switched in two directions. 1: The output is only switched in positive direction. 2: The output is only switched in negative direction.
CamSwitchMode	INT		0: The tappets are calculated position-based. 1: The tappets are calculated time-based, whereby only the value of FirstOnPosition will be used and the output stays TRUE for the given time (Duration).
Duration	TIME		Period of time for which the tappet output stays TRUE in case of CAMSwitchMode=1.

MC_TRACK_TR (STRUCT)

Name	Type	Initial	Description
OnCompensation	LREAL	0	A delay (value positive) of switch-on or an early switch-on (value negative) can be set. The time is given in seconds.
OffCompensation	LREAL	0	A delay (value positive) of switch-off or an early switch-off (value negative) can be set. The time is given in seconds.
Hysteresis	LREAL	0	Additionally a hysteresis can be set, which avoids a permanent switching of the output, which might occur e.g. if the servo-controller is exactly in switch-position and slightly swinging around that position due to the position control.

MC_TAPPETMODE (ENUM)

Name	Value	Description
tp_mode_auto	0	Auto mode
tp_mode_demandposition	1	Use set values
tp_mode_actualposition	2	Use actual values

NOTE

If the following conditions are fulfilled, output might oscillate wrongly. Be sure to read information below and avoid that.

By setting a certain time to OnCompensation, activated time of tappet output can be exactly 0, which is normally unnecessary usage. In that case, tappet output might oscillate. Be sure to set parameters so that tappet output is activated in a certain time.

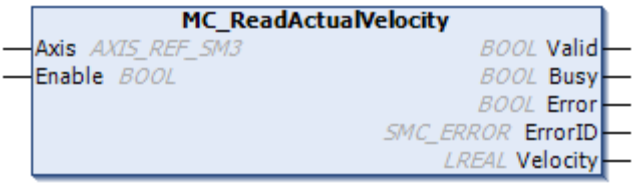
9.3.4 MC_ReadActualTorque

Name	Description	Type
MC_ReadActualTorque	This FB returns the value of the actual torque.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	Torque	LREAL	Value of current torque

9.3.5 MC_ReadActualVelocity

Name	Description	Type
MC_ReadActualVelocity	This FB returns the value of the actual velocity.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	Velocity	LREAL	Value of current velocity [u/s]

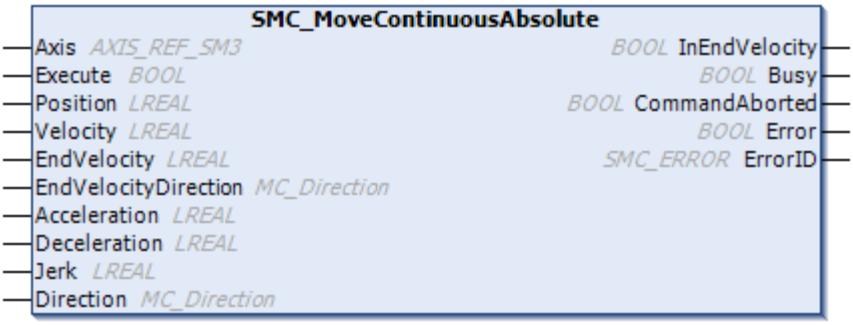
9.3.6 MC_SetPosition

Name	Description	Type
MC_SetPosition	This FB shifts the coordinate system of an axis by manipulating both the set-point position as well as the actual position of an axis with the same value without any movement caused.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Position	LREAL	Position unit [u]
	Mode	BOOL	TRUE: Relative FALSE: Absolute
OUT	Done	BOOL	TRUE: Position has been assigned to new value.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.3.7 SMC_MoveContinuousAbsolute

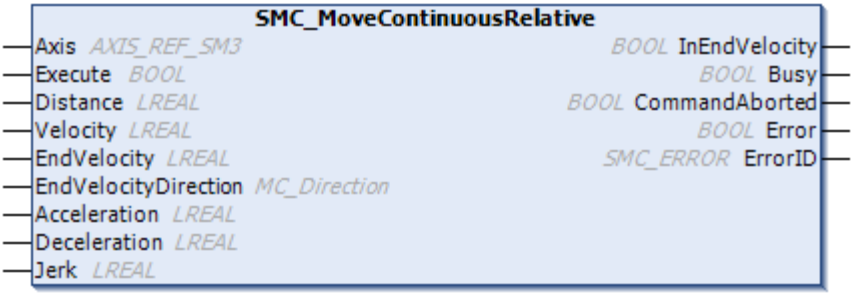
Name	Description	Type
SMC_MoveContinuousAbsolute	This FB commands a controlled motion to a specified absolute position ending with the specified velocity.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Position	LREAL	Target position [u] (positive or negative)
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	EndVelocity	LREAL	End velocity [u/s] (positive)
	EndVelocityDirection	MC_Direction	Determines direction of end velocity. Permissible values: current (2), positive (1), negative (-1) Not applicable: fastest (3), shortest (0) (Refer to section 9.11 Enumeration (ENUM))
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
	Direction	MC_Direction	Direction for linear/finite axes: positive (1), negative (-1) for rotary/modulo axes: fastest (3), current (2), positive (1), shortest (0), negative (-1) (Refer to section 9.11 Enumeration (ENUM))
OUT	InEndVelocity	BOOL	TRUE: Commanded position has been reached.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.3.8 MC_MoveContinuousRelative

Name	Description	Type
SMC_MoveContinuousRelative	This FB commands a controlled motion to a specified relative distance ending with the specified velocity.	FB

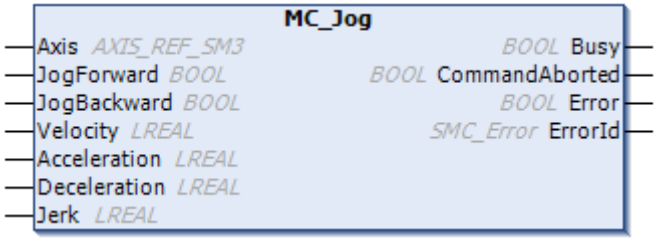


Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Distance	LREAL	Relative distance [u] (positive or negative)
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	EndVelocity	LREAL	End velocity [u/s] (positive)
	EndVelocityDirection	MC_Direction	Determines direction of end velocity. Permissible values: current (2), positive (1), negative (-1) Not applicable: fastest (3), shortest (0) (Refer to section 9.11 Enumeration (ENUM))
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
OUT	InEndVelocity	BOOL	TRUE: Commanded distance has been reached.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.4 PLCopen Part 3 for Single-Axis

9.4.1 MC_Jog

Name	Description	Type
MC_Jog	This FB commands a jogged movement to a specified axis as long as the input 'JogForward/Backward' is set.	FB



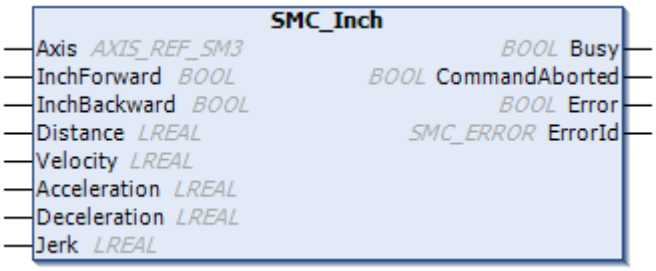
Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	JogForward	BOOL	TRUE: Axis is moved with the specified dynamic values velocity, acceleration, deceleration and jerk in a positive direction. (No motion is executed if JogBackward is TRUE at the same time)
	JogBackward	BOOL	TRUE: Axis is moved with the specified dynamic values velocity, acceleration, deceleration and jerk in a negative direction. (No motion is executed if JogForward is TRUE at the same time)
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
OUT	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

NOTE

When 'JogForward' input or 'JogBackward' input is reset (TRUE to FALSE), the specified axis is in deceleration. If the axis status changes to Errorstop while deceleration before stopping by an unexpected reason, for example limit switch detected, then 'Busy' output of MC_Jog is activated, and no command can be accepted. In this case, perform [Reset warm] or [Reset cold] to restart the PLC.

9.4.2 SMC_Inch

Name	Description	Type
SMC_Inch	This FB commands an inching movement to a specified axis as long as the moving distance is not reached and the input 'InchForward' or 'InchBackward' is set.	FB

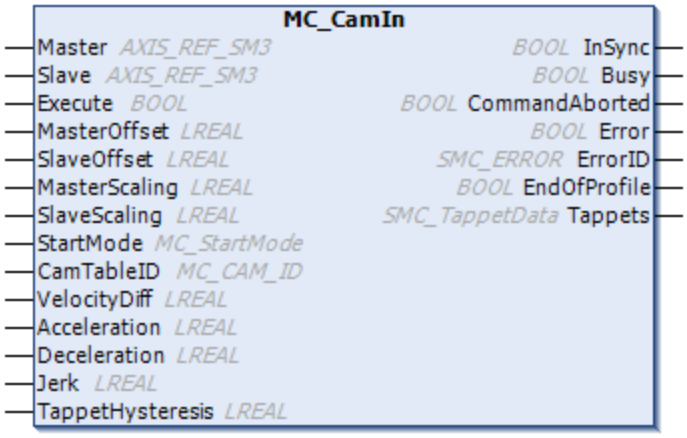


Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	InchForward	BOOL	TRUE: Axis is moved with the dynamic values velocity, acceleration, deceleration and jerk in a positive direction until distance has been travelled. If 'InchForward' is set to FALSE and back to TRUE, a further motion is started. If 'InchForward' is set to FALSE before distance has been travelled, the axis is immediately decelerated to the velocity value zero. 'Busy' is then set to FALSE. If 'InchBackward' and 'InchForward' are TRUE at the same time, then no motions are carried out.
	InchBackward	BOOL	TRUE: Axis is moved with the dynamic values velocity, acceleration, deceleration and jerk in a negative direction until distance has been travelled. If 'InchBackward' is set to FALSE and back to TRUE, a further motion is started. If 'InchBackward' is set to FALSE before distance has been travelled, the axis is immediately decelerated to the velocity value zero. 'Busy' is then set to FALSE. If 'InchBackward' and 'InchForward' are TRUE at the same time, then no motions are carried out.
	Distance	LREAL	Distance that is travelled [u] (positive)
	Velocity	LREAL	Maximum velocity [u/s] (positive)
	Acceleration	LREAL	Acceleration [u/s^2] (positive)
	Deceleration	LREAL	Deceleration [u/s^2] (positive)
	Jerk	LREAL	Jerk [u/s^3] (positive)
OUT	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.5 PLCopen for Multi-Axis

9.5.1 MC_CamIn

Name	Description	Type
MC_CamIn	This FB engages the CAM.	FB



Name		Type	Description
IN_OUT	Master	AXIS_REF_SM3	Reference to master axis
	Slave	AXIS_REF_SM3	Reference to slave axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	MasterOffset	LREAL	Offset on master table
	SlaveOffset	LREAL	Offset on slave table
	MasterScaling	LREAL	Scaling factor for master profile
	SlaveScaling	LREAL	Scaling factor for slave profile
	StartMode	MC_StartMode	Start mode
	CamTableID	MC_CAM_ID	Identification of the cam table. The input is connected with the output of the instance of MC_CamTableSelect.
	VelocityDiff	LREAL	Maximum velocity difference for 'ramp in' mode. [u/s]
	Acceleration	LREAL	Acceleration for 'ramp_in' mode. [u/s^2]
	Deceleration	LREAL	Deceleration for 'ramp_in' mode. [u/s^2]
	Jerk	LREAL	Jerk for 'ramp_in' mode. [u/s^3]
	TappetHysteresis	LREAL	Size of the hysteresis for tappets in [u]. A positive value means that the tappet cannot fire immediately after it has fired. The master position first needs to move away from the tappet by more than the value given for TappetHysteresis. For example, if the master is an encoder, the master position may oscillate by a few increments around the tappet position. Without a hysteresis, the tappet may fire all the time.
OUT	InSync	BOOL	TRUE: Cam has been engaged for the first time.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	EndOfProfile	BOOL	Pulsed output: Cyclic end of the cam profile
	Tappets	SMC_TappetData	Tappets: Has to be evaluated by SMC_GetTappetValue FB.

MC_STARTMODE (ENUM)

Name	Value	Description
absolute	0	Cam plate is positioned absolutely with respect to the current master and slave.
relative	1	Cam plate is positioned relative to the current master and slave.
ramp_in	2	With acceleration
ramp_in_pos	3	With acceleration in positive direction
ramp_in_neg	4	With acceleration in negative direction

SMC_TAPPETDATA (STRUCT)

Name	Type	Initial	Description
pTaps	ARRAY [0..2] OF POINTER TO SMC_CAMTappet		This is a STRUCT for interface between MC_CamIn output and SMC_GetTappetValue input.
dwCycleTime	DWORD		
byChannels	BYTE	3	
bRestart	BOOL		

SMC_CAMTAPPET (STRUCT)

Name	Type	Initial	Description
Ctt	SMC_CAMTAPPETTYPE (ENUM)		See SMC_CAMTAPPETTYPE below.
Cta	SMC_CAMTAPPETACTION (ENUM)		See SMC_CAMTAPPETACTION below.
dwDelay	DWORD		In case of ‘cta’ =Tappetaction.tappetaction_time, this value determines the delay time [μs].
dwDuration	DWORD		In case of ‘cta’ =Tappetaction.tappetaction_time, this value determines the time for which the tappet is switched to on. [μs]
iGroupID	INT		Group or track ID of the tappet output that is switched.
x	LREAL		Master position where tappet is switched.
dwActive	DWORD	16#FFFFFFFF	Internal variable

SMC_CAMTAPPETTYPE (ENUM)

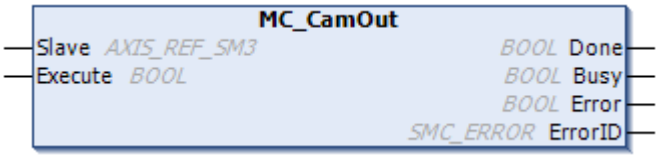
Name	Value	Description
TAPPET_pos	0	Tappet action active when the master passes its position in positive direction.
TAPPET_all	1	Tappet action active when the master passes its position in both directions.
TAPPET_neg	2	Tappet action active when the master passes its position in negative direction.

SMC_CAMTAPPETACTION (ENUM)

Name	Value	Description
TAPPETACTION_on	0	Switches on.
TAPPETACTION_off	1	Switches off.
TAPPETACTION_inv	2	Inverts.
TAPPETACTION_time	3	Switches on after a delay for a certain time period.

9.5.2 MC_CamOut

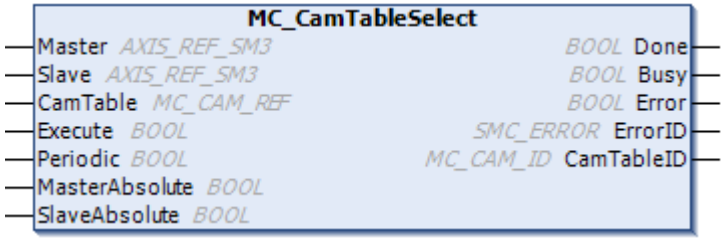
Name	Description	Type
MC_CamOut	This FB disengages the slave axis from the master axis immediately.	FB



Name		Type	Description
IN_OUT	Slave	AXIS_REF_SM3	Reference to the slave axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
OUT	Done	BOOL	TRUE: Cam has been disengaged.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.5.3 MC_CamTableSelect

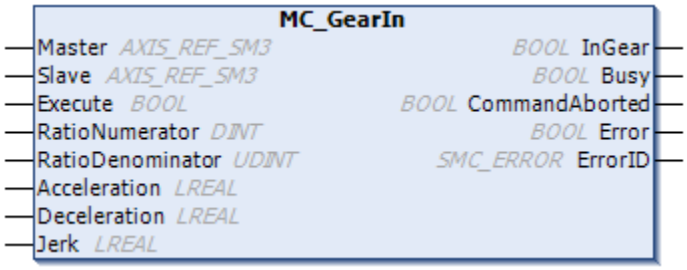
Name	Description	Type
MC_CamTableSelect	This FB selects the CAM tables by setting the connections to the relevant tables.	FB



Name		Type	Description
IN_OUT	Master	AXIS_REF_SM3	Reference to the master axis
	Slave	AXIS_REF_SM3	Reference to the slave axis
	CamTable	MC_CAM_REF	Reference to the cam description
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Periodic	BOOL	TRUE: Periodic FALSE: Non periodic
	MasterAbsolute	BOOL	TRUE: Absolute FALSE: Relative coordinates
	SlaveAbsolute	BOOL	TRUE: Absolute FALSE: Relative coordinates
OUT	Done	BOOL	TRUE: Preselection has been done.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	CamTableID	MC_CAM_ID	Identifier of the cam table be used for the function block. (Connect to input of MC_CamIn)

9.5.4 MC_GearIn

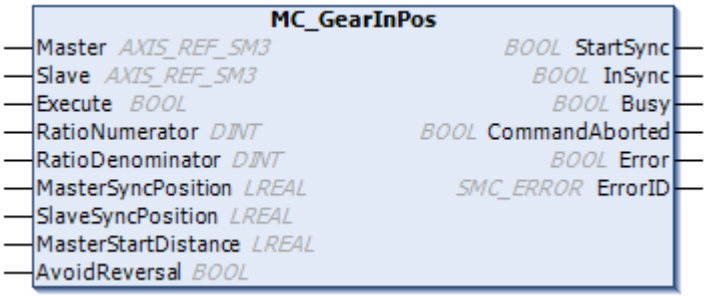
Name	Description	Type
MC_GearIn	This FB commands a ratio between the velocity of the slave and master axis.	FB



Name		Type	Description
IN_OUT	Master	AXIS_REF_SM3	Reference to the master axis
	Slave	AXIS_REF_SM3	Reference to the slave axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	RatioNumerator	DINT	Gear ratio Numerator
	RatioDenominator	UDINT	Gear ratio Denominator
	Acceleration	LREAL	Target acceleration when coupling[u/s^2]
	Deceleration	LREAL	Target deceleration when coupling[u/s^2]
	Jerk	LREAL	Jerk when coupling [u/s^3]
OUT	InGear	BOOL	TRUE: Coupling has taken place.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.5.5 MC_GearInPos

Name	Description	Type
MC_GearInPos	This FB commands a gear ratio between the position of the slave and master from the synchronization point onwards.	FB



Name		Type	Description
IN_OUT	Master	AXIS_REF_SM3	Reference to the master axis
	Slave	AXIS_REF_SM3	Reference to the slave axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	RatioNumerator	DINT	Gear ratio Numerator
	RatioDenominator	DINT	Gear ratio Denominator
	MasterSyncPosition	LREAL	Master position where the axes run in sync.
	SlaveSyncPosition	LREAL	Slave position where the axes run in sync.
	MasterStartDistance	LREAL	Master distance for the gear in procedure (where the slave axis will be started for getting into synchronization). In other words, the slave is brought into sync with the master during this distance, i.e. from MasterSyncPosition - MasterStartDistance until MasterSyncPosition. If MasterStartDistance is 0 (or negative), then the slave movement is started immediately.
	AvoidReversal	BOOL	TRUE: Signals that the reversal of the module slave is physically impossible or might lead to damage. FALSE: Signals that the reversal of the slave is physically possible and acceptable.
OUT	StartSync	BOOL	TRUE: Commanded gearing has been started.
	InSync	BOOL	TRUE: Commanded gearing has been completed.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

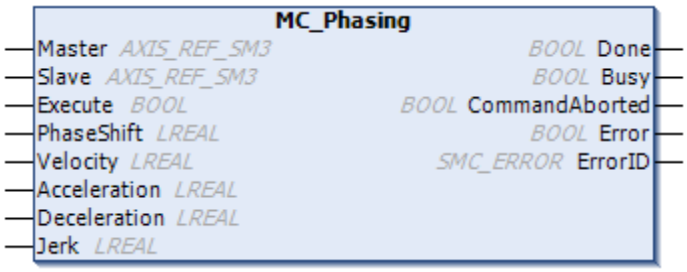
9.5.6 MC_GearOut

Name	Description	Type
MC_GearOut	This FB disengages the slave axis from the master axis.	FB

Name		Type	Description
IN_OUT	Slave	AXIS_REF_SM3	Reference to the slave axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
OUT	Done	BOOL	TRUE: Slave axis has been disengaged.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.5.7 MC_Phasing

Name	Description	Type
MC_Phasing	This Function Block creates a phase shift in the master position of a slave axis relative to the existing phase shift. The master position is shifted in relation to the real physical position.	FB

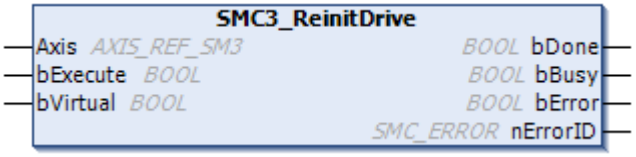


Name		Type	Description
IN_OUT	Master	AXIS_REF_SM3	Reference to the master axis
	Slave	AXIS_REF_SM3	Reference to the slave axis
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	PhaseShift	LREAL	Phase difference between master and slave [u]
	Velocity	LREAL	Maximum velocity for reaching phase difference [u/s]
	Acceleration	LREAL	Maximum acceleration for reaching phase difference [u/s^2]
	Deceleration	LREAL	Maximum deceleration for reaching phase difference [u/s^2]
	Jerk	LREAL	Maximum jerk for reaching phase difference [u/s^3]
OUT	Done	BOOL	TRUE: Commanded phasing has been reached.
	Busy	BOOL	TRUE: The FB is in operation.
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.6 Utility Function Blocks

9.6.1 SMC3_ReinitDrive

Name	Description	Type
SMC3_ReinitDrive	This FB reinits a drive/axis. That means that the start-up phase is run through again and the application cannot control the drive until the function block set bDone = TRUE.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	bVirtual	BOOL	TRUE: Virtual mode
OUT	bDone	BOOL	TRUE: Reinitialization has been completed.
	bBusy	BOOL	TRUE: The FB is in operation.
	bError	BOOL	TRUE: Error has occurred within the FB.
	nErrorID	SMC_ERROR	Error identification

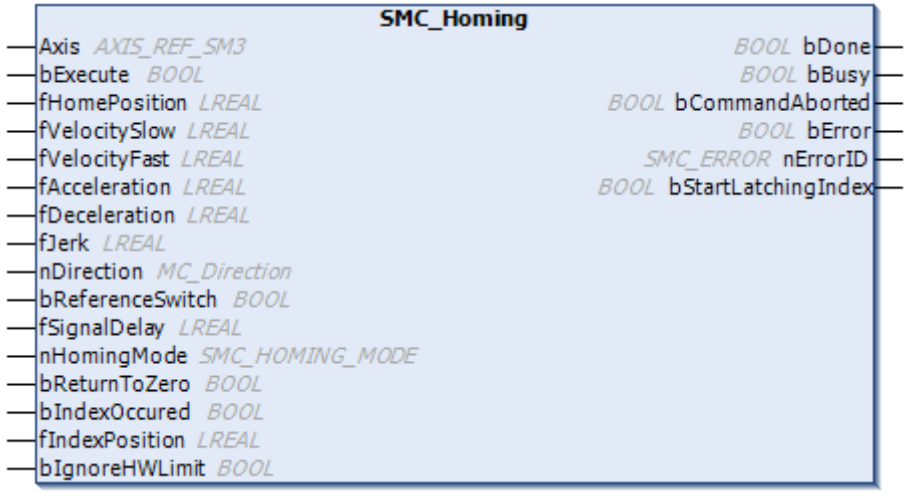
9.6.2 SMC_GetTappetValue

Name	Description	Type
SMC_GetTappetValue	This FB evaluates the output Tappets of function block MC_CamIn and contains the current tappet status.	FB

Name		Type	Description
IN_OUT	Tappets	SMC_TappetData	Tappet signals to be evaluated by MC_GetTappetValue
IN	iID	INT	Group ID of the tappet to be evaluated
	bInitValue	BOOL	Initial value of the tappet to be assigned at first call
	bSetInitValueAtReset	BOOL	TRUE: Sets the value of the tappet to bInitValue at a restart of the MC_CamIn FB. FALSE: Retains the tappet value at a restart of the MC_CamIn FB.
OUT	bTappet	BOOL	Tappet value

9.6.3 SMC_Homing

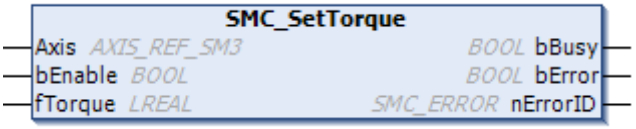
Name	Description	Type
SMC_Homing	This FB causes the execution of a homing drive of the axis. If SMC_Homing is executed, the axis is moved at fVelocityFast in the direction specified by nDirection as long as bReferenceSwitch = FALSE. The reference switch is then closed. The axis is decelerated and driven at fVelocitySlow in the opposite direction. At the point at which the reference switch opens with bReferenceSwitch = TRUE, the reference position fHomePosition is set and the drive is stopped.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	fHomePosition	LREAL	Home position taken after homing completed [u].
	fVelocitySlow	LREAL	Low velocity; used to drive out of the reference switch [u/s]
	fVelocityFast	LREAL	High velocity; used until reference switch is found [u/s]
	fAcceleration	LREAL	Acceleration [u/s^2] (positive)
	fDeceleration	LREAL	Deceleration [u/s^2] (positive)
	fJerk	LREAL	Jerk [u/s^3] (positive)
	nDirection	MC_Direction	Direction positive (1), negative (-1) (Refer to section 9.11 Enumeration (ENUM))
	bReferenceSwitch	BOOL	TRUE: Switches the reference.
	fSignalDelay	LREAL	Time [s] for bReferenceSwitch to be transmitted. (The result of (fVelocitySlow * fSignalDelay) will be added to home position as a offset after homing done.)
	nHomingMode	SMC_HOMING_MODE	Homing mode (Refer to section 9.11 Enumeration (ENUM))
	bReturnToZero	BOOL	TRUE: Moves to position zero after homing.
	bIndexOccurred	BOOL	Index pulse
	fIndexPosition	LREAL	Position where index occurred
	bIgnoreHWLimit	BOOL	TRUE: Sets bHWLimitEnable (parameter in AXIS_REF_SM3) = FALSE during homing.
OUT	bDone	BOOL	TRUE: Homing has been done.
	bBusy	BOOL	TRUE: The FB is in operation.
	bCommandAborted	BOOL	TRUE: Command has been aborted by another command.
	bError	BOOL	TRUE: Error has occurred within the FB.
	nErrorID	SMC_ERROR	Error identification
	bStartLatchingIndex	BOOL	For some homing modes, the index pulse is evaluated. TRUE: Storing of the index pulse has been started and must be done by the application. The result is expected in the inputs bIndexOccured and fIndexPosition.

9.6.4 SMC_SetTorque

Name	Description	Type
SMC_SetTorque	This FB can be used to create a torque if the drive is in controller mode ‘torque’.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	bEnable	BOOL	TRUE: Enables the execution of the FB.
	fTorque	LREAL	Torque [Nm]
OUT	bBusy	BOOL	TRUE: The FB is in operation.
	bError	BOOL	TRUE: Error has occurred within the FB.
	nErrorID	SMC_ERROR	Error identification

9.6.5 SMC_SetControllerMode

Name	Description	Type
SMC_SetControllerMode	This FB sets the byControllerMode (command value of operation mode) parameter of the axis and waits until the parameter byRealControllerMode (actual value of operation mode) reflects this value.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	nControllerMode	SMC_CONTROLLER_MODE	Controller mode (ENUM)
OUT	bDone	BOOL	TRUE: Mode switching has been done.
	bBusy	BOOL	TRUE: The FB is in operation.
	bError	BOOL	TRUE: Error has occurred within the FB.
	nErrorID	SMC_ERROR	Error identification

9.6.6 SMC_SetMovementType

Name	Description	Type
SMC_SetMovementType	This FB sets the movement type of a virtual axis to linear or modulo.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	iMovementType	INT	0: modulo 1: linear
	fPositionPeriod	LREAL	The new position period for modulo movement, must be positive.
OUT	bDone	BOOL	TRUE: Movement setting has been done.
	bError	BOOL	TRUE: Error has occurred within the FB.
	eErrorID	SMC_ERROR	Error identification

9.6.7 SMC_SetRampType

Name	Description	Type
SMC_SetRampType	This FB sets the ramp type of an axis to a new value. Can only be used when the axis is in the state 'Standstill' or power_off.	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	eRampType	SMC_RAMPTYPE (ENUM)	Defines the new ramp type.
OUT	bDone	BOOL	TRUE: Ramp type has been set.
	bError	BOOL	TRUE: Error has occurred within the FB.
	eErrorID	SMC_ERROR (ENUM)	Error identification

9.6.8 SMC_InPosition

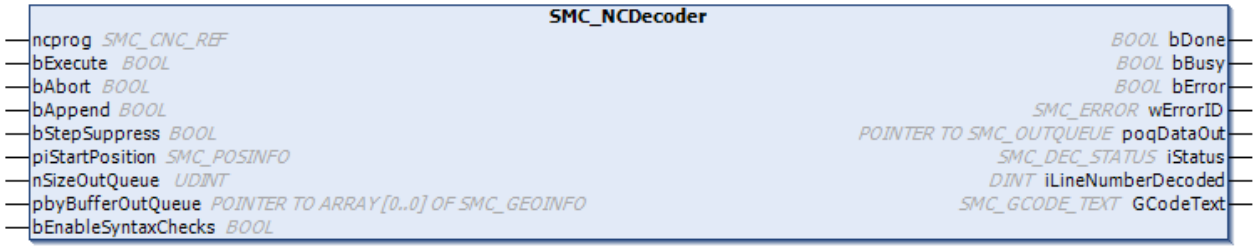
Name	Description	Type
SMC_InPosition	This FB monitors the offset between the nominal and actual positions of an axis (drag error). This tests whether the drag error lies within a specified value range for over a defined period of time (position window).	FB

Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	bEnable	BOOL	TRUE: Enables the execution of the FB.
	fPosWindow	LREAL	The drive is inside the position window, if fPosWindow >= Distance (actual position, set position) [u].
	fPosTime	LREAL	Time that the FB has to stay inside the position window before bInPosition is set [s].
	fTimeOut	LREAL	If the time since enabling the FB is larger than this value and bInPosition is not set, bTimeOut is set; this mechanism is deactivated, if fTimeOut = 0.
OUT	bInPosition	BOOL	TRUE: Parameter is available
	bBusy	BOOL	TRUE: The FB is in operation.
	bTimeout	BOOL	TRUE: Error has occurred within the FB.

9.7 CNC Control

9.7.1 SMC_NCDecoder

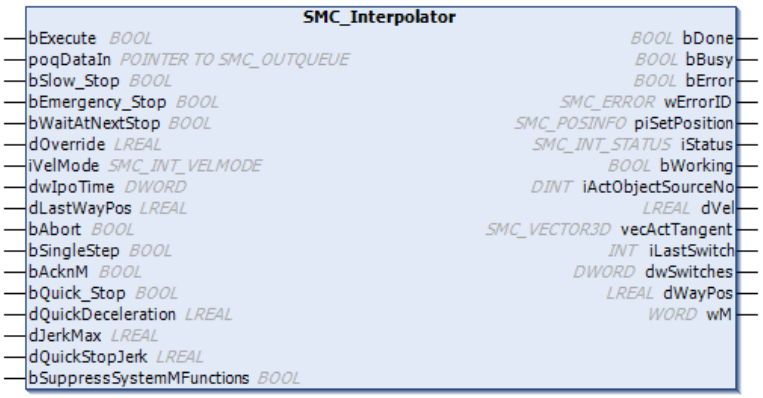
Name	Description	Type
SMC_NCDecoder	This FB converts a CNC program (G-code) into a list of SMC_GEOINFO structure objects. In each cycle, one line will be decoded.	FB



Name		Type	Description
IN_OUT	ncprog	SMC_CNC_REF	CNC program
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	bAbort	BOOL	TRUE: The current processing is aborted.
	bAppend	BOOL	TRUE: Newly incoming data to be written to the end of the DataOutQueue.
	bStepSuppress	BOOL	TRUE: Lines of the CNC program starting with "/" will be ignored.
	piStartPosition	SMC_POSINFO	Position of point, from where the interpolated movement is supposed to start.
	nSizeOutQueue	UDINT	The size of the data buffer
	pbyBufferOutQueue	POINTER TO ARRAY [0..0] OF SMC_GEOINFO	The first byte of the memory area that is allocated for the OUTQUEUE structure.
	bEnableSystaxChecks	BOOL	TRUE: Invalid G-code is detected.
OUT	bDone	BOOL	TRUE: The input data from DataIn has been processed completely.
	bBusy	BOOL	TRUE: The FB is in operation.
	bError	BOOL	TRUE: Error has occurred within the FB.
	wErrorID	SMC_ERROR	Error identification
	poqDataOut	POINTER TO SMC_OUTQUEUE	Pointer to the SMC_OUTQUEUE
	iStatus	SMC_DEC_STATUS	The current status of the module
	iLineNumberDecoded	DINT	0-based line number of the CNC file
	GCodeText	SMC_GCODE_TEXT	G-code text

9.7.2 SMC_Interpolator

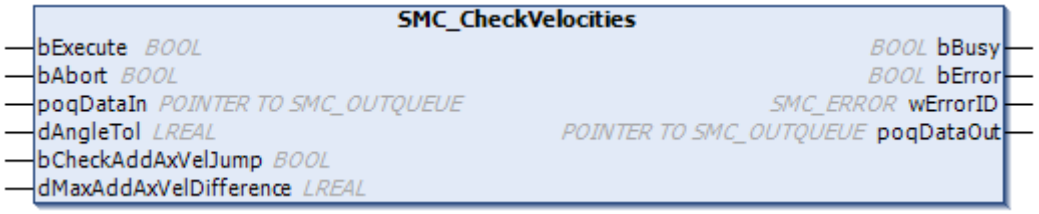
Name	Description	Type
SMC_Interpolator	This FB converts a continuous path described by SMC_GEOINFO-objects into discrete path position points taking into account a defined velocity profile and time pattern.	FB



Name		Type	Description
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	poqDataIn	POINTER TO SMC_OUTQUEUE	Pointer to SMC_GEOINFO structure objects.
	bSlow_Stop	BOOL	TRUE: FB will be caused to reduce the velocity to 0 according to the defined velocity profile (iVelMode).
	bEmergency_Stop	BOOL	TRUE: FB will cause an immediate stop.
	bWaitAtNextStop	BOOL	TRUE: FB will be caused to retain the position at the next regular stop.
	dOverride	LREAL	The scheduled velocity of the particular objects will get scaled by dOverride. (default:1, min.:0.01)
	iVelMode	SMC_INT_VELMODE	The velocity profile
	dwIpoTime	DWORD	Cycle time, which must be same as EtherCAT_Master cycle time (unit: μs)
	dLastWayPos	LREAL	When dWayPos output is connected, measured length of the path is seen in dLastWayPos.
	bAbort	BOOL	TRUE: The current processing is aborted.
	bSingleStep	BOOL	TRUE: FB will stop at the transition between two path objects for the duration of one cycle.
	bAcknM	BOOL	TRUE: M-option is cleared and the path processing will be continued.
	bQuick_stop	BOOL	TRUE: FB will reduce the velocity to 0 with velocity profile of [iVelMode] and [dQuickDeceleration].
	dQuickDeceleration	LREAL	Deceleration value used for bQuick_stop
	dJerkMax	LREAL	Max. jerk only used for Quadratic velocity modes
	dQuickStopJerk	LREAL	Max. jerk used by a quick stop
	bSuppressSystemMFunctions	BOOL	TRUE: The output wM will not be set for internal M-functions created by G75 or G4 commands.
OUT	bDone	BOOL	TRUE: The input data (poqDataIn) has been processed completely.
	bBusy	BOOL	TRUE: The FB is in operation.
	bError	BOOL	TRUE: Error has occurred within the FB.
	wErrorID	SMC_ERROR	Error identification
	piSetPosition	SMC_POSINFO	Calculated set position
	iStatus	SMC_INT_STATUS	The current status of the FB
	bWorking	BOOL	Connect to bEnable input of SMC_ControlAxisByPos.
	iActObjectSourceNo	DINT	Value of member of active SMC_GEOINFOR object of poqDataIn-queue
	dVel	LREAL	The current path velocity
	vecActTangent	SMC_VECTOR3D	The path tangent (unit: vector)
	iLastSwitch	INT	The last switch passed
	dwSwitches	DWORD	The current switch status of all switches 1 to 32
	dWayPos	LREAL	See dLastWayPos input.
	wM	WORD	This output will be set to the value associated to the M-function.

9.7.3 SMC_CheckVelocities

Name	Description	Type
SMC_CheckVelocities	This FB checks the track speed of the particular path segments. If OutQueue has not been created by the editor, but by the IEC program (e.g. SMC_NCDecoder), this FB has to be called straight before each call to the interpolator.	FB



Name		Type	Description
IN	bExecute	BOOL	Starts the execution of the FB at rising edge.
	bAbort	BOOL	TRUE: The current processing is aborted.
	poqDataIn	POINTER TO SMC_OUTQUEUE	Points to the SMC_OUTQUEUE structure object, which describes the SMC_GEOINFO objects of the path.
	dAngleTol	LREAL	Tolerance angle (angle leeway) up to which at a sharp bend of the path no stop shall be executed.
	bCheckAddAxVelJump	BOOL	TRUE: Velocity jumps are checked.
	dMaxAddAxVelDifference	LREAL	Max. allowed velocity jumps [u/s]
OUT	bBusy	BOOL	TRUE: The FB is in operation.
	bError	BOOL	TRUE: Error has occurred within the FB.
	wErrorID	SMC_ERROR	Error identification
	poqDataOut	POINTER TO SMC_OUTQUEUE	The output path queue of SMC_OUTQUEUE

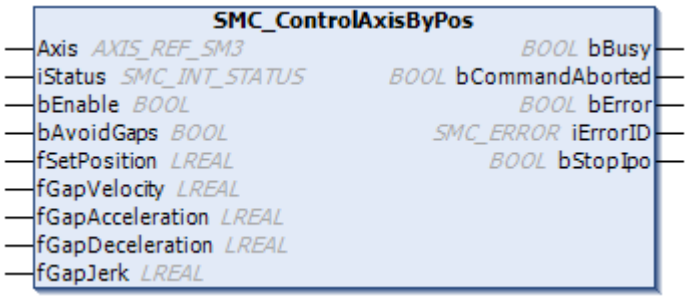
9.7.4 SMC_TRAFO_Gantry2

Name	Description	Type
SMC_TRAFO_Gantry2	Reverse transformation for two-dimentional portal systems.	FB

Name		Type	Description
IN	pi	SMC_PosInfo	Target vector position (x, y), output of interpolator.
	dOffsetX	LREAL	Additional offset for x-axis
	dOffsetY	LREAL	Additional offset for y-axis
OUT	dx	LREAL	Resulting position for x-axis
	dy	LREAL	Resulting position for y-axis

9.7.5 SMC_ControlAxisByPos

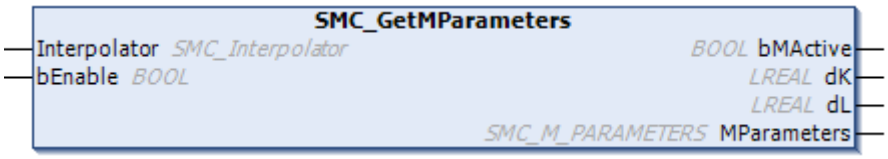
Name	Description	Type
SMC_ControlAxisByPos	This FB writes the set position to the drive structure Axis and monitors Axis for jumps.	FB



Name		Type	Description
IN_OUT	Axis	AXIS_REF_SM3	Reference to the axis
IN	iStatus	SMC_INT_STATUS	Status of the instance of SMC_Interpolator (connect iStatus output)
	bEnable	BOOL	TRUE: Enables the execution of the FB.
	bAvoidGaps	BOOL	TRUE: Starts the monitoring of the position. If the velocity exceeds the limit value which is set in AXIS_REF_SM3.fSWMaxVelocity and configured in the drive dialog with the max. values setting, then the bStopIpo output is set. The axis is moved to the position with the values fGapVelocity, fGapAcceleration and fGapDeceleration. On reaching the set position, bStopIpo is set to FALSE.
	fSetPosition	LREAL	Set position of the axis. Typically connected to the output of the SMC_TRAFO.
	fGapVelocity	LREAL	Velocity for the bypassing of the jump in [u/s]
	fGapAcceleration	LREAL	Acceleration for the bypassing of the jump in [u/s^2]
	fGapDeceleration	LREAL	Deceleration for the bypassing of the jump in [u/s^2]
	fGapJerk	LREAL	Jerk for the bypassing of the jump in [u/s^3]
OUT	bBusy	BOOL	TRUE: The FB is in operation.
	bCommandAborted	BOOL	TRUE: Command has been aborted by another command.
	bError	BOOL	TRUE: Error has occurred within the FB.
	iErrorID	SMC_ERROR	Error identification
	bStopIpo	BOOL	TRUE: Jump in velocity or position occurred and adaptation to new position is running.

9.7.6 SMC_GetMParameters

Name	Description	Type
SMC_GetMParameters	This FB can be used to poll the parameters that have been set for this M-function.	FB

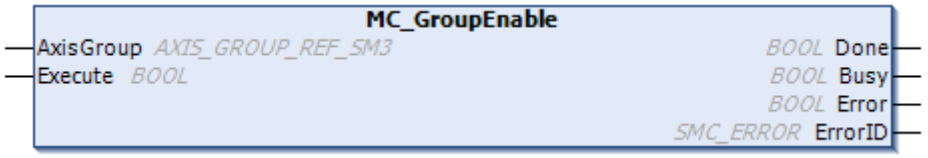


Name		Type	Description
IN_OUT	Interpolator	SMC_Interpolator	Instance of interpolator
IN	bEnable	BOOL	TRUE: Enables the execution of the FB.
OUT	bMActive	BOOL	TRUE: M-function is currently processed.
	dK	LREAL	M-parameter specified via word K
	dL	LREAL	M-parameter specified via word L
	MParameters	SMC_M_PARAMETERS	M-parameters, specified by the global data structure gSMC_MParameters or by the variable passed by O.

9.8 PLCopen Part 4 Coordinated Motion (Administrative)

9.8.1 MC_GroupEnable

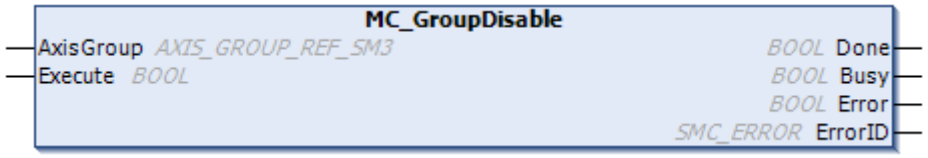
Name	Description	Type
MC_GroupEnable	This FB changes the state for a group from GroupDisabled to GroupStandby.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
OUT	Done	BOOL	TRUE: Group is in state GroupStandby
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.8.2 MC_GroupDisable

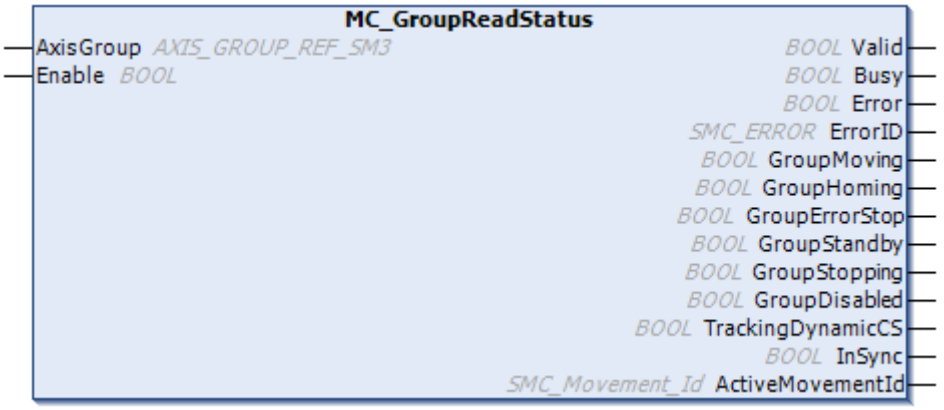
Name	Description	Type
MC_GroupDisable	This FB changes the state for a group from GroupStandby to GroupDisabled.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
OUT	Done	BOOL	TRUE: Group is in state GroupDisabled
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.8.3 MC_GroupReadStatus

Name	Description	Type
MC_GroupReadStatus	This FB returns the status of an axis group.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
OUT	Valid	BOOL	TRUE: A valid output is available.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	GroupMoving	BOOL	TRUE: GroupMoving (see section 8.2.1 State diagram)
	GroupHoming	BOOL	TRUE: GroupHoming (see section 8.2.1 State diagram)
	GroupErrorStop	BOOL	TRUE: GroupErrorStop (see section 8.2.1 State diagram)
	GroupStandby	BOOL	TRUE: GroupStandby (see section 8.2.1 State diagram)
	GroupStopping	BOOL	TRUE: GroupStopping (see section 8.2.1 State diagram)
	GroupDisabled	BOOL	TRUE: GroupDisabled (see section 8.2.1 State diagram)
	TrackingDynamicCS	BOOL	TRUE: The active movement is commanded using dynamic coordination system.
	InSync	BOOL	Only used in case of TrackingDynamicCS: Continuous path movements: the current position belongs to the specified path. PTP movements: the current position equals the target position of the movements.
	ActiveMovementId	SMC_Movement_Id	The identifier of the active movement. An Id of 0 means no movement is active.

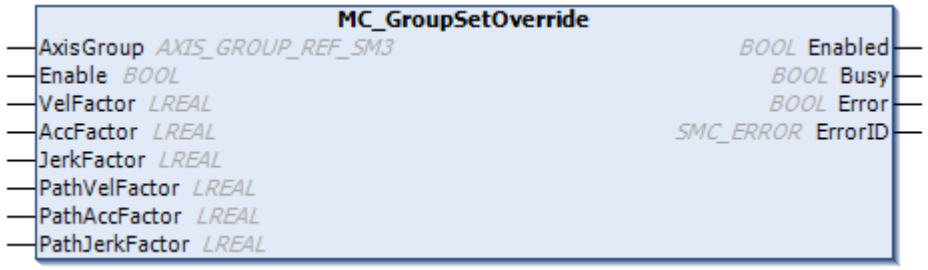
9.8.4 MC_GroupReset

Name	Description	Type
MC_GroupReset	This FB makes the transition from the state GroupErrorStop to GroupStandby by resetting all internal group-related errors.	FB

Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
OUT	Done	BOOL	TRUE: Reset for axis group and all axes in this group done
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.8.5 MC_GroupSetOverride

Name	Description	Type
MC_GroupSetOverride	This FB allows to change the velocity, acceleration, or jerk of active and commanded movements.	FB

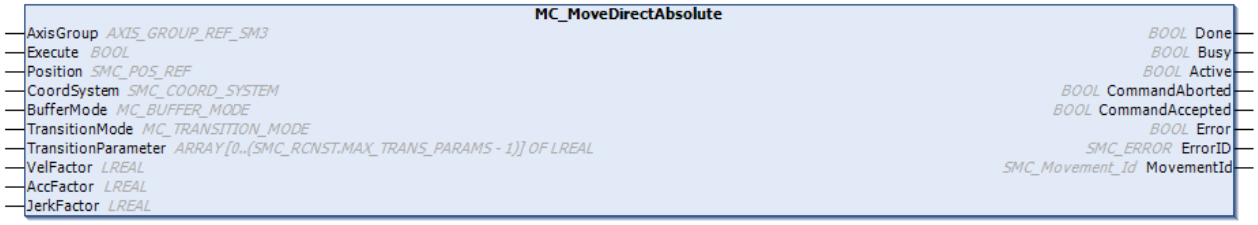


Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Enable	BOOL	TRUE: Enables the execution of the FB.
	VelFactor	LREAL	Factor for axis velocity (0.0 to 1.0)
	AccFactor	LREAL	Factor for axis acceleration and deceleration (0.0 to 1.0)
	JerkFactor	LREAL	Factor for axis jerk (0.0 to 1.0)
	PathVelFactor	LREAL	Factor for path velocity (0.0 to 1.0)
	PathAccFactor	LREAL	Factor for path acceleration and deceleration (0.0 to 1.0)
	PathJerkFactor	LREAL	Factor for path jerk (0.0 to 1.0)
OUT	Done	BOOL	TRUE: signals that the override factors have been set successfully.
	Busy	BOOL	TRUE: The FB is in operation.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification

9.9 PLCopen Part 4 Coordinated Motion (Motion)

9.9.1 MC_MoveDirectAbsolute

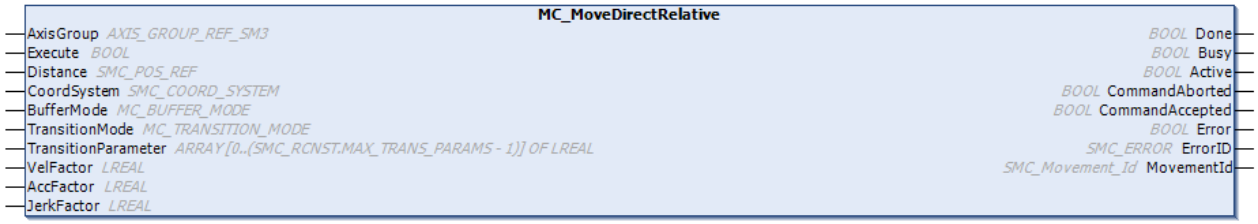
Name	Description	Type
MC_MoveDirectAbsolute	This FB commands a movement of an axis group to the specified absolute position in the specific coordinate system. Each axis is moved to its target position independently, the movement is only synchronized such that all axes reach the target at the same time. This means that the path travelled by the TCP depends on the kinematic transformation used. In general, it will no be a line.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Position	SMC_POS_REF	End position
	CoordSystem	SMC_COORD_SYSTEM	Reference to the applicable coordinate system
	BufferMode	MC_BUFFER_MODE	Defines the chronological sequence of the FB relative to the previous block.
	TransitionMode	MC_TRANSITION_MODE	Defines the blending in case of a bending buffer mode.
	TransitionParameter	ARRAY [0..(SMC_RCNST.MAX_TRANS_PARAMS-1)] OF LREAL	Parameters for blending
	VelFactor	LREAL	Max. velocity of each axis is multiplied by this factor (0 to 1)
	AccFactor	LREAL	Max. acceleration of each axis is multiplied by this factor (0 to 1)
	JerkFactor	LREAL	Max. jerk of each axis is multiplied by this factor (0 to 1)
OUT	Done	BOOL	TRUE: Commanded end positions reached for all axes.
	Busy	BOOL	TRUE: The FB is in operation.
	Active	BOOL	TRUE: The FB has control on the axis
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	CommandAccepted	BOOL	TRUE: Command has been accepted.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	MovementId	SMC_Movement_Id	The unique identifier of the movement.

9.9.2 MC_MoveDirectRelative

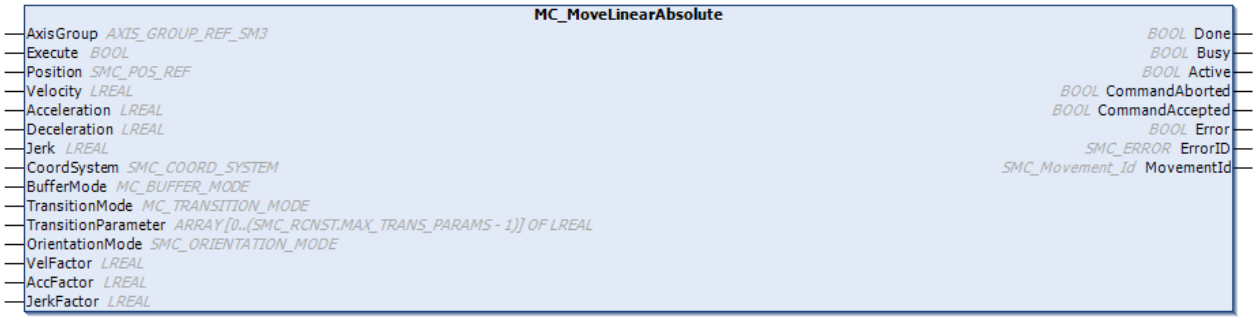
Name	Description	Type
MC_MoveDirectRelative	This FB commands a movement of an axis group to the specified relative position in the specific coordinate system. Each axis is moved to its target position independently, the movement is only synchronized such that all axes reach the target at the same time. This means that the path travelled by the TCP depends on the kinematic transformation used. In general, it will no be a line.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Distance	SMC_POS_REF	Relative distance in the specified coordinate system [u]
	CoordSystem	SMC_COORD_SYSTEM	Reference to the applicable coordinate system
	BufferMode	MC_BUFFER_MODE	Defines the chronological sequence of the FB relative to the previous block.
	TransitionMode	MC_TRANSITION_MODE	Defines the blending in case of a bending buffer mode.
	TransitionParameter	ARRAY [0..(SMC_RCNST.MAX_TRANS_PARAMS-1)] OF LREAL	Parameters for blending
	VelFactor	LREAL	Max. velocity of each axis is multiplied by this factor (0 to 1)
	AccFactor	LREAL	Max. acceleration of each axis is multiplied by this factor (0 to 1)
	JerkFactor	LREAL	Max. jerk of each axis is multiplied by this factor (0 to 1)
OUT	Done	BOOL	TRUE: Commanded end positions reached for all axes.
	Busy	BOOL	TRUE: The FB is in operation.
	Active	BOOL	TRUE: The FB has control on the axis
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	CommandAccepted	BOOL	TRUE: Command has been accepted.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	MovementId	SMC_Movement_Id	The unique identifier of the movement.

9.9.3 MC_MoveLinearAbsolute

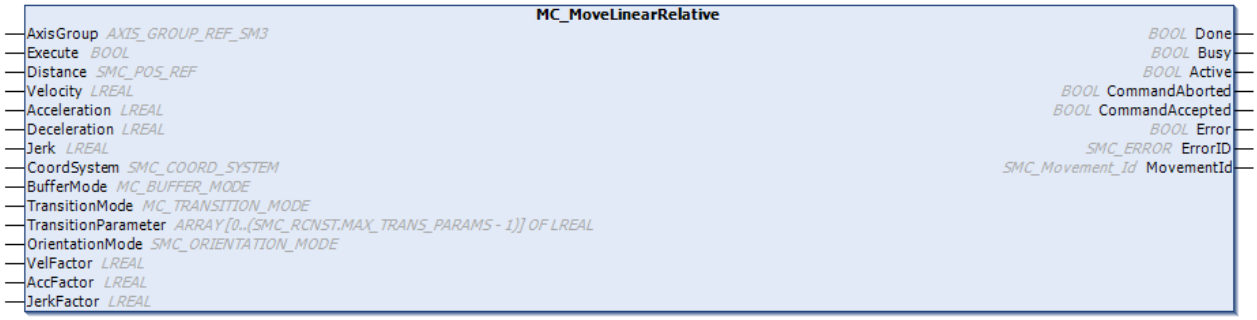
Name	Description	Type
MC_MoveLinearAbsolute	This FB commands an interpolated linear movement of an axis group to an absolute position in the specified coordinate system.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Position	SMC_POS_REF	End position [u]
	Velocity	LREAL	Max. path velocity [u/s] for the coordinate system in which the path is defined. Always positive. Not necessarily reached.
	Acceleration	LREAL	Max. path acceleration [u/s^2]. Always positive. Not necessarily reached.
	Deceleration	LREAL	Max. path deceleration [u/s^2]. Always positive. Not necessarily reached.
	Jerk	LREAL	Max. path jerk [u/s^3]. Always positive. Not necessarily reached.
	CoordSystem	SMC_COORD_SYSTEM	Reference to the applicable coordinate system
	BufferMode	MC_BUFFER_MODE	Defines the chronological sequence of the FB relative to the previous block.
	TransitionMode	MC_TRANSITION_MODE	Defines the blending in case of a bending buffer mode.
	TransitionParameter	ARRAY [0..(SMC_RCNST.MAX_TRANS_PARAMS-1)] OF LREAL	Parameters for blending
	OrientationMode	SMC_ORIENTATION_MODE	Determines how the orientation is interpolated.
	VelFactor	LREAL	Max. velocity of each axis is multiplied by this factor (0 to 1)
	AccFactor	LREAL	Max. acceleration of each axis is multiplied by this factor (0 to 1)
	JerkFactor	LREAL	Max. jerk of each axis is multiplied by this factor (0 to 1)
OUT	Done	BOOL	TRUE: Commanded end positions reached for all axes.
	Busy	BOOL	TRUE: The FB is in operation.
	Active	BOOL	TRUE: The FB has control on the axis
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	CommandAccepted	BOOL	TRUE: Command has been accepted.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	MovementId	SMC_Movement_Id	The unique identifier of the movement.

9.9.4 MC_MoveLinearRelative

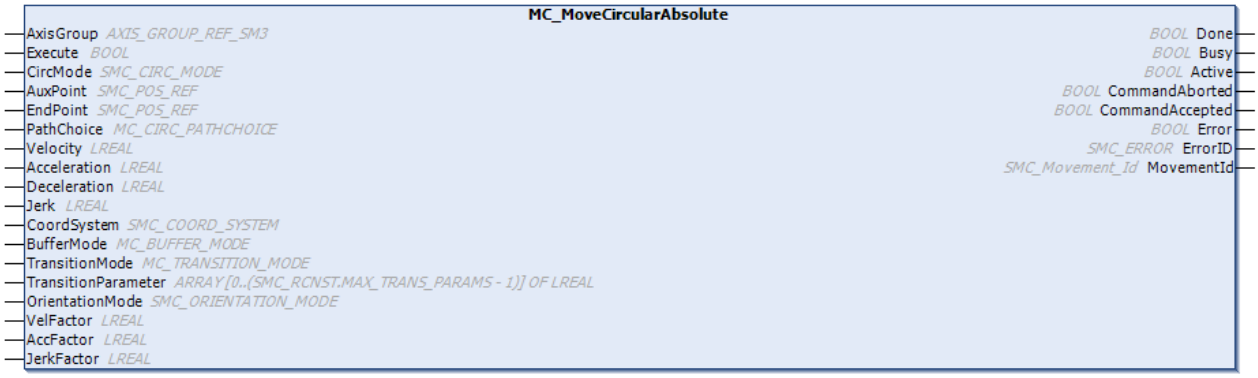
Name	Description	Type
MC_MoveLinearRelative	This FB commands an interpolated linear movement of an axis group by a (relative) distance in the specified coordinate system.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	Distance	SMC_POS_REF	Relative distance in the specified coordinate system [u]
	Velocity	LREAL	Max. path velocity [u/s] for the coordinate system in which the path is defined. Always positive. Not necessarily reached.
	Acceleration	LREAL	Max. path acceleration [u/s^2]. Always positive. Not necessarily reached.
	Deceleration	LREAL	Max. path deceleration [u/s^2]. Always positive. Not necessarily reached.
	Jerk	LREAL	Max. path jerk [u/s^3]. Always positive. Not necessarily reached.
	CoordSystem	SMC_COORD_SYSTEM	Reference to the applicable coordinate system
	BufferMode	MC_BUFFER_MODE	Defines the chronological sequence of the FB relative to the previous block.
	TransitionMode	MC_TRANSITION_MODE	Defines the blending in case of a bending buffer mode.
	TransitionParameter	ARRAY [0..(SMC_RCNST.MAX_TRANS_PARAMS-1)] OF LREAL	Parameters for blending
	OrientationMode	SMC_ORIENTATION_MODE	Determines how the orientation is interpolated.
	VelFactor	LREAL	Max. velocity of each axis is multiplied by this factor (0 to 1)
	AccFactor	LREAL	Max. acceleration of each axis is multiplied by this factor (0 to 1)
	JerkFactor	LREAL	Max. jerk of each axis is multiplied by this factor (0 to 1)
OUT	Done	BOOL	TRUE: Commanded end positions reached for all axes.
	Busy	BOOL	TRUE: The FB is in operation.
	Active	BOOL	TRUE: The FB has control on the axis
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	CommandAccepted	BOOL	TRUE: Command has been accepted.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	MovementId	SMC_Movement_Id	The unique identifier of the movement.

9.9.5 MC_MoveCircularAbsolute

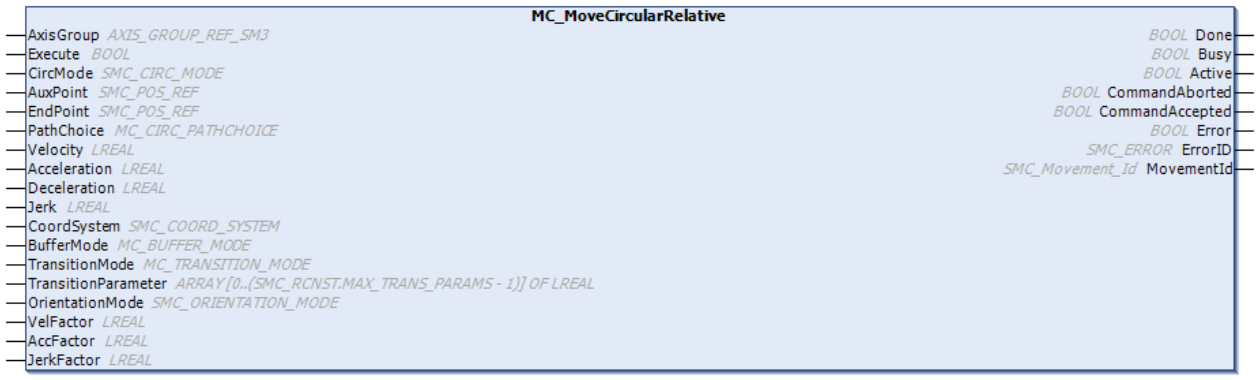
Name	Description	Type
MC_MoveCircularAbsolute	This FB commands an interpolated circular movement of an axis group to an absolute position in the specified coordinate system.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	CircMode	SMC_CIRC_MODE	Specifies the meaning of the inputs AuxPoint and CircDirection.
	AuxPoint	SMC_POS_REF	Auxiliary point in the specified coordinate system.
	EndPoint	SMC_POS_REF	End position in the specified coordinate system.
	PathChoice	MC_CIRC_PATHCHOICE	Choice of path: clockwise or counterclockwise
	Velocity	LREAL	Max. path velocity [u/s] for the coordinate system in which the path is defined. Always positive. Not necessarily reached.
	Acceleration	LREAL	Max. path acceleration [u/s^2]. Always positive. Not necessarily reached.
	Deceleration	LREAL	Max. path deceleration [u/s^2]. Always positive. Not necessarily reached.
	Jerk	LREAL	Max. path jerk [u/s^3]. Always positive. Not necessarily reached.
	CoordSystem	SMC_COORD_SYSTEM	Reference to the applicable coordinate system
	BufferMode	MC_BUFFER_MODE	Defines the chronological sequence of the FB relative to the previous block.
	TransitionMode	MC_TRANSITION_MODE	Defines the blending in case of a bending buffer mode.
	TransitionParameter	ARRAY [0..(SMC_RCNST.MAX_TRANS_PARAMS-1)] OF LREAL	Parameters for blending
	OrientationMode	SMC_ORIENTATION_MODE	Determines how the orientation is interpolated.
	VelFactor	LREAL	Max. velocity of each axis is multiplied by this factor (0 to 1)
	AccFactor	LREAL	Max. acceleration of each axis is multiplied by this factor (0 to 1)
	JerkFactor	LREAL	Max. jerk of each axis is multiplied by this factor (0 to 1)
OUT	Done	BOOL	TRUE: Commanded end positions reached for all axes.
	Busy	BOOL	TRUE: The FB is in operation.
	Active	BOOL	TRUE: The FB has control on the axis
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	CommandAccepted	BOOL	TRUE: Command has been accepted.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	MovementId	SMC_Movement_Id	The unique identifier of the movement.

9.9.6 MC_MoveCircularRelative

Name	Description	Type
MC_MoveCircularRelative	This FB commands an interpolated circular movement of an axis group to a relative position in the specified coordinate system.	FB



Name		Type	Description
IN_OUT	AxisGroup	AXIS_GROUP_REF_SM3	Reference to an axis group
IN	Execute	BOOL	Starts the execution of the FB at rising edge.
	CircMode	SMC_CIRC_MODE	Specifies the meaning of the inputs AuxPoint and CircDirection.
	AuxPoint	SMC_POS_REF	Auxiliary point in the specified coordinate system. The point is relative to the starting point.
	EndPoint	SMC_POS_REF	End position in the specified coordinate system. The point is relative to the starting point.
	PathChoice	MC_CIRC_PATHCHOICE	Choice of path: clockwise or counterclockwise
	Velocity	LREAL	Max. path velocity [u/s] for the coordinate system in which the path is defined. Always positive. Not necessarily reached.
	Acceleration	LREAL	Max. path acceleration [u/s^2]. Always positive. Not necessarily reached.
	Deceleration	LREAL	Max. path deceleration [u/s^2]. Always positive. Not necessarily reached.
	Jerk	LREAL	Max. path jerk [u/s^3]. Always positive. Not necessarily reached.
	CoordSystem	SMC_COORD_SYSTEM	Reference to the applicable coordinate system
	BufferMode	MC_BUFFER_MODE	Defines the chronological sequence of the FB relative to the previous block.
	TransitionMode	MC_TRANSITION_MODE	Defines the blending in case of a bending buffer mode.
	TransitionParameter	ARRAY [0..(SMC_RCNST.MAX_TRANS_PARAMS-1)] OF LREAL	Parameters for blending
	OrientationMode	SMC_ORIENTATION_MODE	Determines how the orientation is interpolated.
	VelFactor	LREAL	Max. velocity of each axis is multiplied by this factor (0 to 1)
	AccFactor	LREAL	Max. acceleration of each axis is multiplied by this factor (0 to 1)
	JerkFactor	LREAL	Max. jerk of each axis is multiplied by this factor (0 to 1)
OUT	Done	BOOL	TRUE: Commanded end positions reached for all axes.
	Busy	BOOL	TRUE: The FB is in operation.
	Active	BOOL	TRUE: The FB has control on the axis
	CommandAborted	BOOL	TRUE: Command has been aborted by another command.
	CommandAccepted	BOOL	TRUE: Command has been accepted.
	Error	BOOL	TRUE: Error has occurred within the FB.
	ErrorID	SMC_ERROR	Error identification
	MovementId	SMC_Movement_Id	The unique identifier of the movement.

9.10 STRUCT

9.10.1 MC_TP_REF

Name	Type	Initial	Description
Number_of_pairs	INT	0	This variable is not used.
lsAbsolute	BOOL	TRUE	TRUE: Absolute FALSE: Relative
MC_TP_Array	ARRAY [1..100] OF SMC_TP		Time/Positions

9.10.2 MC_TV_REF

Name	Type	Initial	Description
Number_of_pairs	INT	0	This variable is not used.
lsAbsolute	BOOL	TRUE	TRUE: Absolute FALSE: Relative
MC_TV_Array	ARRAY [1..100] OF SMC_TV		Time/Velocity

9.10.3 MC_TA_REF

Name	Type	Initial	Description
Number_of_pairs	INT	0	This variable is not used.
lsAbsolute	BOOL	TRUE	TRUE: Absolute FALSE: Relative
MC_TA_Array	ARRAY [1..100] OF SMC_TA		Time/Acceleration

9.10.4 SMC_TP

Name	Type	Initial	Description
delta_time	TIME	0	Period of time between reaching the last and the current point
position	LREAL	0	Position

9.10.5 SMC_TV

Name	Type	Initial	Description
delta_time	TIME	0	Period of time between reaching the last and the current point
Velocity	LREAL	0	Velocity

9.10.6 SMC_TA

Name	Type	Initial	Description
delta_time	TIME	0	Period of time between reaching the last and the current point
Acceleration	LREAL	0	Acceleration

9.10.7 TRIGGER_REF

Name	Type	Initial	Description
iTriggerNumber	INT	-1	Trigger channel; defined by driver (only used when bFastLatching=TRUE)
bFastLatching	BOOL	TRUE	TRUE: Latching is done in drive (precise). FALSE: Latching is done with bInput in the cycle of the motion task (unprecise).
bInput	BOOL		Trigger signal when bFastLatching=FALSE.
bActive	BOOL	FALSE	Internal variable

9.10.8 MC_CAMSWITCH_REF

Name	Type	Initial	Description
NoOfSwitches	BYTE	0	Number of switch positions
CamSwitchPtr	POINTER TO MC_CAMSWITCH_TR	0	Address of MC_CAMSWITCH_TR

9.10.9 MC_CAMSWITCH_TR

Name	Type	Initial	Description
TrackNumber	INT		Number of the output; several position ranges per output are possible. [1..32]
FirstOnPosition	LREAL		Switch-on position of the output
LastOnPosition	LREAL		Switch-off position of the output
AxisDirection	INT		0: The output is switched in two directions. 1: The output is only switched in positive direction. 2: The output is only switched in negative direction.
CamSwitchMode	INT		0: The tappets are calculated position-based. 1: The tappets are calculated time-based, whereby only the value of FirstOnPosition will be used and the output will stay TRUE for the given time 'Duration'.
Duration	TIME		Period of time for which the tappet output stays TRUE in case of CamSwitchMode=1.

9.10.10 MC_CAM_ID

Name	Type	Initial	Description
pCT	POINTER TO BYTE		This STRUCT is an interface between output of MC_CamTableSelect and input of MC_CamIn.
Periodic	BOOL	FALSE	
MasterAbsolute	BOOL	FALSE	
SlaveAbsolute	BOOL	FALSE	
StartMaster	LREAL	0	
EndMaster	LREAL	0	
StartSlave	LREAL	0	
EndSlave	LREAL	0	
byCompatibilityMode	BYTE		

9.10.11 SMC_TAPPETDATA

Name	Type	Initial	Description
pTaps	ARRAY [0..2] OF POINTER TO SMC_CAMTappet		This STRUCT is an interface between output of MC_CamIn and input of SMC_GetTappetValue.
dwCycleTime	DWORD		
byChannels	BYTE	3	
bRestart	BOOL		

9.10.12 SMC_CAMTAPPET

Name	Type	Initial	Description
ctt	SMC_CAMTAPPETTYPE (ENUM)		
cta	SMC_CAMTAPPETACTION (ENUM)		
dwDelay	DWORD		In case of cta = TAPPETACTION.TAPPETACTION_time, this value determines the delay time in µs.
dwDuration	DWORD		In case of cta = TAPPETACTION.TAPPETACTION_time, this value determines the time in µs, for which the tappet is switched to on.
iGroupID	INT		Group or track ID of the tappet output that is switched.
x	LREAL		Master position where tappet is switched.
dwActive	DWORD	16#FFFFFFFF	Internal variable

9.10.13 MC_TRACK_TR

Name	Type	Initial	Description
OnCompensation	LREAL		ON delay time [s]
OffCompensation	LREAL		OFF delay time [s]
Hysteresis	LREAL		Hysteresis

9.10.14 MC_COORD_REF

Name	Type	Initial	Description
X	LREAL		X-coordinate of position
Y	LREAL		Y-coordinate of position
Z	LREAL		Z-coordinate of position
A	LREAL		Angle around z-axis [deg]
B	LREAL		Angle around y'-axis [deg]
C	LREAL		Angle around z'-axis [deg]

9.11 Enumeration (ENUM)

9.11.1 MC_DIRECTION

Name	Value	Description
fastest	3	Selects the direction automatically in order to reach the target position as fast as possible (only modulo axes).
current	2	Keeps the current direction to reach the target (only modulo axes).
positive	1	Moves in positive direction.
shortest	0	Selects the direction according to the shortest distance (only modulo axes).
negative	-1	Moves in negative direction.

9.11.2 MC_TAPPETMODE

Name	Value	Description
tp_mode_auto	0	Auto mode
tp_mode_demandposition	1	Use set values
tp_mode_actualposition	2	Use actual values

9.11.3 MC_STARTMODE

Name	Value	Description
absolute	0	Absolute position
relative	1	Relative position
ramp_in	2	With acceleration
ramp_in_pos	3	With acceleration (positive)
ramp_in_neg	4	With acceleration (negative)

9.11.4 SMC_CAMTAPPETTYPE

Name	Value	Description
TAPPET_pos	0	Tappet action active when the master passes its position in positive direction.
TAPPET_all	1	Tappet action active when the master passes its position in both directions.
TAPPET_neg	2	Tappet action active when the master passes its position in negative direction.

9.11.5 SMC_CAMTAPPETACTION

Name	Value	Description
TAPPETACTION_on	0	Switches on.
TAPPETACTION_off	1	Switches off.
TAPPETACTION_inv	2	Inverts.
TAPPETACTION_time	3	Switches on after a delay for a certain time period.

9.11.6 SMC_RAMPTYPE

Name	Value	Description
trapez	0	Trapezoid
sinsquare	1	Sin^2
quadratic_ramp	2	Quadratic ramp
quadratic_smooth_ramp	3	Quadratic ramp (smooth)

9.11.7 SMC_CONTROLLER_MODE

Name	Value	Description
SMC_nocontrol	0	—
SMC_torque	1	Torque
SMC_velocity	2	Velocity
SMC_position	3	Position
SMC_current	4	Current

9.11.8 SMC_HOMING_MODE

Name	Value	Description
FAST_BSLOW_S_STOP	0	Move with fast velocity onto the reference switch; invert and move with slow velocity out of the reference switch; execute 'Set position'; stop
FAST_BSLOW_STOP_S	1	Move with fast velocity onto the reference switch; invert and move with slow velocity out of the reference switch; stop; execute 'Set position'
FAST_BSLOW_I_S_STOP	2	Move with fast velocity onto the reference switch; invert and move with slow velocity out of the reference switch; wait for the index pulse; execute 'Set position'; stop
FAST_SLOW_S_STOP	4	Move with fast velocity onto the reference switch; move with slow velocity out of the reference switch; execute 'Set position'; stop
FAST_SLOW_STOP_S	5	Move with fast velocity onto the reference switch; move with slow velocity out of the reference switch; stop; execute 'Set position'
FAST_SLOW_I_S_STOP	6	Move with fast velocity onto the reference switch; move with slow velocity out of the reference switch; wait for the index pulse; execute 'Set position'; stop

9.11.9 SMC_COORD_SYSTEM

Name	Value	Description
ACS	0	Axis coordinate system. This is not a Cartesian coordinate system. Instead, each axis of the axis group spans one dimension. A point in this coordinate system is simply the assignment of a value for each axis of the axis group.
MCS	1	Machine coordinate system. This coordinate system is directly associated with the kinematic of one axis group. The position and orientation of the MCS is defined by the kinematic transformation.
WCS	2	World coordinate system. This coordinate system is the common coordinate system for all axis groups working together to solve some task.
PCS_1	3	Product coordinate system number 1. This coordinate system is attached to a product. It may be static or dynamic.
PCS_2	4	Product coordinate system number 2. This coordinate system is attached to a product. It may be static or dynamic.

9.11.10 MC_BUFFER_MODE

Name	Value	Description
Aborting	0	Start FB immediately (default mode).
Buffered	1	Start FB after the currently last motion in queue has finished.
BlendingLow	2	The velocity is blended with the lowest velocity of both FBs.
BlendingPrevious	3	The velocity is blended with the velocity of the first FBs.
BlendingNext	4	The velocity is blended with the velocity of the second FBs.
BlendingHigh	5	The velocity is blended with the highest velocity of both FBs.

9.11.11 MC_TRANSITION_MODE

Name	Value	Description
TMNone	0	No blending
TMStartVelocity	1	Velocity based blending
TMCornerDistance	2	Distance based blending

9.11.12 SMC_CIRC_MODE

Name	Value	Description
Border	0	The circle is defined by a start point, an end point and a border point (AuxPoint).
Center	1	The circle is defined by a start point, an end point and a center point (AuxPoint).
Radius	2	The circle is defined by a start point, an end point and a radius (AuxPoint).

9.11.13 SMC_CIRC_PATHCHOICE

Name	Value	Description
CLOCKWISE	0	Clockwise
COUNTER_CLOCKWISE	1	Counterclockwise

9.11.14 SMC_ORIENTATION_MODE

Name	Value	Description
GreatCircle	0	The orientation is interpolated from the start orientation to the target orientation along the shortest path. Even if the start and the target orientation are in the working space, this interpolation mode may leave the working space.
Axis	1	The orientation axes are interpolated in axis space from their start values to their target values. This mode can be used to move through singularities of the orientation. Not all kinematic transformations support this mode.

9.11.15 SMC_ERROR

Name	Value	Description
SMC_NO_ERROR	0	No error
SMC_DI_GENERAL_COMMUNICATION_ERROR	1	Communication error. For example, Sercos ring has broken.
SMC_DI_AXIS_ERROR	2	Axis error
SMC_DI_FIELDBUS_LOST_SYNCRONICITY	3	Fieldbus has lost synchronism.
SMC_DI_SWLIMITS_EXCEEDED	10	Position outside of permissible range of SWLimit
SMC_DI_HWLIMITS_EXCEEDED	11	Hardware end switch is active.
SMC_DI_LINEAR_AXIS_OUTOFRANGE	12	This error occurs if a linear axis has more than 2^15 32-bit overflows of the position in increments.
SMC_DI_HALT_OR_QUICKSTOP_NOT_SUPPORTED	13	Drive status Halt or Quickstop is not supported.
SMC_DI_VOLTAGE_DISABLED	14	Drive has no power.
SMC_DI_IRREGULAR_ACTPOSITION	15	This error is no longer used.
SMC_DI_POSITIONLAGERROR	16	Position lag error. Difference between set and current position exceeds the given limit.
SMC_DI_HOMING_ERROR	17	Homing error reported by axis.
SMC_REGULATOR_OR_START_NOT_SET	20	Controller enable not done or brake applied.
SMC_WRONG_CONTROLLER_MODE	21	Axis in wrong controller mode
SMC_INVALID_ACTION_FOR_LOGICAL	25	Invalid action at logical axis
SMC_FB_WASNT_CALLED_DURING_MOTION	30	Motion creating module has not been called again before end of the motion.
SMC_AXIS_IS_NO_AXIS_REF	31	Type of given AXIS_REF variable is not AXIS_REF.
SMC_AXIS_REF_CHANGED_DURING_OPERATION	32	AXIS_REF variable has been exchanged while the module was active.
SMC_FB_ACTIVE_AXIS_DISABLED	33	Axis disabled while being moved. MC_Power.bRegulatorOn
SMC_AXIS_NOT_READY_FOR_MOTION	34	Axis in its current state cannot execute a motion command, because the axis doesn't signal currently that it follows the target values.
SMC_AXIS_ERROR_DURING_MOTION	35	The drive reported an error during an ongoing movement.
SMC_VD_MAX_VELOCITY_EXCEEDED	40	Maximum velocity fMaxVelocity exceeded.
SMC_VD_MAX_ACCELERATION_EXCEEDED	41	Maximum acceleration fMaxAcceleration exceeded.
SMC_VD_MAX_DECELERATION_EXCEEDED	42	Maximum deceleration fMaxDeceleration exceeded.
SMC_3SH_INVALID_VELACC_VALUES	50	Invalid velocity or acceleration values (SMC_Homing)
SMC_3SH_MODE_NEEDS_HWLIMIT	51	Mode requests for safety reasons use of end switches. (SMC_Homing)
SMC_FRC_NO_FREE_HANDLE	60	No free handle has been sent to open file.
SMC_SCM_NOT_SUPPORTED	70	Mode not supported (SMC_SetControllerMode)
SMC_SCM_AXIS_IN_WRONG_STATE	71	In current mode, controller mode cannot be changed. (SMC_SetControllerMode)
SMC_SCM_INTERRUPTED	72	SMC_SetControllerMode has been interrupted by MC_Stop or errorstop.
SMC_ST_WRONG_CONTROLLER_MODE	75	Axis not in correct controller mode. Deprecated, no longer returned by SMC_SetTorque.
SMC_RAG_ERROR_DURING_STARTUP	80	Error at startup of the axis group (SMC_ResetAxisGroup)
SMC_RAG_ERROR_AXIS_NOT_INITIALIZED	81	The axis is not yet in the required state.

Name	Value	Description
SMC_PP_WRONG_AXIS_TYPE	85	The function block does not support virtual or logical axes.
SMC_PP_NUMBER_OF_ABSOLUTE_BITS_INVALID	86	The number of absolute bits is invalid, must be in the range 8 .. 32.
SMC_CGR_ZERO_VALUES	90	Invalid values (SMC_ChangeGearingRatio)
SMC_CGR_DRIVE_POWERED	91	Gearing parameters must not be changed as long as the drive is under control. (SMC_ChangeGearingRatio)
SMC_CGR_INVALID_POSPERIOD	92	Invalid modulo period (<= 0 or greater than half the bus bandwidth) (SMC_ChangeGearingRatio)
SMC_CGR_POSPERIOD_NOT_INTEGRAL	93	The modulo period in increments is not an integer, but the modulo-handling is done by the drive. (SMC_ChangeGearingRatio)
SMC_P_FTASKCYCLE_EMPTY	110	Axis contain no information on cycle time (fTaskCycle = 0). (MC_Reset)
SMC_R_NO_ERROR_TO_RESET	120	Axis without error (MC_Reset)
SMC_R_DRIVE_DOESNT_ANSWER	121	Axis does not perform error-reset. (MC_Reset)
SMC_R_ERROR_NOT_RESETTABLE	122	Error could not be reset. (MC_Reset)
SMC_R_DRIVE_DOESNT_ANSWER_IN_TIME	123	Communication with the axis did not work. (MC_Reset)
SMC_RP_PARAM_UNKNOWN	130	Parameter number unknown (MC_ReadParameter)
SMC_RP_REQUESTING_ERROR	131	Error during transmission to the drives. See error number in function block instance ReadDriveParameter. (MC_ReadParameter)
SMC_RP_DRIVE_PARAMETER_NOT_MAPPED	132	No assignment for drive parameters available (MC_ReadParameter)
SMC_RP_PARAM_CONVERSION_ERROR	133	Conversion of the value to / from the drive parameters failed. Unknown SoftMotion parameters. (MC_ReadParameter)
SMC_WP_PARAM_INVALID	140	Parameter number unknown or writing not allowed (MC_WriteParameter)
SMC_WP_SENDING_ERROR	141	See error number in function block instance WriteDriveParameter. (MC_WriteParameter)
SMC_WP_DRIVE_PARAMETER_NOT_MAPPED	142	No assignment for drive parameters available (MC_WriteParameter)
SMC_WP_PARAM_CONVERSION_ERROR	143	Conversion of the value to / from the drive parameters failed. Unknown SoftMotion parameters. (MC_WriteParameter)
SMC_H_AXIS_WASNT_STANDSTILL	170	Axis has not been in standstill state. (MC_Home)
SMC_H_AXIS_DIDNT_START_HOMING	171	Error at start of homing action. (MC_Home)
SMC_H_AXIS_DIDNT_ANSWER	172	Error at start of homing action. (MC_Home)
SMC_H_ERROR_WHEN_STOPPING	173	Error at stop after homing. Deceleration may not be set. (MC_Home)
SMC_H_AXIS_IN_ERRORSTOP	174	Drive is in errorstop status. Homing cannot be executed. (MC_Home)
SMC_MS_UNKNOWN_STOPPING_ERROR	180	Unknown error at stop (MC_Stop)
SMC_MS_INVALID_ACCDEC_VALUES	181	Invalid velocity or acceleration values (MC_Stop)
SMC_MS_DIRECTION_NOT_APPLICABLE	182	Direction = shortest not applicable (MC_Stop)

Name	Value	Description
SMC_MS_AXIS_IN_ERRORSTOP	183	Drive is in errorstop status. Stop cannot be executed. (MC_Stop)
SMC_BLOCKING_MC_STOP_WASNT_CALLED	184	Instance of MC_Stop blocking the axis by Execute = TRUE has not been called yet. MC_Stop (Execute = FALSE) has to be called.
SMC_UNKNOWN_TASK_INTERVAL	200	The task interval of the bus task could not be determined.
SMC_MA_INVALID_VELACC_VALUES	201	Invalid velocity or acceleration values (MC_MoveAbsolute)
SMC_MA_INVALID_DIRECTION	202	Direction error (MC_MoveAbsolute)
SMC_MR_INVALID_VELACC_VALUES	226	Invalid velocity or acceleration values (MC_MoveRelative)
SMC_MR_INVALID_DIRECTION	227	Direction error (MC_MoveRelative)
SMC_MAD_INVALID_VELACC_VALUES	251	Invalid velocity or acceleration values (MC_MoveAdditive)
SMC_MAD_INVALID_DIRECTION	252	Direction error (MC_MoveAdditive)
SMC_MSI_INVALID_VELACC_VALUES	276	Invalid velocity or acceleration values (MC_MoveSuperImposed)
SMC_MSI_INVALID_DIRECTION	277	Direction error (MC_MoveSuperImposed)
SMC_LOGICAL_NO_REAL_AXIS	300	No longer used; only for compatibility
SMC_MV_INVALID_ACCDEC_VALUES	301	Invalid velocity or acceleration values (MC_MoveVelocity)
SMC_MV_DIRECTION_NOT_APPLICABLE	302	Direction = shortest/fastest not applicable (MC_MoveVelocity)
SMC_PP_ARRAYSIZE	325	Erroneous array size (MC_PositionProfile)
SMC_PP_STEP0MS	326	Step time = t#0s (MC_PositionProfile)
SMC_VP_ARRAYSIZE	350	Erroneous array size (MC_VelocityProfile)
SMC_VP_STEP0MS	351	Step time = t#0s (MC_VelocityProfile)
SMC_AP_ARRAYSIZE	375	Erroneous array size (MC_AccelerationProfile)
SMC_AP_STEP0MS	376	Step time = t#0s (MC_AccelerationProfile)
SMC_TP_TRIGGEROCCUPIED	400	Trigger already active (MC_TouchProbe)
SMC_TP_COULDNT_SET_WINDOW	401	DriveInterface does not support the window function. (MC_TouchProbe)
SMC_TP_COMM_ERROR	402	Communication error (MC_TouchProbe)
SMC_AT_TRIGGERNOTOCCUPIED	410	Trigger already de-allocated (MC_AbortTrigger)
SMC_MCR_INVALID_VELACC_VALUES	426	Invalid velocity or acceleration values (MC_MoveContinuousRelative)
SMC_MCR_INVALID_DIRECTION	427	Invalid direction (MC_MoveContinuousRelative)
SMC_MCA_INVALID_VELACC_VALUES	451	Invalid velocity or acceleration values (MC_MoveContinuousAbsolute)
SMC_MCA_INVALID_DIRECTION	452	Invalid direction (MC_MoveContinuousAbsolute)
SMC_MCA_DIRECTION_NOT_APPLICABLE	453	Direction = fastest not applicable (MC_MoveContinuousAbsolute)
SMC_SDL_INVALID_AXIS_STATE	475	SMC_ChangeDynamicLimits may only be called in state standstill or power_off. (SMC_changeDynamicLimits)
SMC_SDL_INVALID_VELACC_VALUES	476	Invalid velocity, acceleration, deceleration or jerk values (SMC_changeDynamicLimits)

Name	Value	Description
SMC_CR_NO_TAPPETS_IN_CAM	600	Cam does not contain any tappets. (SMC_CamRegister)
SMC_CR_TOO_MANY_TAPPETS	601	Tappet group ID exceeds MAX_NUM_TAPPETS. (SMC_CamRegister)
SMC_CR_MORE_THAN_32_ACCESSES	602	More than 32 accesses on one CAM_REF. (SMC_CamRegister)
SMC_CI_NO_CAM_SELECTED	625	No cam selected (MC_CamIn)
SMC_CI_MASTER_OUT_OF_SCALE	626	Master axis out of valid range (MC_CamIn)
SMC_CI_RAMPIN_NEEDS_VELACC_VALUES	627	Velocity and acceleration values must be specified for ramp_in function. (MC_CamIn)
SMC_CI_SCALING_INCORRECT	628	Scaling variables fEditor/TableMasterMin/Max are not correct. (MC_CamIn)
SMC_CI_TOO_MANY_TAPPETS_PER_CYCLE	629	Too many tappets became active during one cycle. (MC_CamIn)
SMC_CB_NOT_IMPLEMENTED	640	Function block for the given cam format is not implemented. (SMC_CAMBounds, SMC_CAMBounds_Pos)
SMC_GI_RATIO_DENOM	675	RatioDenominator = 0 (MC_GearIn)
SMC_GI_INVALID_ACC	676	Acceleration invalid (MC_GearIn)
SMC_GI_INVALID_DEC	677	Deceleration invalid (MC_GearIn)
SMC_GI_MASTER_REGULATOR_CHANGED	678	Status Enable/Disable of the master has changed without permission. (MC_GearIn)
SMC_GI_INVALID_JERK	679	Jerk invalid (MC_GearIn)
SMC_PH_INVALID_VELACCDEC	725	Velocity and acceleration/deceleration values invalid (MC_Phase)
SMC_PH_ROTARYAXIS_PERIOD0	726	Rotation axis with fPositionPeriod = 0 (MC_Phase)
SMC_NO_CAM_REF_TYPE	750	Type of given cam is not MC_CAM_REF.
SMC_CAM_TABLE_DOES_NOT_COVER_MASTER_SCALE	751	Master area, xStart and xEnd, from CamTable is not covered by curve data. (MC_CamTableSelect)
SMC_CAM_TABLE_EMPTY_MASTER_RANGE	752	Cam data table has empty master range. (MC_CamTableSelect)
SMC_CAM_TABLE_INVALID_MASTER_MINMAX	753	Cam data master has invalid max-, min-values. (MC_CamTableSelect)
SMC_CAM_TABLE_INVALID_SLAVE_MINMAX	754	Cam data slave has invalid max-, min-values. (MC_CamTableSelect)
SMC_GIP_MASTER_DIRECTION_CHANGE	775	During coupling of slave axis, master axis has changed direction of rotation. (MC_GearInPos)
SMC_GIP_SLAVE_REVERSAL_CANNOT_BE_AVOIDED	776	Input AvoidReversal is set, but slave reversal cannot be avoided. (MC_GearInPos)
SMC_GIP_AVOID_REVERSAL_FOR_FINITE_AXIS	777	Input AvoidReversal must not be set for finite slave axes. (MC_GearInPos)
SMC_BC_BL_TOO_BIG	800	Gear backlash fBacklash too large (> position period/2) (SMC_BacklashCompensation)
SMC_QPROF_DIVERGES	825	Internal error: computation of quadratic trajectory failed
SMC_QPROF_INVALID_PARAMETER	826	Internal error: computation of quadratic trajectory failed
SMC_QPROF_NO_RESULT	827	Internal error: computation of quadratic trajectory failed
SMC_QPROF_INVALID_NEW_LBD	828	Internal error: computation of quadratic trajectory failed

Name	Value	Description
SMC_QPROF_BAD_NEGOTIATION	829	Internal error: computation of quadratic trajectory failed
SMC_QPROF_INVALID_INTERVAL	830	Internal error: computation of quadratic trajectory failed
SMC_QPROF_NOT_ENOUGH_PHASES	831	Internal error: computation of quadratic trajectory failed
SMC_SRT_NOT_STANDSTILL_OR_POWEROFF	850	Action only permitted in standstill or power_off (SMC_SetRampType)
SMC_SRT_INVALID_RAMPTYPE	851	Invalid ramp type (SMC_SetRampType)
SMC_SMT_NOT_STANDSTILL_OR_POWEROFF	852	Action only permitted in standstill or power_off (SMC_SetMovementType)
SMC_SMT_INVALID_MOVEMENTTYPE_OR_ POSITIONPERIOD	853	Invalid motion type or position period (SMC_SetMovementType)
SMC_SMT_AXIS_NOT_VIRTUAL	854	Function block only applicable to virtual axis (SMC_SetMovementType)
SMC_NO_LICENSE	1000	Target is not licensed for CNC.
SMC_INT_VEL_ZERO	1001	Path cannot be processed because set velocity = 0 (SMC_Interpolator).
SMC_INT_NO_STOP_AT_END	1002	Last object of path has Vel_End > 0 (SMC_Interpolator).
SMC_INT_DATA_UNDERRUN	1003	Warning: GEOINFO-List processed in DataIn but end of list not reached Reason : - EndOfList of the queue in DataIn not be set - SMC_Interpolator faster than path generating function blocks
SMC_INT_VEL_NONZERO_AT_STOP	1004	Velocity at Stop > 0 (SMC_Interpolator)
SMC_INT_TOO_MANY_RECURSIONS	1005	Too much SMC_Interpolator recursions. SoftMotion-Error (SMC_Interpolator)
SMC_INT_NO_CHECKVELOCITIES	1006	SMC_CheckVelocities is not the last processed function block, that accesses to the OutQueue-data by poqDataIn.
SMC_INT_PATH_EXCEEDED	1007	Internal or numeric error
SMC_INT_VEL_ACC_DEC_ZERO	1008	Velocity and acceleration / deceleration is null or to low.
SMC_INT_DWIPOTIME_ZERO	1009	FB called with dwIpoTime = 0
SMC_INT_JERK_NONPOSITIVE	1010	Jerk invalid because jerk must be positive
SMC_INT_QPROF_DIVERGES	1011	Internal error. Calculation algorithm incorrectly
SMC_INT_INVLALID_VELOCITY_MODE	1012	Invalid velocity mode
SMC_INT_TOO_MANY_AXES_INTERPOLATED	1013	More than the allowed number of axes has ben interpolated.
SMC_INT2DIR_BUFFER_TOO_SMALL	1050	Warning: poqDataIn of OutQueue is created too small. Adherence of stops not guaranteed
SMC_INT2DIR_PATH_FITS_NOT_IN_QUEUE	1051	Path does not go completely in queue.
SMC_XINT_INVALID_DIRECTION	1070	Direction input has an invalid value.
SMC_XINT_NOINTERSECTION	1071	Could not determine position on CNC path for the given x-position.
SMC_WAR_INT_OUTQUEUE_TOO_SMALL	1080	Warning: poqDataIn of OutQueue is created too small. Adherence of stops not guaranteed
SMC_WAR_END_VELOCITIES_INCORRECT	1081	Warning: Final velocities inconsistent
SMC_CV_ACC_DEC_VEL_NONPOSITIVE	1100	Velocity and acceleration/deceleration values non-positive

Name	Value	Description
SMC_CA_INVALID_ACCDEC_VALUES	1120	Values of fGapVelocity / fGapAcceleration / fGapDeceleration non-positive
SMC_DEC_ACC_TOO_LITTLE	1200	Acceleration value impermissible
SMC_DEC_RET_TOO_LITTLE	1201	Deceleration value impermissible
SMC_DEC_OUTQUEUE_RAN_EMPTY	1202	Data underrun. Queue has been read and is empty.
SMC_DEC_JUMP_TO_UNKNOWN_LINE	1203	Jump to line cannot be executed because line number is unknown.
SMC_DEC_INVALID_SYNTAX	1204	Syntax invalid
SMC_DEC_3DMODE_OBJECT_NOT_SUPPORTED	1205	Objects are not supported in 3D mode.
SMC_DEC_NEGATIVE_PERIOD	1206	Negative value as a period of additional axes invalid
SMC_DEC_DIMENSIONS_EXCLUSIVE_AU	1207	Not both axes A and U are interpolated. PA and PU are mutually exclusive.
SMC_DEC_DIMENSIONS_EXCLUSIVE_BV	1208	Not both axes B and V are interpolated. PB and PV are mutually exclusive.
SMC_DEC_DIMENSIONS_EXCLUSIVE_CW	1209	Not both axes C and W are interpolated. PC and PW are mutually exclusive.
SMC_GCV_BUFFER_TOO_SMALL	1300	Buffer too small
SMC_GCV_BUFFER_WRONG_TYPE	1301	Buffer elements have wrong type.
SMC_GCV_UNKNOWN_IPO_LINE	1302	Current line of the Interpolator could not be found.
SMC_NO_CNC_REF_TYPE	1500	Given CNC program is not of type SMC_CNC_REF.
SMC_NO_OUTQUEUE_TYPE	1501	Given OutQueue is not of type SMC_OUTQUEUE.
SMC_GEOINFO_BUFFER_MISALIGNED	1502	4-byte aligned buffer part is not used in pbyBuffer.
SMC_3D_MODE_NOT_SUPPORTED	1600	Function block only works with 2D paths.
SMC_SAA_SMOOTHAREA_TOO_LARGE	1700	Range for smoothing too large
SMC_SAA_SP_INVALID_INPUT	1701	Invalid input dSmoothingPart [0..1]
SMC_SA_QUEUE_NOT_IN_BUFFER	1800	SMC_SegmentAnalyzer detects that OutQueue buffer is full but not completed. The function block can only operate when OutQueue fits the buffer completely.
SMC_SA_QUEUE_CHANGED_DURING_OP	1801	OutQueue buffer changed while the function block is operating on them
SMC_OS_INVALID_PARAMETER	1820	Invalid input value in dSplittingParameter
SMC_BSSP_IPO_NOT_ACTIVE	1830	Position cannot be saved. Interpolator is inactive.
SMC_BS_SAVEDPOS_NOT_REACHED	1831	Saved position has not been found so far. It is probably on a different path.
SMC_BS_NO_POS_STORED	1832	Structure passed in ePos contains no saved position. SMC_BlockSearchSavePos is not executed or in a wrong way.
SMC_INVALID_FEATURE_FLAG	1900	Feature flag must be in the range {1, .., 31}.
SMC_SMB_HFUN_NOT_SUPPORTED	1901	Function block does not support h-functions.
SMC_SMB_ONLY_3DMODE	1902	Function block only works in 3D-Mode.
SMC_SMB_ERROR_COMPUTING_SPLINE	1903	Internal error computing the spline.
SMC_SMM_INVALID_PARAM_NUMBER	1910	wAdditionalParameter is too big.
SMC_RNCF_FILE_DOESNT_EXIST	2000	File does not exist.
SMC_RNCF_NO_BUFFER	2001	No buffer allocated
SMC_RNCF_BUFFER_TOO_SMALL	2002	Buffer too small
SMC_RNCF_DATA_UNDERRUN	2003	Data underrun. Buffer has been read, is empty.

Name	Value	Description
SMC_RNCF_VAR_COULDNT_BE_REPLACED	2004	Placeholder variable could not be replaced.
SMC_RNCF_NOT_VARLIST	2005	Input pvl does not point to a SMC_VARLIST object.
SMC_RNCF_NO_STRINGBUFFER	2006	Input pStringBuffer is not used or does not point to a variable of type SMC_StringBuffer.
SMC_RNCF_STRINGBUFFER_OVERRUN	2007	In the CNC program more different strings are used as reserved in pStringBuffer.
SMC_RNCQ_FILE_DOESNT_EXIST	2050	File could not be opened.
SMC_RNCQ_NO_BUFFER	2051	No buffer defined
SMC_RNCQ_BUFFER_TOO_SMALL	2052	Buffer too small
SMC_RNCQ_UNEXPECTED_EOF	2053	Unexpected end of file
SMC_ADL_FILE_CANNOT_BE_OPENED	2100	File could not be opened.
SMC_ADL_BUFFER_OVERRUN	2101	Buffer overrun. WriteToFile must be called more frequently.
SMC_RCAM_FILE_DOESNT_EXIST	2200	File could not be opened.
SMC_RCAM_TOO_MUCH_DATA	2201	Saved cam too big
SMC_RCAM_WRONG_COMPILE_TYPE	2202	Wrong compilation mode
SMC_RCAM_WRONG_VERSION	2203	File has wrong version.
SMC_RCAM_UNEXPECTED_EOF	2204	Unexpected end of file
SMC_ENC_DENOM_ZERO	5000	Nominator of the conversion factor dwRatioTechUnitsDenom of the Encoder reference is 0.
SMC_ENC_AXISUSEDBYOTHERFB	5001	Other module trying to process motion on the Encoder axis
SMC_ENC_FILTER_DEPTH_INVALID	5002	Filter depth is invalid.
SMC_PCCQ_POINTBUFFERTOOSMALL	10000	Buffer pBuffer too small
SMC_PCCQ_INPUTBUFFERFULLBUTNOTFINALIZED	10001	The function block must be applied to a path that fit completely in the buffer.
SMC_AXIS_GROUP_WRONG_STATE	11000	The axis group is in the wrong state for the requested operation.
SMC_AXIS_GROUP_TOO_MANY_AXES	11001	More than the maximum allowed number of axes has been added to an axis group.
SMC_AXIS_GROUP_INVALID_DYNLIMITS	11002	The dynamic limits of a single axis are invalid. (fSWMaxVelocity/Acceleration/Deceleration/Jerk)
SMC_AXIS_GROUP_INVALID_COORD_SYSTEM	11004	The given coordinate system is invalid for the requested operation.
SMC_AXIS_GROUP_SINGLE_AXIS_ERROR	11005	An axis of the axis group is in state error.
SMC_MOVE_INVALID_BUFFER_MODE	11006	The given buffer mode is not supported.
SMC_MOVE_INVALID_DYNAMIC_FACTOR	11007	The dynamic factor is not in the range [0 .. 1].
SMC_MOVE_INVALID_DYNAMICS	11008	The dynamic limits for the movement are invalid.
SMC_AXIS_GROUP_AXIS_NOT_PART_OF_GROUP	11009	The given axis is not part of the axis group.
SMC_AXIS_GROUP_NOT_SUPPORTED	11010	The requested operation is not supported.
SMC_AXIS_GROUP_KINEMATICS_NOT_SET	11011	No kinematic configuration has been configured.
SMC_AXIS_GROUP_WRONG_NUMBER_OF_AXES	11012	The number of axes is not equal to the number of axes needed by the kinematic transformation

Name	Value	Description
SMC_AXIS_GROUP_INTERRUPTED_BY_SINGLE_AXIS	11013	A coordinated movement has been interrupted by a single axis movement.
SMC_AXIS_GROUP_FOLLOW_SETVALUES	11014	An error occurred while following the computed set values.
SMC_AXIS_GROUP_TOO_MANY_DEPENDENCIES	11015	An axis group cannot depend on more than one master axis group.
SMC_AXIS_GROUP_MUTUAL_DEPENDENCY	11016	An axis group A may not depend on another axis group that depends on A.
SMC_AXIS_GROUP_DEPENDENCY_IN_DIFFERENT_TASK	11017	A dependant axis group must be executed in the same task.
SMC_AXIS_GROUP_AXIS_IN_DIFFERENT_TASK	11018	An axis belonging to an axis group must be executed in the same task.
SMC_AXIS_GROUP_PCS_STILL_IN_USE	11019	A second activation of the function block occurred while the PCS was still used by buffered motion commands.
SMC_AXIS_GROUP_CMD_ABORTED_DUE_TO_ERROR	11020	An error ocurred in a previous motion command.
SMC_AXIS_GROUP_INVALID_PARAMETER	11021	A parameter of an administrative function block is invalid.
SMC_AXIS_GROUP_UNSUPPORTED_RAMPTYPE	11022	One of the axes of the group uses an unsupported ramp type. Only trapez and quadratic are supported.
SMC_MOVE_INVALID_TRANSITION_PARAMETER	11023	Invalid transition parameter
SMC_AXIS_GROUP_INTERNAL_ERROR	11024	Internal error in the state machine of the axis group.
SMC_AXIS_GROUP_CPTR_CANNOT_FOLLOW	11025	CP-Tracking: Cannot keep the path; try to reduce the dynamics on the path and / or the dynamics when entering CP-Tracking.
SMC_AXIS_GROUP_CONTINUE_WRONG_POSITION	11026	Current position does not allow continuation.
SMC_AXIS_GROUP_CONTINUE_BUFFER_TOO_SMALL	11027	Buffer in continueData is too small; big external movement-queue-buffer in use.
SMC_AXIS_GROUP_CONTINUE_WRONG_CHECKSUM	11028	The checksum stored in the continue data is wrong. The continue data either was not written by MC_GroupInterrupt, or was modified afterwards.
SMC_KERNEL_PTP_INTERNAL_ERROR	11100	Internal error in the kernel
SMC_KERNEL_PTP_INVALID_TASKCYCLETIME	11101	Task cycle time not positive
SMC_TRAFO_INVALID_PARAMETERS	12000	Invalid parameters
SMC_TRAFO_INVALID_CONSTELLATION	12001	The input constellation (typ. cartesian values) are incompatible with the configuration. Typically this means that the given position is outside of the working area of the kinematic transformation.
SMC_TRAFO_INVALID_COUPLING	12002	The tool cannot work together with the positioning-part of the machine. Either, the positioning-part doesn't implement ISMPositionKinematics2, or the tool cannot deal with the positioning's image of orientations.
SMC_CP_CACHE_FULL	12100	The cache of the CP planner is too small.
SMC_CP_EVAL_ERROR	12101	The evaluation of the position on a geometric element failed.
SMC_CP_NON_CONTINUABLE_STATE	12102	Non-continuable state reached (internal error).
SMC_CP_MAX_LENGTH_EXCEEDED	12103	Maximum trajectory length exceeded (internal error).

Name	Value	Description
SMC_CP_ACCELERATION_TOO_HIGH	12104	Path acceleration too high (invalid state, internal error).
SMC_CP_MAX_ITERATIONS_EXCEEDED	12105	Maximum number of iterations exceeded (internal error).
SMC_CP_NO_TRAJECTORY	12106	No trajectory could be computed (internal error).
SMC_CP_OUT_QUEUE_FULL	12107	The out-queue is full (internal error).
SMC_CP_QUEUE_UNDERRUN	12108	Queue underrun: no element left in queue.
SMC_CP_INVALID_QUEUE	12109	Invalid queue (invalid size or pointer)
SMC_CP_BLENDING_INTERNAL_ERROR	12110	An internal error occurred while blending two CP movements.
SMC_CP_CIRCLE_COLLINEAR_POINTS	12111	The three points that define the circle are collinear.
SMC_CP_CIRCLE_CENTER_NOT_ON_BISECTOR	12112	The center point is not on the perpendicular bisector of the start and end point.
SMC_CP_CIRCLE_RADIUS_ZERO	12113	The radius is zero.
SMC_CP_CIRCLE_DISTANCE_LARGER_THAN_DIAMETER	12114	The distance between start and end point is larger than the diameter. (When trying to create a circle using SMC_Circ_Mode.Radius.)
SMC_CP_CIRCLE_START_AND_ENDPOINT_EQUAL	12115	The start and end point are equal. (SMC_Circ_Mode.Radius)
SMC_CP_BLENDING_DEGENERATE_SPLINE	12116	The blending spline is degenerate (too short or non-regular).
SMC_CP_ELEMENT_TOO_SHORT	12117	The path element cannot be created because it is too short.
SMC_CP_COULD_NOT_CUT_PATH	12118	The path could not be cut for aborting movement (internal error).
SMC_CP_INVALID_ANGULAR_VEL_ACC	12119	The given angular velocity or acceleration is invalid (quaternion with non-zero real part, internal error).
SMC_CP_INVALID_ORIENTATION	12120	The given orientation is invalid (non-orthonormal matrix or non-unit quaternion, internal error).
SMC_CP_TIME_BUDGET_EXCEEDED	12121	The given time budget for the computation is exceeded (internal error).
SMC_AXIS_GROUP_AXIS_LIMIT_VIOLATED	12122	A limit of an axis has been violated. This can happen if a CP movement is done too close to a singularity of the robot or crosses the software position limit of an axis.
SMC_CP_CONFIG_OF_STARTPOS_DIFFERS	12123	The kinematic configuration of the start position differs from the current configuration. The CP movement would pass a singularity.
SMC_CP_CONFIG_OF_ENDPOS_DIFFERS	12124	The kinematic configuration of the end position differs from the current configuration. The CP movement would pass a singularity.
SMC_CP_CONFIGS_DIFFER	12125	The kinematic configuration of the start position differs from the end position. The CP movement would pass a singularity.

Name	Value	Description
SMC_CP_NO_ROOT_IN_INTERVAL_FOUND	12127	The stop trajectory could not be found in the interval (internal error).
SMC_CP_KIN_DOES_NOT_SUPPORT_AXIS_ORIENTATION_IPO	12128	The kinematics does not support the orientation mode “Axis” for continuous path movements.
SMC_CP_AXIS_ORIENTATION_IPO_NOT_SUPPORTED_FOR_CPTR	12129	The axis orientation interpolation mode is not supported for CP movements with a dynamic PCS (tracking).
SMC_CP_INVALID_PATH_ELEM	12130	An invalid path element has been created (internal error).
SMC_TRANSITION_NOT_SMOOTH	12131	The transition between two path elements is not G2 continuous, and there is no stop (internal error).

9.12 UNION

9.12.1 SMC_POS_REF

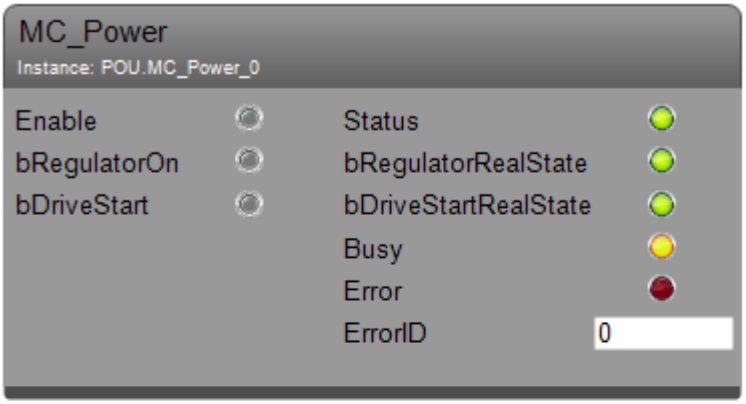
Name	Type	Description
a	TRAFO.AXISPOS_REF	Axis coordinates
c	MC_COORD_REF	Cartesian position
v	ARRAY [0..5] OF LREAL	Array of values, interpolation depends on coordinate system used

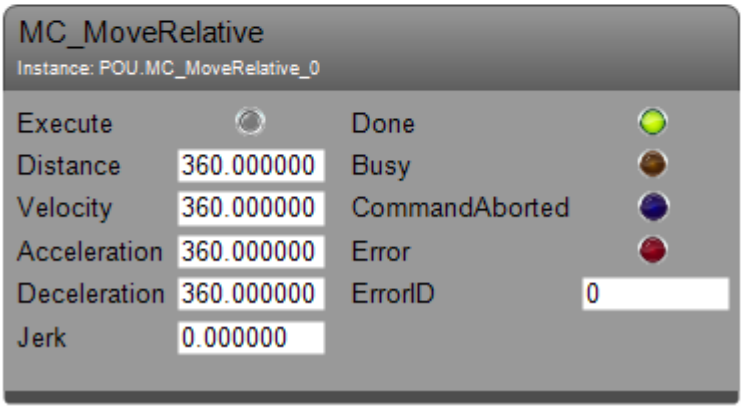
MEMO

Chapter 10 Visualization Template

10.1 Overview

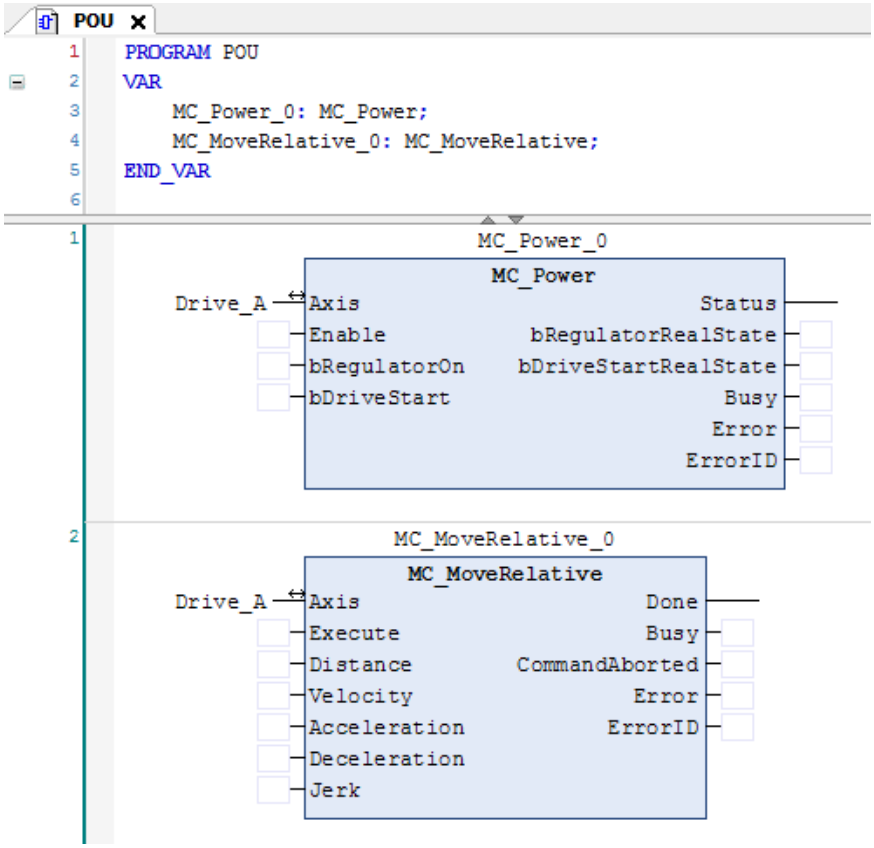
Visualization templates enable efficient debugging without inputs and outputs for function blocks in POUs.





10.2 Programming and Operation

This is a simple program including MC_Power and MC_MoveRelative only. As shown below, all the inputs and outputs other than Axis input can be opened.

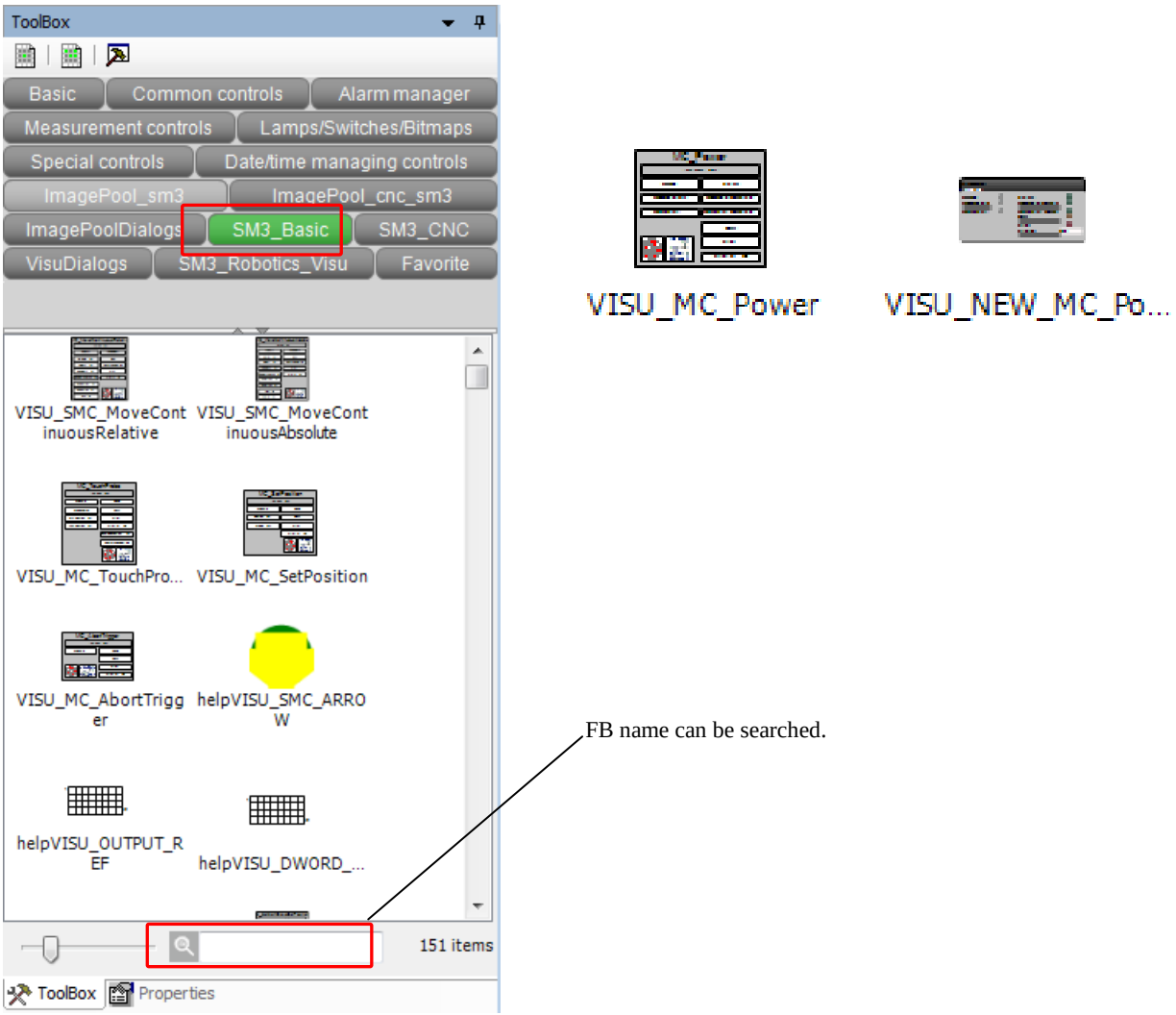


Right click on [Application] and choose [Add Object]-[Visualization...].

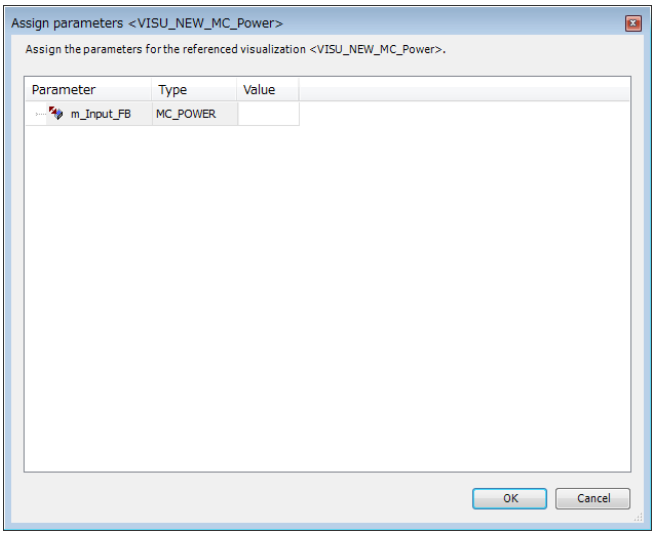
NOTE

When [Visualization] is added, also [WebVisualization] is added together automatically. However, the motion type CPU (HX-CP1S08M) does not support WebVisualization. It works only 30 minutes as a demo mode.

If you click [SM3_Basic] in the Visualization page, the templates for all FBs in SM3_Basic library appear. Drag VISU_MC_Power or VISU_NEW_MC_Power to the Visualization page.

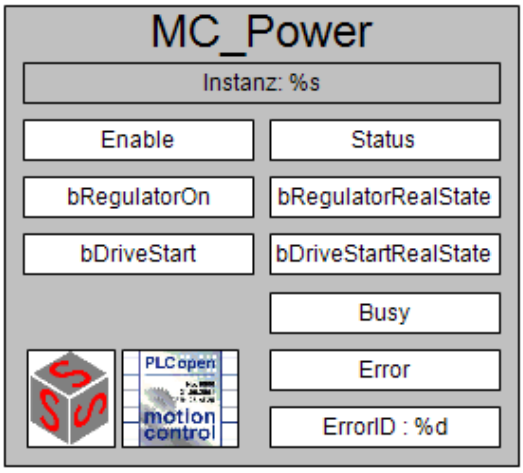


Then [Assign parameters] dialog appears. Click [OK] to proceed.

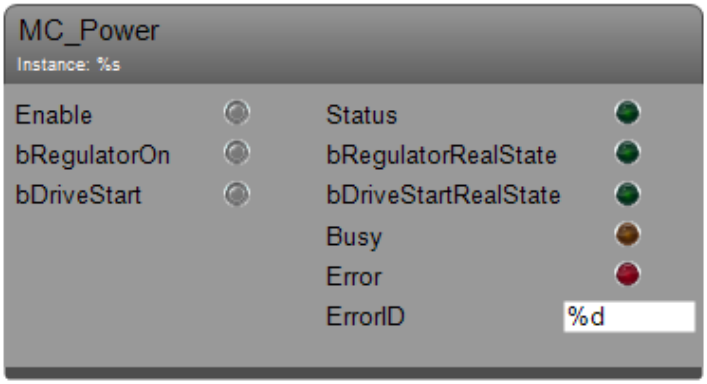


The template VISU_MC_xxx and VISU_NEW_MC_xxx are completely same except for external design.

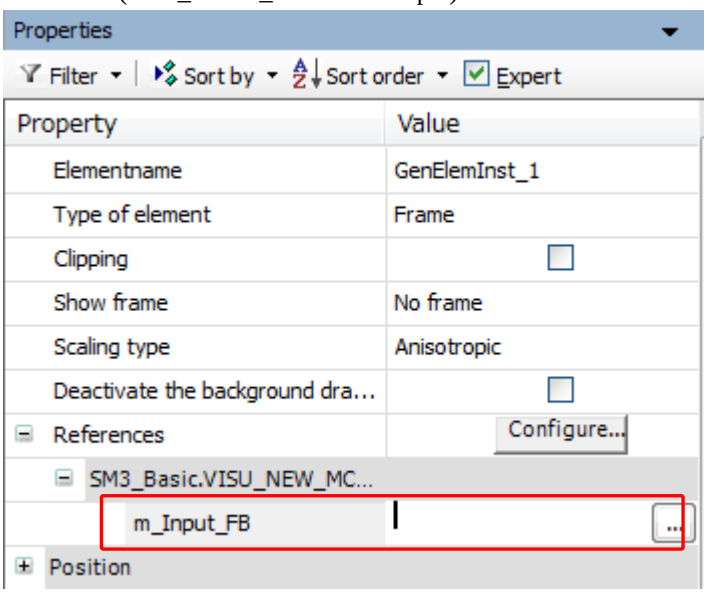
VISU_MC_Power

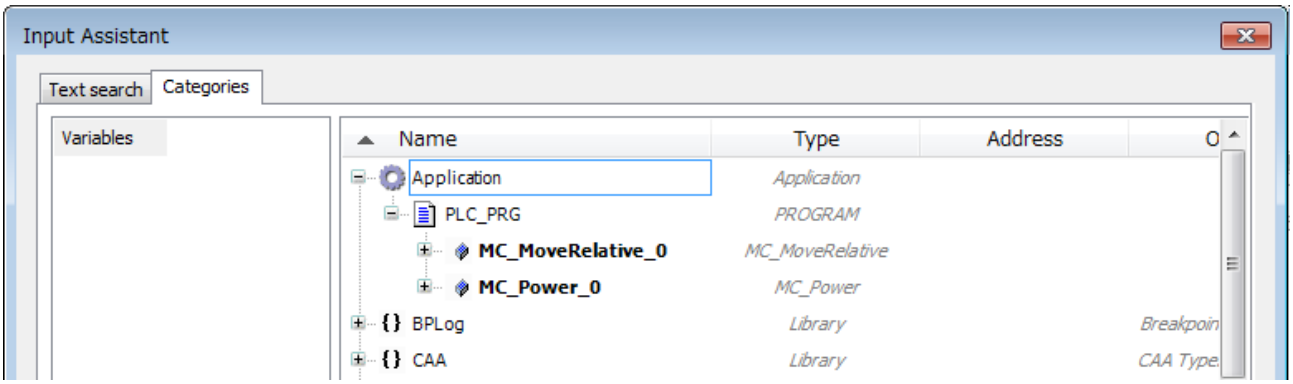


VISU_NEW_MC_Power



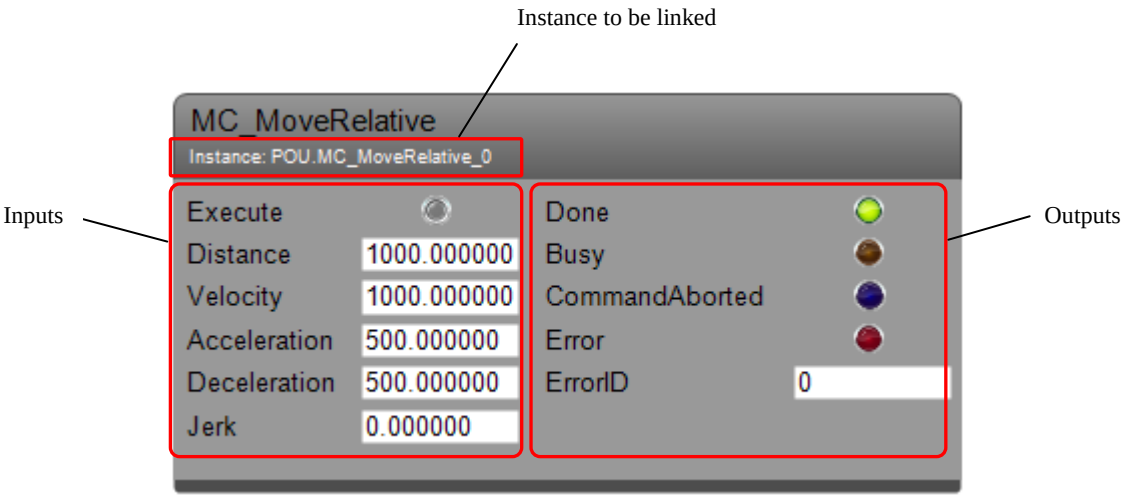
Click the template and click [...] button at [m_Input_FB] under [References] and choose the right instance to be connected ('MC_Power_0' in this sample).

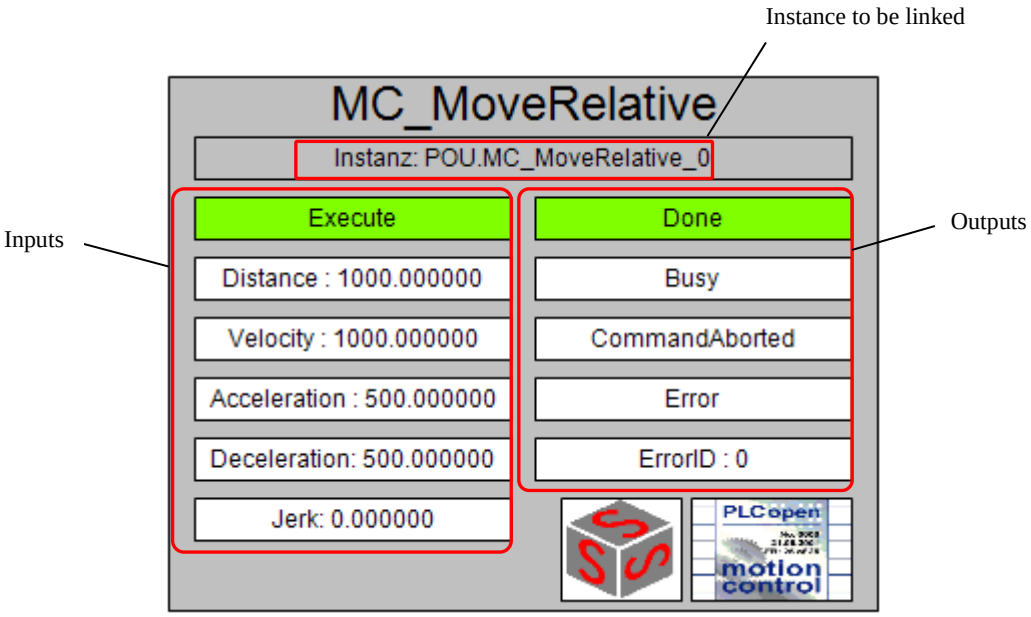




Set up a template for MC_MoveRelative too.

After login and starting PLC, inputs and outputs of function blocks can be accessed with Visualization. The left hand side is input. Boolean inputs can be set or reset like a button and numerical data can be entered in the input field. The right hand side is output. The status of Boolean outputs can be seen as lamps. The numerical data can be seen in the output field.





MEMO

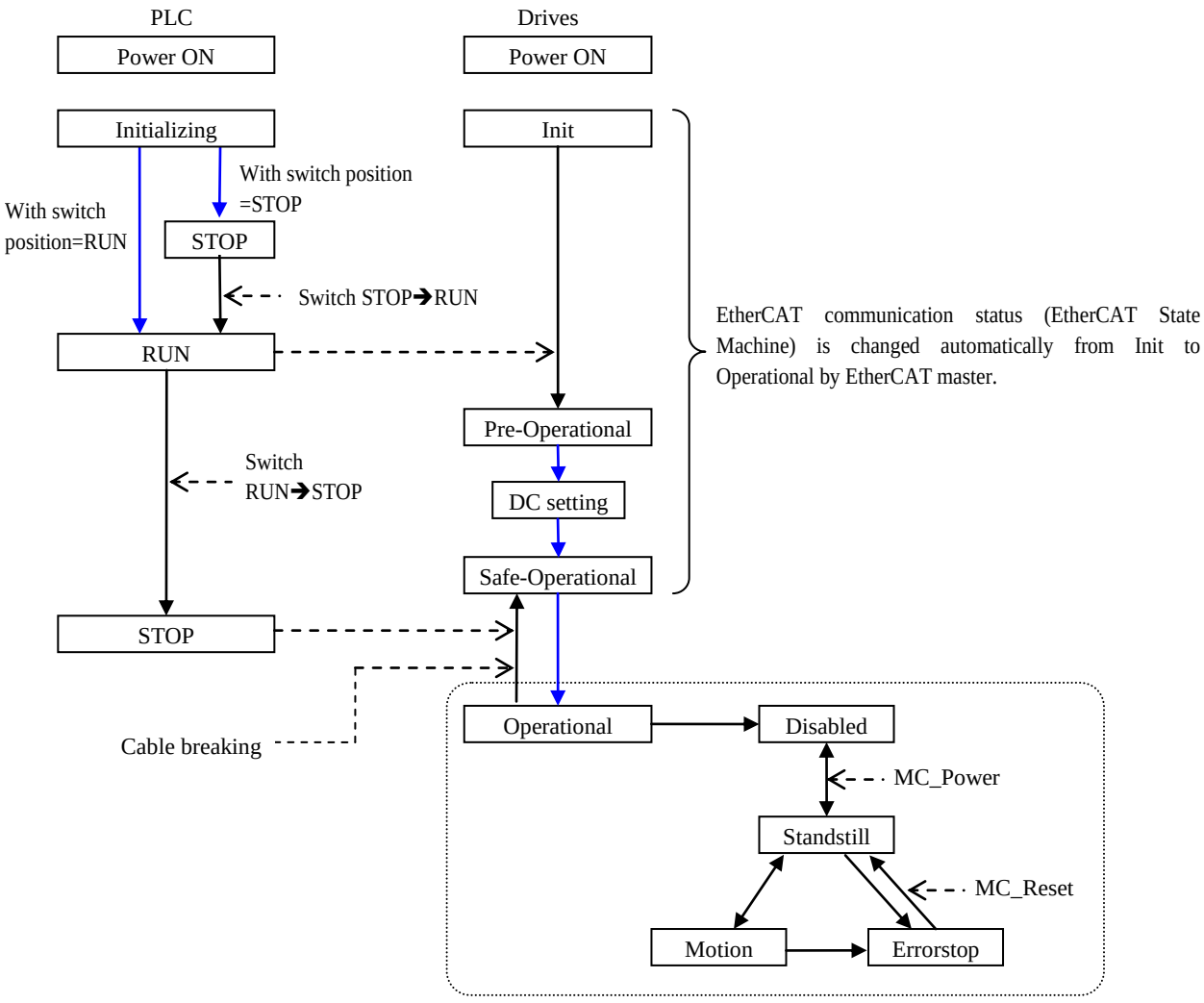
Chapter 11 Trouble Shooting

11.1 Power-up Sequence

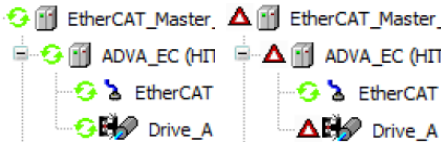
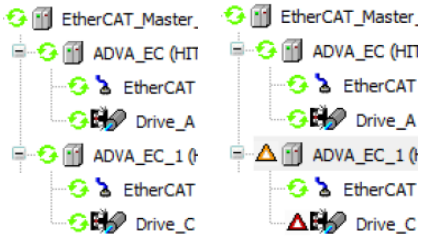
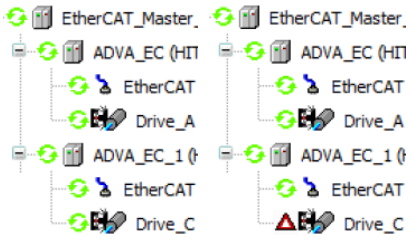
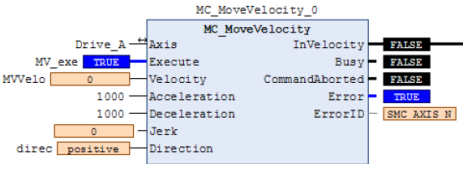
Power-up sequence is shown in the figure below. If your system does not work as expected, possible cause can be located in different area widely. Refer to the hints below or section 11.2 Trouble Shooting to solve.

Possible causes:

- In application program (e.g. Wrong usage of function block)
- In drives (e.g. stopped at Safe-Operational status)
- In network (e.g. DC synchronization is lost)
- In EtherCAT master (e.g. stopped with error)
- In CPU (e.g. stopped with overload error)



11.2 Trouble Shooting

	Check point	How to check	Action
1	Error indication of CPU module	Check error LED and 7-segment LED. Login with HX-CODESYS and check CPU log.	Refer to HX application manual (Hardware).
2	Error indication of drives	Check error LED or error code. Connect dedicated tool and check diagnostic information.	Refer to drive's instruction manual.
3	Status of EtherCAT Master	Login with HX-CODESYS and check the EtherCAT master device. [No error] [Error] 	Restart the EtherCAT master. [Refer to Action-1]
4	Status of drives	(1) Login with HX-CODESYS and check drives' status icon. [No error] [Error]  (2) Login with HX-CODESYS and check slaves' status [Refer to Action-2]	Check the drive's status and make the status be 'Operational'. [Refer to Action-3]
5	Status of axis	(1) Login with HX-CODESYS and check axes' status icon. [No error] [Error]  (2) Login with HX-CODESYS and check axes' status. [Refer to Action-4]	Execute MC_Reset or SMC3_ReinitDrive [Refer to Action-5]
6	Status of function blocks	Check the status of 'Error' output for all function blocks. 	Check input values. (The left figure shows error output because velocity is 0. This can be fixed by setting a value other than 0.)

<< Conditions to reproduce the error status No. 3 to 5 >>

No.3 Error in the EtherCAT master

- The power of the first slave (connected to master) is temporary down.
- Wire breaking between the master and the first slave.

No.4 Error in the drives

- The power of the 2nd or backward slave is temporary down.
- Wire breaking between slaves.

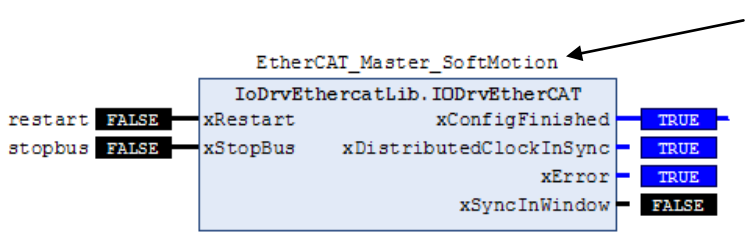
No.5 Error in the axes

- Axis became errorstop mode while 'Operational' mode.

Action-1: Restart the EtherCAT master

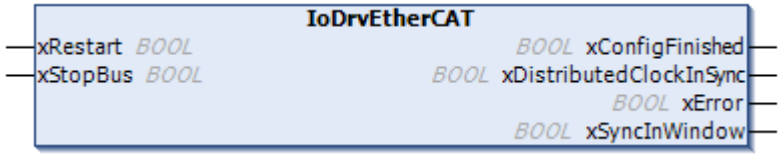
(a) Status checking and restarting the EtherCAT master by function block

Add the function block IoDrvEtherCAT to your program in advance. This FB returns the status and restarts the EtherCAT master.



Use the same instance as EtherCAT master device. Since this FB is implicitly declared when a master device is added, do not declare again in POU. If declaration is duplicated, CPU may stop with error.

Name	Description	Type
IoDrvEtherCAT	This FB returns the status of EtherCAT network and commands to restart or stop bus.	FB



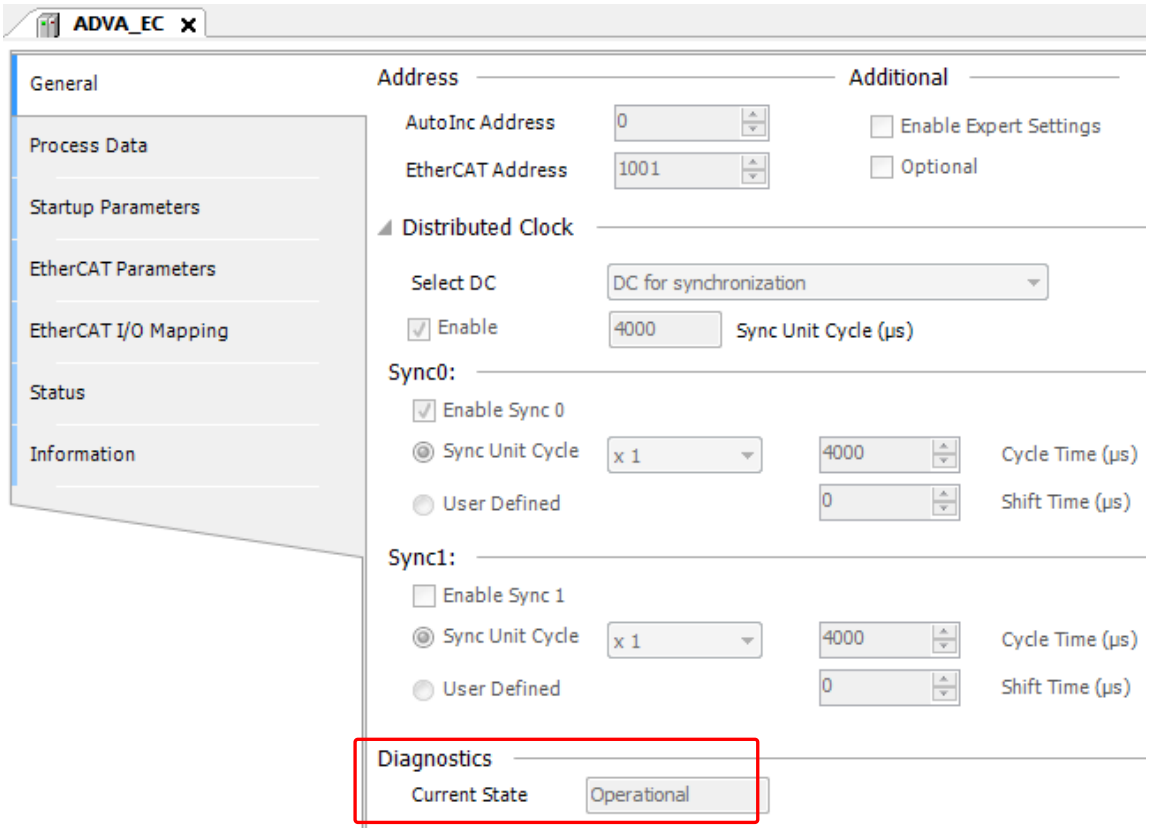
Name		Type	Description
IN	xRestart	BOOL	Rising edge: The master is restarted and all configuration parameters are reloaded.
	xStopBus	BOOL	TRUE: Communication is stopped. No more EtherCAT telegrams are sent. On most devices, a restart is necessary after this because they are switched to error status.
OUT	xConfigFinished	BOOL	TRUE: Transfer of all configuration parameters was completed with no errors. Communication is running on the bus.
	xDistributedClockInSync	BOOL	If distributed clocks are used, then the PLC is synchronized with the first EtherCAT slave with the DC option activated.
	xError	BOOL	TRUE: Error has occurred when starting the EtherCAT stack or communication with the slave is interrupted because no more messages can be received.
	xSyncInWindow	BOOL	The output is TRUE when the *Sync Window Monitoring* option is activated and the synchronization of all slaves is within the Sync Window.

(b) Reset operation

Instead of the FB IoDrvEtherCAT, EtherCAT master can be restarted by manual reset operation from HX-CODESYS. Be noted that CPU stops with this reset operation. The steps to reset are; Login with HX-CODESYS and choose [Online]-[Reset warm]. Then PLC is stopped and network is initialized. Start again manually afterward.

Action-2: Check slave's status

Double click a slave device in the device tree and check [Diagnostics] in [General] tab.



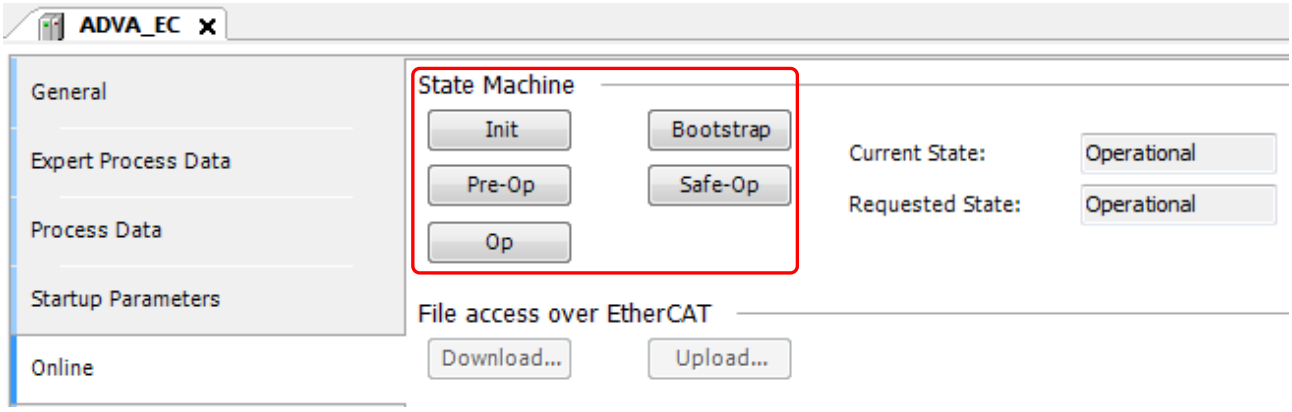
Just in case status is <Bad>, close the dialog and open again to update the status.

Action-3: Change the status to 'Operational'

(a) Manual operation

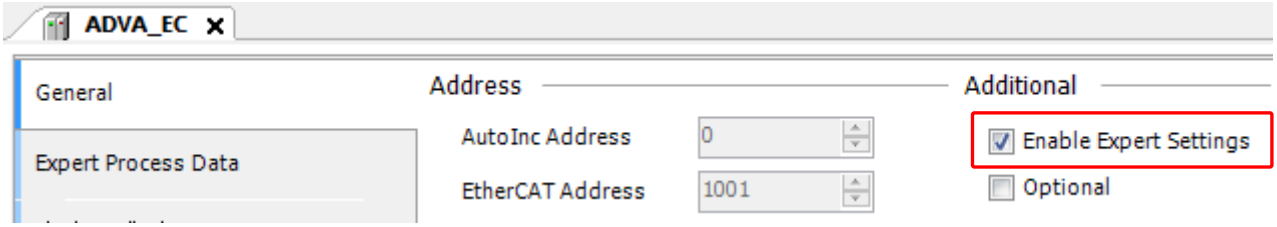
Login with HX-CODESYS, double click the slave device and click [Online] tab.

Change the status manually by the buttons in [State Machine]; [Init]➔[Pre-Op]➔[Safe-Op]➔[Op].



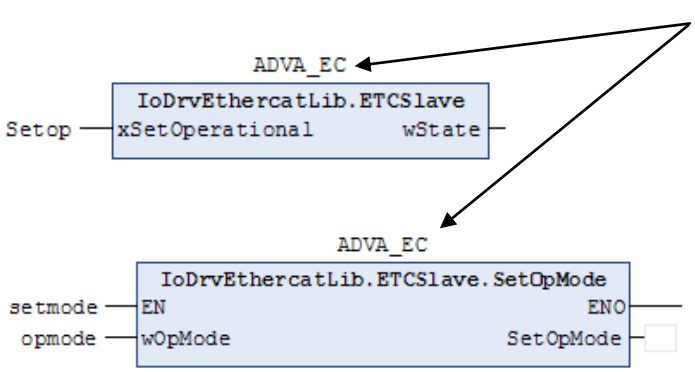
NOTE

Activate [Enable Expert Settings] in [General] tab to show [Online] tab.



(b) Change status by function block

Add the function block ETCSlave to your program in advance. This FB commands a setting operation mode.



Use the same instance as EtherCAT slave device. Since this FB is implicitly declared when a slave device is added, do not declare again in POU. If declaration is duplicated, CPU may stop with error.

Name	Description	Type
ETCSlave	This FB returns the current operation mode and commands a setting operation mode.	FB

Name		Type	Description
IN	xSetOperational	BOOL	Rising edge: An attempt is made to switch to the ETC_SLAVE_ OPERATIONAL mode.
OUT	wState	ETC_SLAVE_STATE	Current state of the slave

ETC_SLAVE_STATE (ENUM)

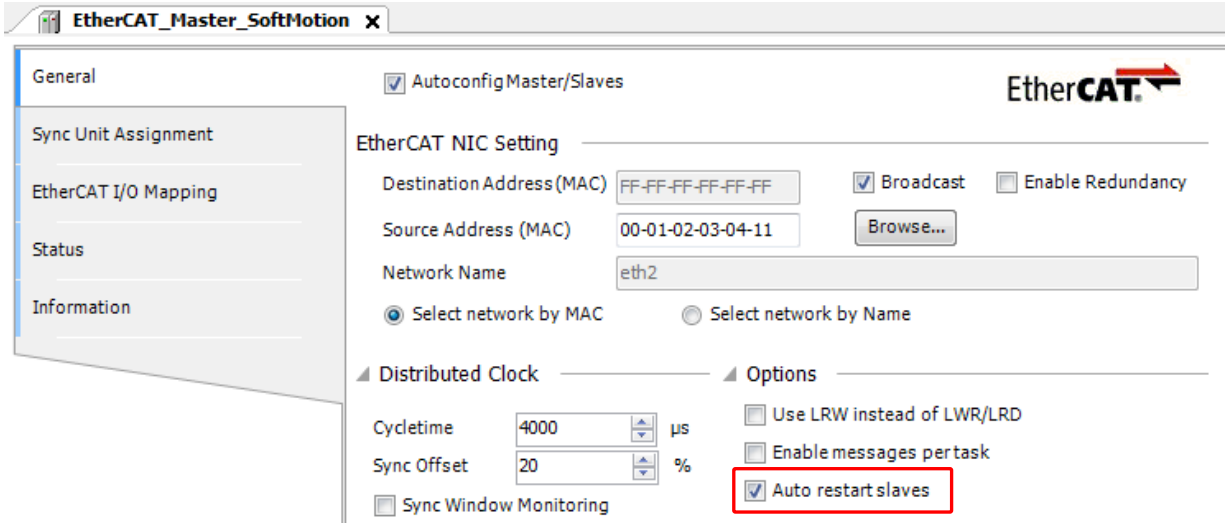
Name	Value	Description
ETC_SLAVE_BOOT	3	Bootstrap (for firmware downloading)
ETC_SLAVE_INIT	1	Init
ETC_SLAVE_PREOPERATIONAL	2	Pre-Operational
ETC_SLAVE_SAVEOPERATIONAL	4	Safe-Operational
ETC_SLAVE_OPERATIONAL	8	Operational

NOTE

xSetOperational input of ETCSlave is effective only when the current mode is ‘Safe-Operational’.
If the current mode is ‘Init’ or ‘Pre-Operational’, use ETCSlave.SetOpMode and set operation mode in the sequence Init➔Pre-Op➔Safe-Op➔Op. The data type of wOpMode is ETC_SLAVE_STATE or WORD.

Tip

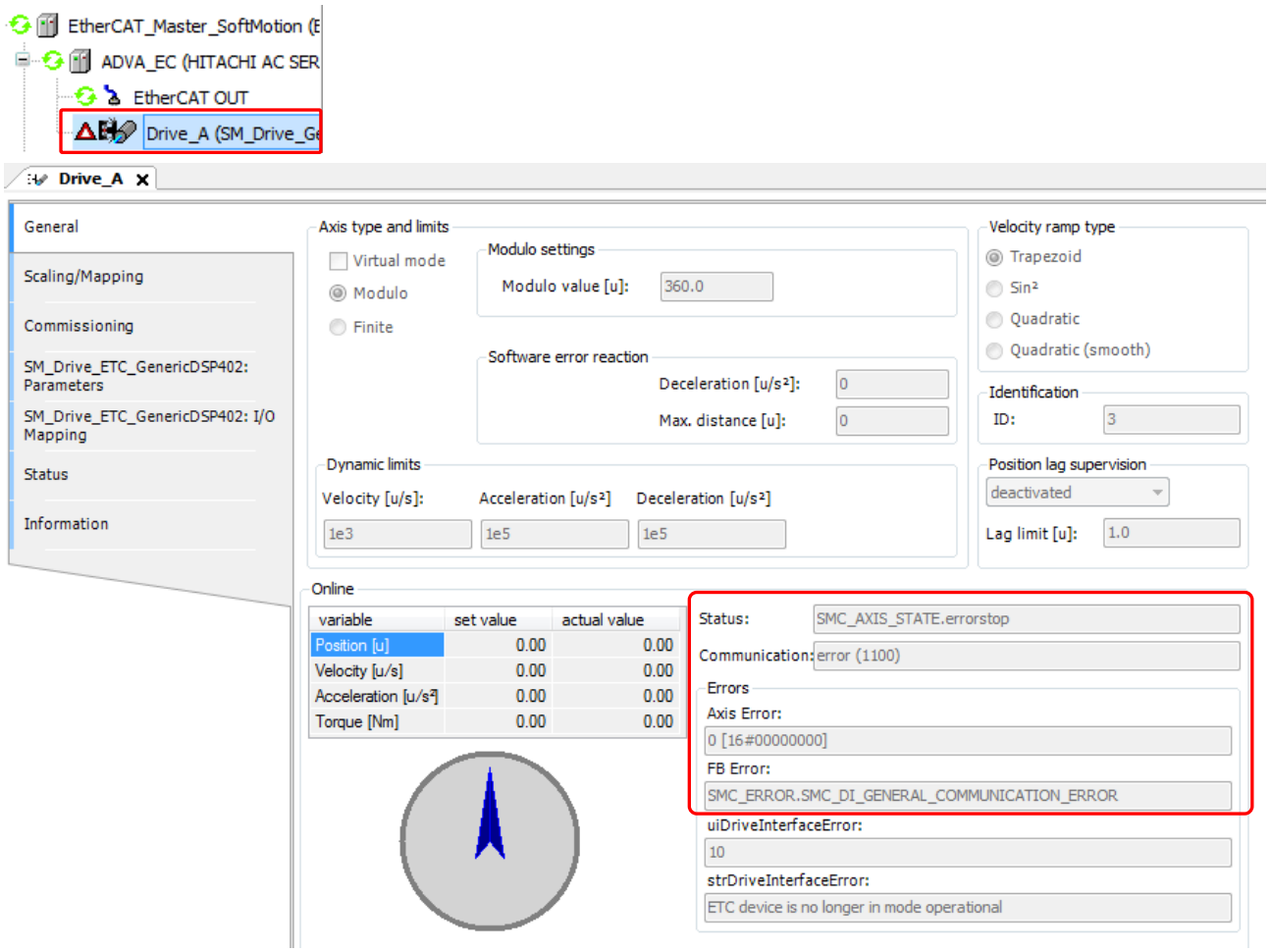
If [Auto restart slaves] in EtherCAT master device is enabled, communication status is changed from ‘Init’ to ‘Operational’ automatically after temporary cable disconnection.



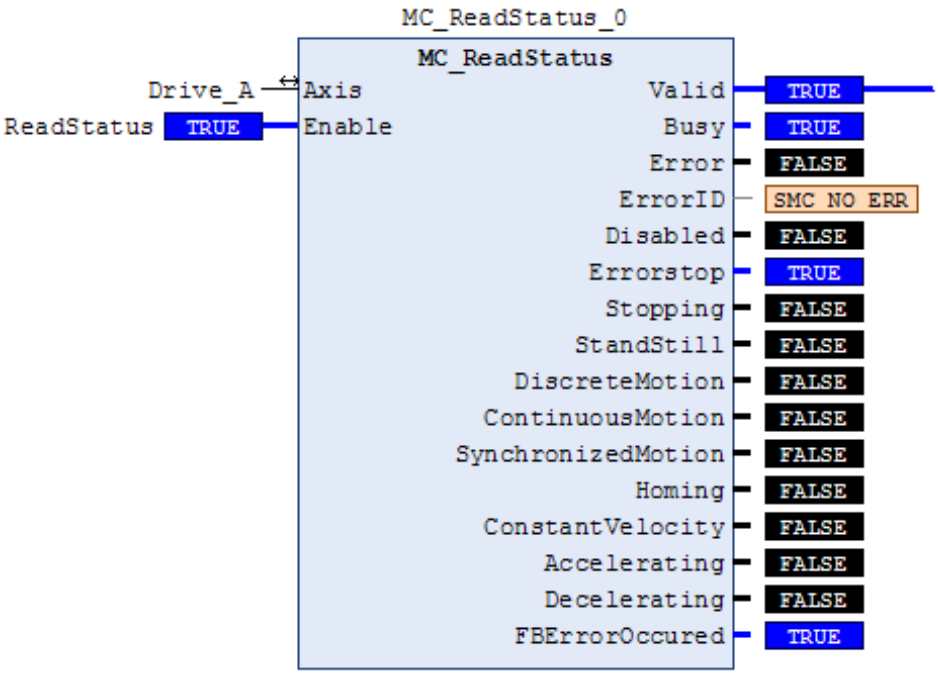
(c) Reset operation
Instead of the FB ETCSlave, communication status can be changed to ‘Operational’ by manual reset operation from HX-CODESYS. Be noted that CPU stops with this reset operation. The steps to reset are; Login with HX-CODESYS and choose [Online]-[Reset warm]. Then PLC is stopped and network is initialized. Start again manually afterward.

Action-4: Check the status of axis

Double click the axis in the device tree and check the status in [General] tab.

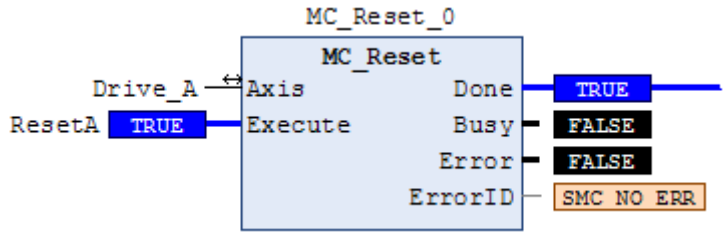


In addition, MC_ReadStatus returns the current axis status as follows.

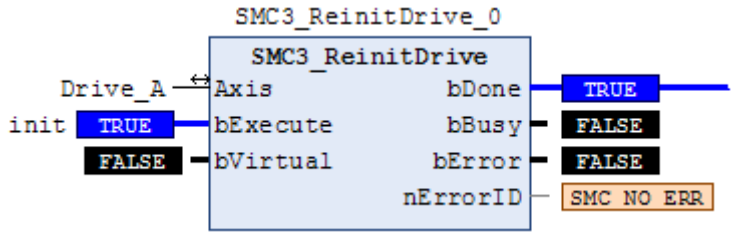


Action-5: Reset error

(a) MC_Reset



(b) If it's still 'Errorstop' status, execute SMC3_ReinitDrive to initialize the axis.



Appendix 1 Abbreviations

Abbreviations	Text
ACS	Axes Coordinate System
CiA	CAN in Automation
CoE	CANopen over EtherCAT
CNC	Computer Numerical Control
DC	Distributed Clock
ENI	EtherCAT Network Information
EoE	Ethernet over EtherCAT
ESI	EtherCAT Slave Information
ESM	EtherCAT State Machine
FB	Function Block
FMMU	Fieldbus Memory Management Unit
FoE	File access over EtherCAT
FTP	File Transfer Protocol
GVL	Global Variable List
MCS	Machine Coordinate System
PCS	Product Coordinate System Progrma Coordinate System
PDO	Process Data Object
POU	Program Organization Unit
SDO	Service Data Object
SoE	Servo drive over EtherCAT
TCP	Tool Center Point

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Appendix 2 List of Motion Commands

SM3_Basic 4.2.1.0

1			SM3_Basic_GetVersion (FUN)
2	DataTypes		
3		DriveBasic	
4			CAM Types	MC_CAM_REF (FB)
5	DriveInterface		
6		AXIS_REF	AXIS_REF_SM3 (FB)
7			SMC3_CommunicateDriveParameter (FB)
8			SMC3_ReadDriveParameter (FB)
9			SMC3_ReadParameter (FB)
10			SMC3_ReinitDrive (FB)
11			SMC3_WriteDriveParameter (FB)
12			SMC3_WriteParameter (FB)
13		AXIS_REF_LOGICAL	AXIS_REF_LOGICAL_SM3 (FB)
14		AXIS_REF_MAPPING	AXIS_REF_MAPPING_SM3 (FB)
15		AXIS_REF_VIRTUAL	AXIS_REF_VIRTUAL_SM3 (FB)
16		ENCODER_REF	ENCODER_REF_SM3 (FB)
17		FB_Templates	FB_Template_Edge (FB)
18			FB_Template_EdgeAbort (FB)
19			FB_Template_EdgeAbortTimeout (FB)
20		FREE_ENCODER_REF	FREE_ENCODER_REF (FB)
21		Performance	SMC_PerfStat (FB)
22			SMC_PerfTimerSum (FUN)
23			SMC_SeriesStat (FB)
24	POUs		
25		Commissioning	SMC_Commissioning (FB)
26		DriveBasic	
27			Brake Control	SMC3_BrakeControl (FB)
28				SMC3_BrakeStatus (FB)
29			Config	SMC3_PersistPosition (FB)
30				SMC3_PersistPositionLogical (FB)
31				SMC3_PersistPositionSingleturn (FB)
32				SMC_ChangeDynamicLimits (FB)
33				SMC_SetControllerMode (FB)
34				SMC_SetCustomRampType (FB)
35				SMC_SetMovementType (FB)
36				SMC_SetRampType (FB)
37				SMC_SetSoftwareLimits (FB)
38			Diagnostic	SMC_CheckAxisCommunication (FB)
39				SMC_GetMaxSetAccDec (FB)
40				SMC_GetMaxSetVelocity (FB)
41				SMC_GetTrackingError (FB)
42				SMC_InPosition (FB)
43				SMC_MeasureDistance (FB)
44			Direct Axis Control	SMC_CheckLimits (FB)
45				SMC_FollowPosition (FB)
46				SMC_FollowPositionVelocity (FB)
47				SMC_FollowSetValues (FB)
48				SMC_FollowVelocity (FB)
49			Error Handling	SMC_ClearFBError (FUN)
50				SMC_ReadFBError (FB)
51			Homing	SMC_Homing (FB)
52			Scale Manipulation	SMC_ChangeGearingRatio (FB)
53			Standard	
54				String Functions	SMC_CONCAT (FUN)
55			Virtual Axis	SMC_VIRTUAL_AXIS (FB)

56		File	
57		CAM FBs	SMC_ReadCAM (FB)
58			SMC_WriteCAM (FB)
59		Diagnostic	SMC_AxisDiagnosticLog (FB)
60		Managers	SMC_CAM_ObjectManager (FB)
61		PLCopen	
62		Additional	
63		CAM	SMC_CAMBounds (FB)
64			SMC_CAMBounds_Pos (FB)
65			SMC_CamEditor (FB)
66			SMC_CamRegister (FB)
67			SMC_GetCamSlaveSetPosition (FB)
68			SMC_GetTappetValue (FB)
69			SMC_BacklashCompensation (FB)
70			SMC_ReadSetPosition (FB)
71			SMC_SetTorque (FB)
72		Master/Slave Function Blocks	MC_CamIn (FB)
73			MC_CamOut (FB)
74			MC_CamTableSelect (FB)
75			MC_GearIn (FB)
76			MC_GearInPos (FB)
77			MC_GearOut (FB)
78			MC_Phasing (FB)
79		Single Axis Function Blocks	
80		Part I	MC_AccelerationProfile (FB)
81			MC_Halt (FB)
82			MC_Home (FB)
83			MC_MoveAbsolute (FB)
84			MC_MoveAdditive (FB)
85			MC_MoveRelative (FB)
86			MC_MoveSuperImposed (FB)
87			MC_MoveVelocity (FB)
88			MC_PositionProfile (FB)
89			MC_Power (FB)
90			MC_ReadActualPosition (FB)
91			MC_ReadAxisError (FB)
92			MC_ReadBoolParameter (FB)
93			MC_ReadParameter (FB)
94			MC_ReadStatus (FB)
95			MC_Reset (FB)
96			MC_Stop (FB)
97			MC_VelocityProfile (FB)
98			MC_WriteBoolParameter (FB)
99			MC_WriteParameter (FB)
100		Part II	MC_AbortTrigger (FB)
101			MC_DigitalCamSwitch (FB)
102			MC_ReadActualTorque (FB)
103			MC_ReadActualVelocity (FB)
104			MC_SetPosition (FB)
105			MC_TouchProbe (FB)
106			SMC_MoveContinuousAbsolute (FB)
107			SMC_MoveContinuousRelative (FB)
108		Part III	MC_Jog (FB)
109			SMC_Inch (FB)
110		SimpleTest	SMC_StartupDrive (FB)
111	Project Information		GetBooleanProperty (FUN)
112			GetCompany (FUN)
113			GetNumberProperty (FUN)
114			GetTextProperty (FUN)
115			GetTextProperty2 (FUN)
116			GetTitle (FUN)
117			GetVersion (FUN)
118			GetVersionProperty (FUN)

SM3_CNC 4.2.1.3

1			SM3_CNC_GetVersion (FUN)
2	Projektinformationen		GetBooleanProperty (FUN)
3			GetCompany (FUN)
4			GetNumberProperty (FUN)
5			GetTextProperty (FUN)
6			GetTextProperty2 (FUN)
7			GetTitle (FUN)
8			GetVersion (FUN)
9			GetVersionProperty (FUN)
10	SM_CNC_Data types		
11		SoftMotion CNC	SMC_CNC_REF (FB)
12			SMC_OUTQUEUE (FB)
13	SM_CNC_POUs		
14		File	
15			Help functions	SMC_StringBuffer (FB)
16			ReadNCFile	
17				Stream	SMC_FileStream (FB)
18					SMC_StringStream (FB)
19				Token	SMC_NCTokenizer (FB)
20					SMC_ReadNCTokens (FB)
21					SMC_Token (FB)
22					SMC_TokenQueue (FB)
23					SMC_ReadNCFile (FB)
24					SMC_ReadNCQueue (FB)
25		SoftMotion CNC		
26			Coordinate Transformations	SMC_CoordinateTransformation3D (FB)
27				SMC_DetermineCuboidBearing (FB)
28				SMC_InvCoordinateTransformation3D (FB)
29				SMC_TeachCoordinateSystem (FB)
30				SMC_UnitVectorToRPY (FB)
31			Direct Axis Control	SMC_ControlAxisByPos (FB)
32				SMC_ControlAxisByPosVel (FB)
33				SMC_ControlAxisByVel (FB)
34			GCode Viewer	SMC_GCodeViewer (FB)
35			GeoInfo Help Functions	SMC_AdaptHelpMarks (FUN)
36				SMC_CalcEndPnt (FUN)
37				SMC_CalcLengthGeo (FUN)
38				SMC_CalcStartPnt (FUN)
39				SMC_CutEnd (FUN)
40				SMC_CutStart (FUN)
41				SMC_GeoinfoInit (FUN)
42				SMC_GetAccVec (FUN)
43				SMC_GetAddAxValue (FUN)
44				SMC_GetClosestPnt (FUN)
45				SMC_GetLengthOfPrefix (FUN)
46				SMC_GetPnt (FUN)
47				SMC_GetPntPI (FUN)
48				SMC_GetTanVec (FUN)
49				SMC_GetTanVec3D (FUN)
50				SMC_InvertDirection (FUN)
51				SMC_RampInCorr (FUN)
52				SMC_RampOutCorr (FUN)
53				SMC_RecalculateHelpMarks (FUN)
54				SMC_SingleCorr (FUN)

55			OutQueue Functions	SMC_AppendObj (FUN)
56				SMC_DeleteObj (FUN)
57				SMC_GetCount (FUN)
58				SMC_GetHistoryCount (FUN)
59				SMC_GetLastObj (FUN)
60				SMC_GetObj (FUN)
61				SMC_GetObjFromEnd (FUN)
62				SMC_GetObjFromHistory (FUN)
63				SMC_OutQueueInit (FUN)
64				SMC_OutQueueIsSyncing (FUN)
65				SMC_OutQueueRestoreHistory (FUN)
66				SMC_RestoreQueue (FUN)
67				SMC_SetObj (FUN)
68				SMC_SetQueueCapacity (FUN)
69			Queue manipulatoin	SMC_QueueSetReservedEntries (FB)
70				SMC_RotateQueue2D (FB)
71				SMC_ScaleQueue3D (FB)
72				SMC_TranslateQueue3D (FB)
73			SoftMotion Function Blocks	
74			BlockSearch	SMC_BlockSearch (FB)
75				SMC_BlockSearchSavePos (FB)
76			M_Functions	SMC_GetMParameters (FB)
77				SMC_PreAcknowledgeMFunction (FB)
78			NCDecoder_Help_Functions	SMC_GetGWORD (FB)
79				SMC_AvoidLoop (FB)
80				SMC_CheckForLimits (FB)
81				SMC_CheckVelocities (FB)
82				SMC_ExtendedVelocityChecks (FB)
83				SMC_Interpolator (FB)
84				SMC_Interpolator2Dir (FB)
85				SMC_Interpolator2Dir_SlowTask (FB)
86				SMC_LimitCircularVelocity (FB)
87				SMC_LimitDynamics (FB)
88				SMC_NCDecoder (FB)
89				SMC_ObjectSplitter (FB)
90				SMC_RecomputeABCSlopes (FB)
91				SMC_ReduceVelEndAtCorner (FB)
92				SMC_RoundPath (FB)
93				SMC_SegmentAnalyzer (FB)
94				SMC_SmoothAddAxes (FB)
95				SMC_SmoothBSpline (FB)
96				SMC_SmoothMerge (FB)
97				SMC_SmoothPath (FB)
98				SMC_ToolCorr (FB)
99				SMC_XInterpolator (FB)

100	SM_Trafo_POUs		
101		SoftMotion Transformations	
102			Additional FBs	SMC_CalcDirectionFromVector (FB)
103			Gantry systems	SMC_TRAFOF_5Axes (FB)
104				SMC_TRAFOF_Gantry2 (FB)
105				SMC_TRAFOF_Gantry2Tool1 (FB)
106				SMC_TRAFOF_Gantry2Tool2 (FB)
107				SMC_TRAFOF_Gantry3 (FB)
108				SMC_TRAFOF_Gantry3D (FB)
109				SMC_TRAFOF_GantryCutter2 (FB)
110				SMC_TRAFOF_GantryCutter3 (FB)
111				SMC_TRAFOF_GantryH2 (FB)
112				SMC_TRAFOF_GantryT2 (FB)
113				SMC_TRAFOF_GantryT2_O (FB)
114				SMC_TRAFOV_Gantry2 (FB)
115				SMC_TRAFOV_Gantry3 (FB)
116				SMC_TRAFOV_GantryCutter2 (FB)
117				SMC_TRAFOV_GantryCutter3 (FB)
118				SMC_TRAFOV_GantryH2 (FB)
119				SMC_TRAFOV_GantryT2 (FB)
120				SMC_TRAFOV_GantryT2_O (FB)
121				SMC_TRAFO_5Axes (FB)
122				SMC_TRAFO_Gantry2 (FB)
123				SMC_TRAFO_Gantry2Tool1 (FB)
124				SMC_TRAFO_Gantry2Tool2 (FB)
125				SMC_TRAFO_Gantry3 (FB)
126				SMC_TRAFO_GantryCutter2 (FB)
127				SMC_TRAFO_GantryCutter3 (FB)
128				SMC_TRAFO_GantryH2 (FB)
129				SMC_TRAFO_GantryT2 (FB)
130				SMC_TRAFO_GantryT2_O (FB)
131			Parallel Systems	
132				Bipod_Arm	SMC_TRAFOF_Bipod_Arm (FB)
133					SMC_TRAFO_Bipod_Arm (FB)
134				Tripod	SMC_TRAFOF_Tripod (FB)
135					SMC_TRAFO_Tripod (FB)
136				Tripod_Arm	SMC_TRAFOF_Tripod_Arm (FB)
137					SMC_TRAFO_Tripod_Arm (FB)
138				Tripod_Lin	SMC_TrafoF_Tripod_Lin (FB)
139					SMC_Trafo_Tripod_Lin (FB)
140			Robot Kinematiks	SMC_TrafoF_4AxisPalletizer (FB)
141				SMC_TrafoF_ArticulatedRobot_6DOF (FB)
142				SMC_Trafo_4AxisPalletizer (FB)
143				SMC_Trafo_ArticulatedRobot_6DOF (FB)
144			Scara System	SMC_TRAFOF_Polar (FB)
145				SMC_TRAFOF_Scara2 (FB)
146				SMC_TRAFOF_Scara3 (FB)
147				SMC_TRAFO_Polar (FB)
148				SMC_TRAFO_Scara2 (FB)
149				SMC_TRAFO_Scara3 (FB)

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1	SM3Robotics		
2		Administrative	MC_AddAxisToGroup (FB)
3			MC_GroupContinue (FB)
4			MC_GroupDisable (FB)
5			MC_GroupEnable (FB)
6			MC_GroupInterrupt (FB)
7			MC_GroupReadActualAcceleration (FB)
8			MC_GroupReadActualPosition (FB)
9			MC_GroupReadActualVelocity (FB)
10			MC_GroupReadConfiguration (FB)
11			MC_GroupReadError (FB)
12			MC_GroupReadStatus (FB)
13			MC_GroupReset (FB)
14			MC_GroupSetOverride (FB)
15			MC_GroupSetPosition (FB)
16			MC_ReadCoordinateTransform (FB)
17			MC_ReadKinTransform (FB)
18			MC_RemoveAxisFromGroup (FB)
19			MC_SetCoordinateTransform (FB)
20			MC_SetDynCoordTransform (FB)
21			MC_SetKinTransform (FB)
22			MC_TrackConveyorBelt (FB)
23			MC_TrackRotaryTable (FB)
24			MC_UngroupAllAxes (FB)
25			SMC_GroupConvertPosition (FB)
26			SMC_GroupGetContinuePosition (FB)
27			SMC_GroupPower (FB)
28			SMC_GroupReadSetAcceleration (FB)
29			SMC_GroupReadSetPosition (FB)
30			SMC_GroupReadSetVelocity (FB)
31			SMC_GroupSetAncillaryAxisLimits (FB)
32			SMC_GroupSetAncillaryPathLimits (FB)
33			SMC_GroupTargetPosition (FB)
34			SMC_GroupUpdate (FB)
35			SMC_SetDynCoordTransformEx (FB)
36			SMC_SetDynamicLimitFactors (FB)
37			SMC_SetKinConfiguration (FB)
38			SMC_SetMovementQueueBuffer (FB)
39			SMC_TuneCPKernel (FB)
40		Axis_Group	
41		Helpers	SMC_IsClosePos (FUN)
42		Movements	SMC_GetEffectiveAxisDynLimits (FUN)
43		Schedule	SMC_Schedule_Planning (FB)
44			AXIS_GROUP_REF_SM3 (FB)
45		Coordinated	MC_GroupHalt (FB)
46			MC_GroupStop (FB)
47			MC_MoveCircularAbsolute (FB)
48			MC_MoveCircularRelative (FB)
49			MC_MoveDirectAbsolute (FB)
50			MC_MoveDirectRelative (FB)
51			MC_MoveLinearAbsolute (FB)
52			MC_MoveLinearRelative (FB)
53			SMC_GroupJog (FB)