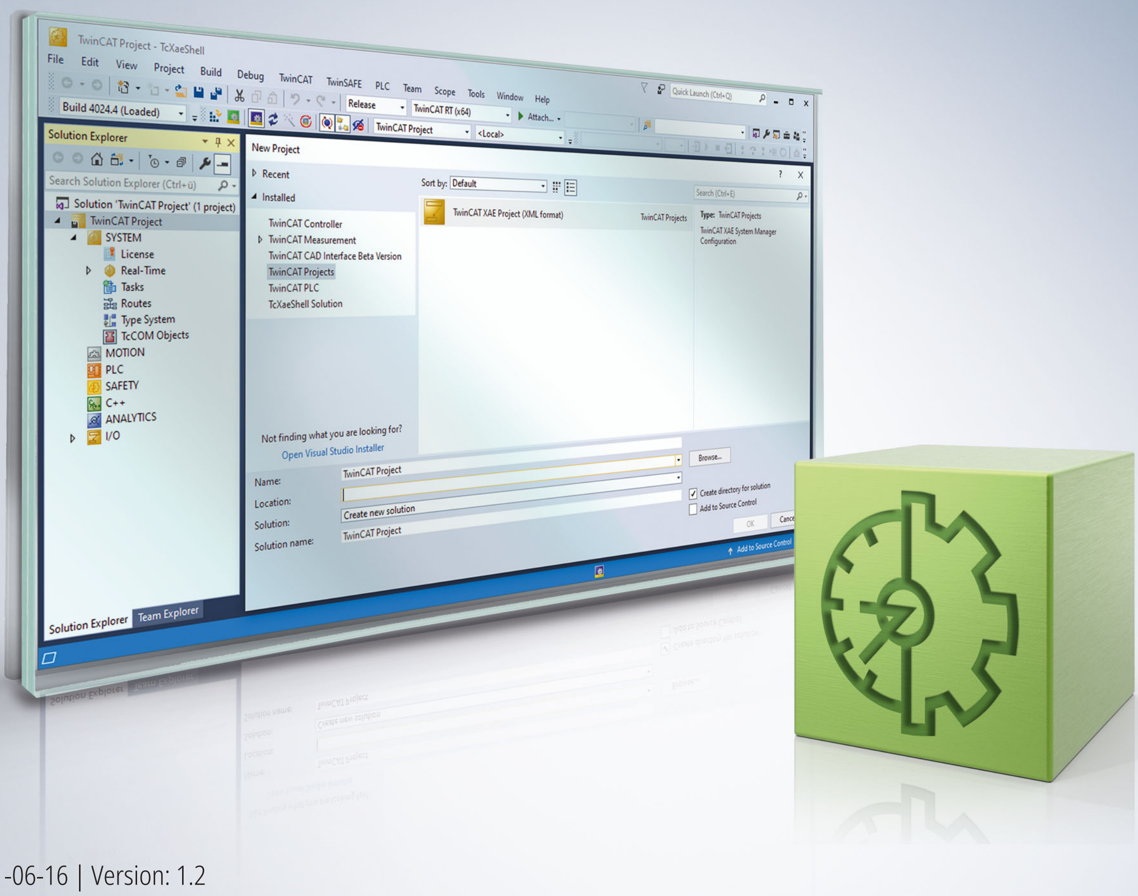
BECKHOFF New Automation Technology

Manual | EN

TE1510

TwinCAT 3 | CAM Design Tool



2021-06-16 | Version: 1.2

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1 Foreword

1.1 Notes on the documentation

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning the components.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.
We reserve the right to revise and change the documentation at any time and without prior announcement.
No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

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Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents:
EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702
with corresponding applications or registrations in various other countries.

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1.2 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

Description of symbols

In this documentation the following symbols are used with an accompanying safety instruction or note. The safety instructions must be read carefully and followed without fail!

⚠ DANGER

Serious risk of injury!

Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.

⚠ WARNING

Risk of injury!

Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.

⚠ CAUTION

Personal injuries!

Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.

NOTE

Damage to the environment or devices

Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.

Tip or pointer

This symbol indicates information that contributes to better understanding.

1.3 Notes on information security

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2 Introduction

A cam plate editor is used to design the motions for a cam plate.

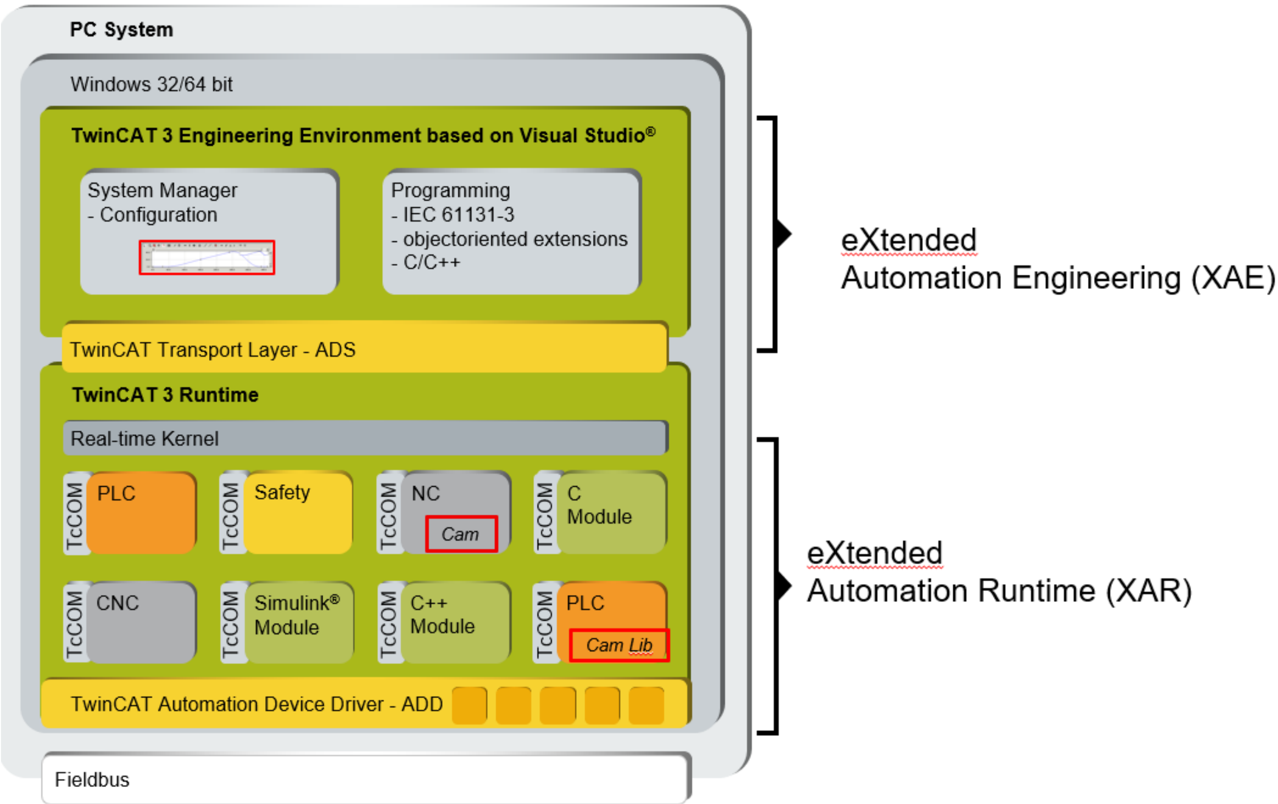
The cam plate editor is a flexible tool that provides optimum user support. The responsibility for the choice of parameters lies with you (the user). You should check carefully whether the start and end points meet the specification. The graphic display options provide optimum support for controlling velocities, accelerations and jerk.

Notwithstanding the wide range of options, please bear in mind the limits to possible motions imposed by physical constraints.

The CAM Design Tool is the cam plate editor of TwinCAT. It is integrated into the XAE engineering environment based on Visual Studio™. In the user interface it can be found under the **System Manager** (see diagram).

Cam plates that have been designed with the tool are stored in the respective project file. When the system is started, the cam plates are automatically transferred to the eXtended Automation Runtime (XAR).

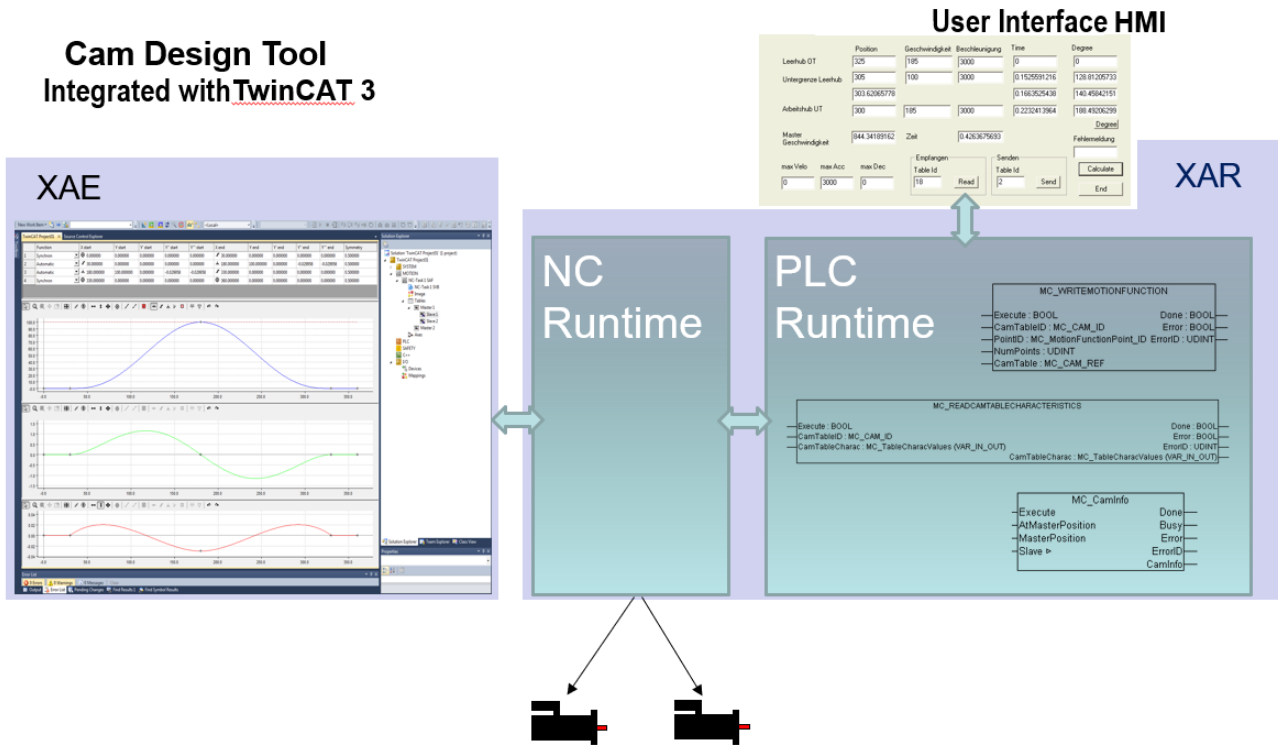
eXtended Automation (XA) architecture



In XAR, the NC includes the functionalities required for coupling cam plates. These extensive functionalities can be called by the PLC with the TC-NC Camming library (TF5050). In addition to the standard function blocks of PLC Open, the library also contains compatible function blocks with extended functionalities. The following overview illustrates the options available through interaction of the CAM Design Tool with the NC and the PLC.

It is also possible, for example, to upload cam plates generated by the PLC, which were loaded into the NC via a function block, into the CAM Design Tool.

A user interface (HMI) can be connected via the PLC.



Generate CAM offline: CAM Design Tool	Generate CAM online: PLC Code
Engineering: For designing a cam plate. • Motions are defined segment by segment. • The position, velocity and acceleration can be checked.	PLC: For use in the production machine. • A touch probe option is available. • The format can be changed via the HMI. • Facilitates checking of characteristic values, if required.

Information about the TF5050 PLC library can be found here.

PLC open Motion Control

The function blocks listed in the PLC library are based on:

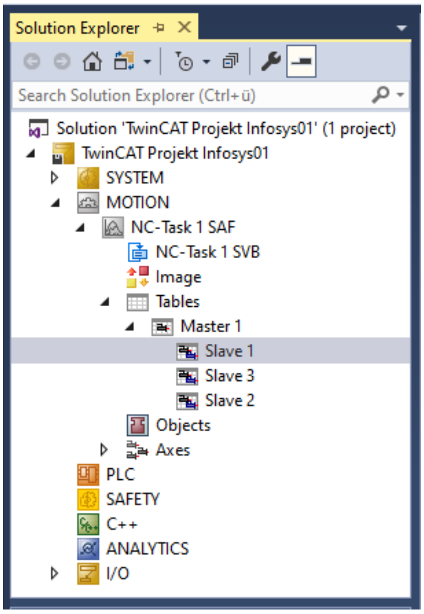
Technical Specification

- PLCopen - Technical Committee 2 - Task Force
- Function blocks for motion control

Create project

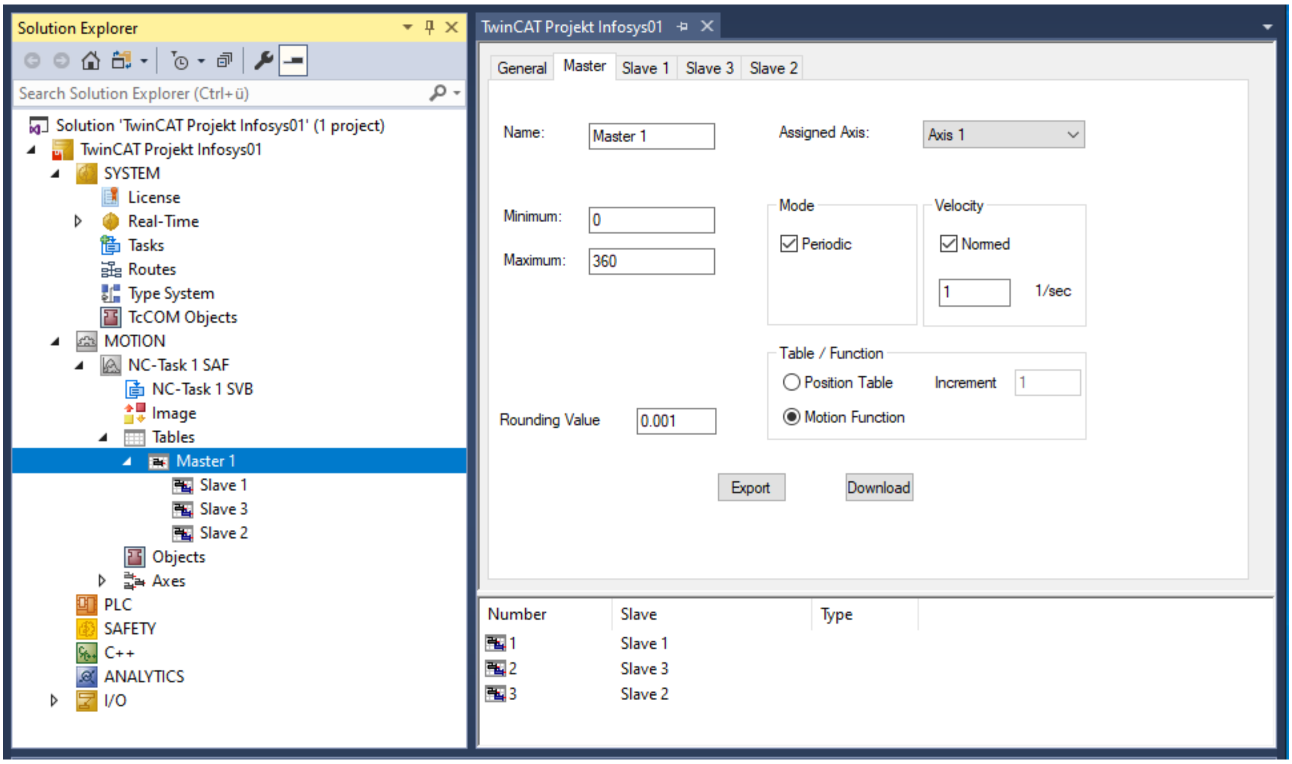
> A license is required to access the full functionality of the TE1510 CAM Design Tool, see Licensing [▶ 14].

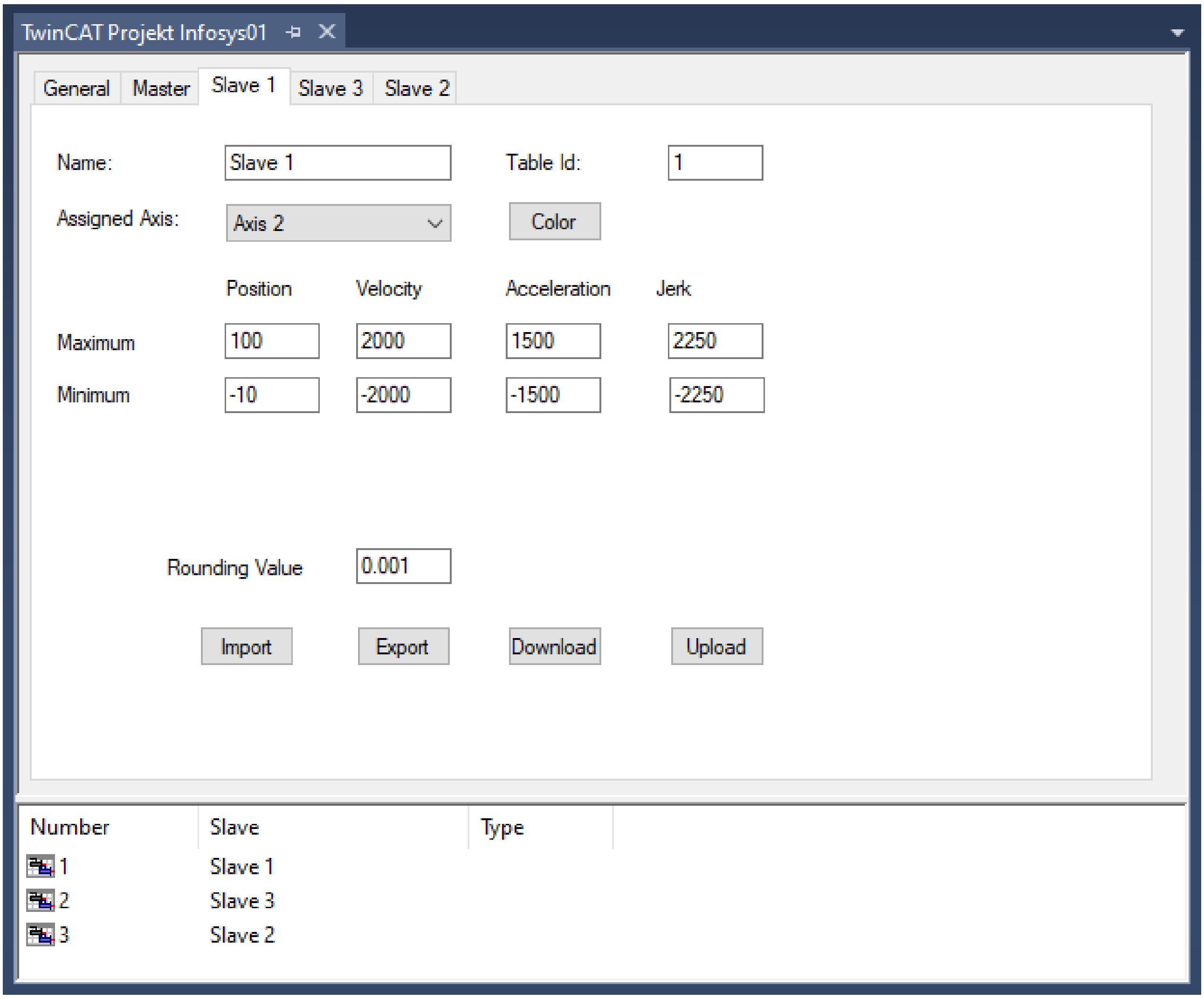
The cam plate editor integrated in TwinCAT 3 can be found in a Twin CAT project under **MOTION > Tables**.



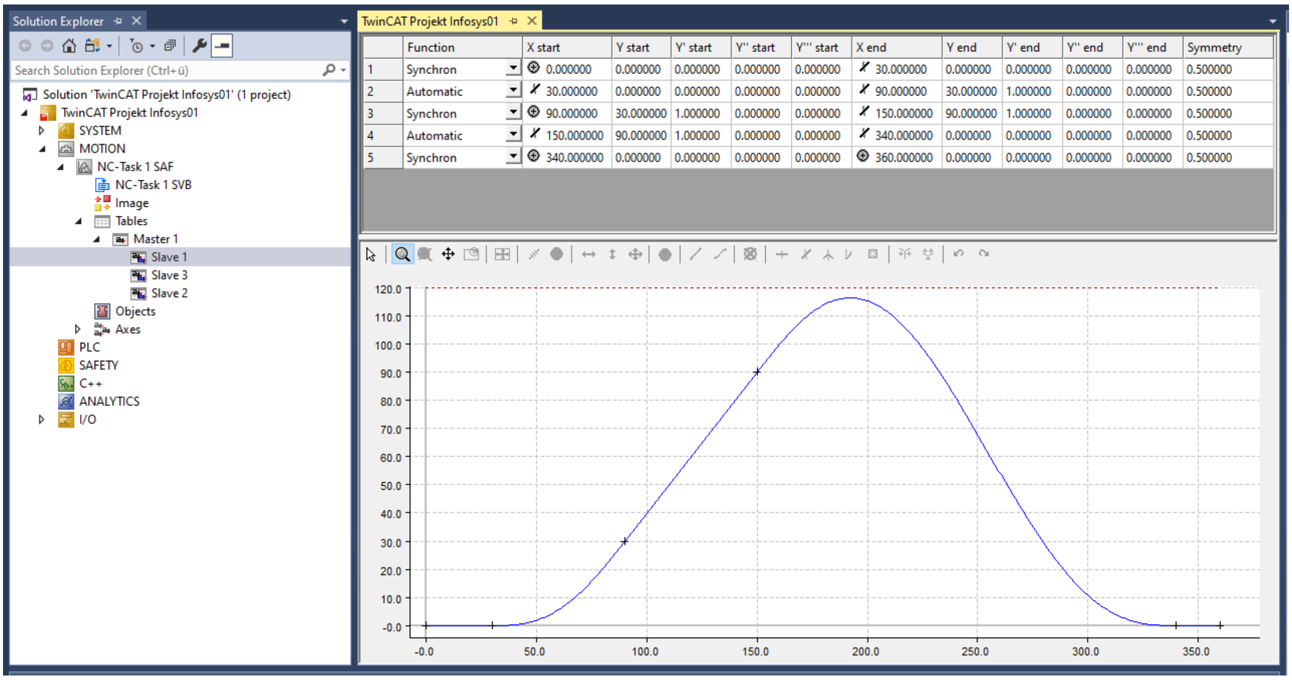
Here you can insert additional **Masters** and below that corresponding **Slaves** by right-clicking.

Click the **Master** in the structure tree to open the property pages. Not only the properties of the Master [▶ 15] but also those of the associated Slaves [▶ 17] can be set on these pages.





The general procedure for designing a cam plate is based on VDI Guideline 2143. The rough design of the motion - the motion plan - defines the start and end points of the motion section. However, the cam plate editor does not differentiate between the motion sketch and the motion diagram containing the detailed motion description.

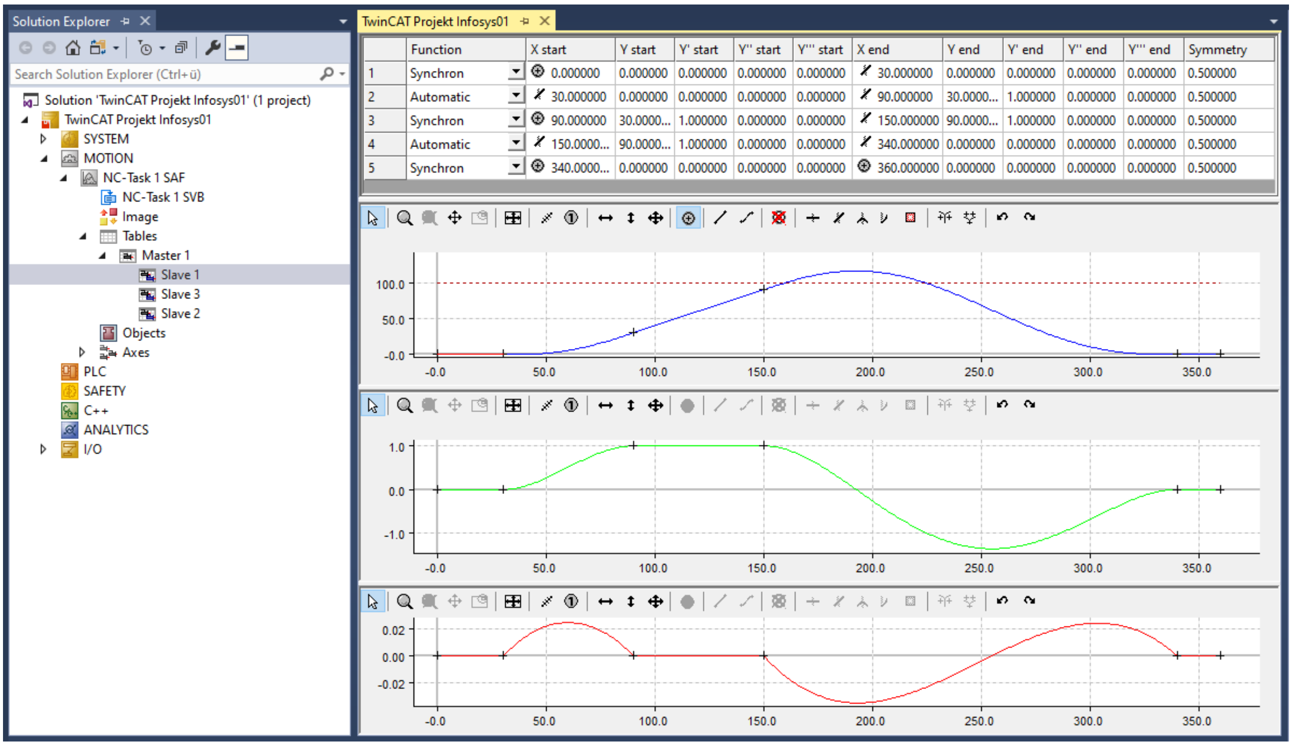


The user's interface to the cam plate editor is largely graphic. Following interactive graphic entry of the points in the graphic window, the co-ordinates of the points are displayed in the table window above it.

New points can only be inserted in the graph, and it is only possible to delete existing points via the graph. The properties of the points - the co-ordinate values or their derivatives - can also be interactively manipulated in the table window.

The following parameters can be displayed in the graphical area:

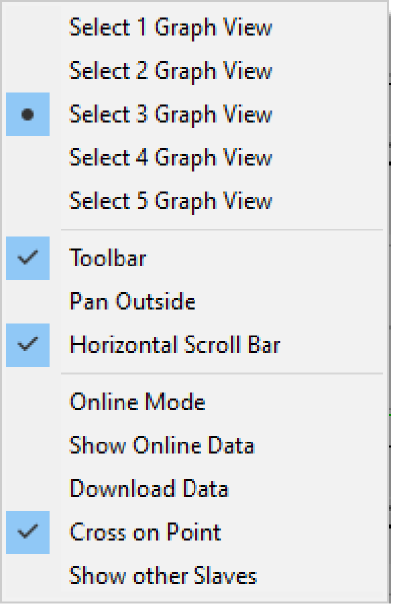
- position,
- velocity,
- acceleration,
- jerk.



Change display

✓ The mouse pointer is in the graphic window.

1. Right-click.
2. Select the desired views in the menu window.



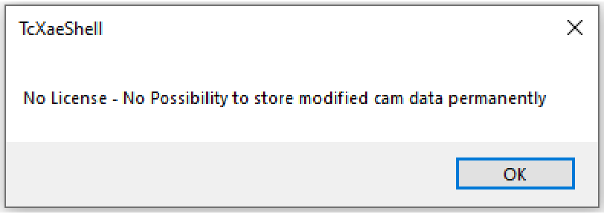
⇨ For example, a separate graphic window [▶ 19] is created for each derivative.

3 Licensing

The functionality of the CAM Design Tool is included in the XAE of TwinCAT, which means there is no need to download an additional software module. A license is required to save a cam plate in a project file. See "Ordering and activation of TwinCAT 3 standard licenses".

Once a cam plate has been created in a project it cannot be changed, but it remains in the project. A license is only required on the workstations on which cam plates are designed or modified.

If no license is available at the workstation, a message is displayed the first time a new cam plate is created, which the user must confirm:



Required licenses:

TE1510 CAM Design Tool

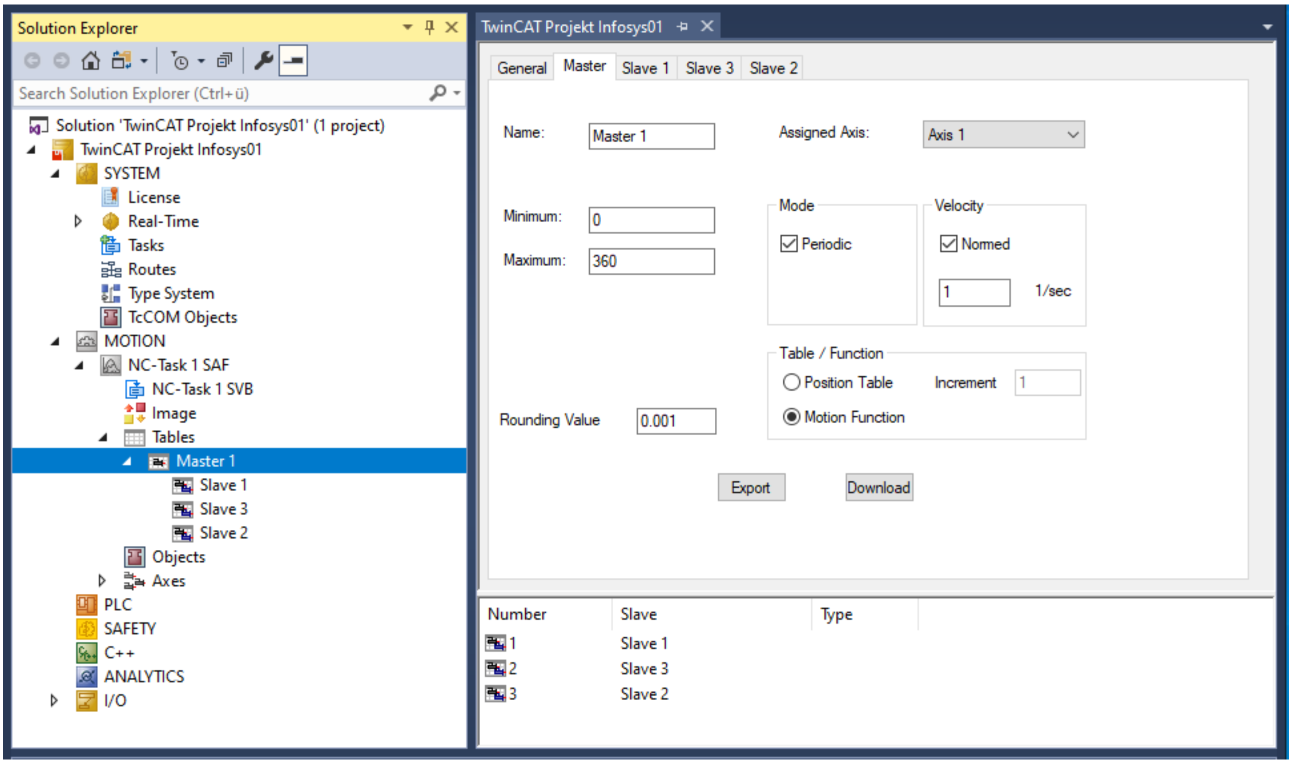
This license is an engineering license and must be activated on the engineering system. For testing purposes, a demo mode simulation can be used without a license.

Restrictions in the demo version

Cam plates generated without a license can be loaded into the XAR. However, they are ignored when the project is saved.

4 The Properties of the Master

On the property page of the master, the **minimum** and **maximum** of the master position can be set.



Velocity

The **Normed** checkbox can be used to choose between the normalized display and a physical display that shows the velocities, accelerations and jerk of the slaves as a function of time. The normalized display refers these displays to the master position.

Mode

For the physical representation the velocity of the master is required. First, a distinction is made between a **linear axis and a rotary axis** (values are given as angles in degrees). The choice between linear and rotary axis determines the table type – linear or cyclic – for transferring the data to the numerical control (NC).

For a **rotary Master**, the first and second derivatives at the end are set equal to the corresponding figures at the start of the motion cycle, if the start and end positions of the slave correspond to the minimum and maximum positions of the master.

Table/Function

The **Position table** function is used to select the tables with the table values (master value, slave value) at a defined distance from the master values (increment).

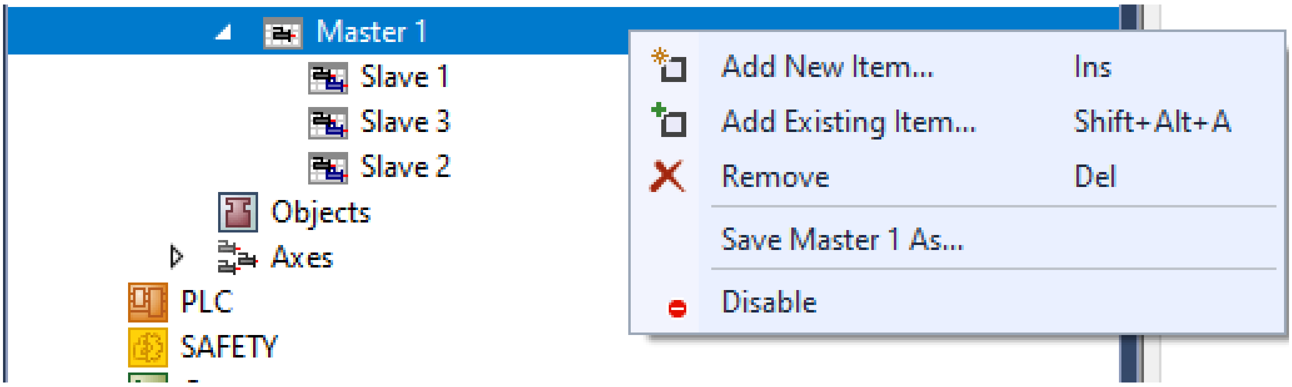
The **Increment** function defines the increment of the master position for outputting the tables to a file. If an equidistant table is to be generated, the total length (the actual maximum minus the minimum) should be divisible by the increment. When the configuration is activated, the information for creating and transferring the tables with this increment to the NC is generated automatically.

Motion Function can be used to transfer the complete slave information to the NC. This means that only the edge points of the segments and the corresponding information, such as the law of motion, are loaded into the NC. The NC then calculates the corresponding slave values (position, velocity and acceleration) for the current master position during runtime. Past problems that had their origin in the discretization of the data in the table essentially no longer exist.

Functionalities such as special motion laws that are not yet available in the NC are marked in red in the cam plate editor. These may not be selected.

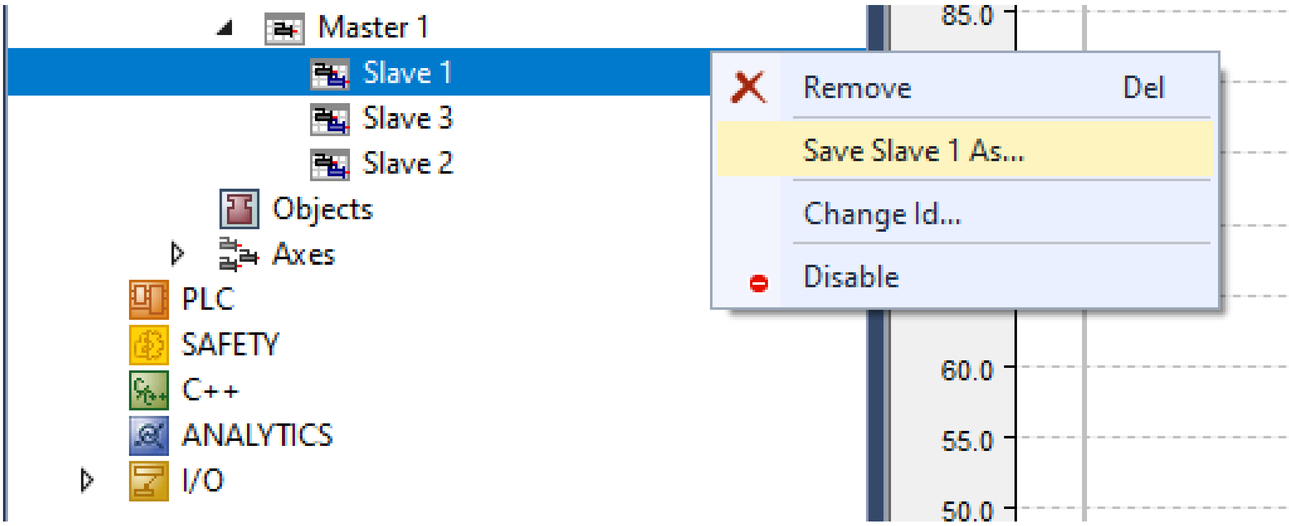
The **Rounding Value** rounds the master position in the graphic input with the given value.

Importing slaves



- Right-click the master in the tree view and select the **Add existing element**.

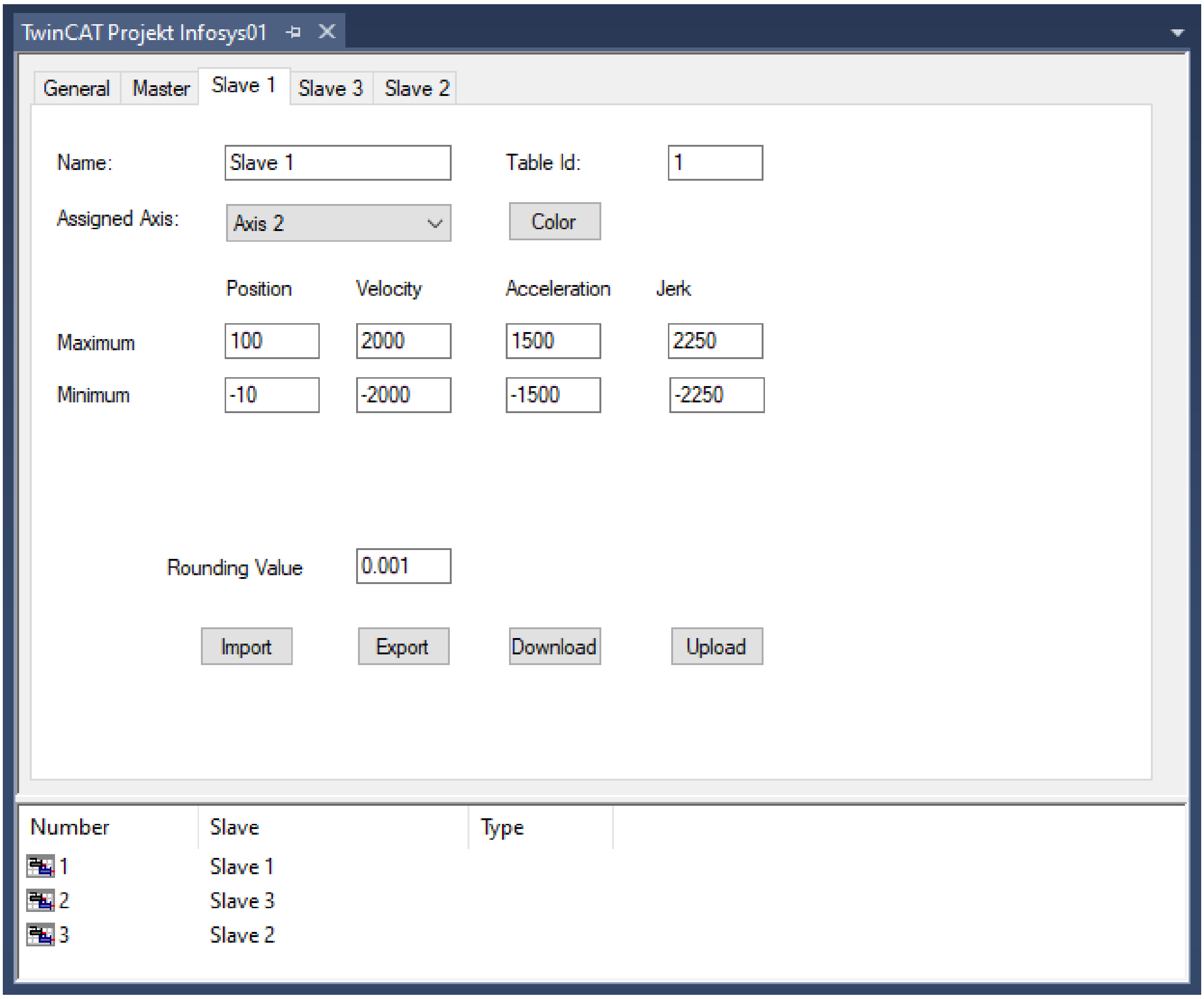
Saving and exporting slaves



1. Right-click the slave in the tree view and select **Save slave 1 as**.
2. Save the file as an export file (*.xti).

⇨ The data can be imported via the tree view under **Master**.

5 The Properties of the Slave



Settings on the property page of the slave

- Maximum and minimum position,
- Velocity,
- Acceleration,
- Jerk.

These values can be used as initial specifications when the graphic window is first displayed.

The current values in the diagram can be adjusted in the respective graphic window with the command

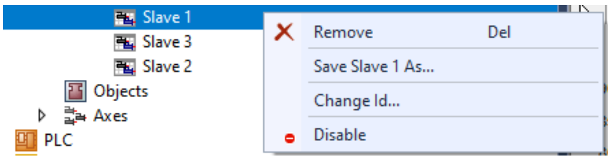
Adjust extreme values  .

Button/Input	Description
Rounding value	Rounds the slave positions in the graphical input with the specified value.
Export	The Export button can be used to store the slave values in a line in an ASCII file in the form master and slave position. The master position increment is specified in the master's property page.
Import	The Import button can be used to import files in the form just described. The values can then be displayed as cubic splines. The type of the spline still needs to be adjusted in the table, according to the values.
Download	The Download button can be used to transfer the current data to the NC, as long as the slave is not coupled, since the tables are deleted completely and refilled with data.
Upload	The Upload button can be used to upload the function information from the NC. Existing data are deleted entirely, and the NC data can be manipulated in the table as well as in the graphic.
Table ID	The Table Id provides a unique identifying number (1-4095) for the table, with the aid of which the table data is stored in the NC.

When uploading cyclic data, the period length of the master must match that of the loaded data. The master can be set to linear (non-cyclic) for direct data checking.

Table ID

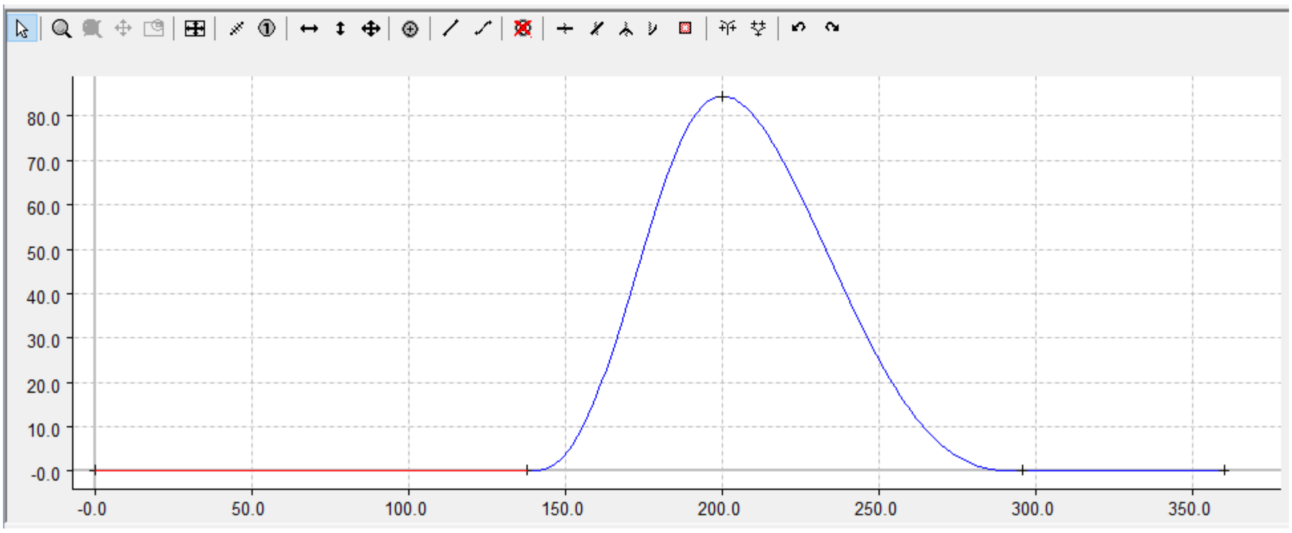
The table ID can be changed by right-clicking the slave in the tree view and selecting the command **Change ID**.



The option **Save Slave...** can be used to save the motion diagram data in an export file (*.xti). This data can be imported again under a master.

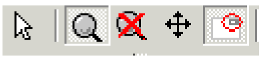
6 Graphic Window

The slave's position and derivatives are each shown in separate graphic windows.

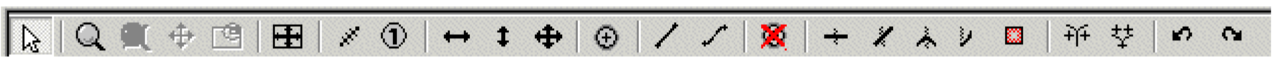


Toolbar

The toolbar of the graphic window contains buttons that only refer to the diagram:



as well as the special commands for the cam plate editor:



The graphic commands are divided into:

- **Input mode**: 

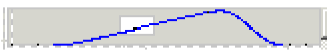
There are also zoom and move commands:

-  **Zoom**
-  **Zoom all**
-  **Move:** This command only becomes active when the zoom command has been called.

If you activate the menu item **Pan Outside**, you can move across boundaries.
Pan Outside can be activated via the menu of the graphic window by right-clicking.

 **Overview window on/off**

The window can only be enabled via the button  if you have zoomed into the window.



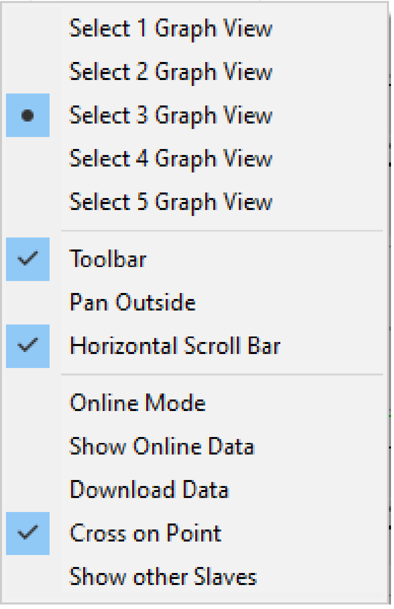
If the **overview window** is activated, the window not only shows which section the graphic is in, you can also move the section or zoom into a new section.

The **horizontal** and **vertical scrollbars** allow you to move the **graphic section**. The horizontal scrollbar applies to all graphic windows simultaneously.

If you use an IntelliMouse with a scroll wheel, you can zoom using the scroll wheel.

Show/hide toolbar

The toolbar containing the commands can be shown or hidden by right-clicking (in the graphic window) the following menu:



If the **Horizontal scrollbar** option is enabled, a horizontal scrollbar is available for this window. All horizontal scrollbars are synchronized.

The **Cross on Point** option causes the start and end points of motion sections to be indicated by a cross.

The **Show online data** option displays the table data currently in the NC with the corresponding table ID as a cubic spline. Currently this can result in a distorted display, because the linear tables are displayed as natural splines (second derivative at the edges equals null). The data is displayed in the same color, but somewhat darker.

The data is automatically transferred by ADS, as soon as **Online Mode** is switched on. The current data can be read by switching the mode on and off.

When the configuration is activated, the information for creating and transferring the tables to the NC is generated automatically.

Use **Download data** to transfer the data to the NC. In this case the restriction applies that the slave is not coupled for the **function** (The Properties of the Slave [▶ 17]). In other words, only the data is transferred.

7 Tables Window

The values for the motion section are displayed in the table window:

	Function	X start	Y start	Y' start	Y'' start	Y''' start	X end	Y end	Y' end	Y'' end	Y''' end	Symmetry
1	Synchron	0.00…	0.00…	0.00…	0.000…	0.000…	30.00…	0.00…	0.000…	0.000000	0.000000	0.500000
2	Automatic	30.0…	0.00…	0.00…	0.000…	0.000…	150.0…	20.0…	0.222…	0.000000	0.000000	0.500000
3	Synchron	150.…	20.0…	0.22…	0.000…	0.000…	240.0…	40.0…	0.222…	0.000000	0.000000	0.500000
4	Automatic	240.…	40.0…	0.22…	0.000…	0.000…	340.0…	0.00…	0.000…	0.000000	0.000000	0.500000
5	Synchron	340.…	0.00…	0.00…	0.000…	0.000…	360.0…	0.00…	0.000…	0.000000	0.000000	0.500000

Table header	Description
Function	Indicates the function type (see function types).
X start	Initial value of the master position. (The icon in front of the value indicates the type of the point.)
Y start	Initial value of the slave position.
Y' start	Initial value of the slave velocity.
Y'' start	Initial value of the slave acceleration.
Y''' start	Start value of the slave jerk.
X end	End value of the master position. (The icon in front of the value indicates the type of the point.)
Y end	End value of the slave position.
Y' end	End value of the slave velocity.
Y'' end	End value of the slave acceleration.
Y''' end	End value of the slave jerk.
Symmetry	Symmetry value of the law of motion.

You can change the values using the keyboard.
The restrictions imposed by the choice of the function type or the boundary conditions for the points are taken into account.

Since motion sections are normally contiguous - except for **Slide Points** - the end point and its derivatives at the end of the section is equal to the corresponding values at the start of the following motion section.

Therefore, you should normally always manipulate the initial values.

In addition, if you find any discrepancies in a finished motion diagram, check that the start and end points match.

If certain values in the table cannot be changed, you should reconsider the boundary conditions of the points and change them if necessary.
The boundary conditions limit the scope of the functions in sections in accordance with their type.

The symmetry of the functions can only be changed for the following types:

- Polynomial3,
- Polynomial5,
- Polynomial8,
- Sineline,
- ModSineline,
- Bestehorn,
- AccTrapezoid.

Normally the inflection on the curve (acceleration = 0) at 50 % = 0.5.

This value can be modified not only in the table, but also in the graph (see Example 6 [▶ 37]).

Function Types

In addition to the standard types (synchronous/automatic), which can be changed by command on the graph, the function type can also be modified in the combobox. When the combobox - or a field in the first column - is first clicked, a rectangle is temporarily shown in the position window, with the start and end points of the section at its corners. As soon as another field in the table window is tapped, either the rectangle for this field is shown or no rectangle.

The types correspond to those of VDI Guideline 2143. In addition, the cubic splines with the boundary conditions natural, tangential and periodic are added.

Type	Description	Boundary condition
Synchronous	Synchronous motion (constant transmission ratio between slave and master, corresponds to normalized velocity).	Constant velocity v, acceleration a=0
Automatic	Automatic adaptation to the boundary values (velocity, acceleration).	
Polynomial3	3rd order polynomial	v=0, a=0
Polynomial5	5th order polynomial (restricted version rest in rest)	v=0, a=0
Polynomial8	8th order polynomial	v=0, a=0
Sineline	Sineline (see VDI Guideline 2143)	v=0, a=0
ModSineline	Modified Sineline (see VDI Guideline 2143)	v=0, a=0
Bestehorn	Bestehorn Sineline (see VDI Guideline 2143)	v=0, a=0
AccTrapezoid	Acceleration trapezoid	v=0, a=0
SinusSyncKombi	Sineline combination	v=0, a=0
ModSineline_VV	Modified Sineline for velocity in velocity.	a=0
HarmonicKombi_RT	Harmonic combination of rest in turn.	v=0; start point: a=0
HarmonicKombi_TR	Harmonic combination of rest in turn.	v=0; end point: a=0
HarmonicKombi_VT	Harmonic combination of velocity in turn.	Start point: a=0; end point: v=0
HarmonicKombi_VT	Harmonic combination of turn in velocity.	Start point: v=0; end point: a=0
AccTrapezoid_RT	Acceleration trapezoid for rest in turn.	v=0; start point: a=0
AccTrapezoid_RT	Acceleration trapezoid for turn in rest.	v=0; end point: a=0
Polynomial7_MM	7th order polynomial with adaptation to the boundary values (velocity, acceleration and jerk).	
Spline	Internal section of a cubic spline.	
Spline Natural	Start or end section of a natural cubic spline.	a=0
Spline Tangential	Start or end section of a tangential cubic spline.	
Spline Periodic	Start or end section of a cyclic cubic spline.	
Polyline	Start or end section of a linear spline.	

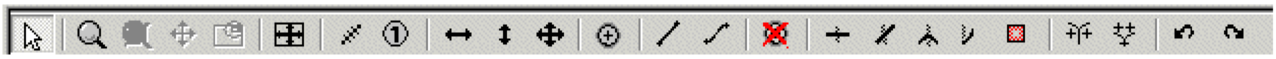
Changing the type of spline at the first point implies that the spline type as a whole is changed, including that of the end point.

If you select the **Spline Tangential** spline type, you should modify the boundary conditions (first derivative at the start point and end point).

For the laws of motion with boundary conditions, **R** stands for rest, **V** for velocity, **T** for turn and **M** for Motion.

8 Commands

Toolbar



The commands of the cam plate editor, which can be called up via the toolbar of the respective graphic window, can only be called up if the input mode  for the graphic commands  is enabled.

The commands only apply to the respective window.

 Adaptation to extreme values

The window's co-ordinates are adjusted to the extreme values of the motion.

 Measure distance

The horizontal and vertical distance to the current point from the point first clicked with the left mouse button is displayed at the top right hand corner of the window (please hold the mouse button down for this).

 Current position

The absolute horizontal and vertical position of the point currently clicked with the left mouse button is displayed at the top right hand corner of the window (please hold the mouse button down for this).

Horizontal shift

This command can be used to move the selected point horizontally.

In the velocity window for **synchronous functions**: shift along a straight line in the position window.

The left-hand edge of the graphic area can be temporarily moved in this way, so that the scale can be more easily read.

 Vertical shift

This command can be used to move the selected point vertically.

In the velocity window for **synchronous functions**: adjustment of the position in the position window to the velocity.

In the acceleration window for **automatic function**: adjustment of the acceleration.

 Shift

This command can be used to move the selected point.

The following commands only apply in the graphic window for position:

Insert point

This command can be used to insert a point at the cursor position.

Synchronous function

The chosen section is passed through with a synchronous function.

Automatic function

An optimal function is automatically selected for the selected section,

including adjustment of the boundary values.

Delete point

The selected point is deleted, as is the corresponding section.

The following four items define specific boundary conditions for the points:

The point type is displayed in the table window before the point. This restriction can mean that the end value of a section does not agree with the initial value for the following section.

Rest point

The selected point is defined as a rest point (boundary condition: v=0, a=0).

Velocity point

The selected point is defined as a velocity point (boundary condition: a=0).

Turning point

The selected point is defined as a turning point (boundary condition v=0).

Motion point

The selected point is defined as a motion point (no boundary conditions).

Ignore point

The selected point is defined as an ignore point. When downloading to the NC as **a Motion Function**, it is transferred as IGNORE POINT. It is ignored in the display and during download as table point. This selection can be reset by setting one of the upper four point types.

Slide point

The starting position of the following section or the end position of the previous section is set at the cursor position, without changing the selected section.

The point can then be moved on to the section using horizontal shift.

Delete slide point

The slide point is deleted and the sections are joined together as they were previously.

Undo

The last change command of the slave is undone. This command can be used several times.

Redo

The last undo command is undone, and the data is restored accordingly. This command can be used several times.

9 Examples

9.1 Overview

The following simple samples illustrate the basic procedure for creating a motion diagram.

Example 1:

Example 1 [▶ 27]

For a rotary motion, a specific linear motion of the slave is to occur in a specified area of the master position.

Example 2:

Example 2 [▶ 29]

For a rotary motion, a specific slave position should be passed through at a defined velocity at a prescribed master position.

Example 3:

Example 3: [▶ 30]

For a rotary motion, a specific linear motion of the slave is to occur in a specified area of the master position. The motion has no rest.

Example 4:

Example 4: [▶ 32]

Synchronization to a given specific motion.

Example 5:

Example 5: [▶ 34]

A rest in turn motion is to be realized.

Example 6:

Example 6: [▶ 37]

For a rest in rest motion, the accelerations are to be adapted by graphically and interactively changing the symmetry value.

Example 7:

Example 7: [▶ 39]

A given motion is to be amended.

9.2 Example 1

The procedure for creating a motion diagram is illustrated in this simple example.

The task:

The following slave motion is to be implemented for a rotation of the master axes from 0 to 360 degrees.

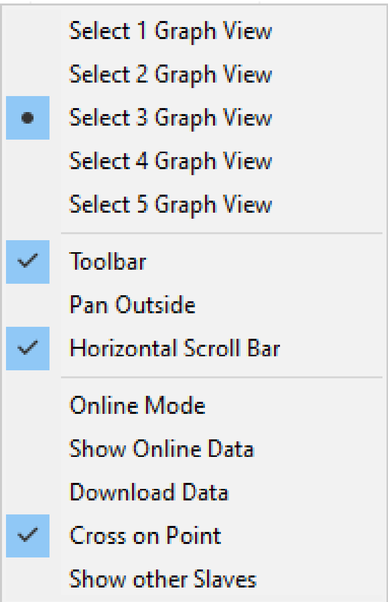
1. A rest (stationary slave axis) between 0 and 30 degrees.
2. A linear motion from 150 to 240 degrees from slave position 20 mm to slave position 40 mm.
3. A rest (stationary slave axis) between 340 and 360 degrees.
4. The other motion sections are to join those mentioned above smoothly and with limited jerk.

- In the tree structure, create a master and its corresponding slave via **MOTION > Tables** (see Introduction).
- After selecting **Slave 1** in the tree structure, both the **graphic window** and the **table window** appear.
- In the graphic window, click the approximate positions of the points in the window using the Insert Point [▶ 25] command.

The corresponding values will then be inserted into the table window.

- To turn the motion plan into a motion diagram, you now need to add some information.
- For the first, third and fifth sections we use the **Synchronous Function** command to specify by clicking with the mouse in the corresponding sections that a linear motion should take place there. In the second and fourth sections, the **Automatic Function** command is used to implement automatic adaptation to the boundary conditions.
- You can now use the move commands to manipulate the position of the points.

By right-clicking and selecting **Select Graph 3 View**, the velocity in the second graph window and the acceleration in the third graph window are displayed in addition to the slave position in the first graph window.

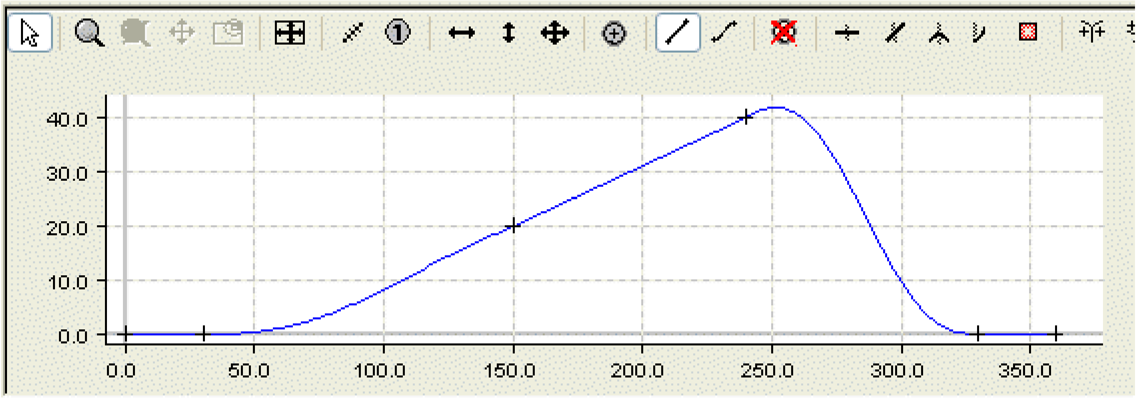


The size of the windows can be changed interactively by positioning the mouse on the edge and moving it with a left click.

- To ensure that the exact positions are realized, enter them now in the table view.

	Function	X start	Y start	Y' start	Y'' start	Y''' start	X end	Y end	Y' end	Y'' end	Y''' end	Symmetry
1	Synchron	0.00…	0.00…	0.00…	0.000…	0.000…	30.00…	0.00…	0.000…	0.000000	0.000000	0.500000
2	Automatic	30.0…	0.00…	0.00…	0.000…	0.000…	150.0…	20.0…	0.222…	0.000000	0.000000	0.500000
3	Synchron	150.…	20.0…	0.22…	0.000…	0.000…	240.0…	40.0…	0.222…	0.000000	0.000000	0.500000
4	Automatic	240.…	40.0…	0.22…	0.000…	0.000…	340.0…	0.00…	0.000…	0.000000	0.000000	0.500000
5	Synchron	340.…	0.00…	0.00…	0.000…	0.000…	360.0…	0.00…	0.000…	0.000000	0.000000	0.500000

The same (basic) commands that can be used in MS Excel can be applied in the table. Cutting and pasting is possible within each cell.



The motion diagram that has been created can be saved as a file in the slave's properties window.

9.3 Example 2

The procedure for creating a motion diagram is illustrated again in this next simple example.

The task:

The following slave motion is to be implemented for a rotation of the master axes from 0 to 360 degrees.

1. A rest (stationary slave axis) between 0 and 50 degrees.
2. A velocity of -0.4 (normalized) at master position 150 and slave position 45.
3. A rest (stationary slave axis) between 270 and 360 degrees.

- In the tree structure, create a master and its corresponding slave via **MOTION > Tables** (see Introduction).
- After selecting **Slave 1** in the tree structure, both the **graphic window** and the **table window** appear.
- In the graphic window, click the approximate positions of the points in the window using the Insert Point [▶ 25] command.

The corresponding values will then be inserted into the table window.

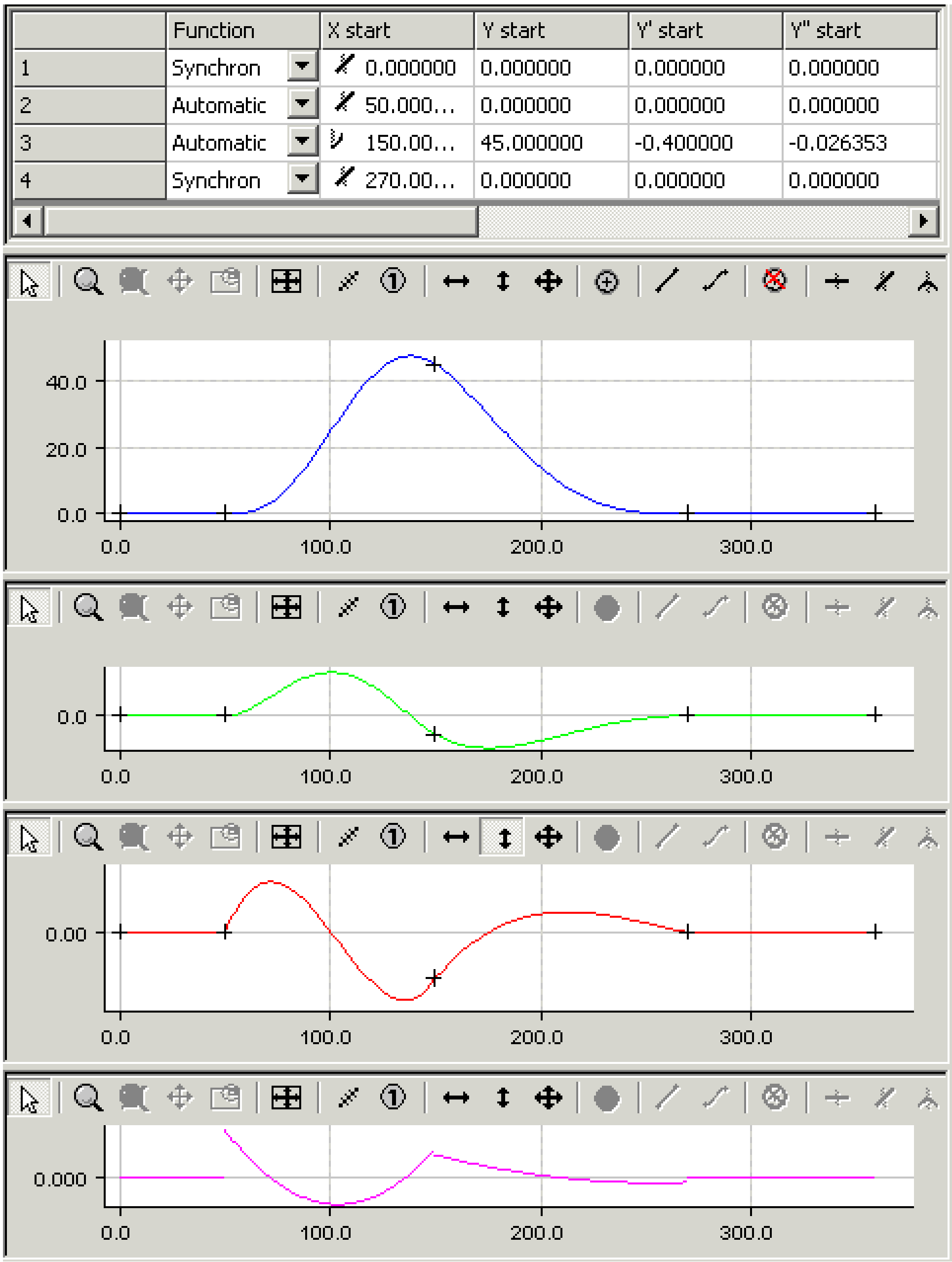
- To turn the motion plan into a motion diagram, you now need to add some information.
- For the first and fourth sections, use the **Synchronous Function** command to define a linear motion by clicking in the corresponding sections. In the second and third sections, the **Automatic Function** command is used to implement automatic adaptation to the boundary conditions.

By right-clicking and selecting **Select Graph 3 View**, the velocity in the second graph window and the acceleration in the third graph window are displayed in addition to the slave position in the first graph window.

- Enter a velocity of -0.4 in the table.

The acceleration is set to a zero value by default. Since at this point, however, no zero crossing of the acceleration is to be forced, but the jerk-free possible course is to be realized, the third point must now be moved interactively in the acceleration window in vertical direction.

- If you want to control the jerk, you can display the jerk by right-clicking and selecting **Select Graph 4 View**.



The motion diagram that has been created can be saved as a file in the slave's properties window.

9.4 Example 3

The procedure for creating a motion diagram is illustrated again in this next simple example.

The task:

The following slave motion is to be implemented for a rotation of the master axes from 0 to 360 degrees.

1. A velocity of -0.2 (normalized) from master position 140 to 240 and from slave position 10.
2. The motion has no rest.

- In the tree structure, create a master and its corresponding slave via **MOTION > Tables** (see Introduction).
- After selecting **Slave 1** in the tree structure, both the **graphic window** and the **table window** appear.
- In the graphic window, click the approximate positions of the points in the window using the Insert Point [▶ 25] command.

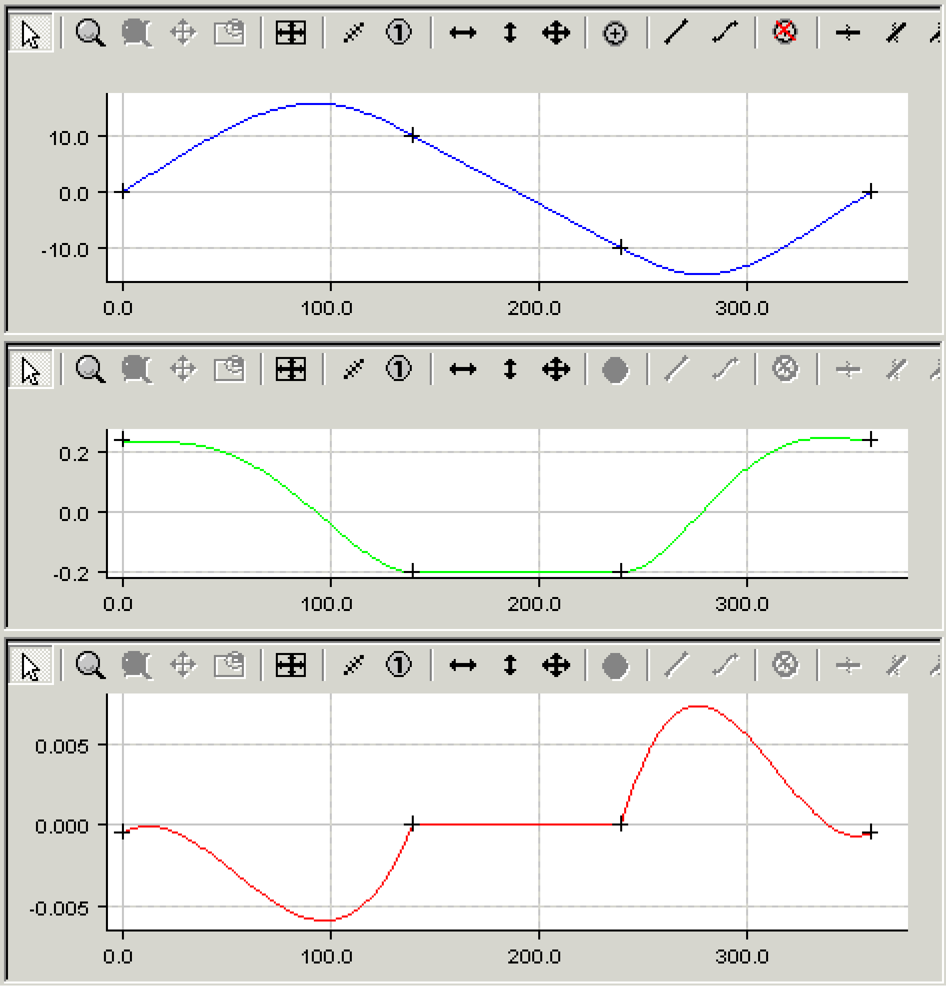
The corresponding values will then be inserted into the table window.

- To turn the motion plan into a motion diagram, you now need to add some information.
- For the second section we use the **Synchronous Function** command to specify, by clicking with the mouse inside that section, that a linear movement is to be used there. In the first and third sections, the **Automatic Function** command is used to implement automatic adaptation to the boundary conditions.
- You can now use the move commands to manipulate the position of the points.

By right-clicking and selecting **Select Graph 3 View**, the velocity in the second graph window and the acceleration in the third graph window are displayed in addition to the slave position in the first graph window.

The fact that it is a rotary axis is specified in the master's [▸ 15] properties. Because the start position corresponds to the master's minimum, and the end position corresponds to its maximum, the first and second derivatives at the end of the diagram are set equal to those at the beginning. It is still possible to adjust the velocity and acceleration at the beginning interactively (vertical shifting) in their windows.

	Function	X start	Y start	Y' start	Y'' start
1	Automatic	0.000000	0.000000	0.233462	-0.000484
2	Synchron	140.00...	10.000000	-0.200000	0.000000
3	Automatic	240.00...	-10.000000	-0.200000	0.000000

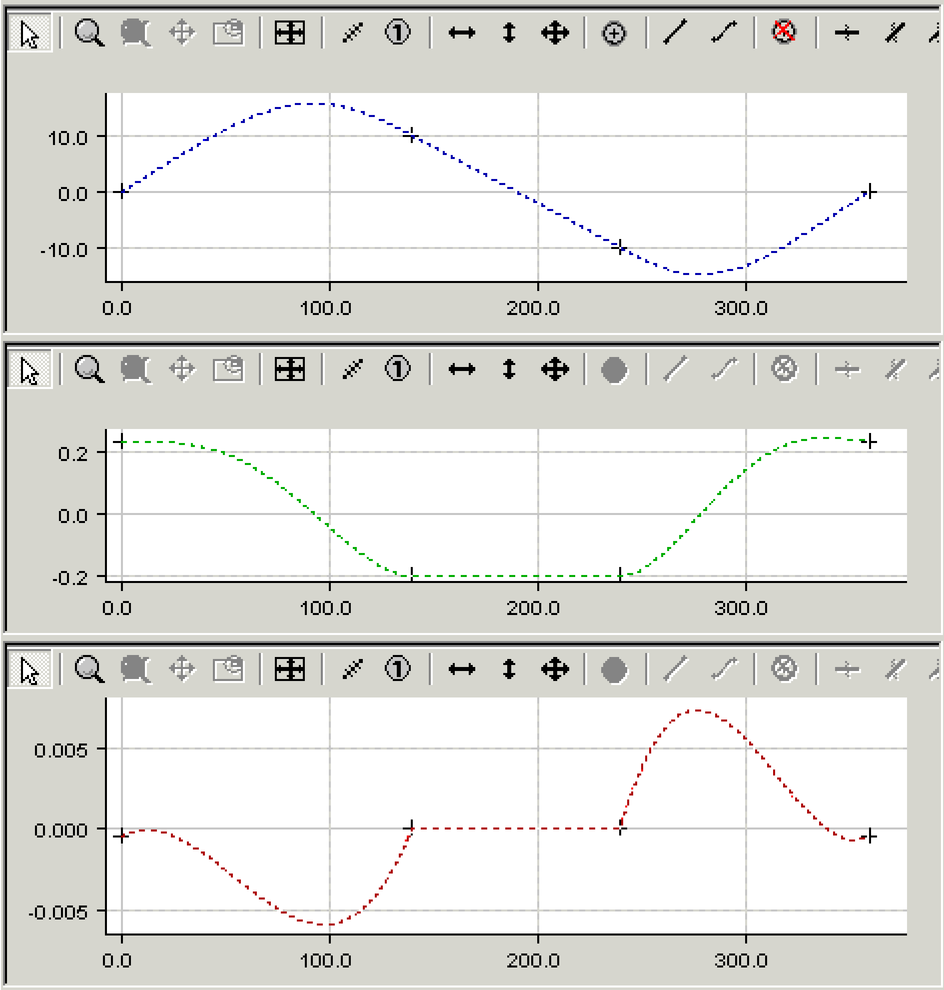


- Save the data.
- Activate the configuration.
- Restart TwinCAT 3.

The online data can now be displayed by right-clicking and selecting **Select Graph 2 View**.

They are displayed as a dotted line in the same color.

	Function	X start	Y start	Y' start	Y'' start
1	Automatic	0.000000	0.000000	0.233462	-0.000484
2	Synchron	140.00...	10.000000	-0.200000	0.000000
3	Automatic	240.00...	-10.000000	-0.200000	0.000000



9.5 Example 4

The procedure for creating a motion diagram is illustrated in this simple example.

The task:

The following slave motion is to be implemented for a rotation of the master axes from 0 to 360 degrees.

1. A rest (stationary slave axis) between 0 and 30 degrees.
2. Synchronization to a specified motion (from master position 100 and slave position 10 to the positions 200 and 90 respectively, with an eighth order polynomial motion function).
3. A rest (stationary slave axis) between 300 and 360 degrees.

- In the tree structure, create a master and its corresponding slave via **MOTION > Tables** (see Introduction).
- After selecting **Slave 1** in the tree structure, both the **graphic window** and the **table window** appear.
- In the graphic window, click the approximate positions of the points in the window using the Insert Point [▶ 25] command.

The corresponding values will then be inserted into the table window.

- To turn the motion plan into a motion diagram, you now need to add some information.
- For the first, third and fifth sections we use the **Synchronous Function** command to specify by clicking with the mouse in the corresponding sections that a linear motion should take place there. In the second and fourth sections, the **Automatic Function** command is used to implement automatic adaptation to the boundary conditions.
- You can now use the move commands to manipulate the position of the points.

By right-clicking and selecting **Select Graph 3 View**, the velocity in the second graph window and the acceleration in the third graph window are displayed in addition to the slave position in the first graph window.

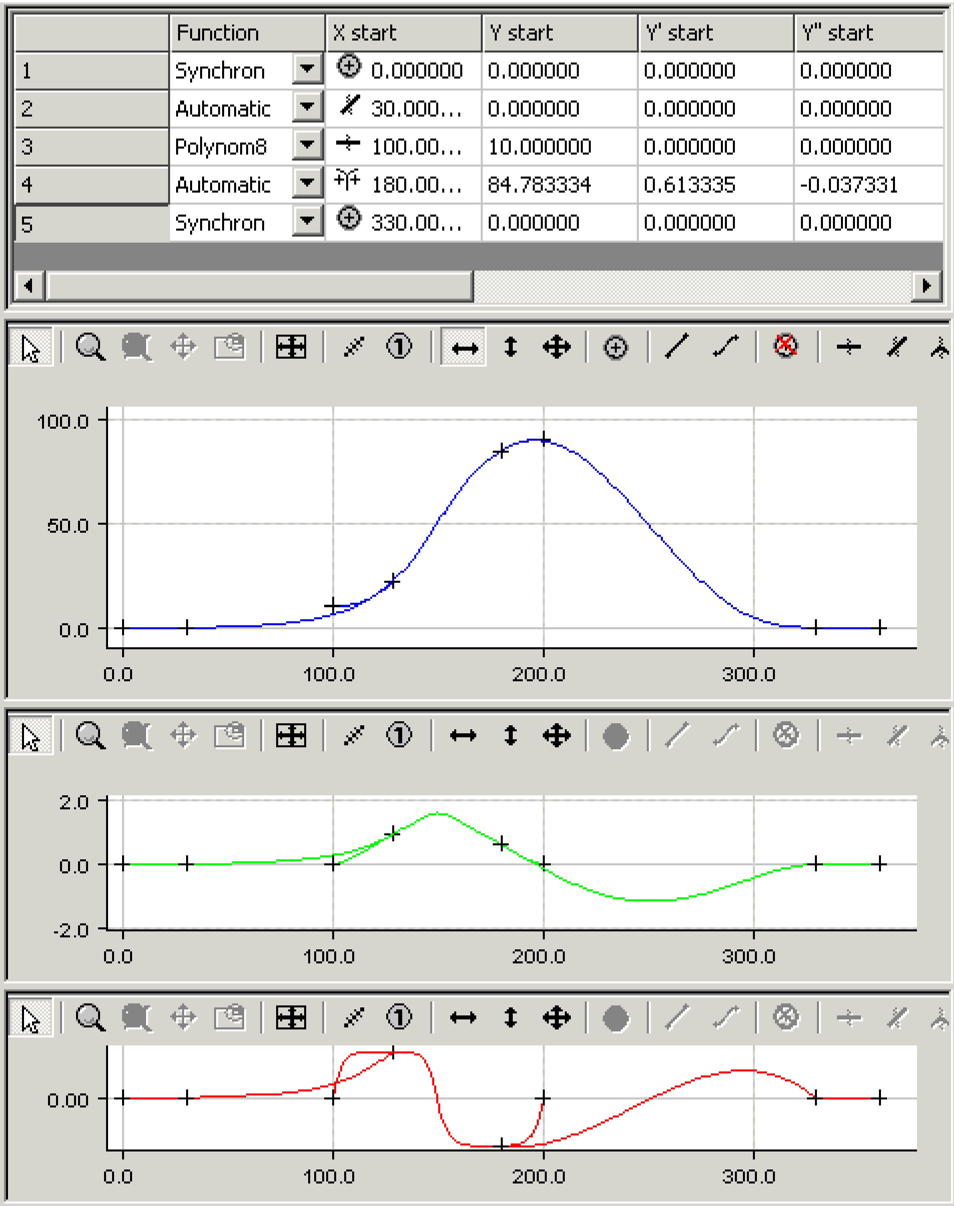
Using the **Slide point** command, and by selecting a point in the first half of the third section, the end point of the second section is placed on the function graph of the third. Using the **Slide point** command, and by selecting a point in the second half of the third section, the starting point of the fourth section is placed on the function graph of the third.

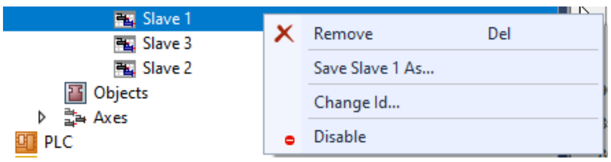
- Now set the master and slave positions in the table for the third section.
- Change the function type in the combo box to polynomial8.
- Then set the master and slave positions of the first and fifth sections.

With a vertical shift you can now move the end point of the third section or the start point of the fourth section to the third.

The first and second derivatives are automatically adjusted.

Cam plates with slide point cannot be transferred to the NC as a motion function.





Select **Save Slave...** by right-clicking on the slave in the tree view to save the data of the motion diagram in an export file (*.xti). This data can be imported again under a master.

9.6 Example 5

The procedure for creating a motion diagram is illustrated in this simple example.

The task:

The following slave motion is to be implemented for a rotation of the master axes from 0 to 360 degrees.

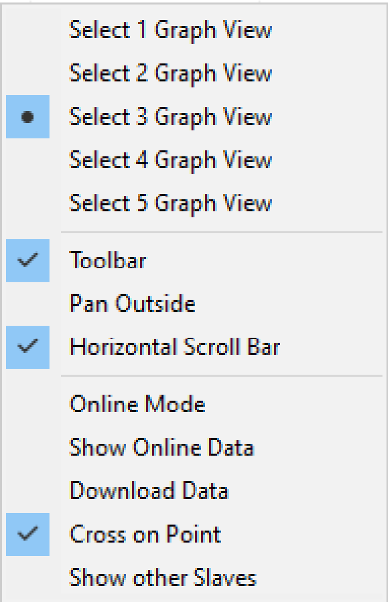
1. A rest (stationary slave axis) between 0 and 20 degrees.
2. A 180 degree turn at a slave position of 100.
3. A rest (stationary slave axis) between 340 and 360 degrees.

- In the tree structure, create a master and its corresponding slave via **MOTION > Tables** (see Introduction).
- After selecting **Slave 1** in the tree structure, both the **graphic window** and the **table window** appear.
- In the graphic window, click the approximate positions of the points in the window using the Insert Point [▶ 25] command.

The corresponding values will then be inserted into the table window.

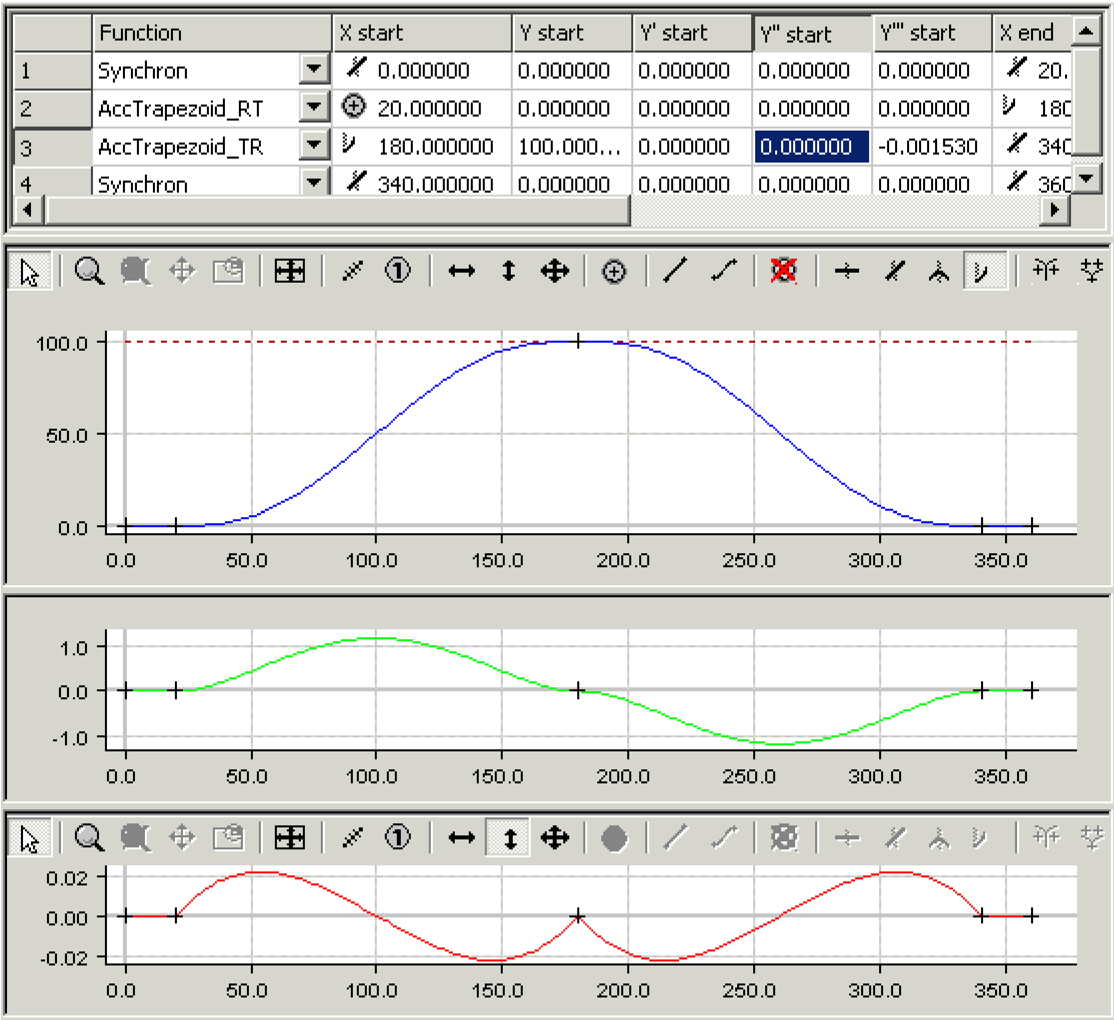
- To turn the motion plan into a motion diagram, you now need to add some information.
- For the first and fourth sections, use the **Synchronous Function** command to define a linear motion by clicking in the corresponding sections.
- In the second section in the table, select the function type acceleration trapezoid from rest to turn (AccTrapezoid_RT: Rest in Turn) and in the third section as acceleration trapezoid from turn to rest (AccTrapezoid_TR).

By right-clicking and selecting **Select Graph 3 View**, the velocity in the second graph window and the acceleration in the third graph window are displayed in addition to the slave position in the first graph window.



The size of the windows can be changed interactively by positioning the mouse on the edge and moving it with a left click.

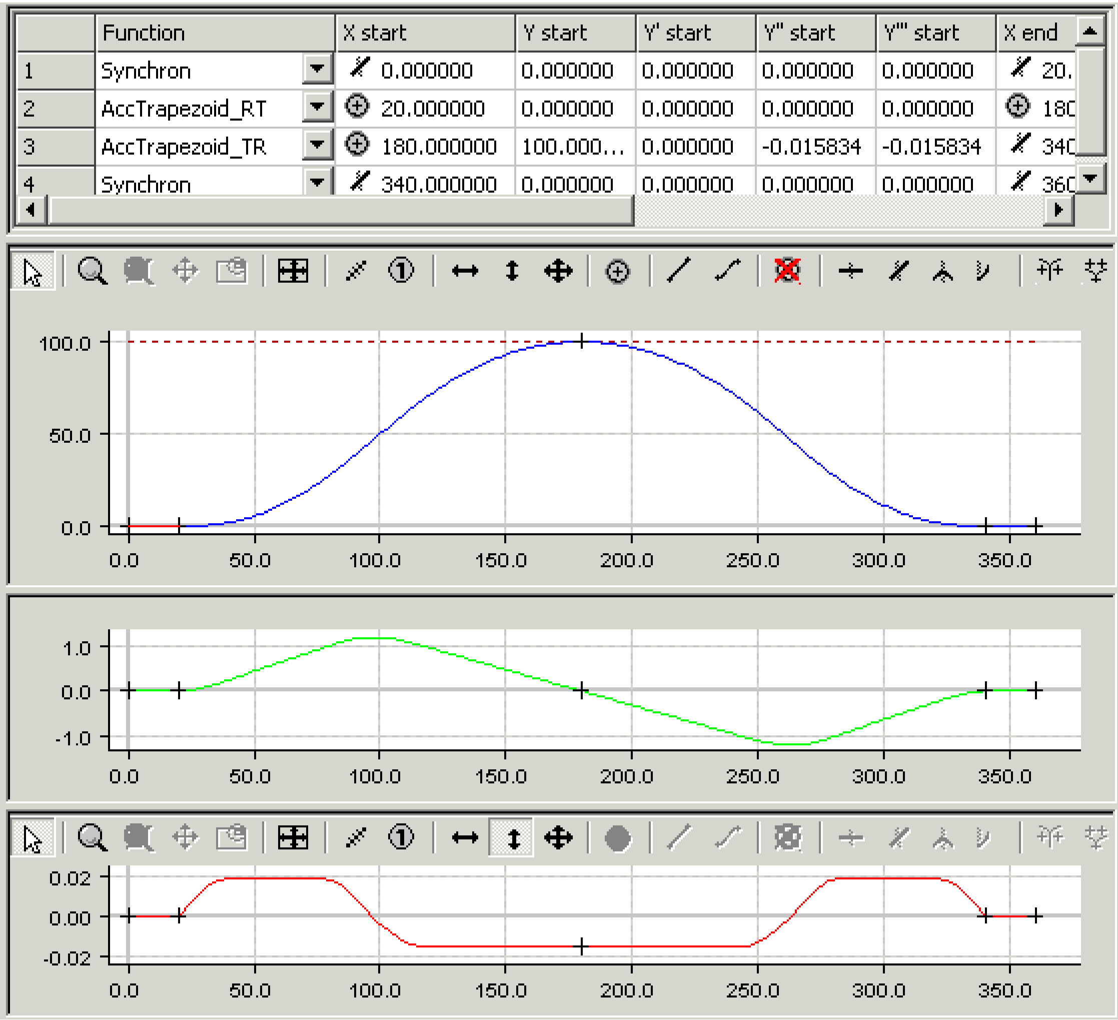
- To ensure that the exact positions are realized, enter them now in the table view.



Since the boundary conditions at point (180,100) are still such that the second derivative is zero, the display shown above is obtained.

Here, however, 5th order polynomials are still used for the function, since the acceleration trapezoid cannot meet these boundary conditions.

If the point is now interactively moved in the negative direction at the master position of the turn in the acceleration graph, the acceleration trapezoid can be used from a defined acceleration.



The acceleration at the turning point can then be further manipulated interactively.

9.7 Example 6

The procedure for creating a motion diagram is illustrated in this simple example.

The task:

The following slave motion is to be implemented for a rotation of the master axes from 0 to 360 degrees.

1. A rest (stationary slave axis) between 0 and 20 degrees.
2. The rest from 170 to 190 degrees with a slave position of 100 is to be linked to an 8th order polynomial.
3. A rest (stationary slave axis) between 340 and 360 degrees.

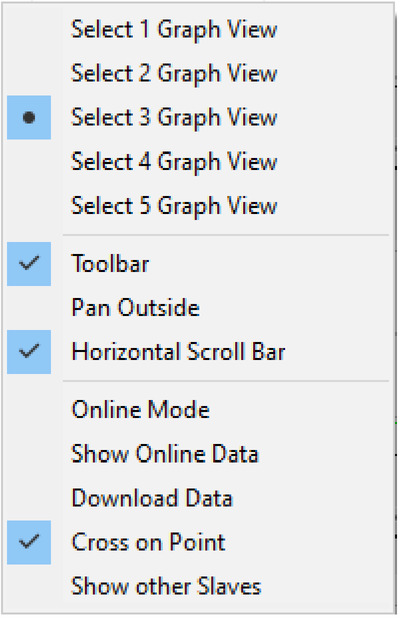
- In the tree structure, create a master and its corresponding slave via **MOTION > Tables** (see Introduction).
- After selecting **Slave 1** in the tree structure, both the **graphic window** and the **table window** appear.
- In the graphic window, click the approximate positions of the points in the window using the Insert Point [▸ 25] command.

The corresponding values will then be inserted into the table window.

- To turn the motion plan into a motion diagram, you now need to add some information.

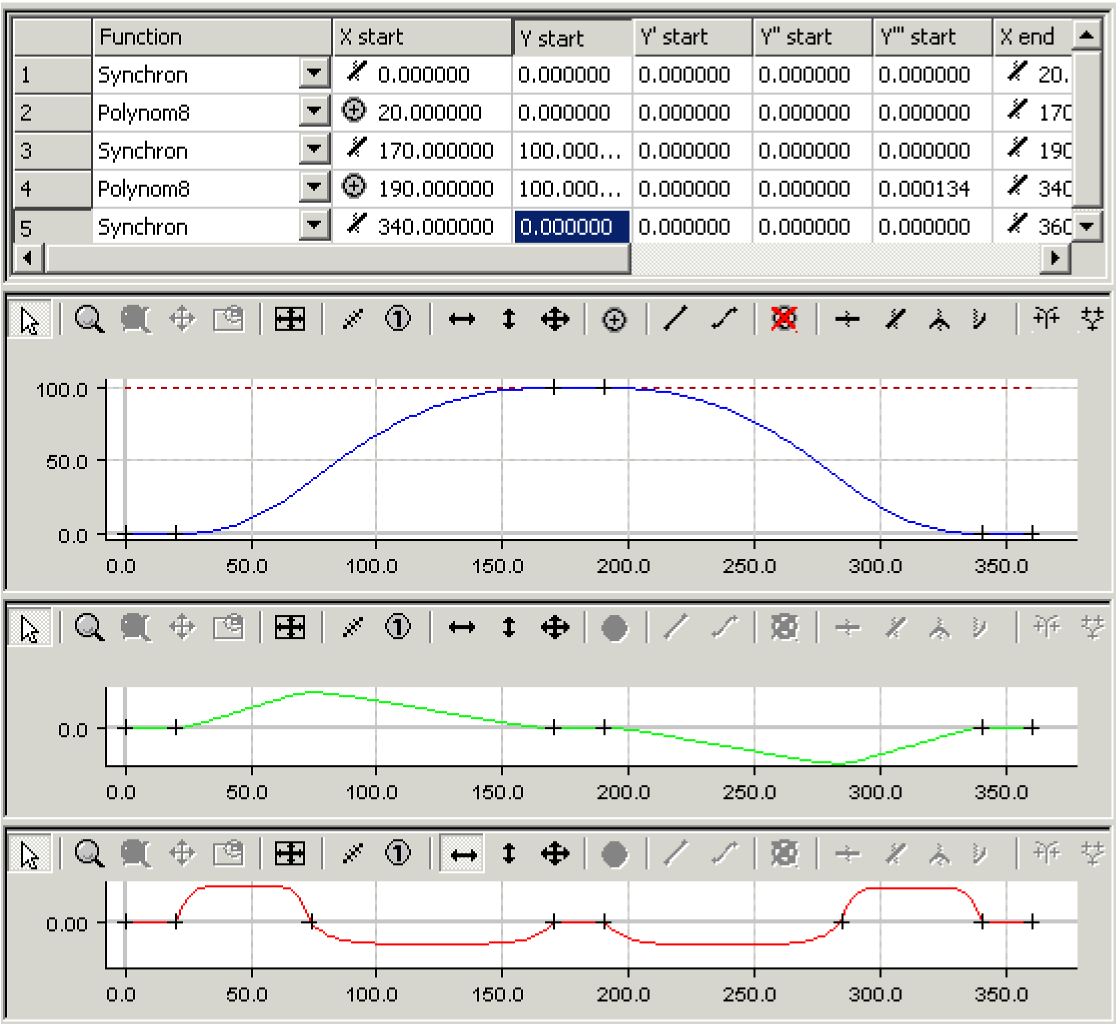
- For the first, third and fifth sections we use the **Synchronous Function** command to specify by clicking with the mouse in the corresponding sections that a linear motion should take place there. In the second and fourth sections, the function type is defined in the table as an 8th order polynomial.
- In the second section in the table, select the function type acceleration trapezoid from rest to turn (AccTrapezoid_RT: Rest in Turn) and in the third section as acceleration trapezoid from turn to rest (AccTrapezoid_TR).

By right-clicking and selecting **Select Graph 3 View**, the velocity in the second graph window and the acceleration in the third graph window are displayed in addition to the slave position in the first graph window.



The size of the windows can be changed interactively by positioning the mouse on the edge and moving it with a left click.

- To ensure that the exact positions are realized, enter them now in the table view.



In the acceleration graph, points are now also visible at the zero crossing. These can be shifted horizontally and thus change the symmetry value. This way the positive and negative acceleration can be adjusted interactively.

However, this option is only available for the rest in rest motion laws (Polynomial3, Polynomial5, Polynomial8, Sineline, ModSineline, Bestehorn, AccTrapezoid), which have no other parameters to change.

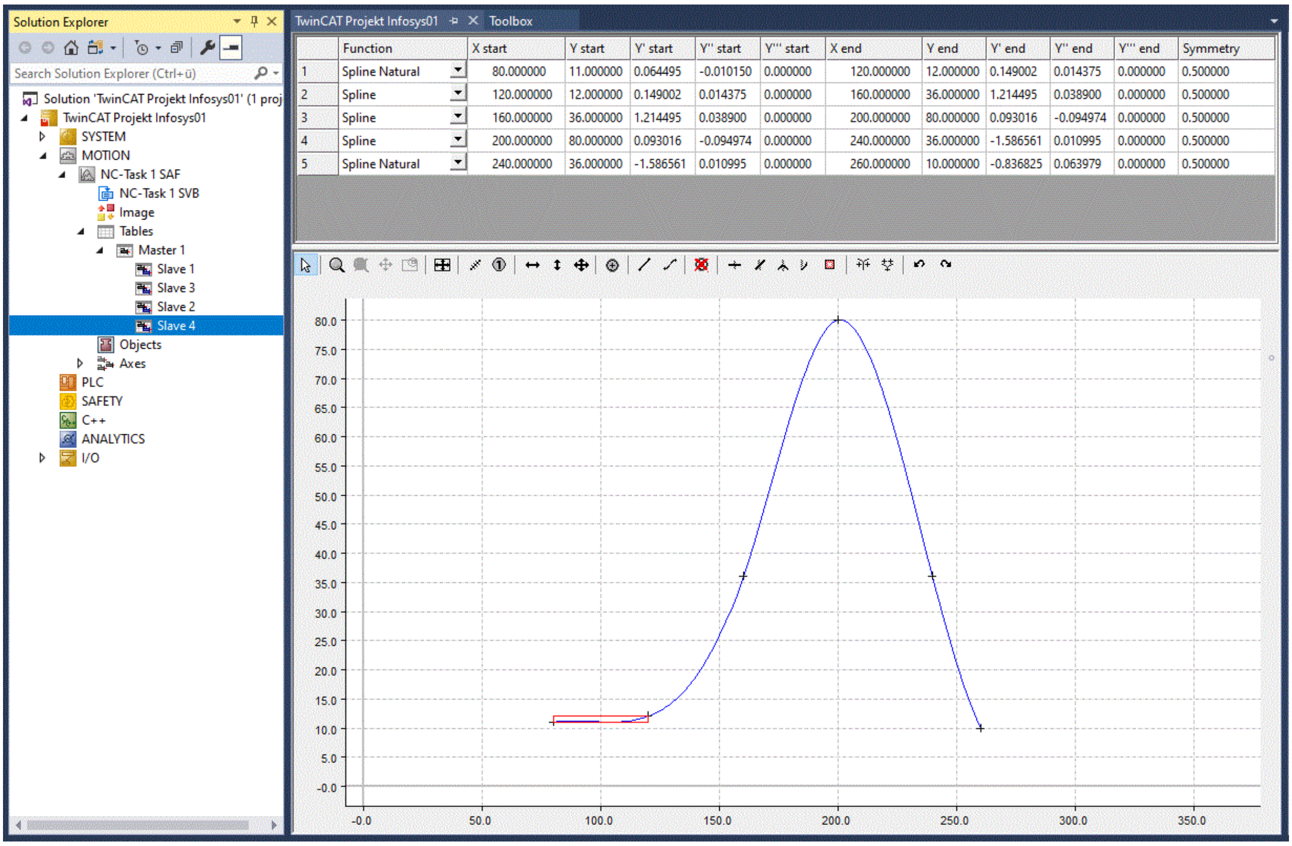
9.8 Example 7

This simple example illustrates the procedure of importing and modifying a CSV file.

The task:

✓ A given motion imported via CSV file is to be supplemented by further points on a master axis from 0 to 360 degrees and corrected as desired.

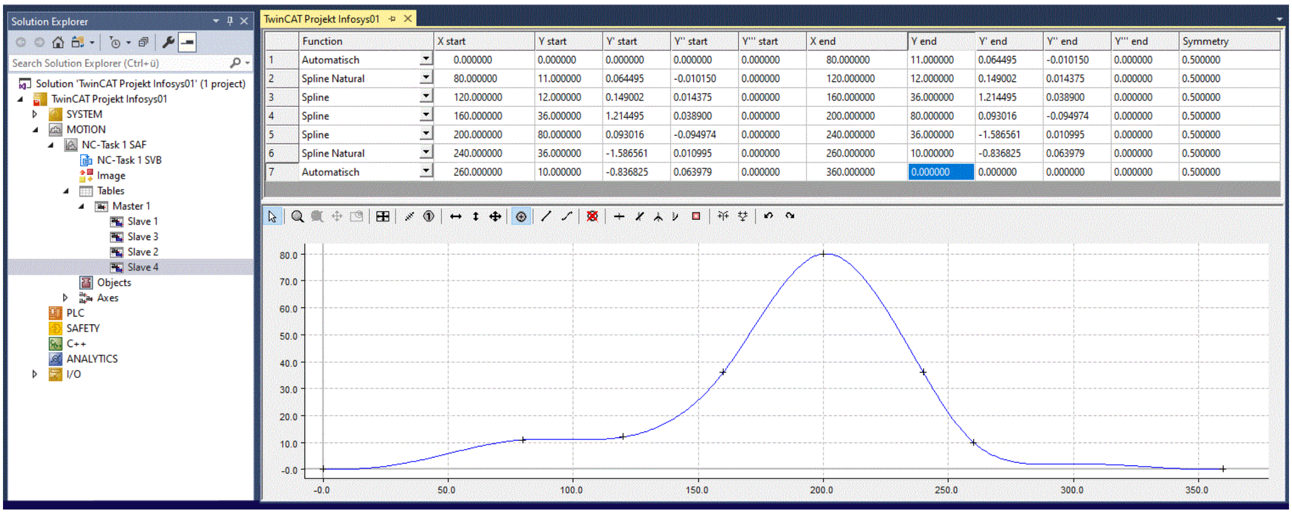
1. In the tree structure, create a master and its corresponding slave via **MOTION > Tables** (see Introduction [▶ 8]).
2. Click the **Import** button in the properties window of the slave.
3. Select the desired CSV file in the dialog box and confirm the process.
4. Select the corresponding **slave** in the tree structure.



⇨ The imported graph is displayed in the **Graph window** and the **Table window**.

✓ The function type is set to **Function selection > Automatic** in both sections (first and last line).

1. Use the command to insert the start point at approximately (0,0) and the end point at (360,0).
2. Set the exact value of (0,0) in the first line of the table in the columns "X Start" and "Y Start“.
3. Correct the last point in the bottom line in the column "X End" (360.0) and in the column "Y End" (0.0) to the exact values.



⇨ Add more points to the graph as required.

More Information:
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