

PLCopen Part 4 Coordinated Motion

Class No. TRM010-MPiec-PLCopenPart4

Rev. 1.00

Date: March 15, 2016



Contents

- *Class Project*
 - *eLV.MPiec.02.PLCo4_ClsPrj*
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 - *eLV.MPiec.04.PLCo4_Blend*

This is the PDF training guide for this series of eLearning videos

Instructor Introduction

Matt Pelletier

Product Training Engineer

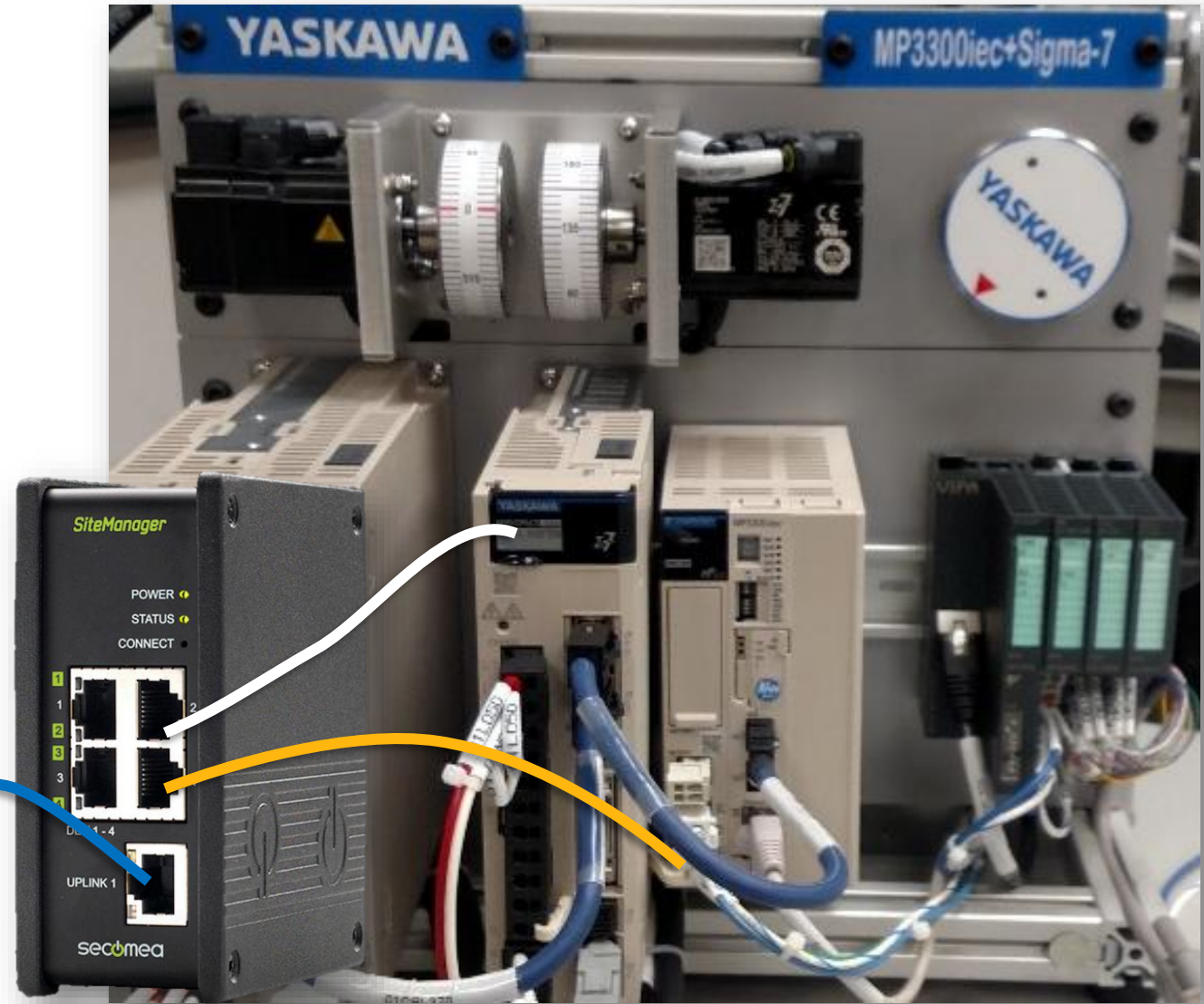
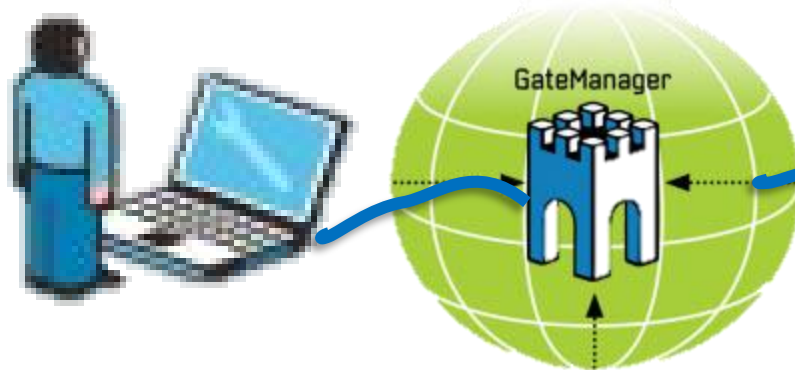
training@yaskawa.com

1-800-YASKAWA



Remote Demo System

- Request access by Email
 - Training@yaskawa.com
- Remote Connection Process
 - `eLV.MPIec.01.PLCoPen_RmtCnct`





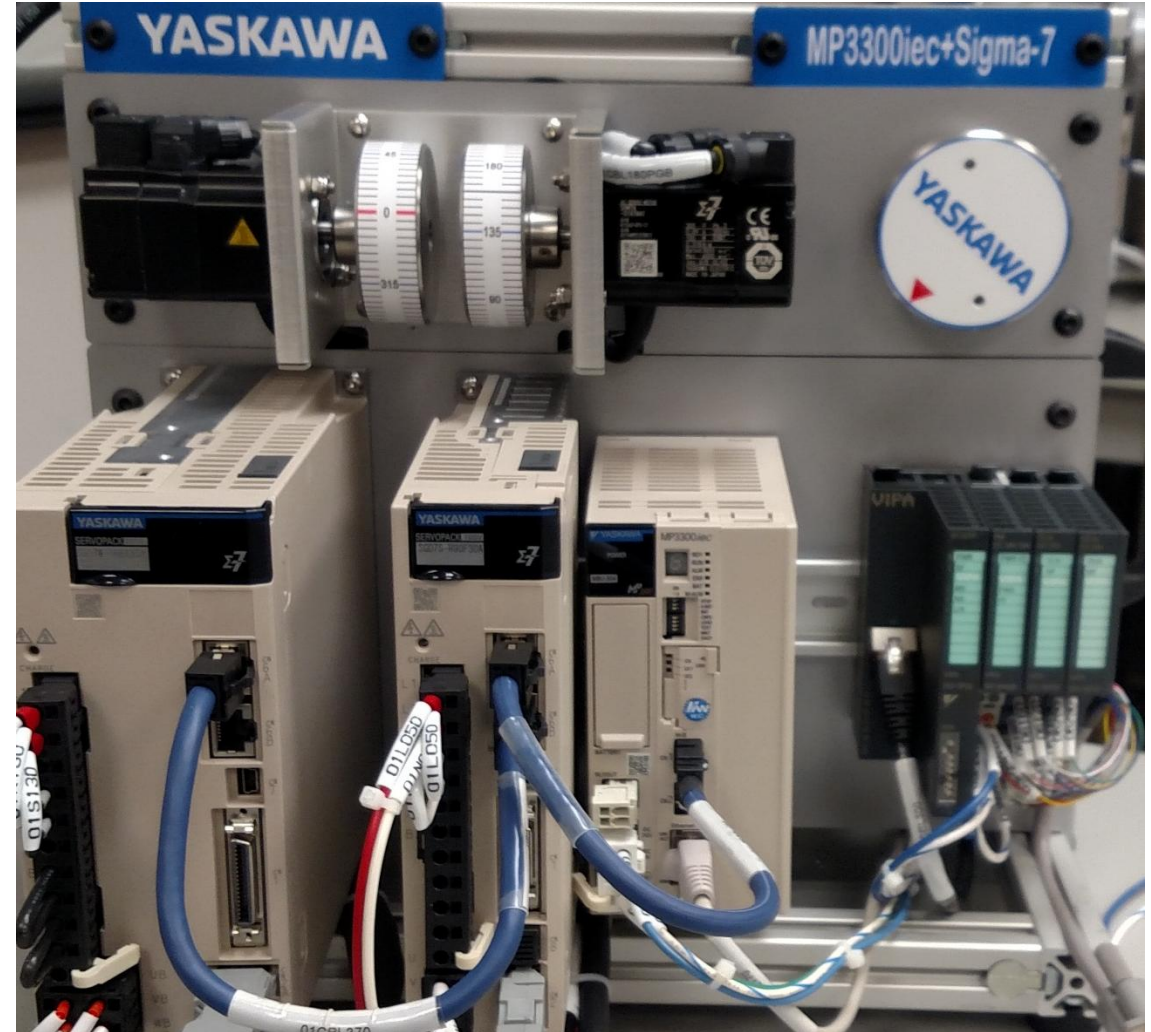
PLCopen Part 4: Coordinated Motion

Class Project

- *Open Project*
- *Overview Project*
- *Configuration Summary*
- *Save Configuration*
- *Verify Operation*

Purpose

- *“Class Project” not specifically related to PLCopen part 4*
- *Quickly get demo system operational*
- *Implement configuration and programming in subsequent videos*



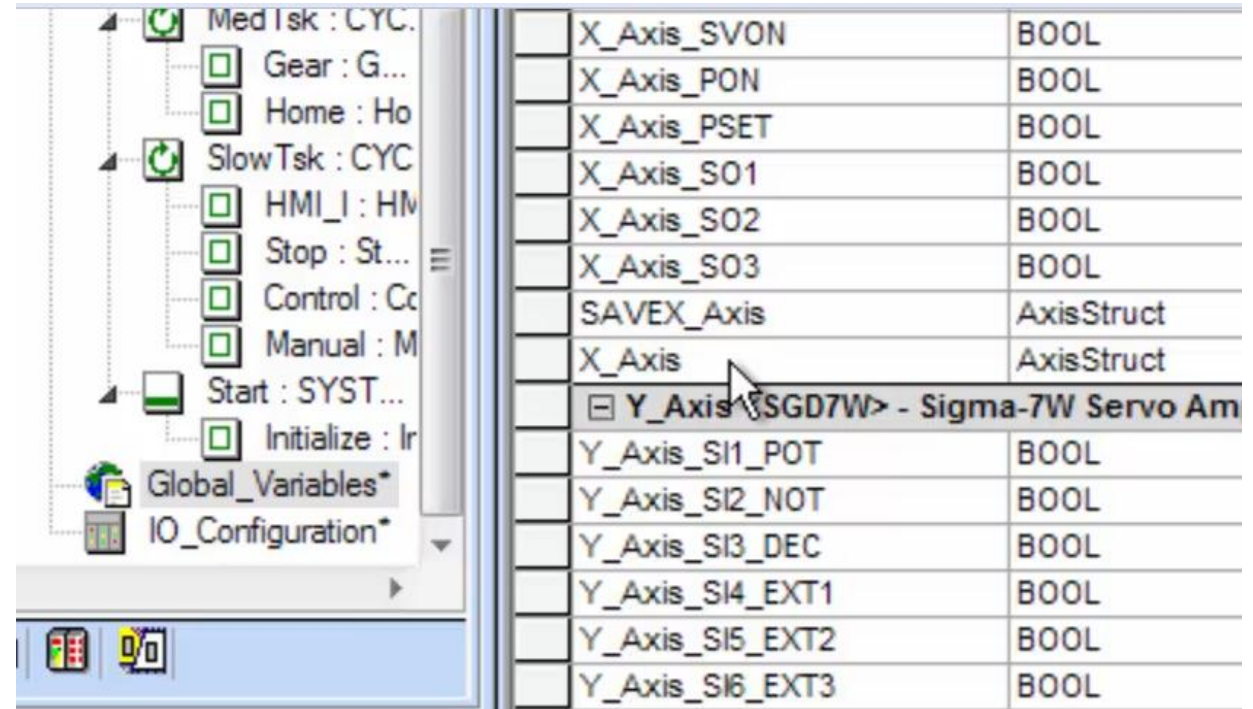
Requirements

- *MotionWorks IEC version 3.2 or higher*
- *Project “PLCo4Training”*
 - *Download from yaskawa.com*
- *Access to an MP3300iec Demo*



Tour The Project

- *Modified PLCopen Training Project*
- *Libraries*
 - *Latest toolbox 3xx versions*
- *Datatypes (none)*
- *Logical POUs from PLCopen Training*
 - *FastTsk, MedTsk, SlowTsk*
- *Global Variables*
 - *Axis_Ref changed to AxisStruct with multi-element*



X_Axis_SVON	BOOL
X_Axis_PON	BOOL
X_Axis_PSET	BOOL
X_Axis_S01	BOOL
X_Axis_S02	BOOL
X_Axis_S03	BOOL
SAVEX_Axis	AxisStruct
X_Axis	AxisStruct
Y_Axis<SGD7W> - Sigma-7W Servo Am	
Y_Axis_SI1_POT	BOOL
Y_Axis_SI2_NOT	BOOL
Y_Axis_SI3_DEC	BOOL
Y_Axis_SI4_EXT1	BOOL
Y_Axis_SI5_EXT2	BOOL
Y_Axis_SI6_EXT3	BOOL

Configuration Summary

■ Axes

- *X and Y axis of 2 dimensional gantry*
 - » *Gantry configuration in next video*
- *Z axis not used*
- *3 virtual axes*
- *Units: mm, 360/rev for easier visualization*
- *OT disable*
- *1-phase 200VAC power*

The screenshot shows the configuration interface for the X-axis. It includes input fields for Feed Constant (360), Gear Ratio (1), Position Scale (360), and Reference Units per User Unit (46603.3777777778). Below the configuration area is a table of parameters.

Parameter #	Parameters	Current Value
10	Moving Average Filter 1 Enable	False
11	Moving Average Filter 1 Time Constant	0.1
17	Load Type	Linear
19	Axis Name	X_Axis
21	Logical Axis Number	3

MP3300iec Demo

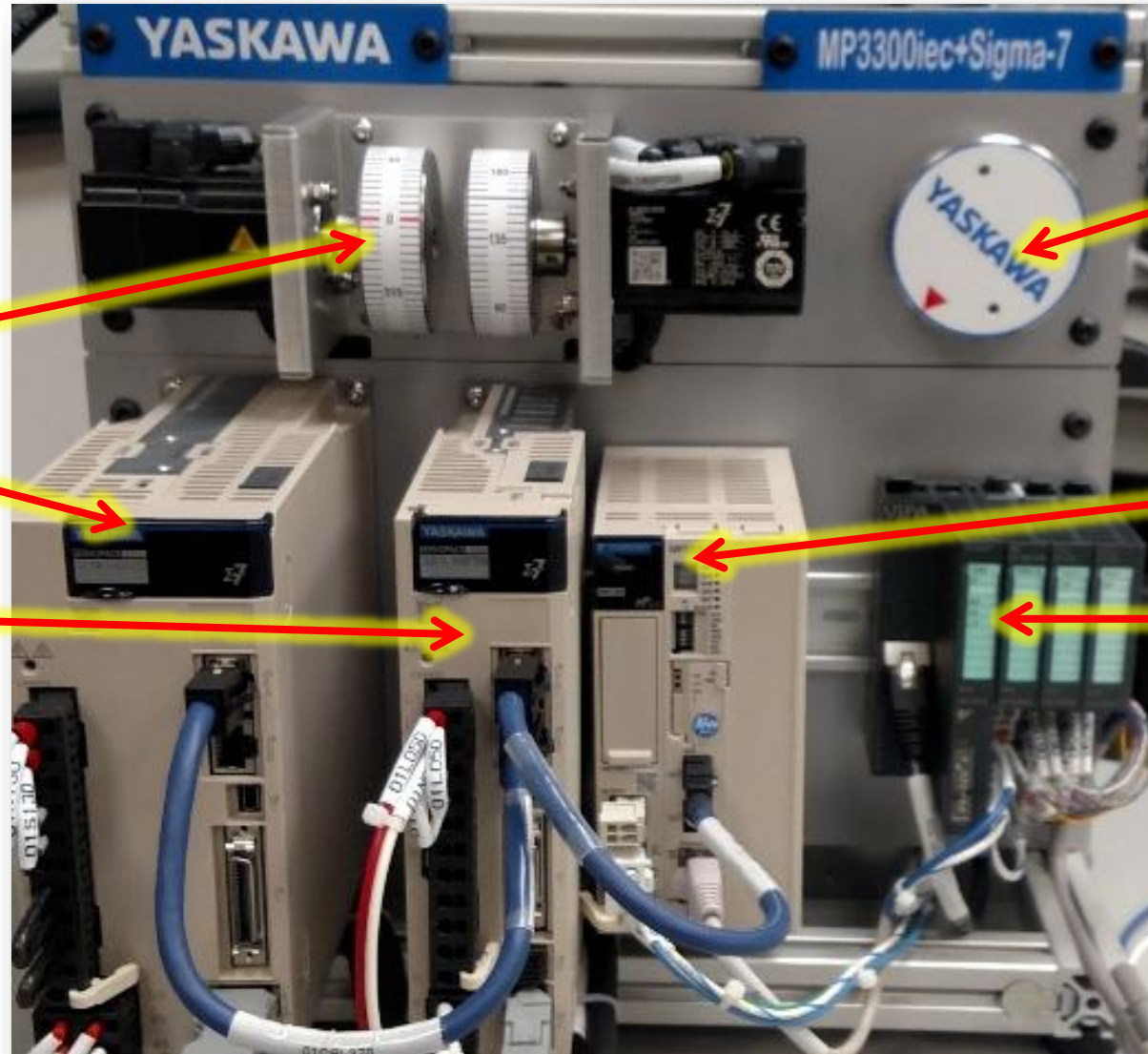
- *Sigma-7*
“W”

- *Axis X and Y*

- *Dual axis amplifier*

- *Sigma-7*

- *Single axis amplifier*



- *Sigma-7 Motor*

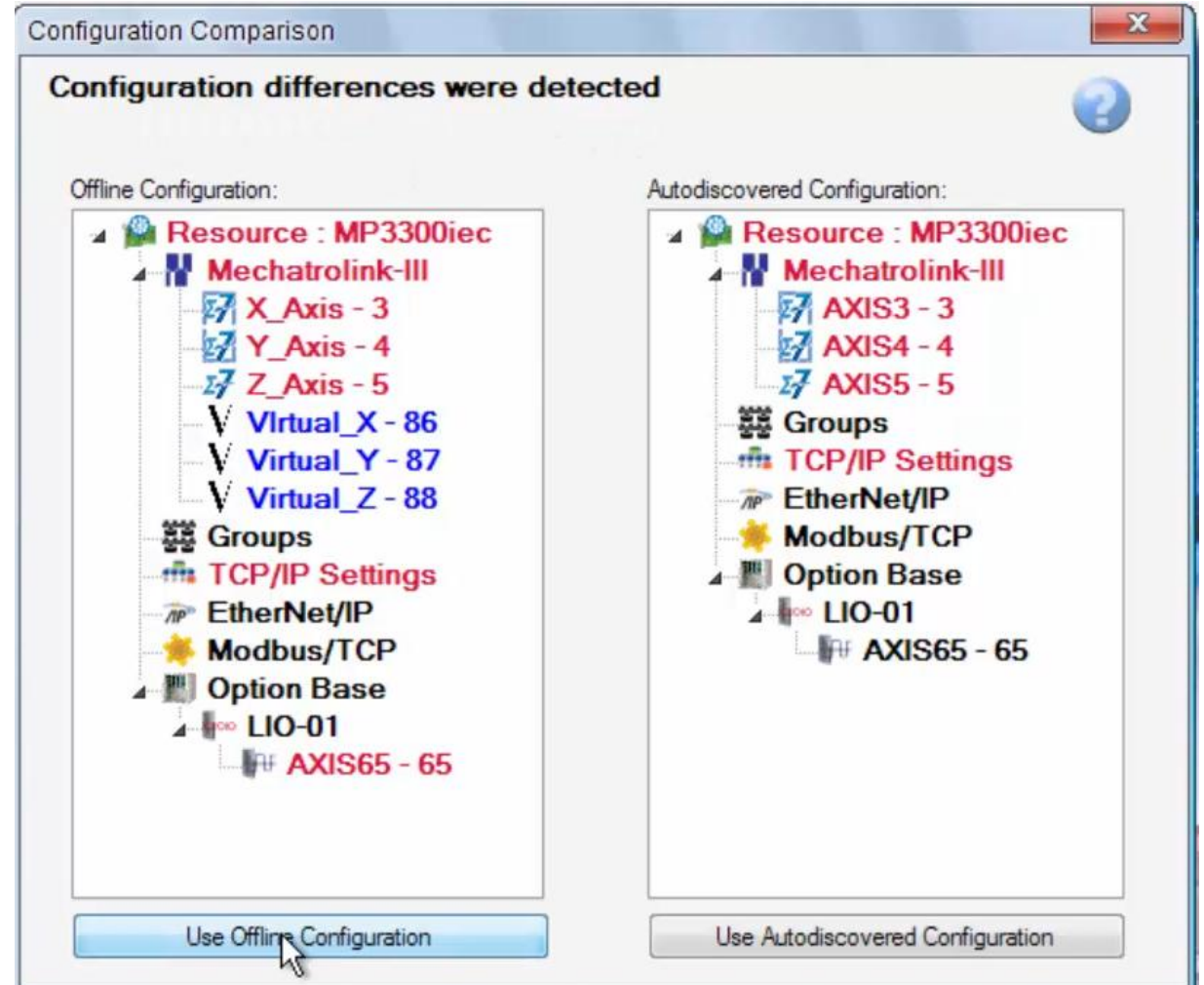
- *Axis Z*

- *MP3300iec*

- *VIPA E/IP remote I/O*

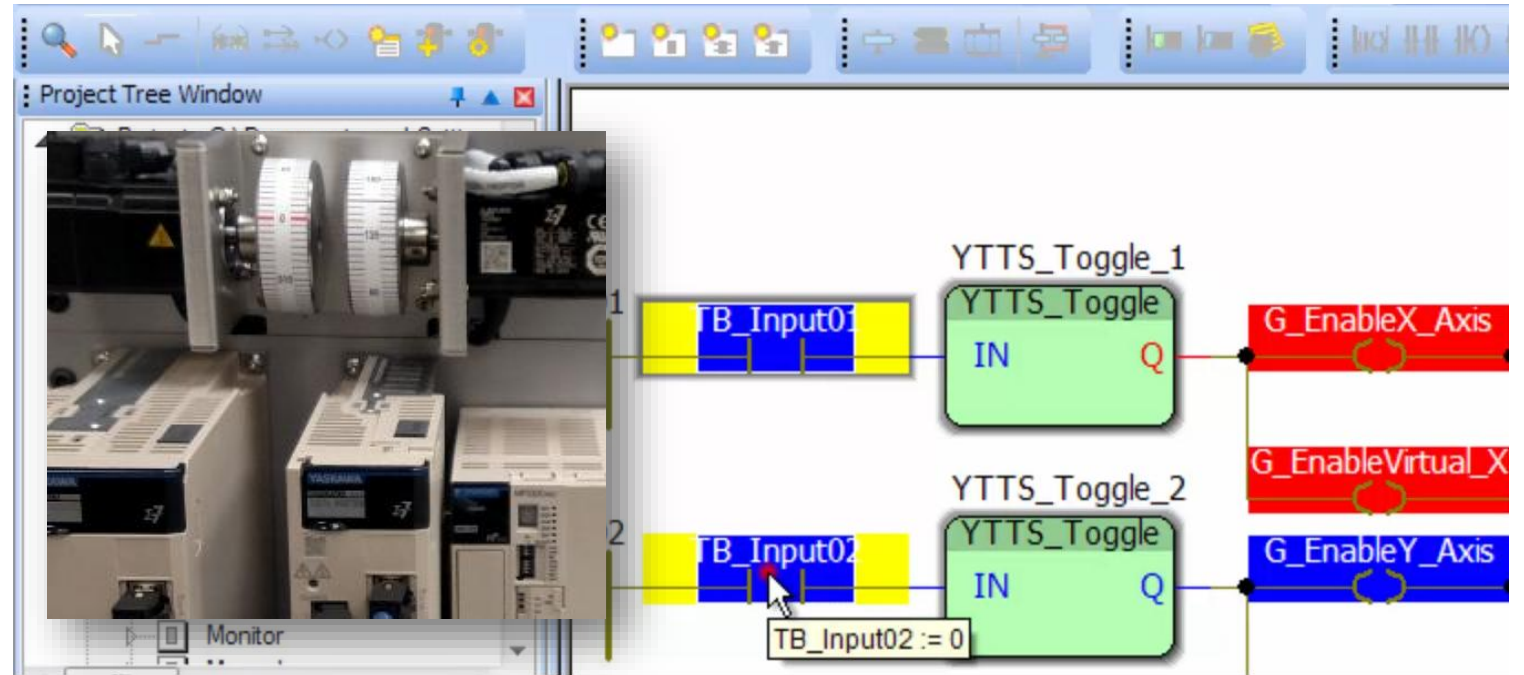
Send Hardware Configuration

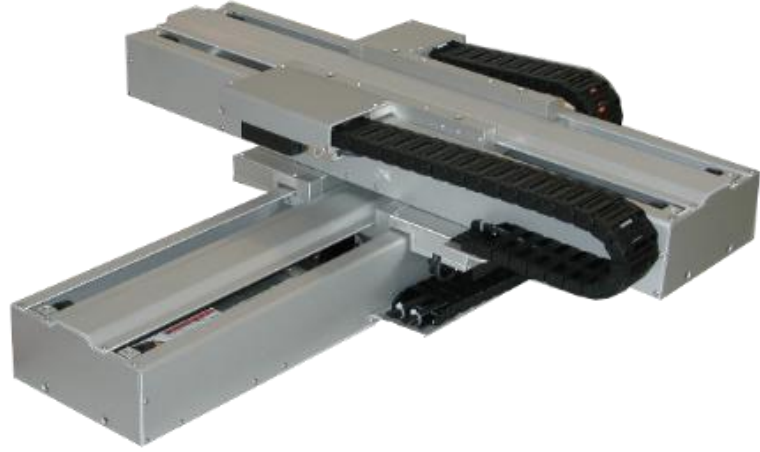
- *IP address, Connect HC to controller*
- *Use Offline Configuration*
- *Save online*
- *Reboot Controller*
- *Make, Download*



Verify Operation

- *Cold start, Stop, Warm Start*
- *Debug*
- *HMI_I POU*
 - *Toggle Boolean*
 - *Servos On*
 - *Jog*
 - *Zero Set*





PLCopen Part 4: Coordinated Motion Group Configuration

- *Add Group*
- *Assign Axes*
- *Update Project*

Requirements

- *Class Project “PLCo4_Training”*
- *MotionWorks IEC Pro*
 - *Ver 3.2 or higher*



Overview

- *2 Dimensional Gantry*
 - *X Axis*
 - *Y Axis*
- *Cartesian Coordinates*
 - *X direction*
 - *Y direction*



Quick Reference Guide


- *Start at step 3*
 - *Steps 1 and 2 completed in previous video*

Multi-Axis Coordinated Motion (PLCopen Part 4)

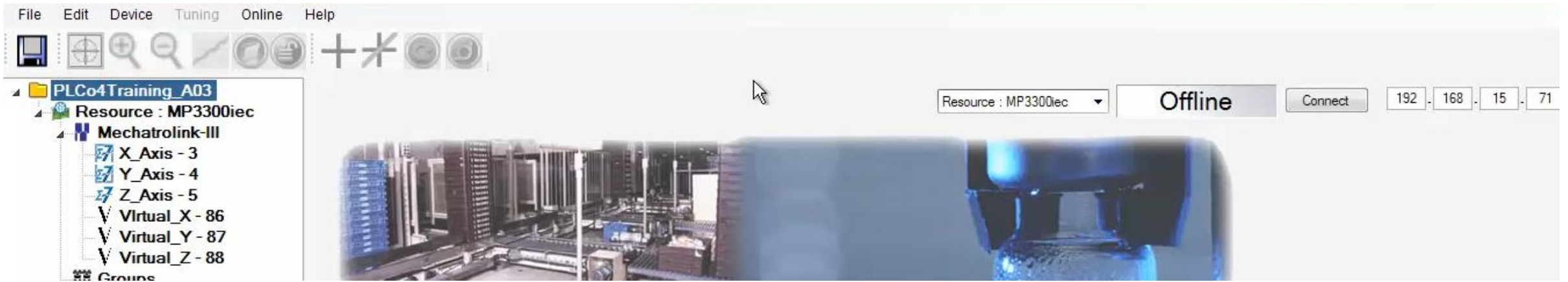
Create Groups

Axes for coordinated motion are organized into groups for PLCopen Part 4 function blocks

Hardware configuration defines what role each axis plays for a particular mechanical system

Step	Description	Detail
1	Go Online with Hardware Configuration	Start MotionWorks IEC Version 3.2 or higher. Open the project or start a new project. Click the hardware configuration icon. Click "connect".
2	Configure Axes	Set units, set axis parameters, file-save, online- reboot controller, test run
3	Go Offline	Click "disconnect". <i>1/8/2016 groups cannot be created online</i>
4	Add a group 	In hardware tree click Groups, Add Group. Edit the Group Name. <i>The group name appears in the hardware tree.</i>
5	Mechanism Type	In hardware tree click on the new group. Choose the mechanism type that most closely approximates the machine. <i>Kinematic equations for each mechanism exist in the controller firmware</i>

Offline Hardware Configuration



Resource : MP3300iec

Offline

Connect

192

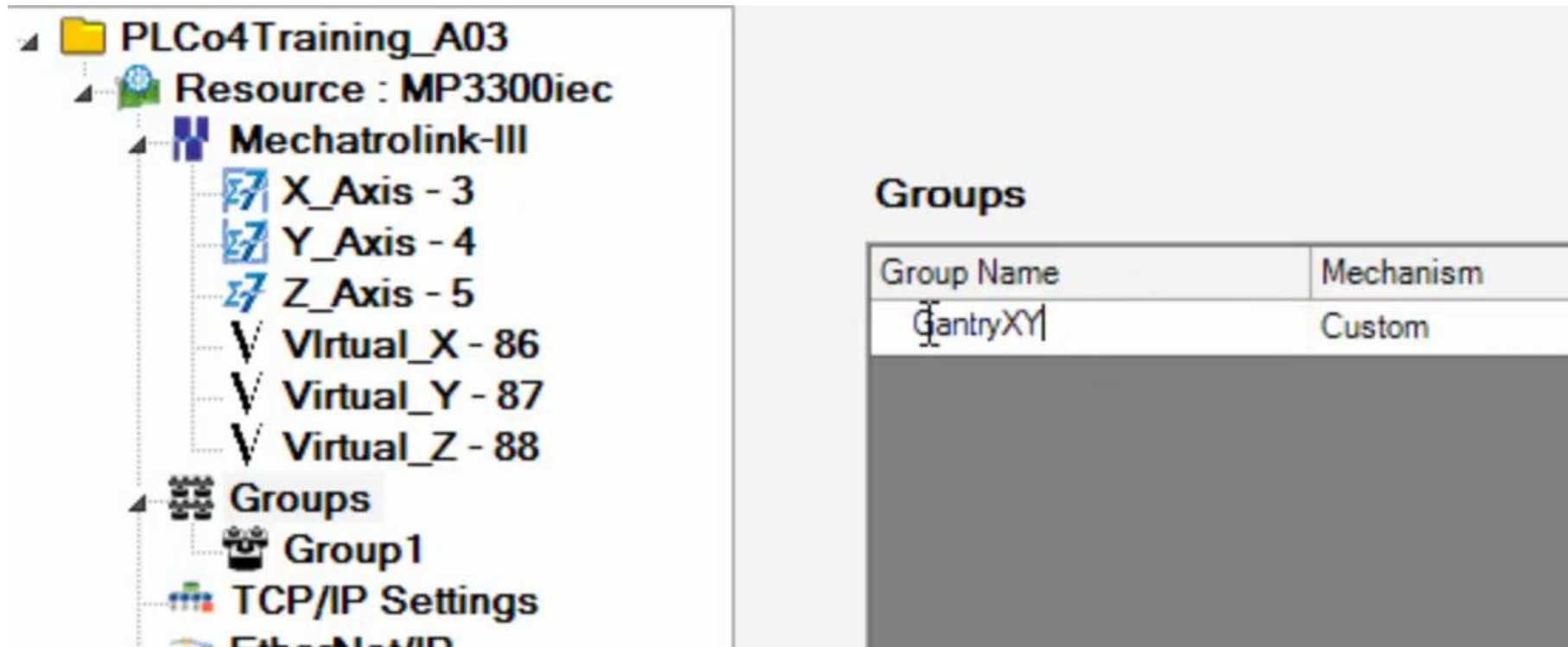
. 168

. 15

. 71

Add a group

- *Button “Add Group”*
- *Edit Group Name*



The screenshot displays the Yaskawa software interface. On the left, a tree view shows the project structure:

- PLCo4Training_A03
 - Resource : MP3300iec
 - Mechatrolink-III
 - X_Axis - 3
 - Y_Axis - 4
 - Z_Axis - 5
 - Virtual_X - 86
 - Virtual_Y - 87
 - Virtual_Z - 88
 - Groups
 - Group1
 - TCP/IP Settings
 - EtherNet/IP

On the right, a table titled "Groups" is shown:

Group Name	Mechanism
GantryXY	Custom

Mechanism Type

- *Select Group*
- *Choose Mechanism*

The screenshot displays the configuration interface for a Yaskawa robot system. On the left, a tree view shows the project structure under 'PLCo4Training_A03' and 'Resource : MP3300iec'. The 'Mechatrolink-III' folder is expanded, showing 'X_Axis - 3', 'Y_Axis - 4', 'Z_Axis - 5', and 'Virtual_X - 86', 'Virtual_Y - 87', 'Virtual_Z - 88'. The 'Groups' folder is also expanded, showing 'GantryXY', 'TCP/IP Settings', 'EtherNet/IP', 'Modbus/TCP', and 'Option Base'. Under 'Option Base', 'LIO-01' is expanded, showing 'AXIS65 - 65'.

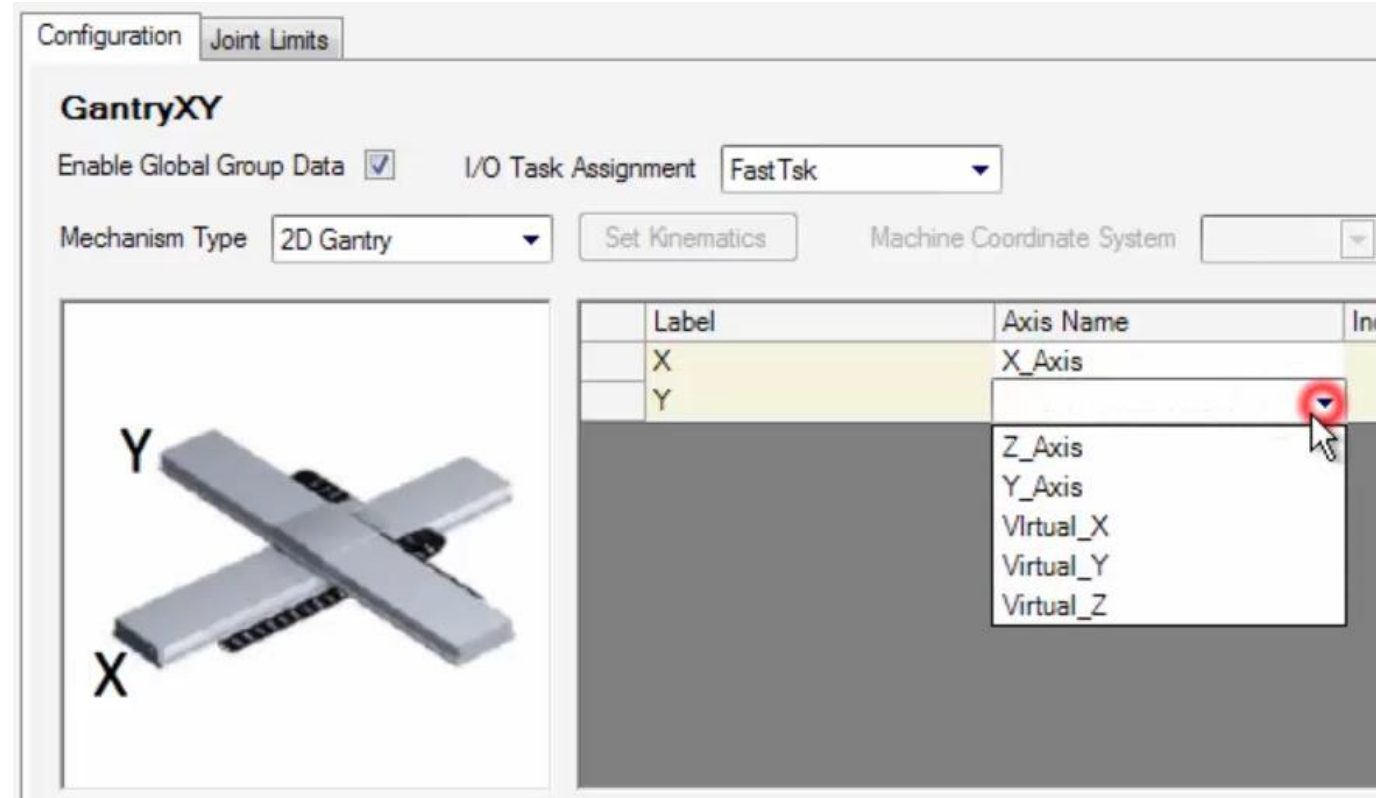
On the right, the 'Configuration' tab is active, showing the 'GantryXY' mechanism type. The 'Mechanism Type' dropdown is set to '2D Gantry'. The 'I/O Task Assignment' is set to 'FastTsk'. A 'Set Kinematics' button and 'Machine Coord' are also visible.

Below the configuration options, there is a 3D model of a 2D gantry mechanism with 'X' and 'Y' axes labeled. To the right of the model is a table with the following content:

Label	Axis
X	
Y	

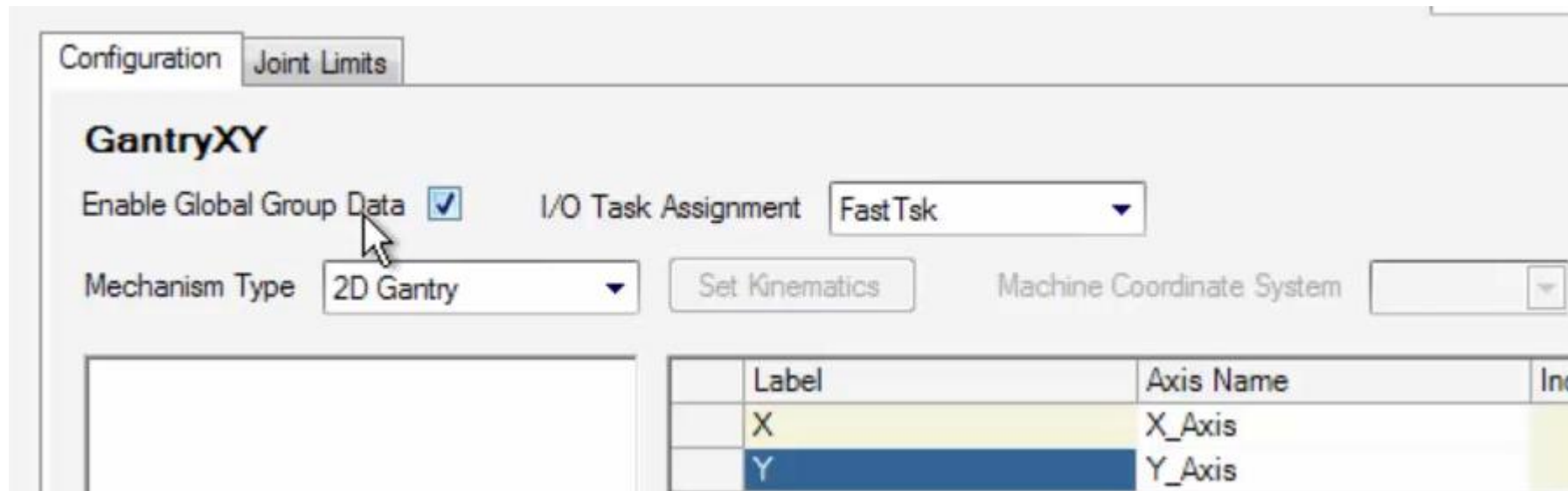
Assign Axes

- Choose Axis Name



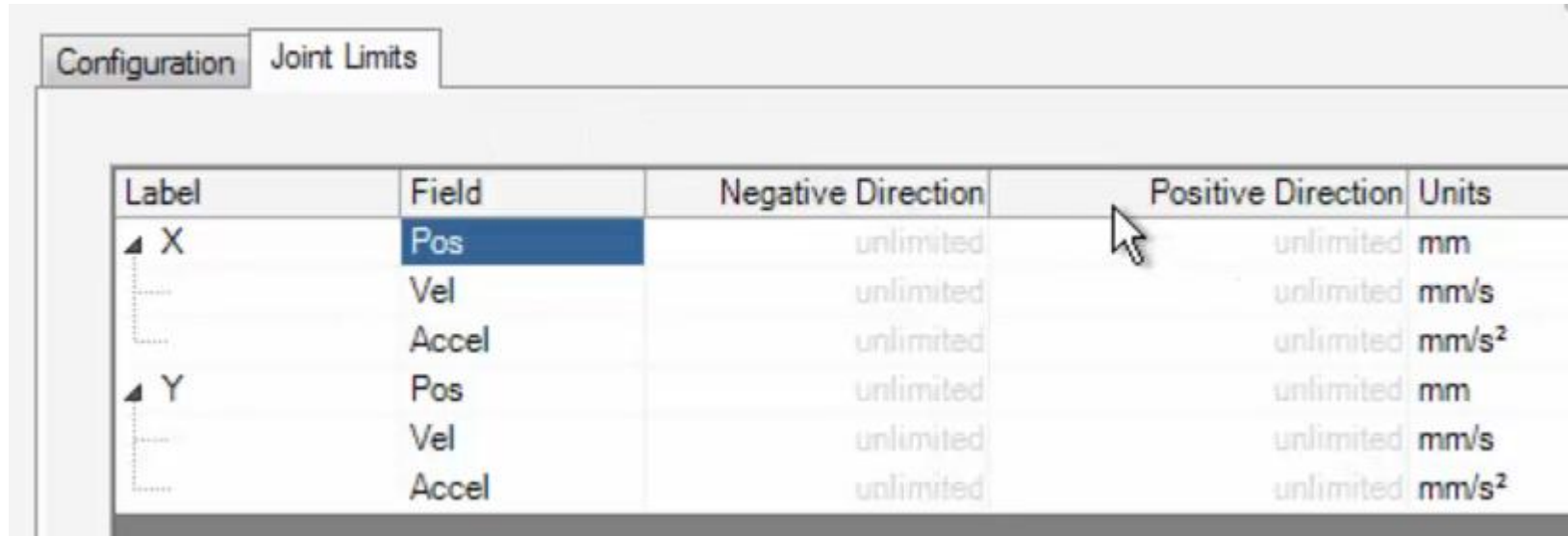
Group Data

- *Variable created for group*
- *Update Rate to Code*



Joint Limits

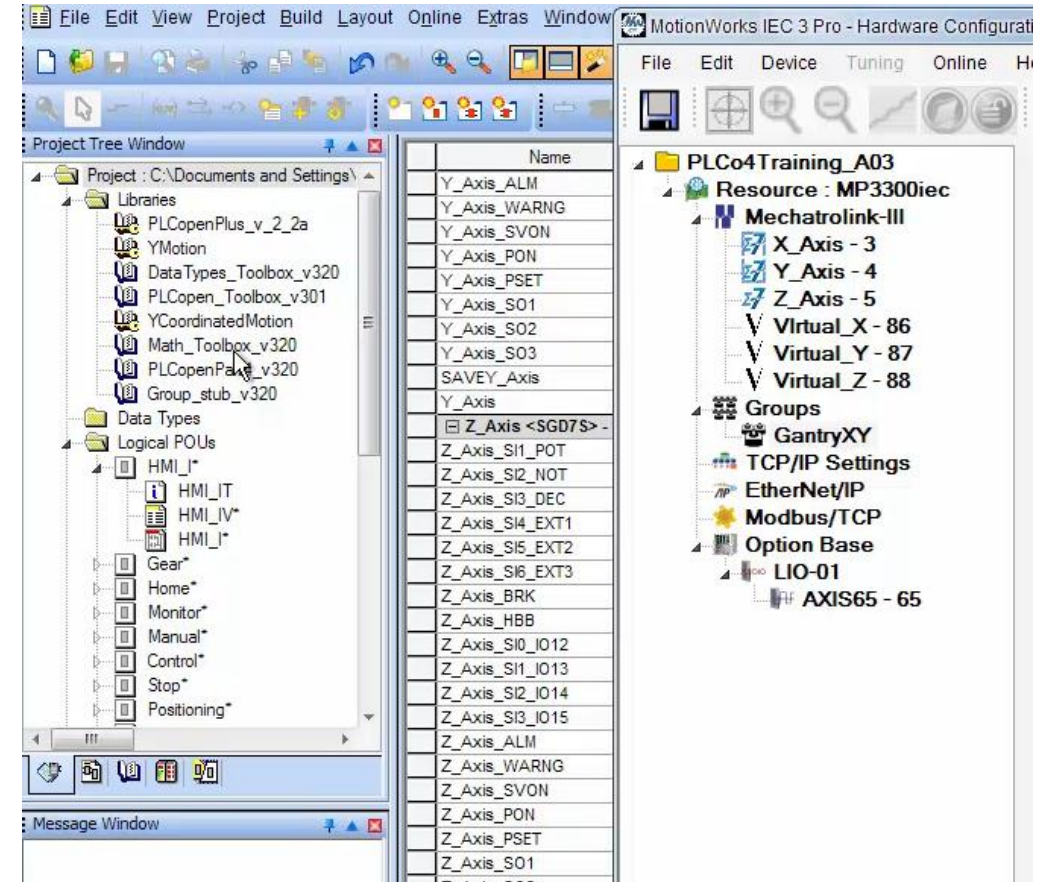
- *Set max and min positions for each axis*



Label	Field	Negative Direction	Positive Direction	Units
X	Pos	unlimited	unlimited	mm
	Vel	unlimited	unlimited	mm/s
	Accel	unlimited	unlimited	mm/s ²
Y	Pos	unlimited	unlimited	mm
	Vel	unlimited	unlimited	mm/s
	Accel	unlimited	unlimited	mm/s ²

Offline Save

- *Creates Global variables*
 - *Axis_Group_Ref*
- *Adds Libraries*
 - *YCoordinatedMotion*
 - *Math_Toolbox*
 - *PLCopenPart4*
 - » *Contains blocks such as MC_MoveLinearAbsolute*
 - *Group_Stub*
- *Updates IO_Configuration*
 - *Drivers*



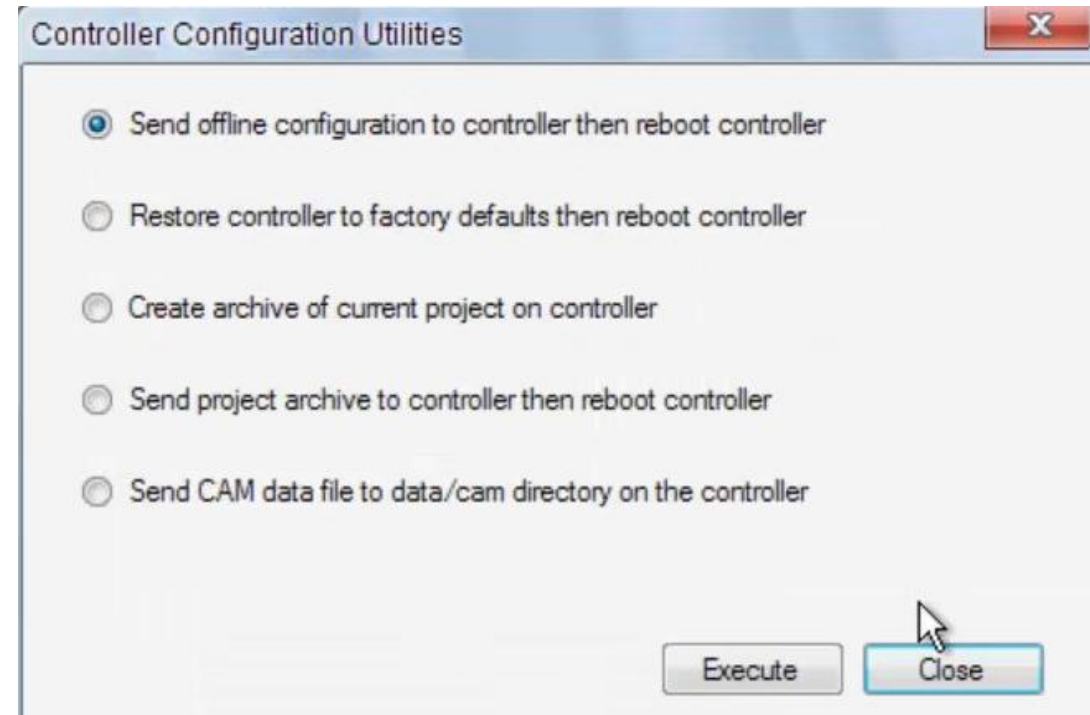
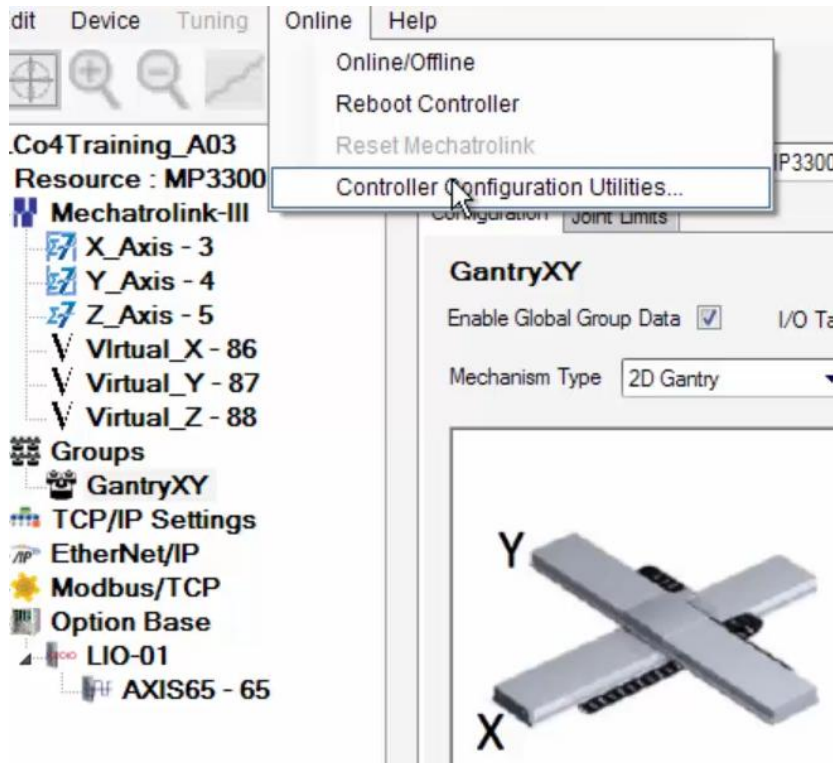
[-] GantryXY <Group> - Mechatrolink Group - 1 (* Do Not Modify Group Name or Status Variable. *)			
GantryXY	AXES_GROUP_...	VAR_GLOBAL	(* Do Not Modify! *)
IAG1	BYTE	VAR_GLOBAL	(* Do Not Modify! *)

MAKE project



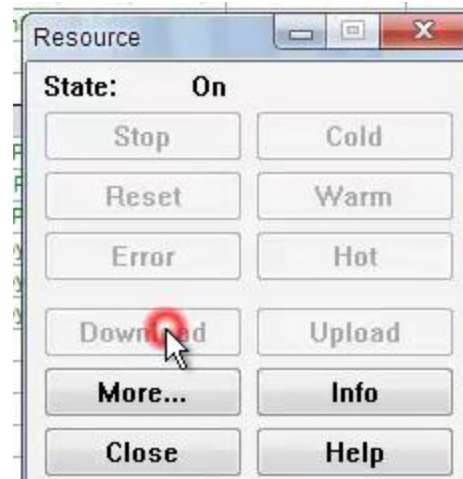
Send Offline Configuration and Reboot

- *MP3300iec*
 - *Firmware 3.2 or higher*
- *Offline*
- *Set IP address*



Download

- *Download and warm start*



Help

- *Help available within Hardware Configuration*

The screenshot displays the MotionWorks IEC Configuration software interface. On the left, a 'Contents' pane lists various configuration options, including 'Mechatrolink Configuration' and 'Group Configuration'. The main window shows a tree view of a 'MyMachine' configuration with a 'Mechatrolink-II' group containing five axes (AXIS1 to AXIS5) and a 'Gantry1' group containing 'TCP/IP Settings', 'EtherNet/IP', and 'Modbus/TCP [Slot_1]'. The 'Gantry1' configuration is expanded, showing a 3D model of the gantry and a table of axis assignments. The table has columns for 'Label', 'Axis Name', and 'Index'. The 'Y' label is selected, and 'AXIS3' is chosen in the 'Axis Name' dropdown. Red arrows point to the 'Add Secondary Axis' button and the 'AXIS3' selection in the table. Text annotations indicate 'Click to add Prime axis' and 'Select a main axis'. The status bar shows 'Offline' and 'Connect' buttons.

This setting is applicable for MECHATROLINK groups only.

Label	Axis Name	Index
X	AXIS1	1
X	AXIS2	1
Y	AXIS3	2
Z	AXIS4	3



PLCopen Part 4: Coordinated Motion Programming Linear Moves

- *Required Motion*
- *MC_MoveLinearAbsolute*
- *VECTOR* datatype
- *MC_GroupEnable*
- *Calibrate Zero*
- *Test Motion*

Requirements

- *Class Project “PLCo4_Training”*
- *Group configured for 2DGantry*
 - *See previous section*
- *MotionWorks IEC Pro*
 - *Ver 3.2 or higher*

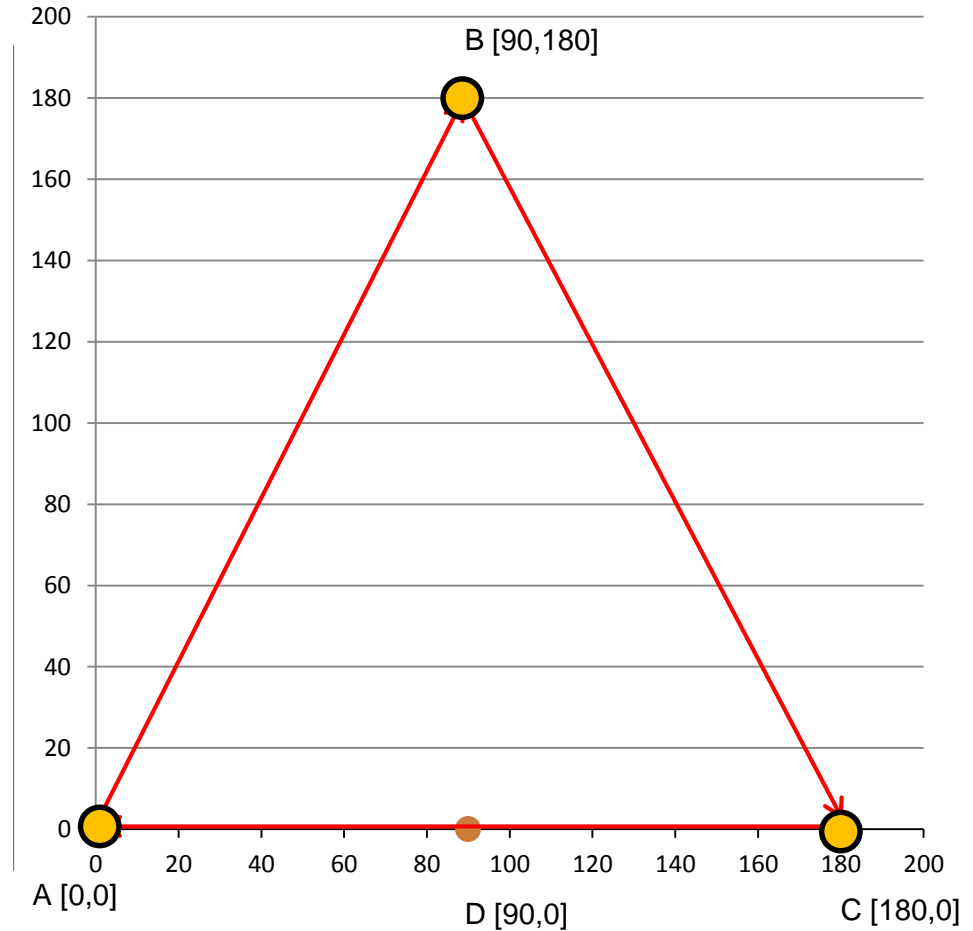
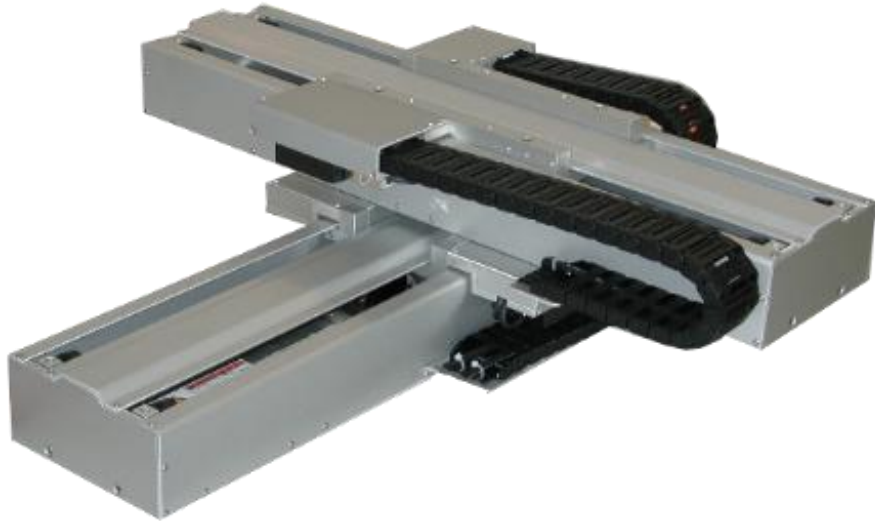
The screenshot displays the MotionWorks IEC Pro interface for a 2D Gantry system. It is divided into four main sections:

- Project Tree Window:** Shows a hierarchical view of the project. The 'Tasks' folder is expanded, showing various tasks like 'FastTsk', 'Positioning', 'MedTsk', 'Gear', 'Home', 'SlowTsk', 'HMI', 'Stop', 'Control', 'Manual', 'Start', and 'Initialize'.
- Ladder Logic:** Shows three input points: '001 TB_Input01', '002 TB_Input02', and '003 TB_Input03', each with a normally open contact.
- Resource Tree:** Shows the configuration for 'Resource : MP3300iec'. Under 'Mechatrolink-III', it lists 'X_Axis - 3', 'Y_Axis - 4', and 'Z_Axis - 5'. Under 'Groups', 'GantryXY' is selected. Other options include 'TCP Settings', 'EtherNet/IP', 'Modbus/TCP', 'Option Base', and 'LIO-01'.
- Configuration Panel:** Shows the 'GantryXY' configuration. The 'Mechanism Type' is set to '2D Gantry'. A table below shows the axis assignments:

Label	Axis
X	X_Ax
Y	Y_Ax

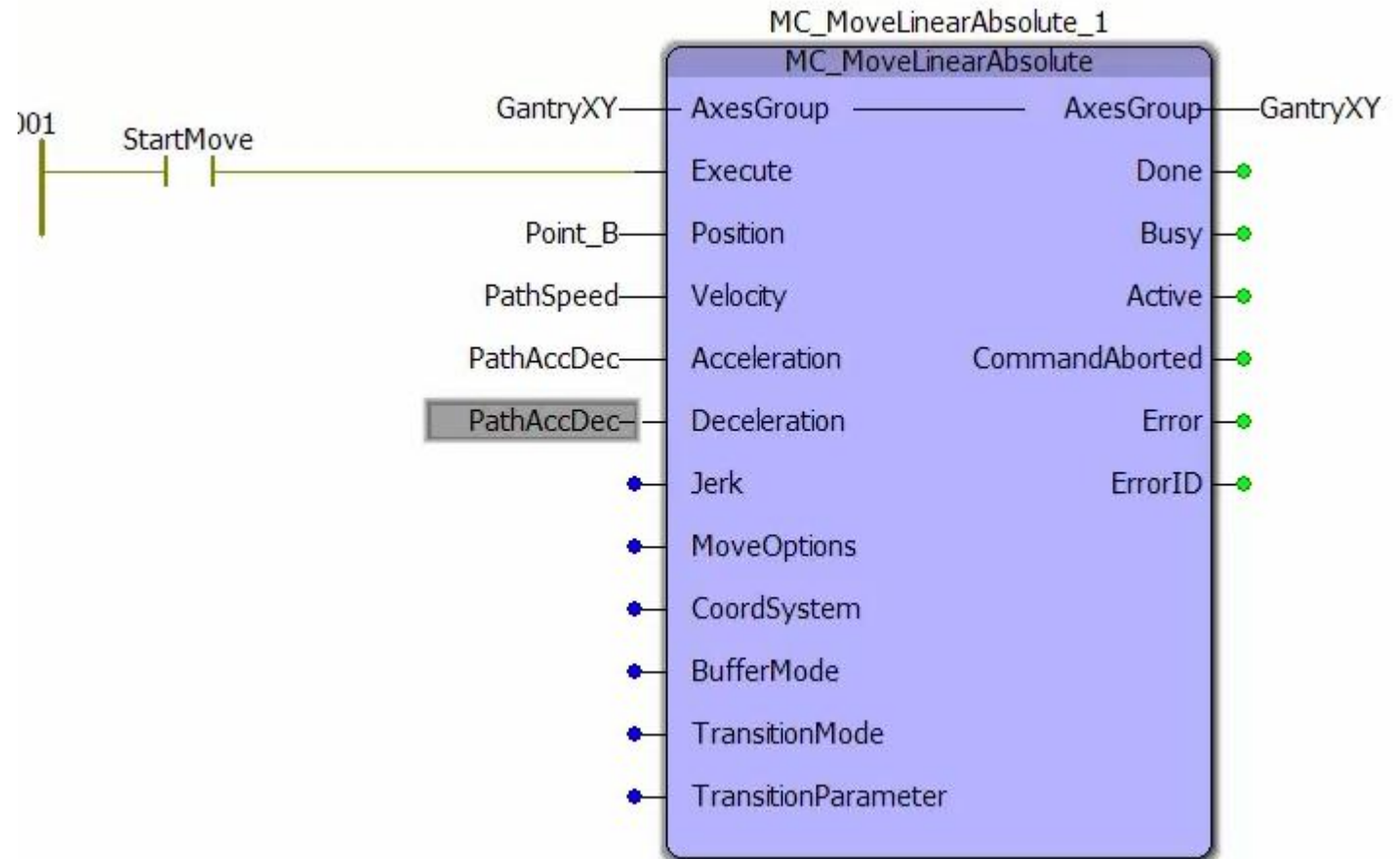
Required Motion

- *Move from A to B then stop*
- *Move from B to C then stop*
- *Move from C to A then stop*



MC_MoveLinearAbsolute

- *“Linear” program POU running in FastTsk*
- *Position is VECTOR datatype*
- *Velocity, Acceleration, Deceleration along path*
- *Other inputs can be left disconnected*



Vector Datatype

- *Array of coordinate positions*

Variable Properties

Name: Point_B

Data Type: VECTOR

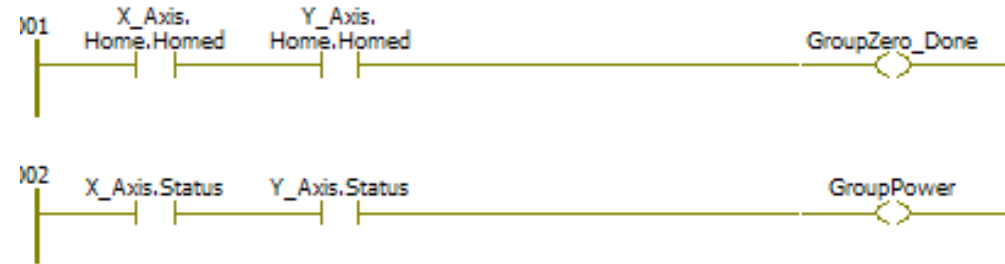
Usage: VAR RETAIN

Initial value:

ame	Type	Description	Init. value
Point_B	VECTOR		[90.0, 180.0]
..... [1]	LREAL		90.0
..... [2]	LREAL		180.0
..... [3]	LREAL		
..... [4]	LREAL		
..... [5]	LREAL		
..... [6]	I RFAI		

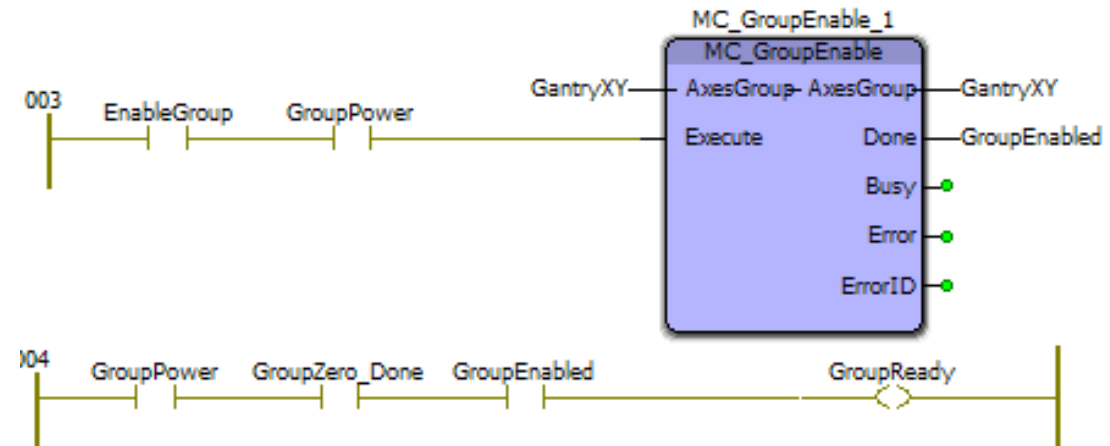
Before Executing a Coordinated Move

1. *Calibrate Zero Point*



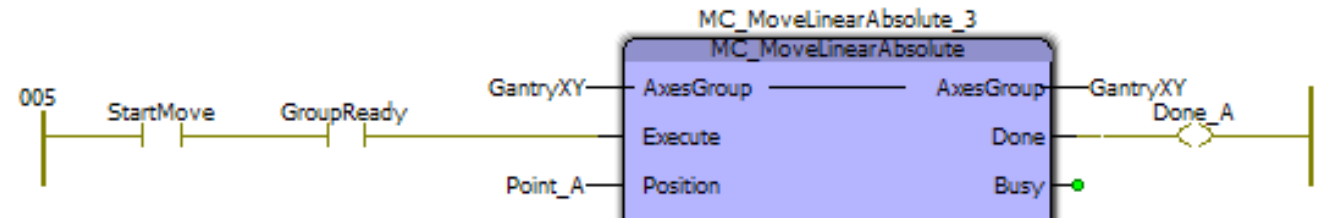
2. *Servos On*

3. *Enable Group*



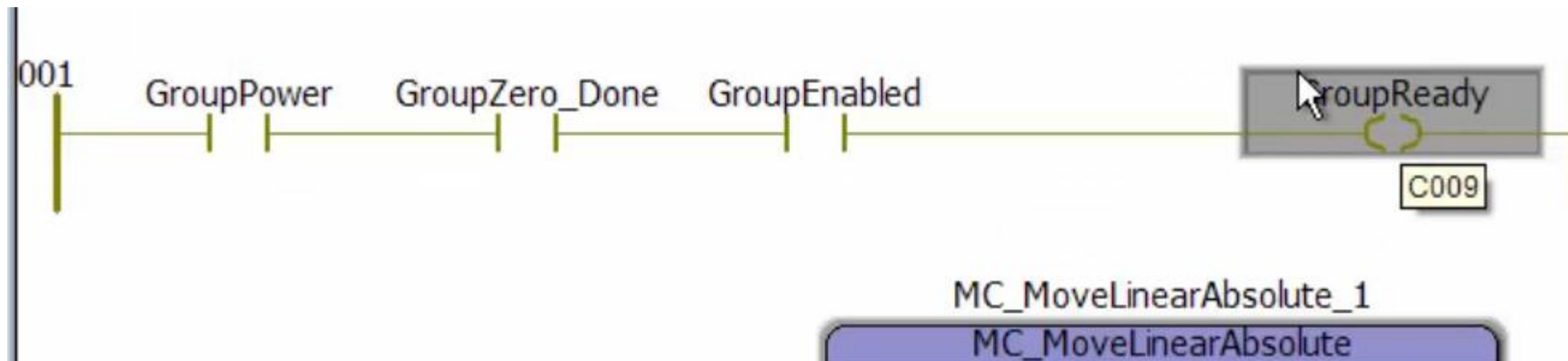
■ *Group Ready*

- *All above conditions met*



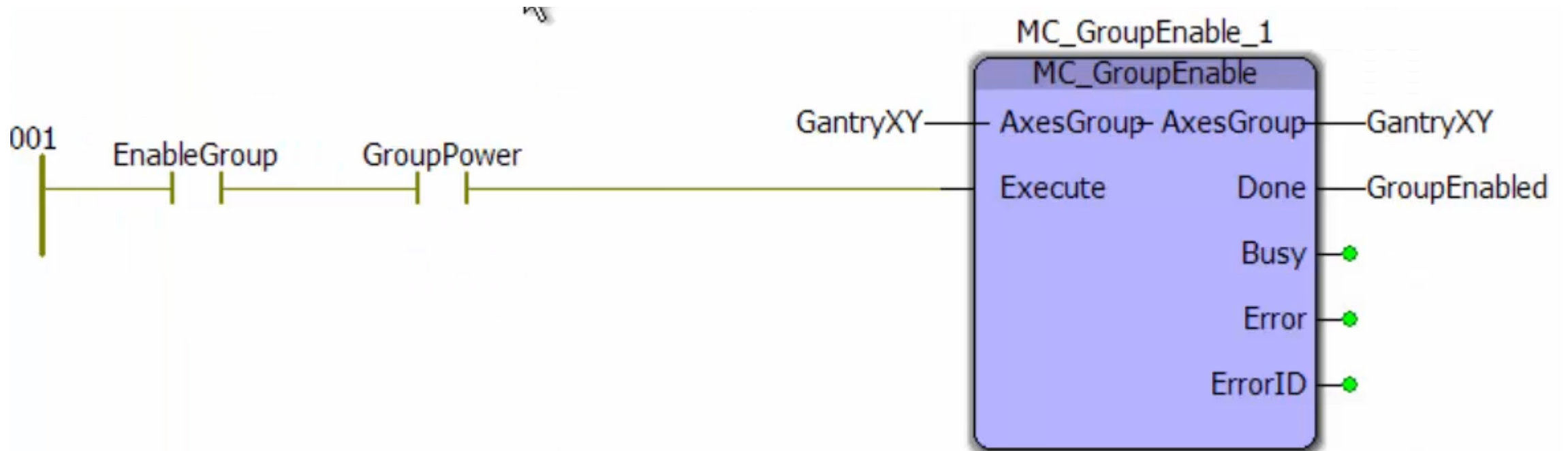
Group Ready

- *Create logic to check for 3 required conditions before executing a linear move*



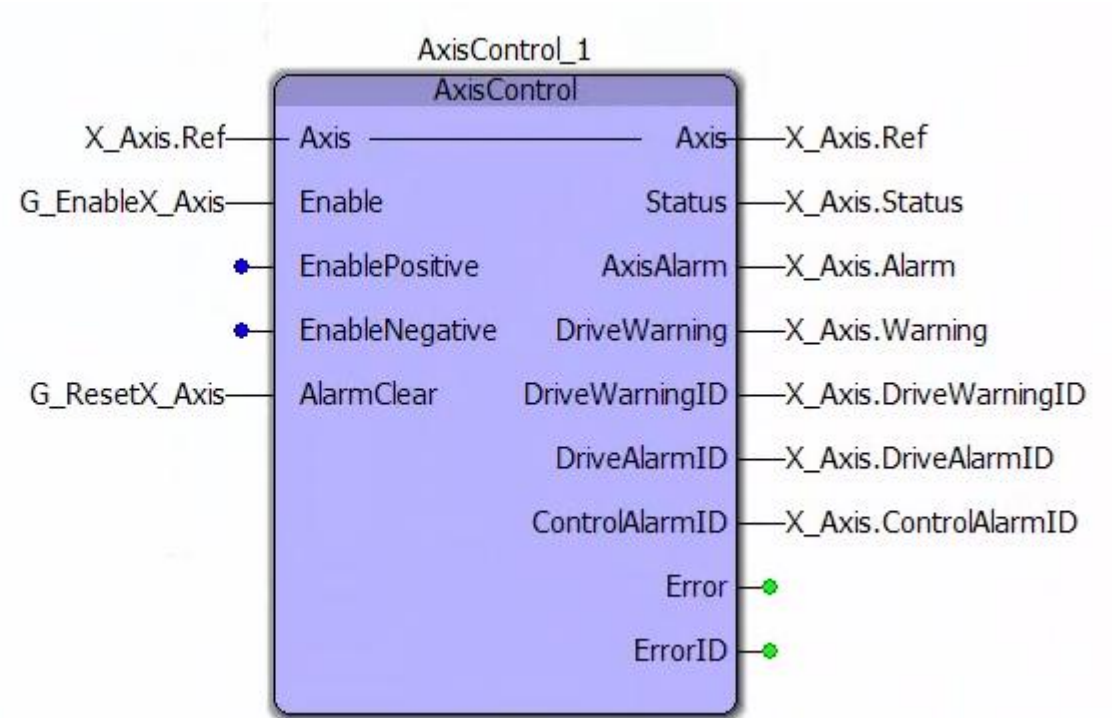
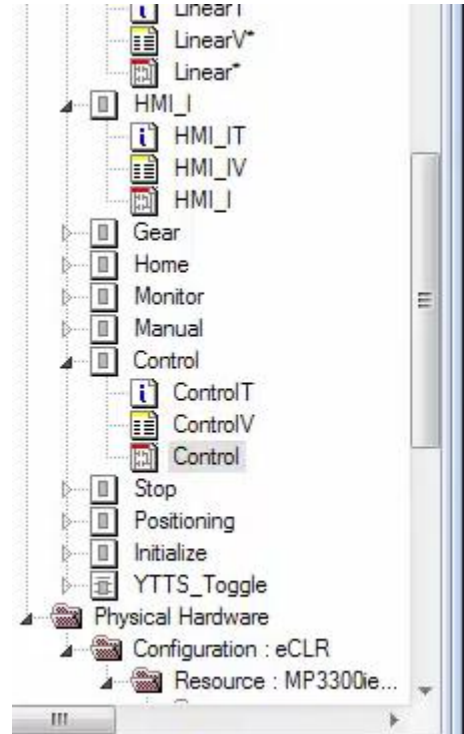
MC_GroupEnable

- *Enables coordinated moves*
- *Disables individual axis moves*



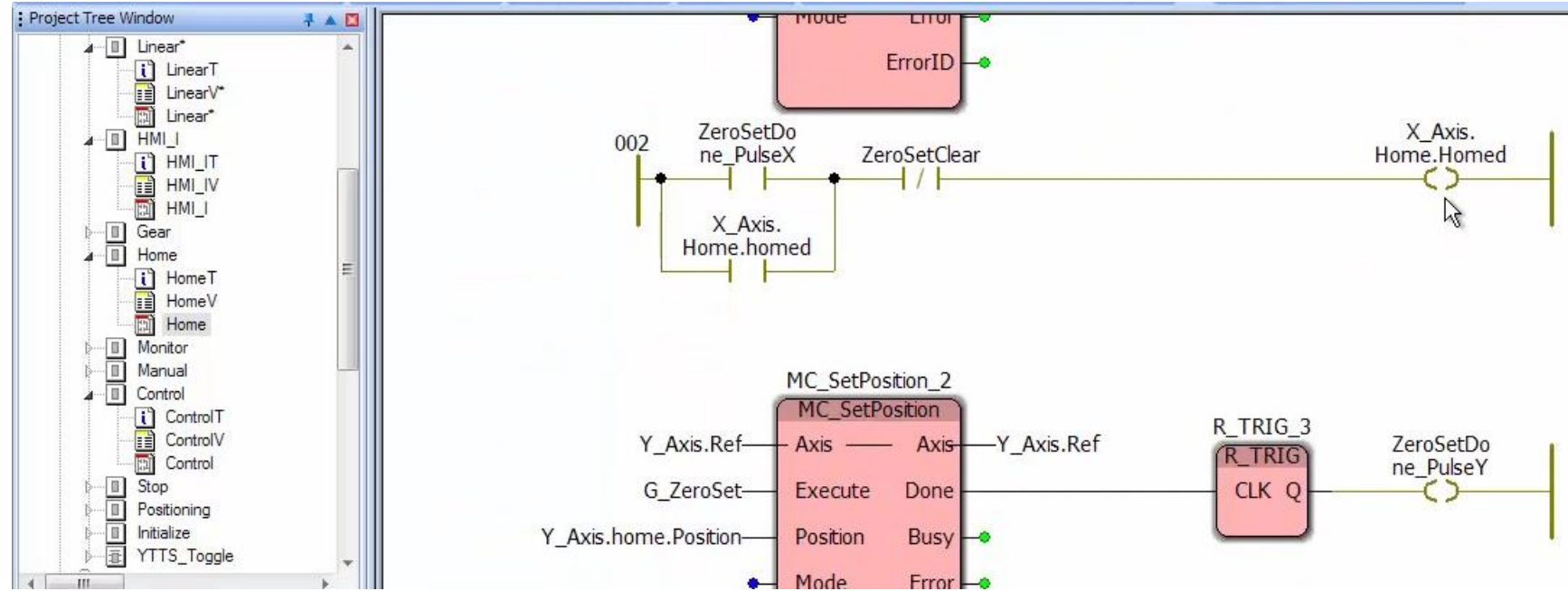
Servos On

- Turn servos on with individual AxisControl



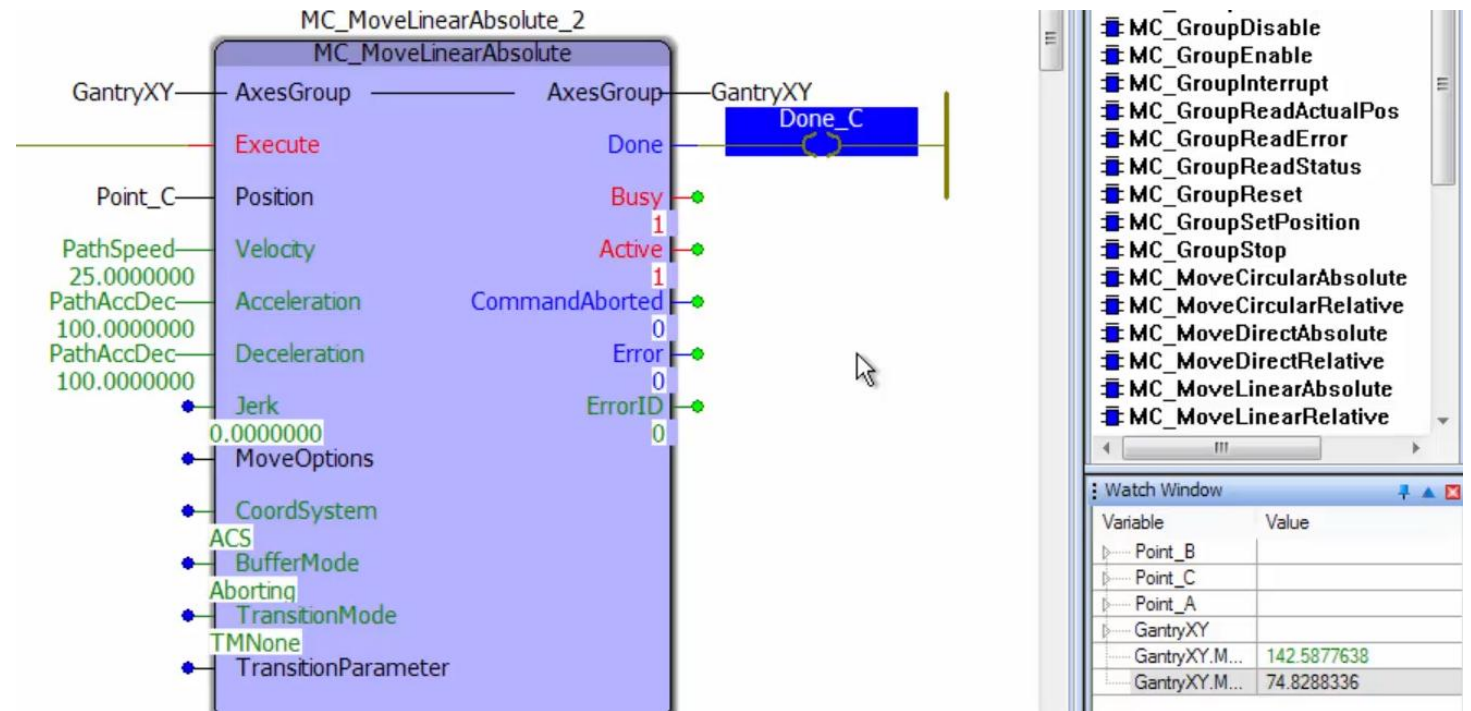
Calibrate Zero

- Individual axis *MC_SetPosition*



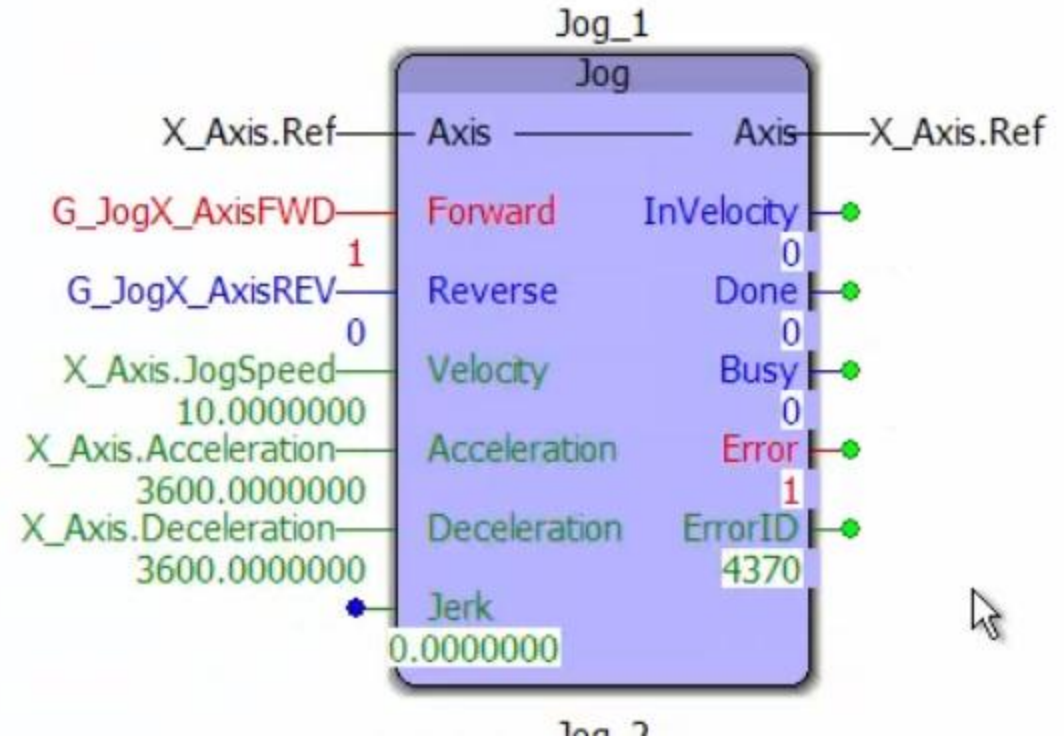
Verification

1. Make, Download
2. Debug
3. HMI POU
4. Toggle Boolean
5. Servos On
6. Jog to zero position
7. Set zero point
8. Enable Group



Verification

- *No single-axis control while group enabled*
 - *Example: Jog*
 - *Axis Error 4370*
- *Use MC_GroupDisable before single-axis control*



Verification

- *Add to watch window*
 - *Point_A, B, C*
 - *GantryXY*
 - *Gantry.Machine.ActualPosition[1]*
 - *Gantry.Maachine.ActualPosition[2]*

Variable	Value
Point_C	
[1]	180.0000000
[2]	0.0000000
[3]	0.0000000
[4]	0.0000000
[5]	0.0000000
[6]	0.0000000
[7]	0.0000000

Verification

- Start the move

The screenshot displays the Yaskawa robot programming software interface for verifying a linear move. The main window shows three coordinate systems (A, B, C) and their respective parameters. A graph window shows a path from point A [0,0] to point B [90,180] to point C [180,0]. A watch window shows the current values of the variables.

Watch Window Data:

Variable	Value
Point_B	
Point_C	
Point_A	
GantryXY	
GantryXY.Machine.Actu...	124.2521310
GantryXY.Machine.Actu...	111.5061021



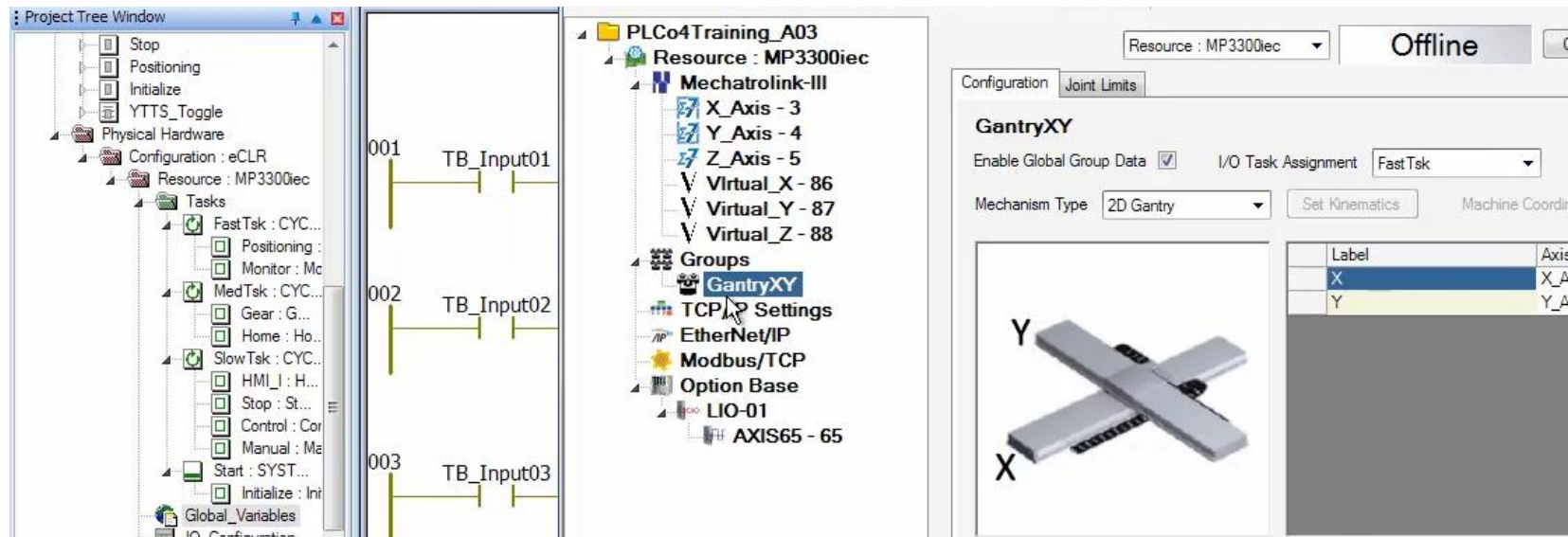
PLCopen Part 4: Coordinated Motion

Blending Linear Moves

- *Required Motion*
- *Smooth Corners*
- *Transitions*
- *Transition Mode*
- *Programming*

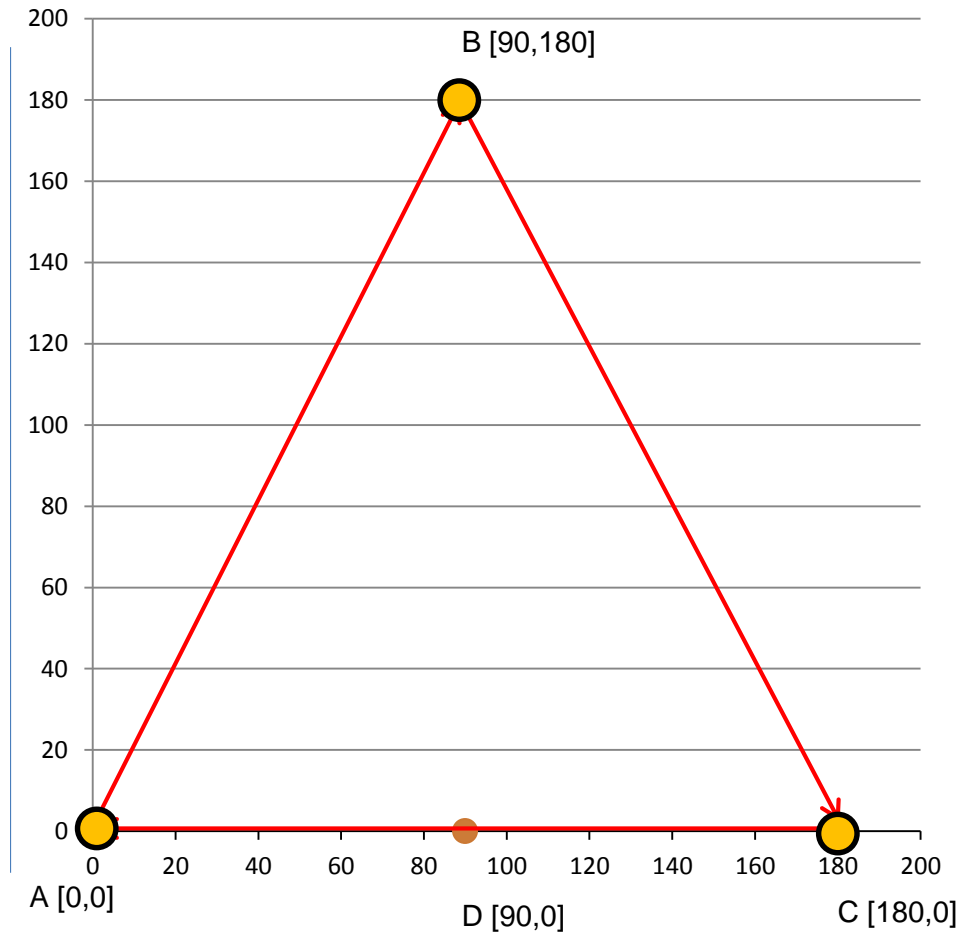
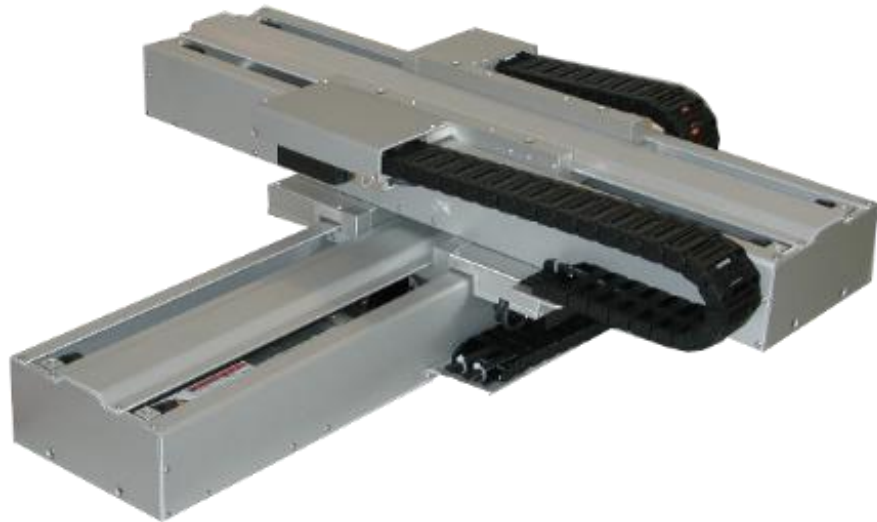
Requirements

- *Class Project “PLCo4_Training”*
 - *Group configured for 2DGantry*
 - *Triangular Path Program*
- *MotionWorks IEC Pro*
 - *Ver 3.2 or higher*
- *MP3300iec controller*
 - *Firmware 3.2 or higher*



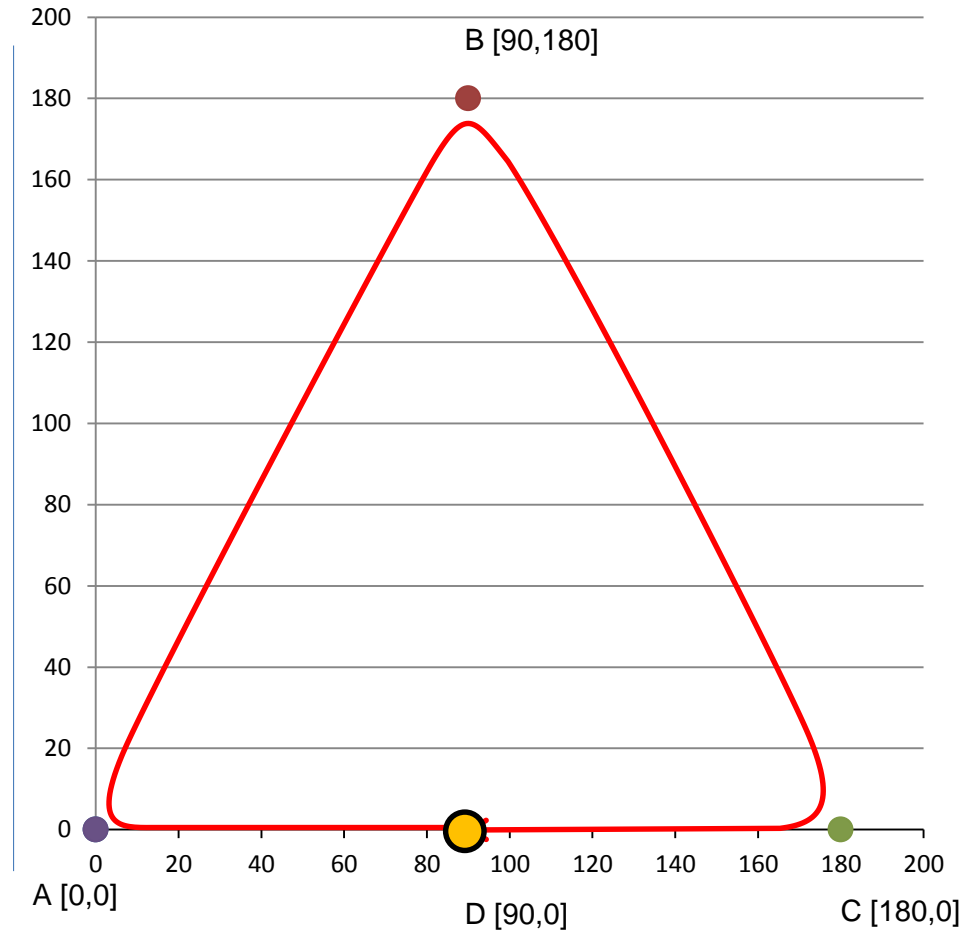
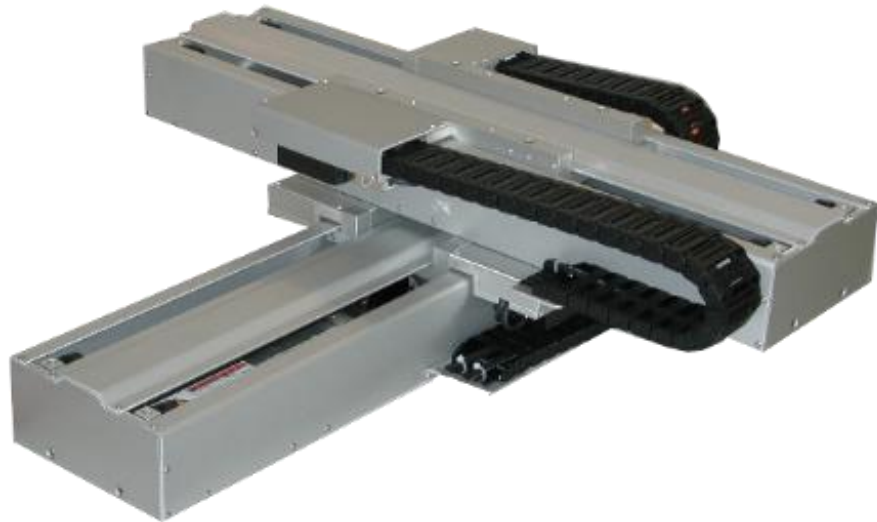
Previous Required Motion

- *Move from A to B then stop*
- *Move from B to C then stop*
- *Move from C to A then stop*



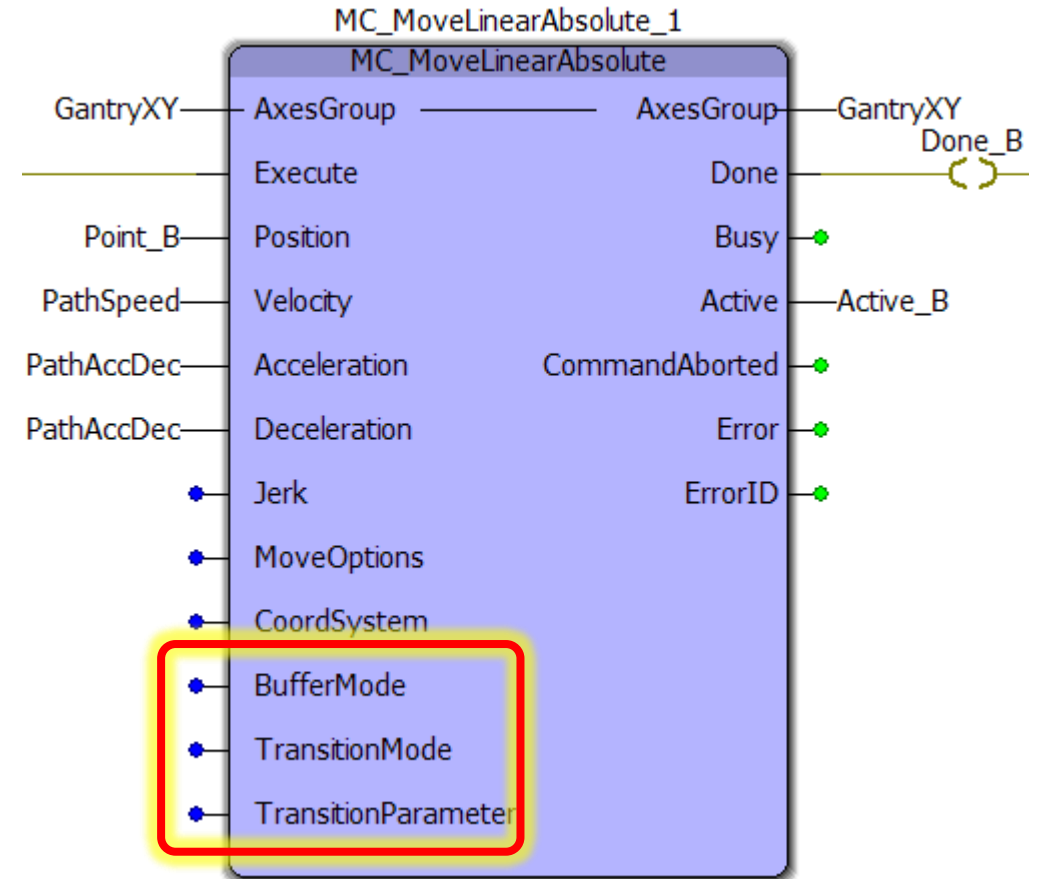
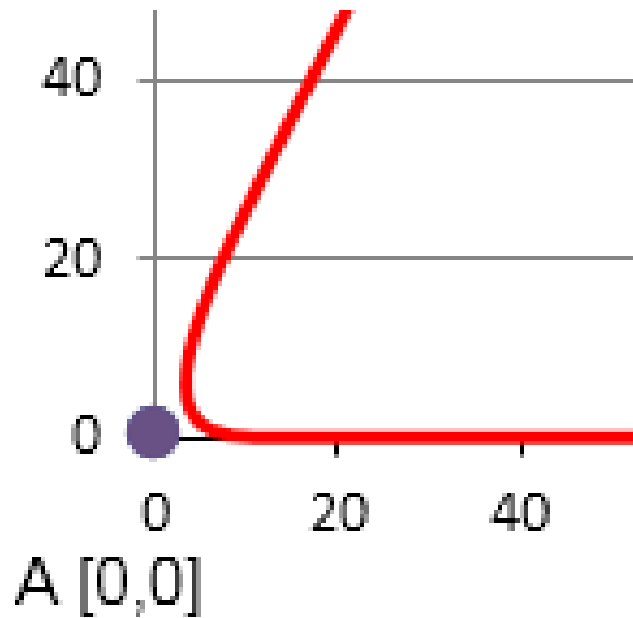
Required Motion

- *Start at D*
- *Move through A, B, C without stop*
- *Smooth corners*
- *Approach each point as closely as possible*
- *Maintain constant velocity*
- *Stop at D*



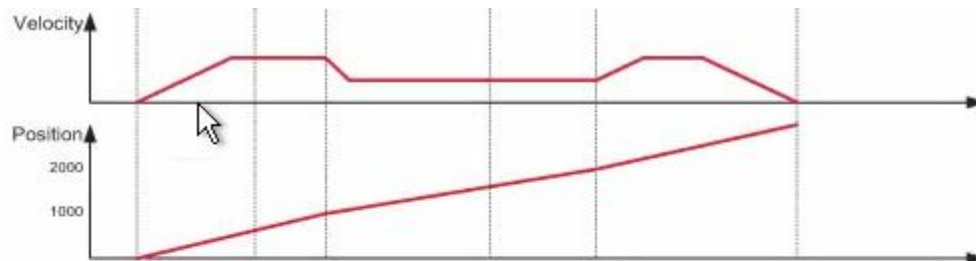
Smooth Corners

- *BufferMode*
- *TransitionMode*
- *TransitionParameter*

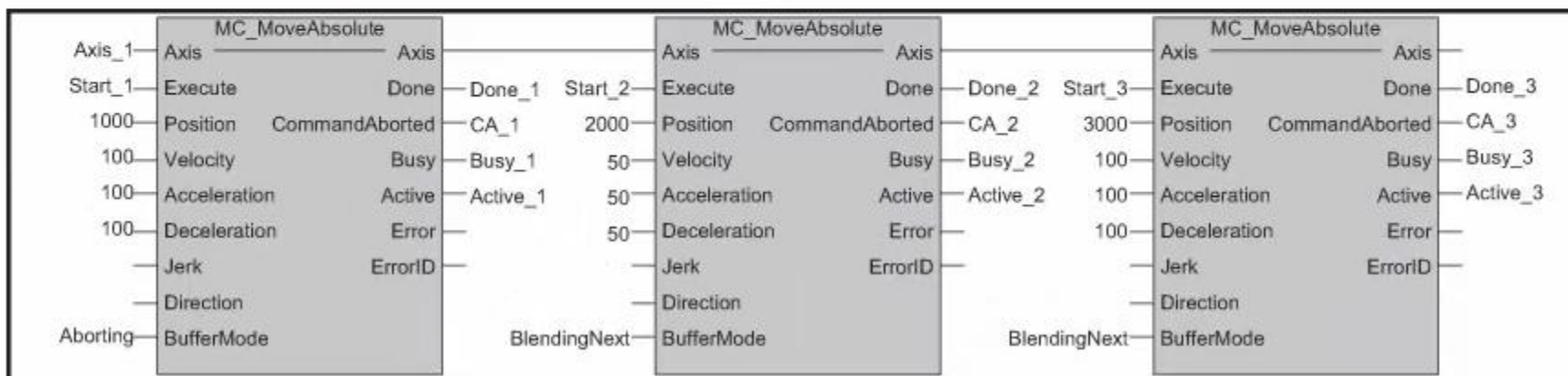


Buffer Mode

- Same as *PLCopen Part 1*



Example 6: BlendingNext motion



Transitions

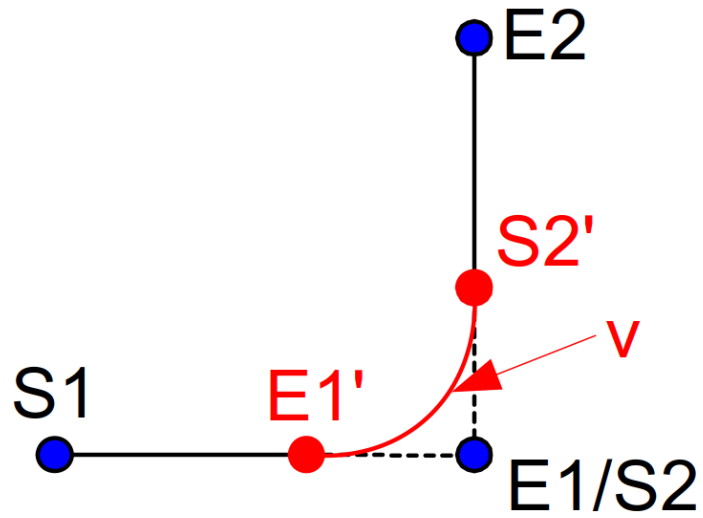
- *Right-Click “help” of MC_MoveLinearAbsolute*
 - *TransitionParameter VECTOR help*

Transition parameters			
Value	MC_Transition_Mode	Transition Parameters (Example)	Units
0	TMNone		n/a
1	TMStartVelocity	Parameters[1]:=100.0;	% of corner entry velocity
2	TMConstantVelocity	Parameters[2]:=100.0;	% of corner entry velocity
3	TMCornerDistance	Parameters[3]:=15.0;	User units of the axes in the group
4	TMMaxCornerDeviation	Parameters[4]:=15.0;	User units of the axes in the group
10	TMMLXBlend	Parameters[10]:=4.0;	Scale value 1 to 8. The MLX has a maximum blend radius pre configured.

		BufferMode					
		Aborting	Buffered	Blending Low	Blending Previous	Blending Next	Blending High
Transition Mode	TMNone	Yes	Yes	No	No	No	No
	TMStartVelocity	n/a	n/a	n/a	n/a	n/a	n/a
	TMConstantVelocity	Yes	No	Yes	Yes	Yes	Yes
	TMCornerDistance	No	No	Yes	Yes	Yes	Yes
	TMMaxCornerDeviation	No	No	Yes	Yes	Yes	Yes

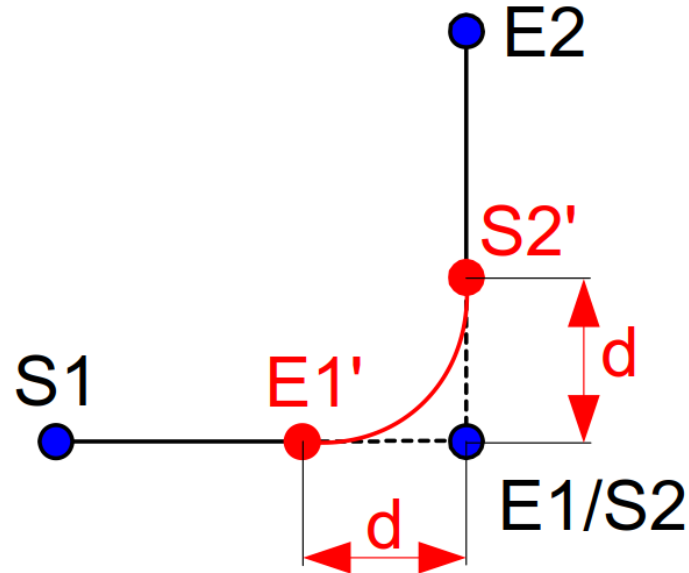
Transition Modes

Constant Velocity



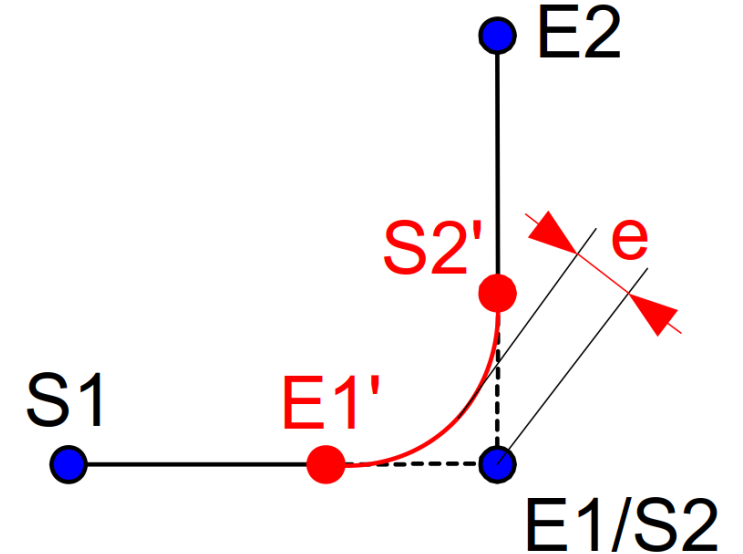
- *Circular Arc*
- *Close to corner*
- *Priority on speed*

Corner Distance



- *Parabolic Path*
- *Close to corner*
- *Corner distance max limit*

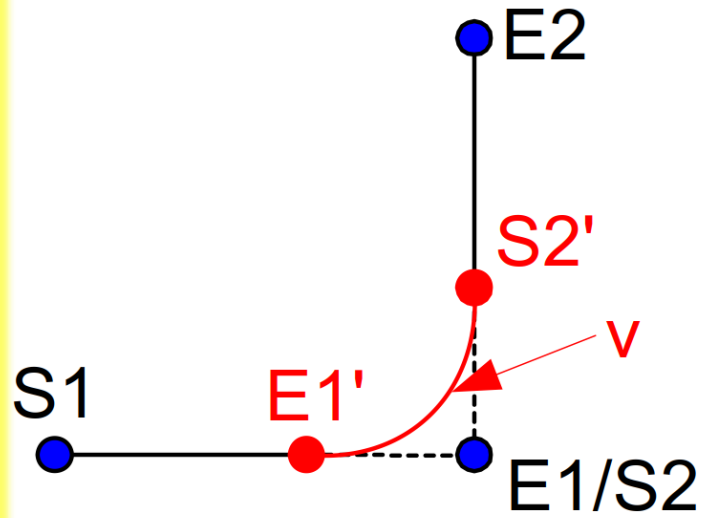
Corner Deviation



- *Parabolic Path*
- *Close to corner*
- *Corner deviation max limit*

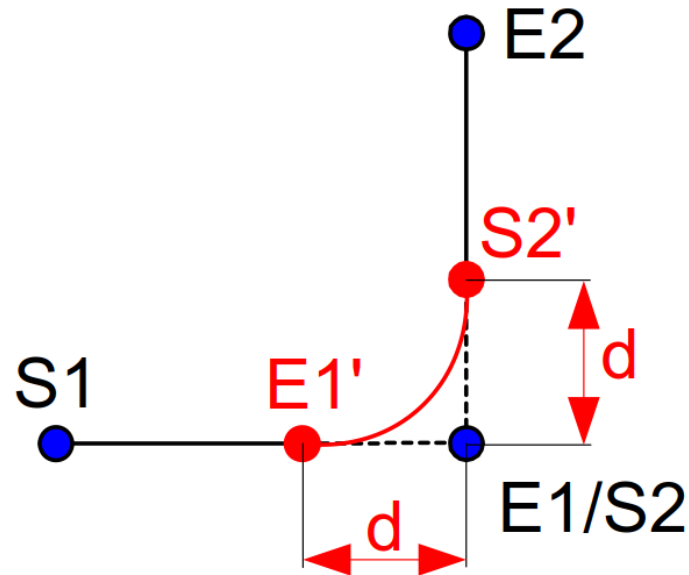
Transition Mode

Constant Velocity



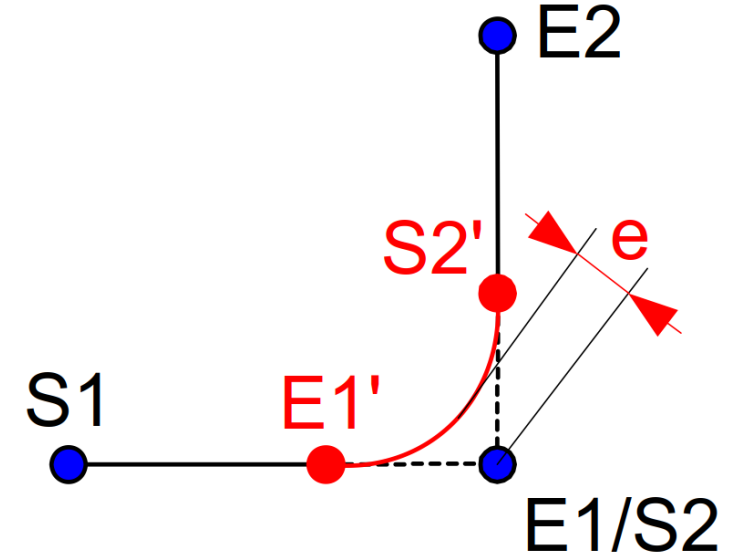
- *Circular Arc*
- *Close to corner*
- *Priority on speed*

Corner Distance



- *Parabolic Path*
- *Close to corner*
- *Corner distance max limit*

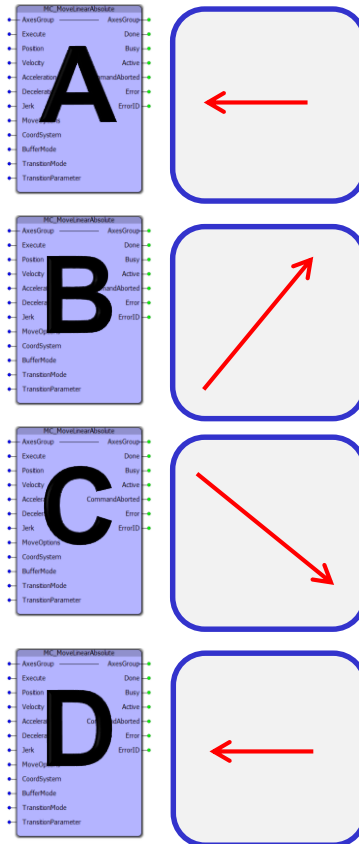
Corner Deviation



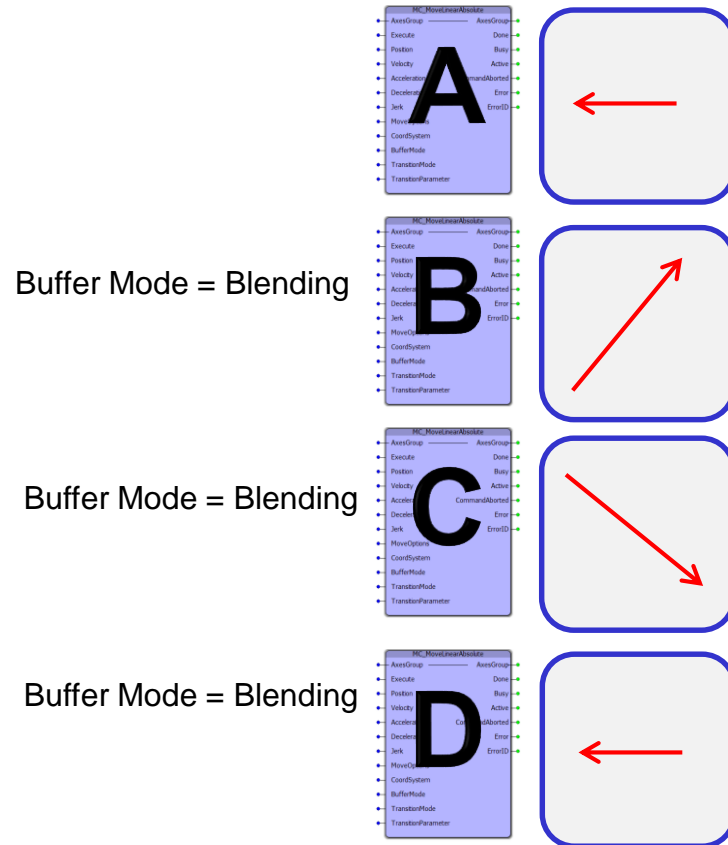
- *Parabolic Path*
- *Close to corner*
- *Corner deviation max limit*

Programming Overview

1. Sequence



Programming Overview

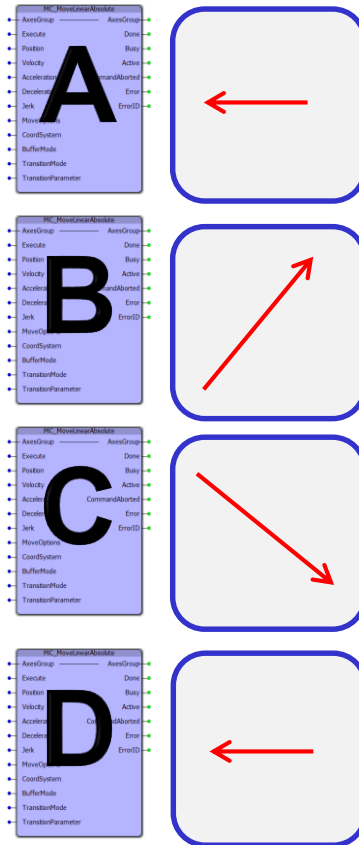


1. *Sequence*

2. *Buffer Mode*

- *Blending*
- *Execute*

Programming Overview



Buffer Mode = Blending
 Transition Mode = **2** (Constant Velocity)
 Transition Parameter 2 = **100** (%Speed)

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 Transition Mode = **2** (Constant Velocity)
 Transition Parameter 2 = **100** (%Speed)

1. *Sequence*

2. *Buffer Mode*

- *Blending*
- *Execute*

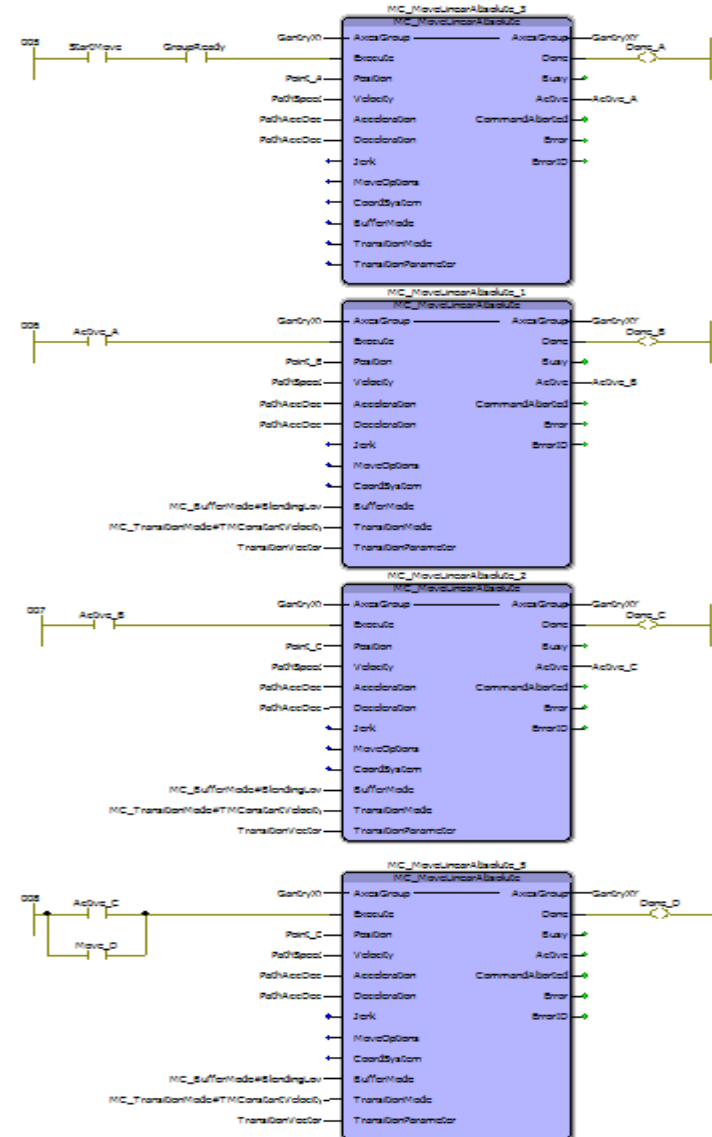
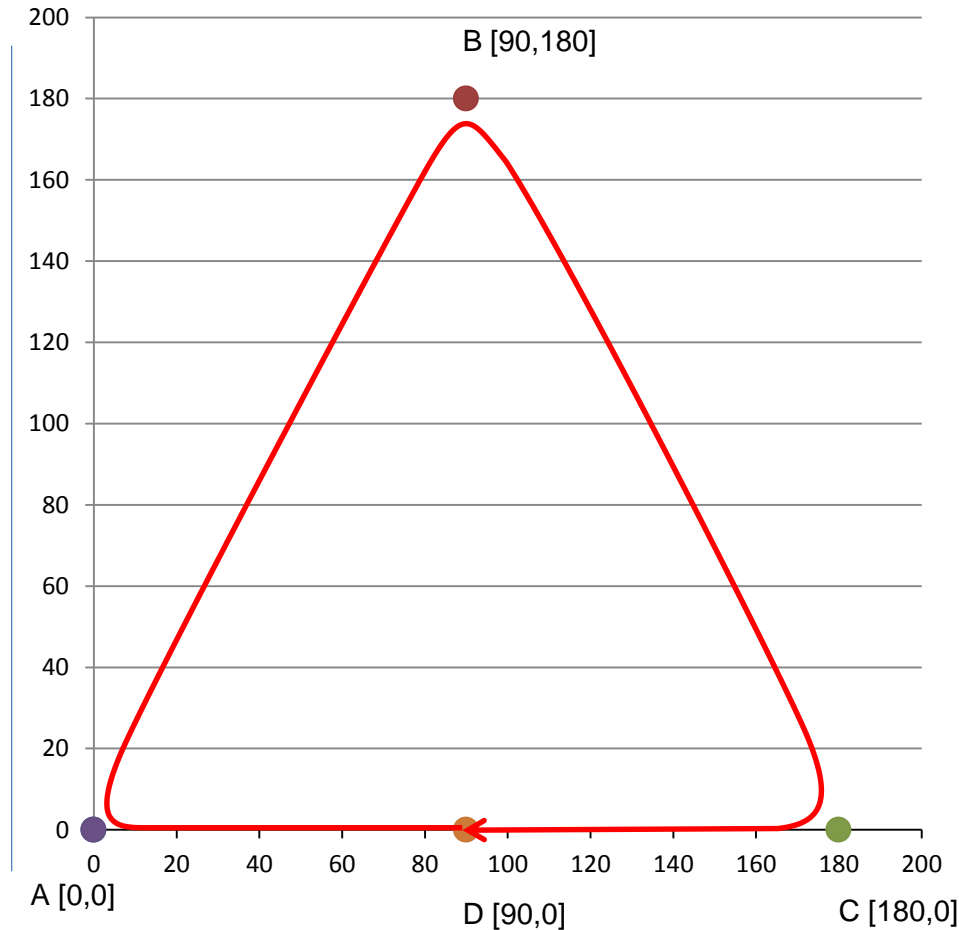
3. *Transition Mode*

4. *Transition Parameter*

Sequence

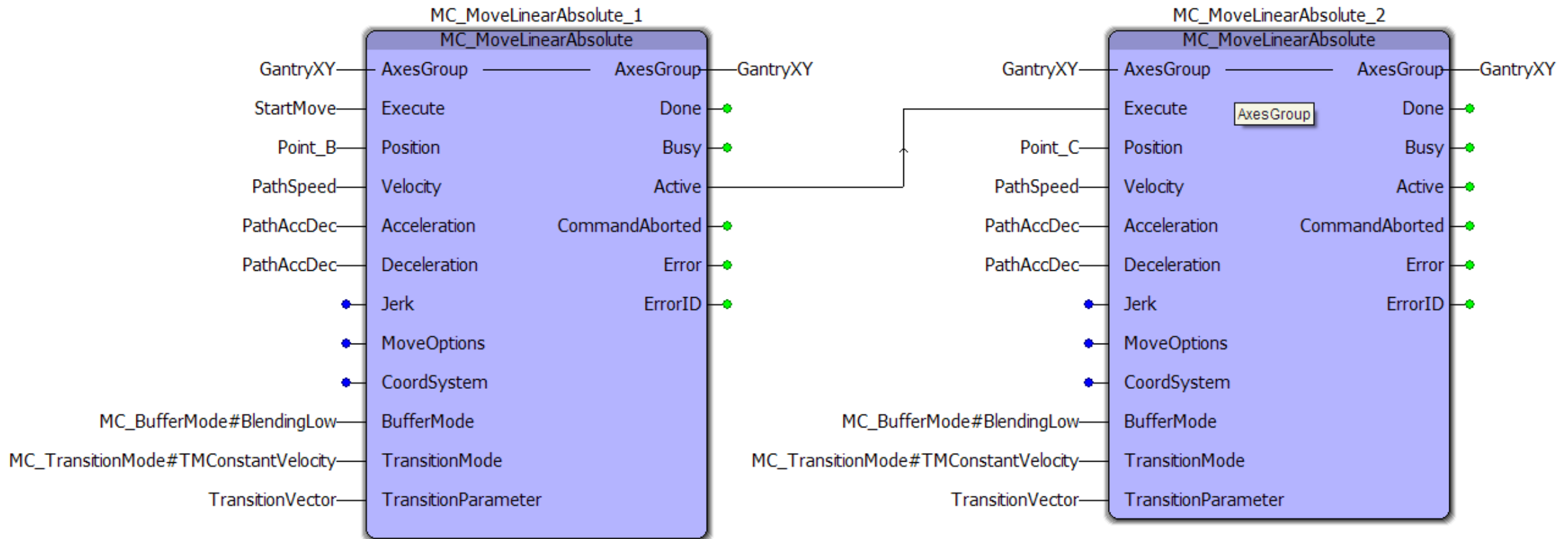
- Sequence the moves from top to bottom

- Point_A
- Point_B
- Point_C
- Point_D



Buffer Mode

- Use the Active output to sequence buffered moves



Transition Mode

- Use *MC_TransitionMode#TMConstantVelocity*
 - *ENUM datatype with value of 2*

Transition parameters			
Value	MC_Transition_Mode	Transition Parameters (Example)	Units
0	TMNone		n/a
1	TMStartVelocity	Parameters[1]:=100.0;	% of corner entry velocity
2	TMConstantVelocity	Parameters[2]:=100.0;	% of corner entry velocity
3	TMCornerDistance	Parameters[3]:=15.0;	User units of the axes in the group
4	TMMaxCornerDeviation	Parameters[4]:=15.0;	User units of the axes in the group
10	TMMLXBlend	Parameters[10]:=4.0;	Scale value 1 to 8. The MLX has a maximum blend radius pre configured.

MC_TransitionMode#TMConstantVelocity

Transition

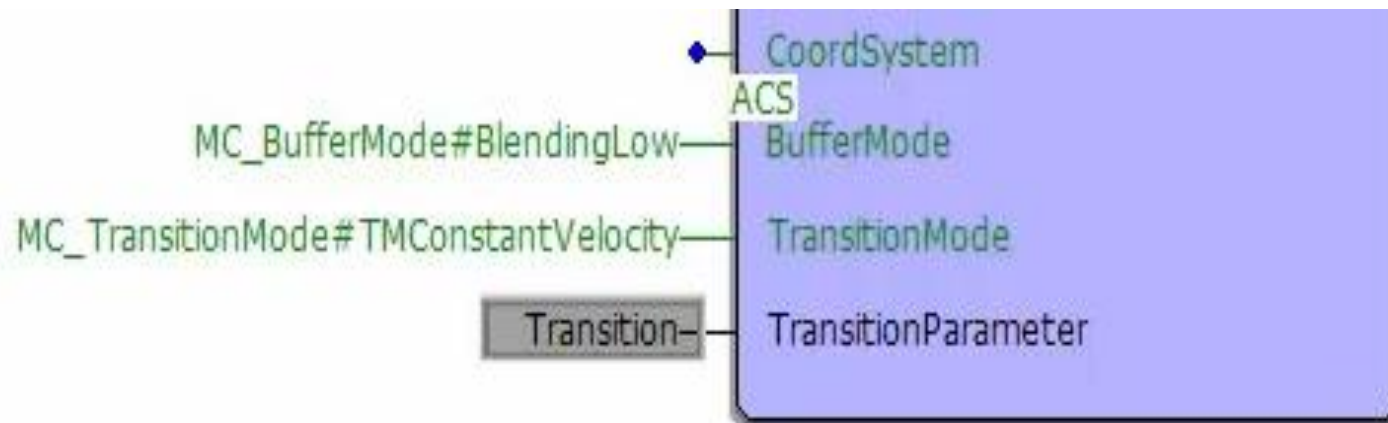
TransitionMode

TransitionParameter

Transition Parameter

- *Set Transition Parameter to 100%*
 - *Transition[2]:=100.0*

Transition parameters			
Value	MC_Transition_Mode	Transition Parameters (Example)	
0	TMNone		n/a
1	TMStartVelocity	Parameters[1]:=100.0;	% of corner entry velocity
2	TMConstantVelocity	Parameters[2]:=100.0;	% of corner entry velocity
3	TMCornerDistance	Parameters[3]:=15.0;	User units of the axes in the group
4	TMMaxCornerDeviation	Parameters[4]:=15.0;	User units of the axes in the group
10	TMMLXBlend	Parameters[10]:=4.0;	Scale value 1 to 8. The MLX has a r

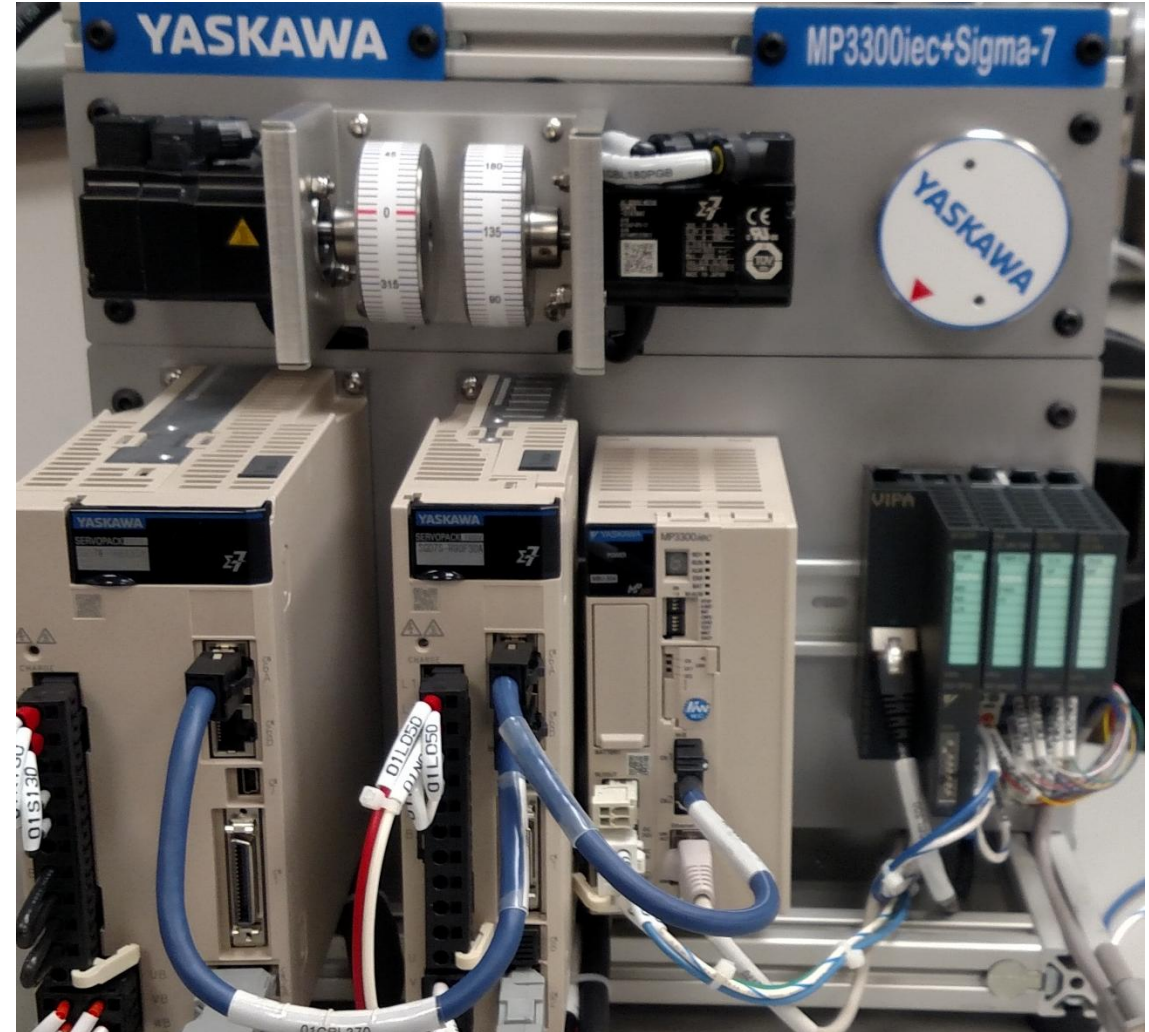


The screenshot shows a 'Watch Window' with a table of variables and their values. The variable 'Transition[2]' is highlighted in grey and has a value of 100.000001.

Variable	Value
Transition	
..... [1]	0.000000
..... [2]	100.000001
..... [3]	0.000000
..... [4]	0.000000
..... [5]	0.000000
..... [6]	0.000000
..... [7]	0.000000
..... [8]	0.000000
..... [9]	0.000000

Verification

1. *Make, Download*
 2. *Debug, Toggle Boolean*
 3. *Add to watch window*
 - *Point_A, B, C, D*
 - *GantryXY*
 - *Transition*
- *Set PathAccelDecel = 25.0*
 - *Low accel/decel exaggerates the corner*



Verification

- *Active Block*
- *Position Feedback*
- *Motor Wheel*

The screenshot displays the MotionWorks IEC 3 Pro software interface. The main window shows a PLC ladder logic diagram with several rungs. A graph window is overlaid on the diagram, showing a triangular path with vertices A [0,0], B [90,180], and C [180,0]. A hand icon is positioned at the bottom vertex D [90,0]. The graph axes range from 0 to 200 on both X and Y. To the right of the graph is an 'Edit Wizard' panel with a list of functions: ADD, AND, CTD, CTU, CTUD, DIV, EQ, F_TRIG, GE, GT, LE, LT, MOD, MOVE, MUL, and NE. Below the Edit Wizard is a 'Watch Window' showing the following data:

Variable	Value
GantryXY	
GantryXY.Machine.Actu...	60.9854050
GantryXY.Machine.Actu...	0.0001931
Point_A	
Point_B	
Point_C	
Point_D	
Transition	

At the bottom right of the software interface, there is a video feed window titled 'Indoor Pan/Tilt IP Camera' showing a physical Yaskawa motor unit with a hand wheel and various cables.

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