Working with the Cam Editor

SIMATIC S7-1500T / TIA Portal V15

https://support.industry.siemens.com/cs/ww/en/view/109749820

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1 Cam Editor

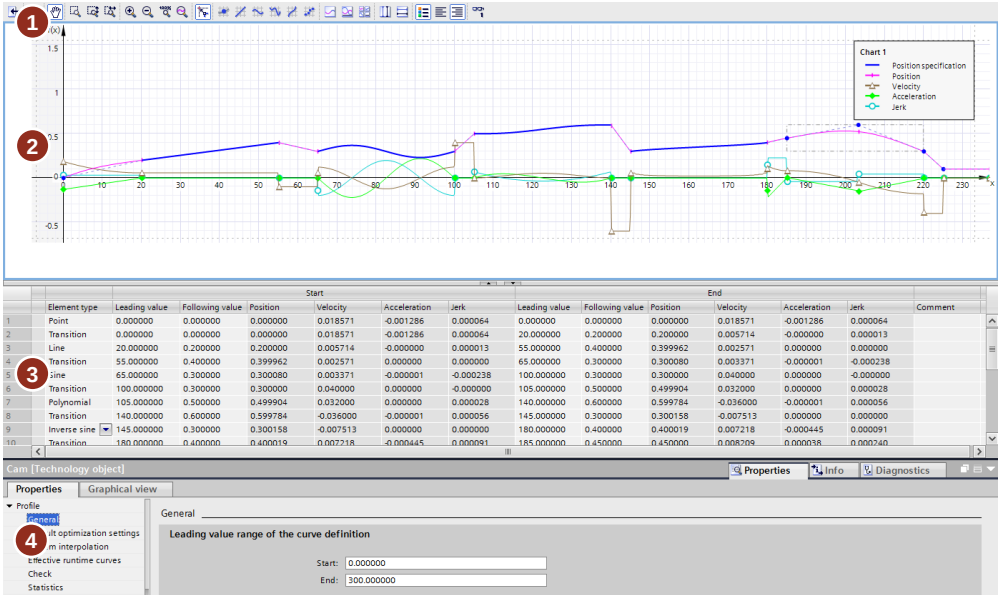
1.1 General Information

The technology object Cam defines for a synchronization the nonlinear relationship between a leading (master) axis and a following (slave) axis.

Using the cam editor you can predefine in graphical form the relationship between the position of the leading axis and the resulting position of the following axis. The position of the leading axis is predefined on the abscissa (X axis) of the cam coordinate system.

A cam is always used when a following axis is to move in the absolute position-specific synchronization of a leading axis, and between the two axes there is partly no linear relationship.

Figure 1-1 Overview of the cam editor



The cam editor can be split into four sections:

1. The toolbar (see section 1.2)
2. The graphical editor of the cam (see section 1.3)
3. The tabular editor of the cam (see section 1.4)
4. The properties of the cam

The cam editor provides the following support in creating a cam:

- Optimization of the curve form
- Generation of continuous and smooth transitions between curve elements
- Optimal-velocity design of the cam

Note Information about the configuration of the technology object "Cam" is available in the section entitled "Configuring the Technology Object Cam" in the function manual "S7-1500T Motion Control V4.0 in the TIA Portal V15".

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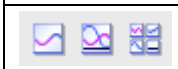
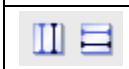
1.2 Toolbar

You operate the graphical editor with the buttons in the toolbar. You can change the display of the editor and add elements to the editor.

You can also use the buttons of the toolbar to import cams into the editor and export cams (see section 5.3).

Table 1-1: Toolbar buttons

Button	Description
	Import and export cams (see section 5.3)
	Edit element / Move view
	Activate zoom, vertical zoom and horizontal zoom
	Enlarge and reduce display
	Activate snap grid setting
	Select elements of the cam (see chapter 2)
	View of cam in a chart with all curves or in multiple charts.
	Show measuring lines
	Show and position legend of curve chart
	Show snapshot of online curve (see section 4.2)

Note A detailed description of the buttons is available in the section entitled "Structure of the graphical editor" of the TIA Portal Online Help.

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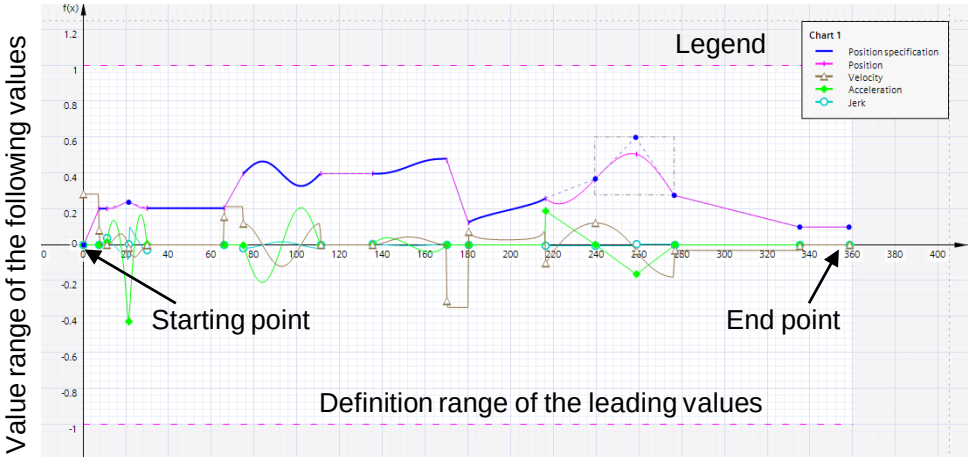
1.3 Graphical Editor of the Cam

You can edit the elements of the cam in the graphical editor. You can insert, edit and delete the elements. In Figure 1-2 the blue elements represent a cam element specified by the user and the magenta lines represent the interpolated transitions between the cam elements. When you select a curve in the legend it is brought to the foreground in the graphical editor and the value range of the ordinate is adapted to the value range of the curve. Single curves are arranged in charts. It is possible to display up to four charts at the same time which can include multiple curves and in which you can show and hide individual curves.

Figure 1-2 Graphical display of the cam



- The leading value range (definition range) is displayed on the abscissa (x axis).
- The following value range (value range) is displayed on the ordinate (y axis).
- You click an entry in the editor legend and the selected curve is activated and the value range of the following values is displayed.

If you click the button "View: A chart with all curves" (see Table 1-1), you can have a display not only of the cam position progression but also of the standardized changes of velocity, acceleration and jerk on the following axis.

Charts and curves

In the "Graphical view" configuration window of the cam you can change the "Charts and curves" display. You can choose a color and line type for each curve in a chart. You can also have more curves from the current or another cam displayed in the chart. For this, in the relevant chart you click the <Add new curve> line and select a curve from the cams displayed.

Each curve of a chart can be adjusted with the offset factor and the multiplier scaling factor. This enables you to synchronize the cam display with the parameterization of the Motion Control instruction "MC_CamIn".

Note

Only the display of the curve in the chart is affected. You specify the scaling and offset of the cam in the cam synchronization on the Motion Control instruction "MC_CamIn".

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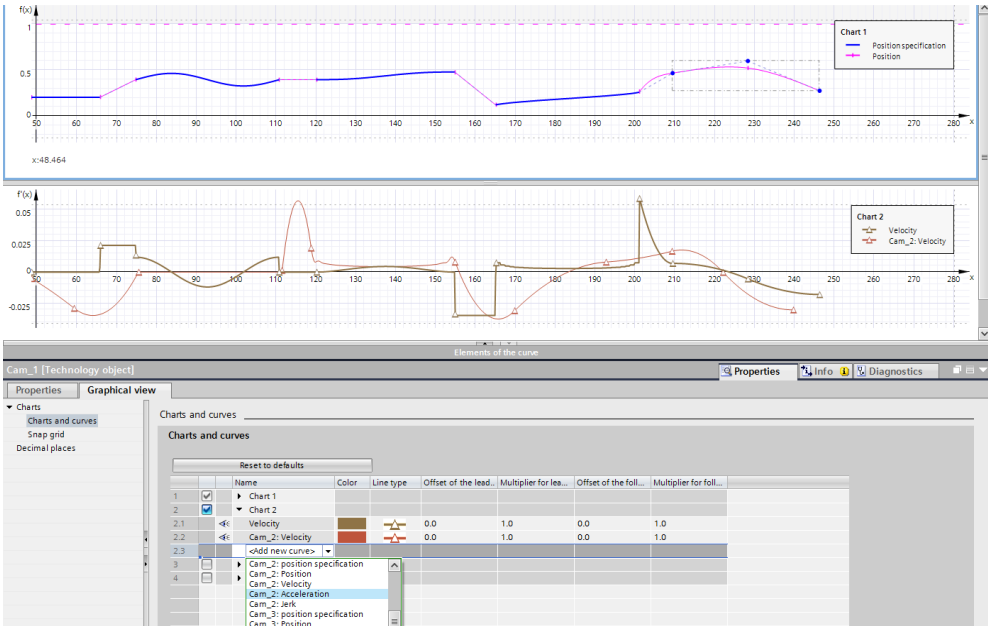
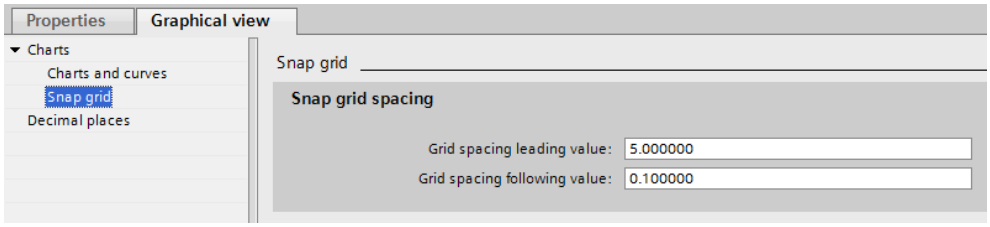
Figure 1-3 Display of multiple curves



Snap grid

In the "Snap grid" configuration window you configure the snap grid spacing for the alignment of curve elements in the graphical editor. When "snapping" is activated, the inputs and element end points are aligned to this grid and the end points of neighboring curve elements. If an element is moved after being added, it is moved in the grid by the snap grid spacing that has been set.

Figure 1-4 Snap grid settings

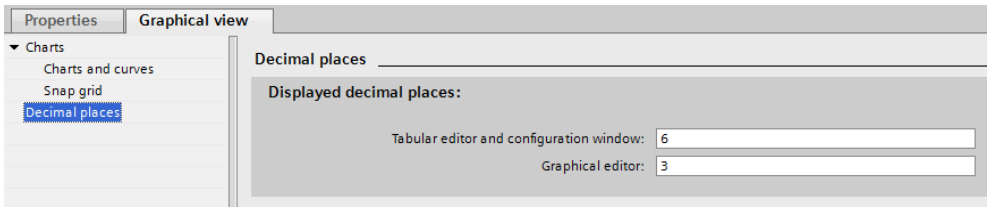


The snap grid is active when the "Activate snap grid" button  is activated in the toolbar (see Table 1-1).

Decimal places

In the "Decimal places" configuration window you configure the number of decimal places to be displayed for the values in the graphical and tabular editor, and in the configuration windows. The values in the displays are rounded off. The settings do not affect the calculation of the curves. The curves are calculated with high accuracy regardless of the settings.

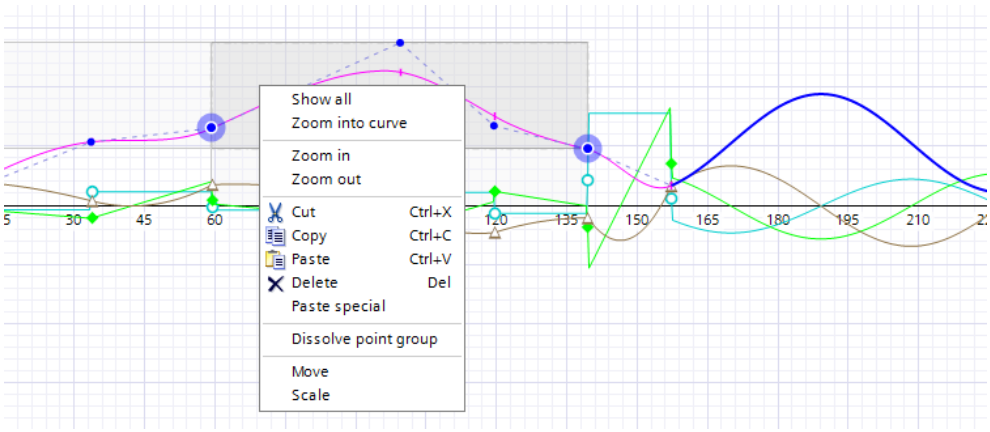
Figure 1-5 Decimal places



Shortcut menu

Right-click in the graphical editor to open the shortcut menu.

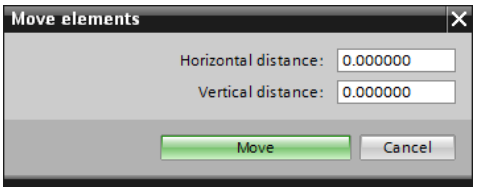
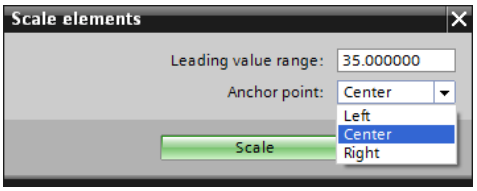
Figure 1-6 Shortcut menu in the graphical editor



The following functions are available in the shortcut menu:

Table 1-2 Shortcut menu functions

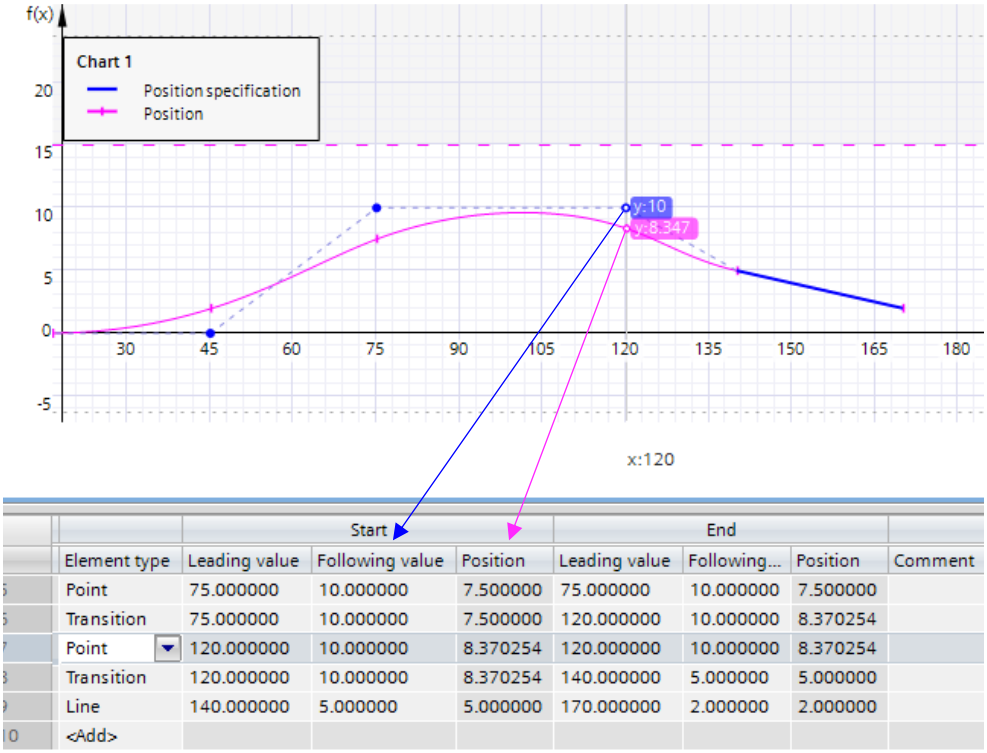
Function	Description
Show all	Display of the complete definition and value range
Zoom into curve	Fitting the display area to the curve selected in the chart legend
Zoom in/out	Enlarging/reducing the display
Cut	Cutting out the selected elements and copying them to the clipboard
Copy	Copying the selected elements to the clipboard
Paste	Pasting the elements from the clipboard after the last element
Delete	Deleting the selected elements Transitions to any available elements are also deleted. A new transition is created between the remaining elements.

Function	Description
Paste special	If there is a cam element in the clipboard, a dialog opens for inserting the element with the following options: • Overwrite elements to the left • Overwrite elements to the right • Overwrite both directions • Scale elements from the clipboard → Paste after last element The neighboring elements of the selection are overwritten.
Group points	Grouping of the selected points into a point group. The entry is displayed under the following conditions: • Only points are selected in the graphical/tabular editor. • There are no other elements between the selected points.
Dissolve point group	If a point group is selected, the group is dissolved into single points.
Move	The element can be moved by the entered distances. 
Scale	The element can be scaled by a leading value range and an anchor point. The leading value range is the definition range between the starting point and end point of an element. Through scaling you reduce/enlarge the definition range starting from the selected anchor point. 

1.4 Tabular Editor of the Cam

The tabular editor of the cam lists all the element types with the associated start and end values of the single elements of the cam.

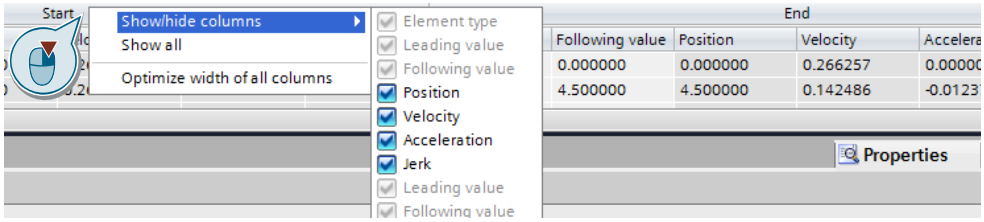
Figure 1-7 Tabular editor of the cam



		Start			End			
	Element type	Leading value	Following value	Position	Leading value	Following...	Position	Comment
5	Point	75.000000	10.000000	7.500000	75.000000	10.000000	7.500000	
6	Transition	75.000000	10.000000	7.500000	120.000000	10.000000	8.370254	
7	Point	120.000000	10.000000	8.370254	120.000000	10.000000	8.370254	
8	Transition	120.000000	10.000000	8.370254	140.000000	5.000000	5.000000	
9	Line	140.000000	5.000000	5.000000	170.000000	2.000000	2.000000	
10	<Add>							

In the tabular editor you can define leading values and following values of the elements used. By default the interpolated following value (position) at the start and end of the element are already displayed (see Figure 1-7). Right-click the column header to show the additional calculated dynamic values.

Figure 1-8 Show more columns

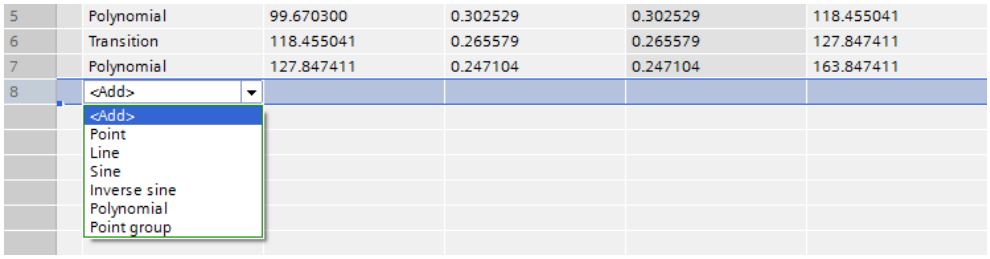


You add new elements by clicking the <Add> cell. A transition is inserted automatically between the previous element and the new element.

If the start or end value is chosen so that it intersects with the definition range of an element, the neighboring element is overwritten to the specified point.

You can remove elements by marking the table row and pressing the <Del> button. The associated transition is automatically removed.

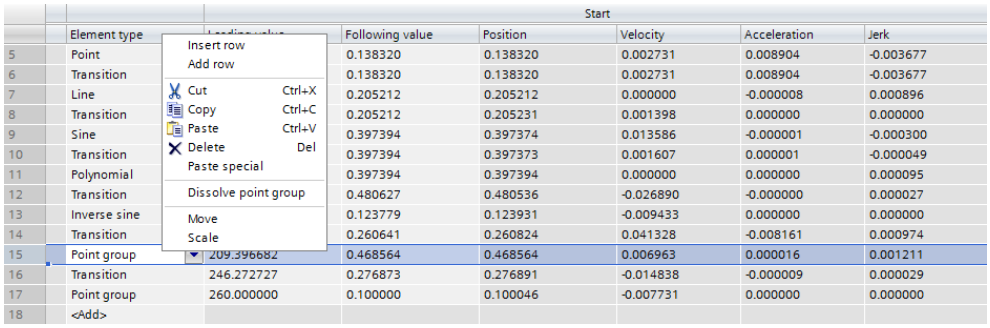
Figure 1-9 Adding elements to the table



Shortcut menu

Right-click in the table to open the shortcut menu.

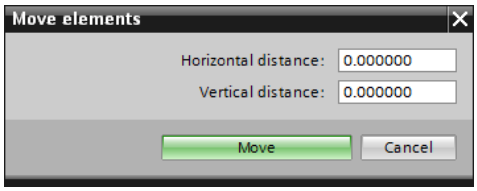
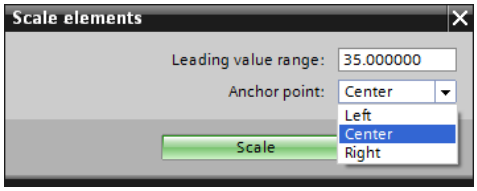
Figure 1-10 Shortcut menu in the tabular editor



The following functions are available in the shortcut menu:

Table 1-3 Shortcut menu functions

Function	Description
Insert row	A new row is inserted before the selected element
Add row	A new row is inserted after the selected element
Cut	Cutting out the selected elements and copying them to the clipboard
Copy	Copying the selected elements to the clipboard
Paste	Pasting the elements from the clipboard after the last element
Delete	Deleting the selected elements Transitions to any available elements are also deleted. A new transition is created between the remaining elements.
Paste special	If there is a cam element in the clipboard, a dialog opens for inserting the element with the following options: • Overwrite to the left • Overwrite to the right • Overwrite in both directions • Scale elements from the clipboard → Paste after last element The neighboring elements of the selection are overwritten.

Function	Description
Group points	Grouping of the selected points into a point group. The entry is displayed under the following conditions: • Only points are selected in the graphical/tabular editor. • There are no other elements between the selected points.
Dissolve point group	If a point group is selected, this is dissolved into single points.
Move	The element can be moved by the entered distances. 
Scale	The element can be scaled by a leading value range and an anchor point. The leading value range is the definition range between the starting point and end point of an element. Through scaling you reduce/enlarge the definition range starting from the selected anchor point. 

2 Cam Elements

Using the buttons of the toolbar in the graphical editor you can add the following elements to a cam:

- Point
- Point Group
- Straight line
- Sine
- Inverse sine
- Polynomial

Note A detailed description of the properties of the cam elements is available in the TIA Portal Online Help.

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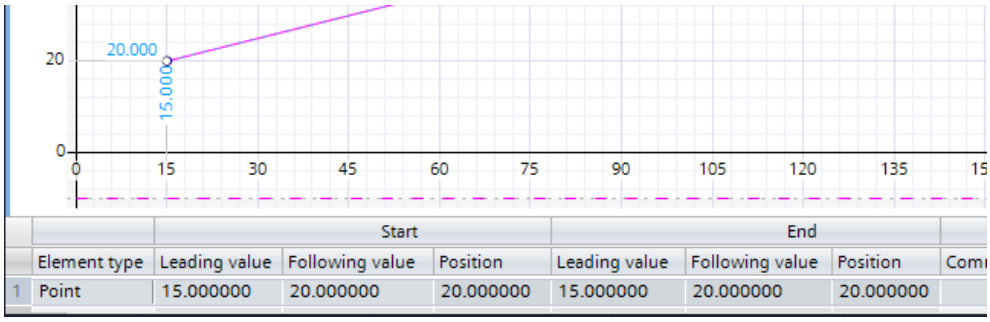
2.1 Point

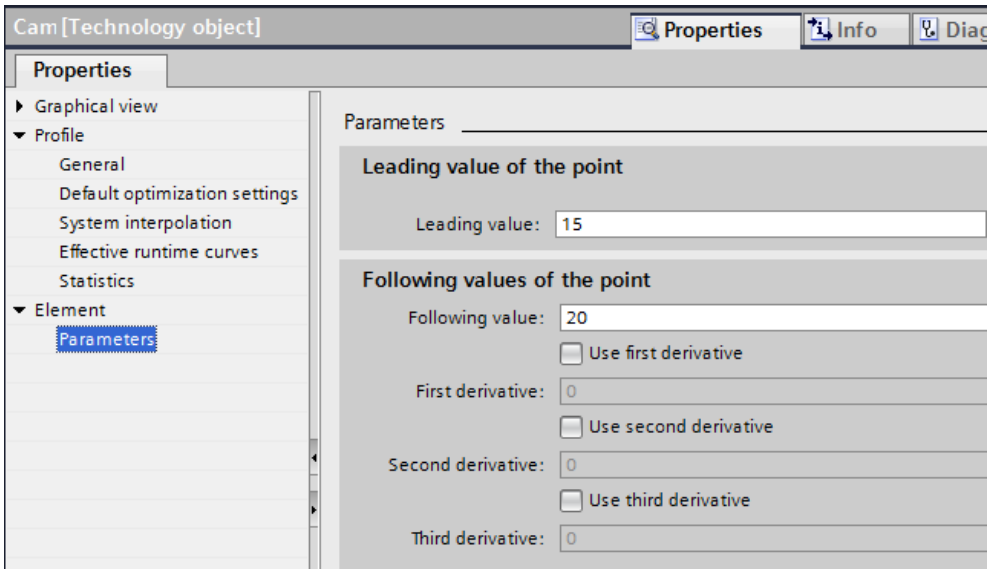
The cam element "Point" assigns a defined following value to a defined leading value. You can change these values in the tabular view or in the properties of the element.

Figure 2-1: Cam element "Point"



In the properties of the element you can activate and specify three derivatives of the following value. Via the first, second and third derivatives you can specify the velocity, acceleration and jerk in this point. These derivatives are considered in the interpolation of the cam if the corresponding transition to the left or right of the point uses VDI-based optimization. The derivatives are not considered when using the system interpolation (see section 3.1).

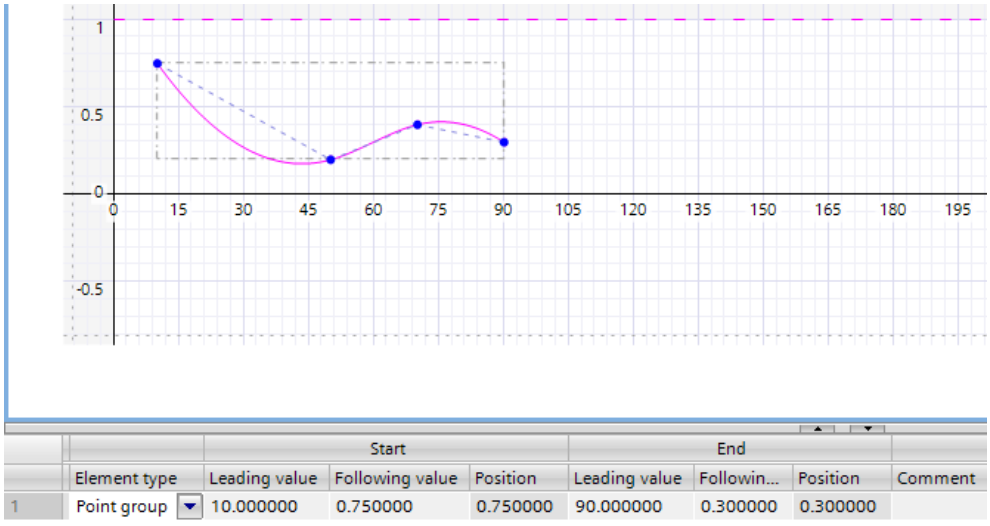
Figure 2-2: "Point" properties



2.2 Point Group

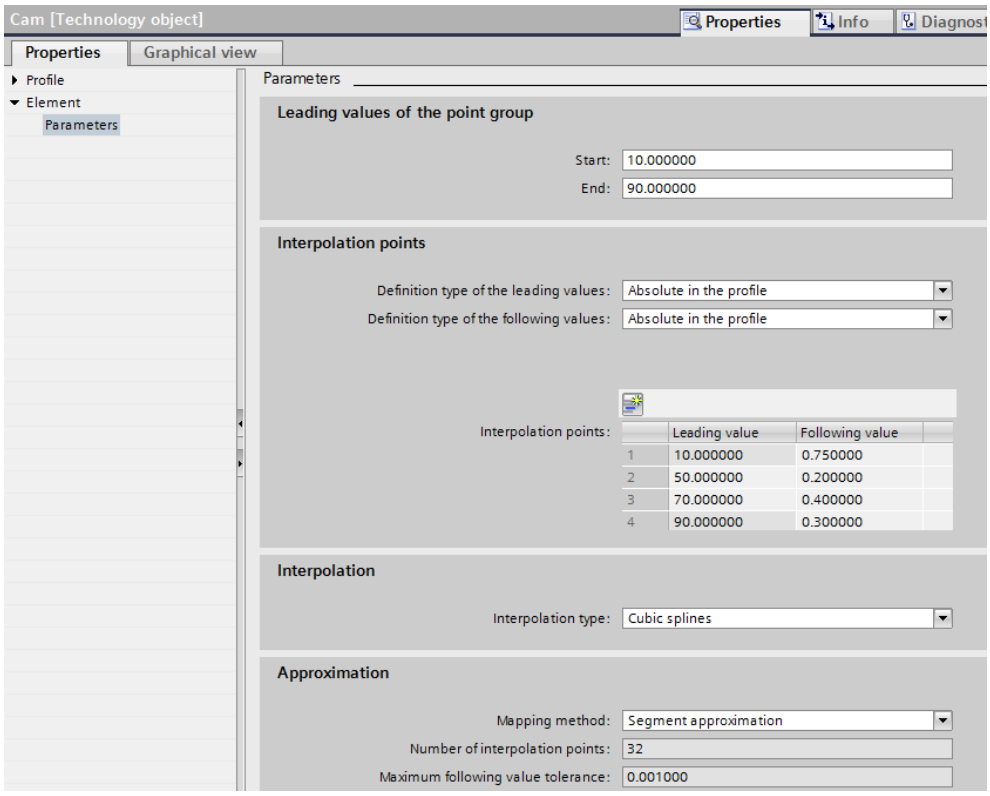
A point group groups together two or more points into a commonly interpolated element and permits exact interpolation specifications between the points.

Figure 2-3 Cam element "Point group"



In the properties of the "Point group" you can define the start and end values, the type of interpolation, the interpolation points and the approximation.

Figure 2-4 "Point group" properties



Interpolation points

You use the interpolation points to define the interpolation between the start and end points of the point group. Both the leading values and following values of the interpolation points can be set absolutely in the profile or relative to the segment.

Absolutely in the profile

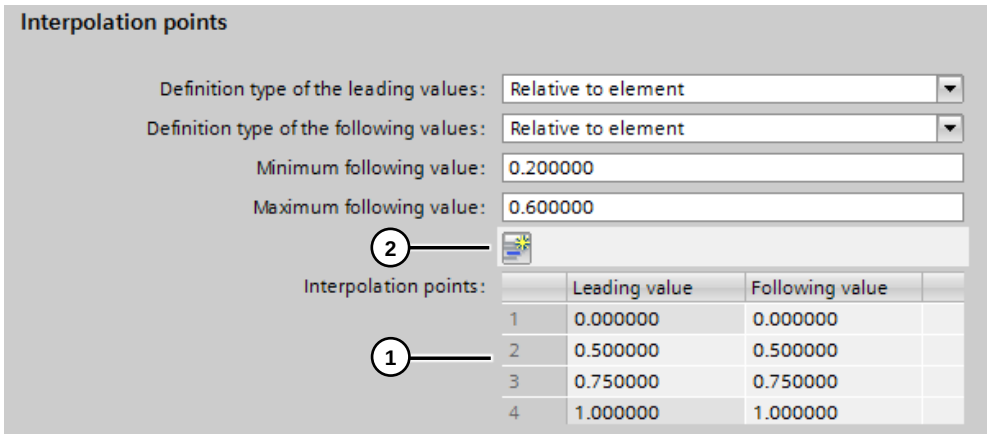
The leading/following values of the interpolation points are specified as absolute values in the definition range of the cam.

Relative to the segment

The interpolation points of the point group are defined standardized via a value range of 0.0 to 1.0.

- **Leading values**
  You specify the leading values of the interpolation points relative to the point group from 0.0 to 1.0. The value 0.0 corresponds to the start of the point group. The value 1.0 corresponds to the end of the point group.
- **Following values**
  You specify the following values of the interpolation points relative to the following value range of the point group from 0.0 to 1.0. The value 0.0 corresponds to the configured minimum following value of the point group. The value 1.0 corresponds to the configured maximum following value of the point group.

Figure 2-5 Definition type of the leading/following values "relative to the element"



In the interpolation point table (1) all the points of the point group are listed in ascending order of the leading value. By clicking the "Insert interpolation point" button (2) you can add more interpolation points. You can remove interpolation points by marking the table row and pressing the <Del> button. The point group is transformed into the element type "Point" if you delete all the interpolation points except one.

Interpolation type

Select the interpolation type with which the points of the point group are to be interpolated. The following interpolation types are available for selection:

- Interpolation with cubic splines
- Interpolation with Bézier splines

Information about interpolation types is available in section 3.1.

Approximation

The following mapping methods are available for approximation:

- Point approximation
- Segment approximation

By default a point group is shown as a segment approximation via one or more 6th-degree polynomials.

Using the "Point approximation" mapping method the curve is shown through a configurable number of interpolation points and the areas between the interpolation points is interpolated by the system.

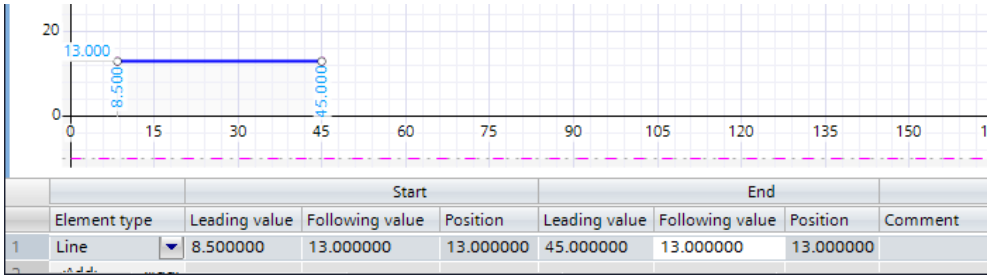
Specify the maximum following value tolerance (absolute) of the approximation of the interpolation points. If the configured value is exceeded, a warning is displayed on the point group in the graphical editor.

Note The point approximation is less accurate than the segment approximation. The greater the number of interpolation points for the approximation, the higher the accuracy of the point approximation. However, this reduces the number of available points (see section 5.2) of the cam.

2.3 Line

The "Line" cam element describes the movement with constant velocity from the starting point of the line to the end point. The exact definition of the line is given in the properties of the cam element.

Figure 2-6: "Line" cam element

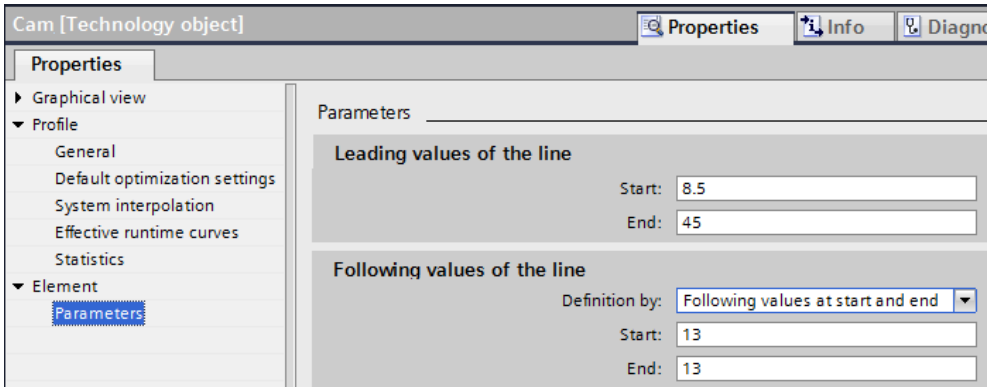


In the properties of the element you can enter the minimum and maximum leading values of the line. You have a choice of three entries when defining the following values of the line:

- Specify the following values at the starting point and end point of the line
- Specify the following values at the starting point and incline of the line
- Specify the following values at the end point and incline of the line

The incline of the line corresponds to the constant velocity. A horizontal line has zero velocity.

Figure 2-7: "Line" properties



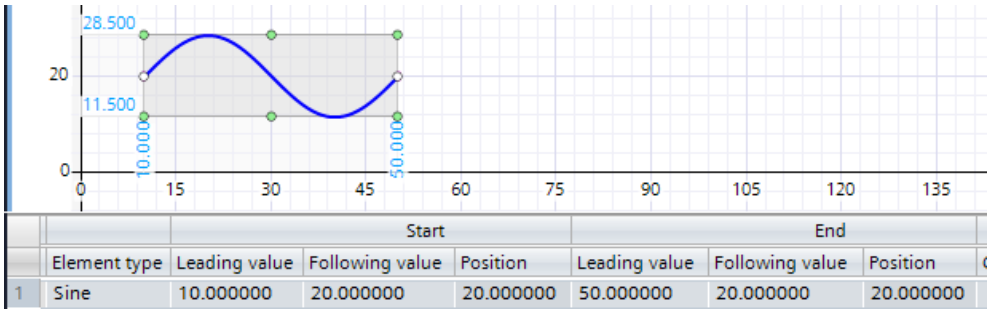
2.4 Sine

The "Sine" cam element describes a movement according to the sine function. In the properties of the cam element you modify the sine function with the following parameters:

- Phase angle at the starting point and at the end point
- Period length of the sine function
- Amplitude of the sine function
- Offset of the zero line
- Inclination of the sine function

Not always all settings are available depending on the definition of the sine function.

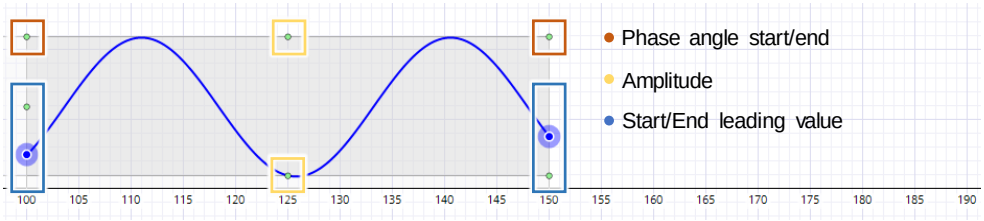
Figure 2-8: "Sine" cam element



		Start			End		
	Element type	Leading value	Following value	Position	Leading value	Following value	Position
1	Sine	10.000000	20.000000	20.000000	50.000000	20.000000	20.000000

Alternatively, you can change the phase angle, amplitude and start/end leading value parameters by dragging the green points directly in the graphical editor.

Figure 2-9 Parameterization via the graphical editor

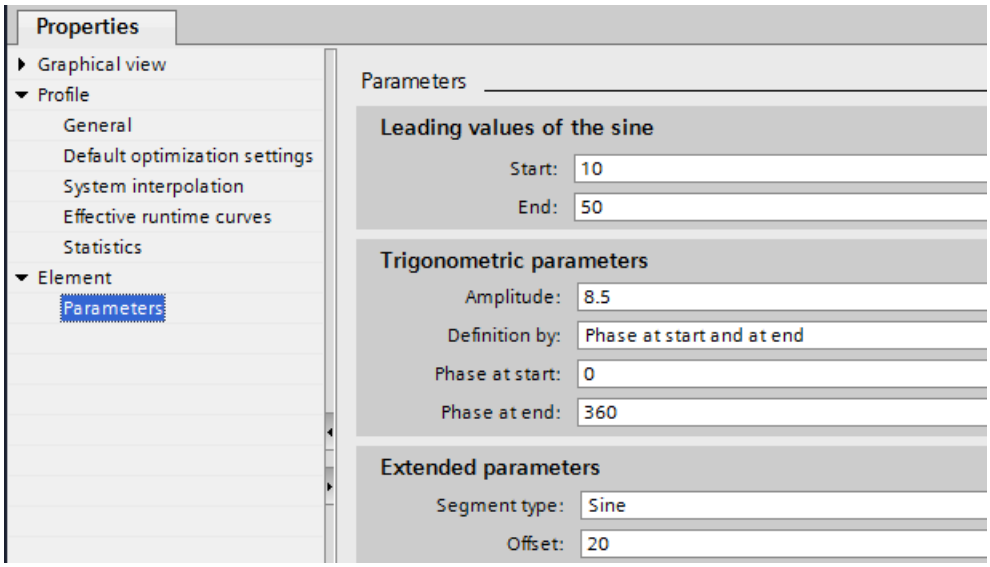


In the trigonometric parameters of the sine function you can choose between five different entry options:

- Phase at the start and at the end of the function
- Phase at the start and the period length of the function
- Phase at the start and the frequency of the function
- Period length and phase at the end of the function
- Frequency and phase at the end of the function

The leading value settings remain the same when you change the parameters of the sine function.

Figure 2-10: "Sine properties"



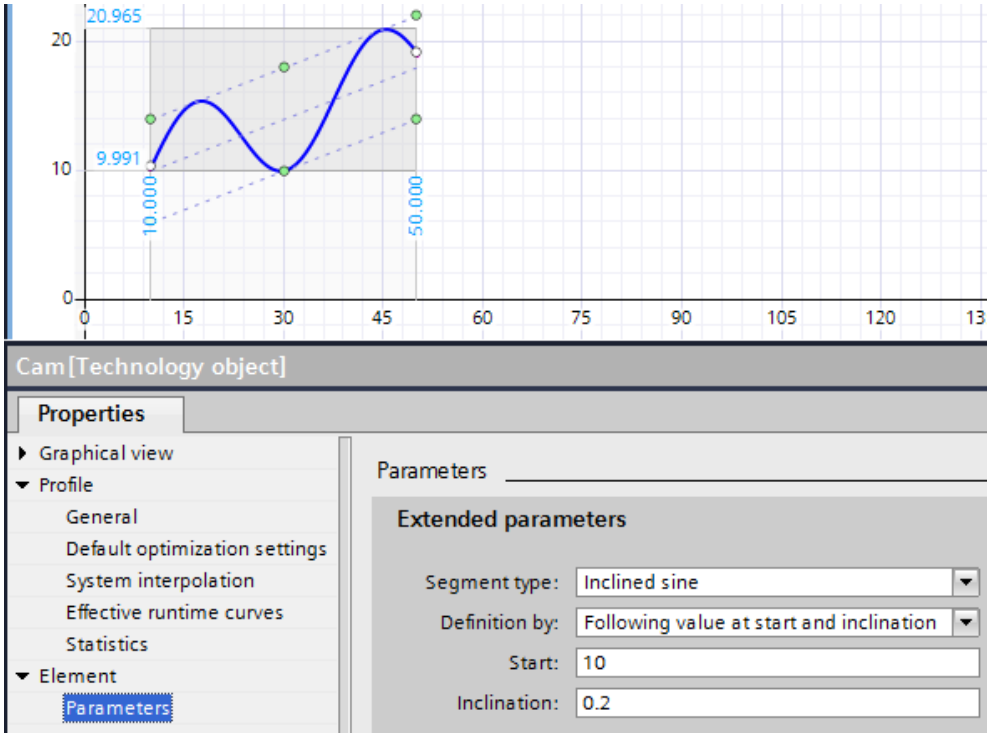
In the extended parameters you can choose between the "Sine" and "Inclined sine" segment types.

With the "Sine" segment option you can specify the zero line offset.

With the "Inclined sine" option you can choose between three different definitions:

- Following value at the start and at the end of the function
- Following value at the start and at the inclination of the function
- Inclination and following value at the end of the function

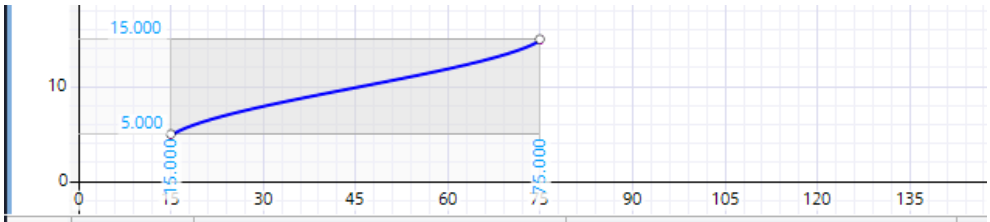
Figure 2-11: Inclined sine



2.5 Inverse sine

The "Inverse sine" cam element describes a movement according to the arc sine function. The arc sine function is the inverse function of the sine function. The inverse sine can be calculated for the definition range [-1, 1] or a limited definition range of the arc sine function. An inverse sine is approximated via the interpolation points of the arc sine function.

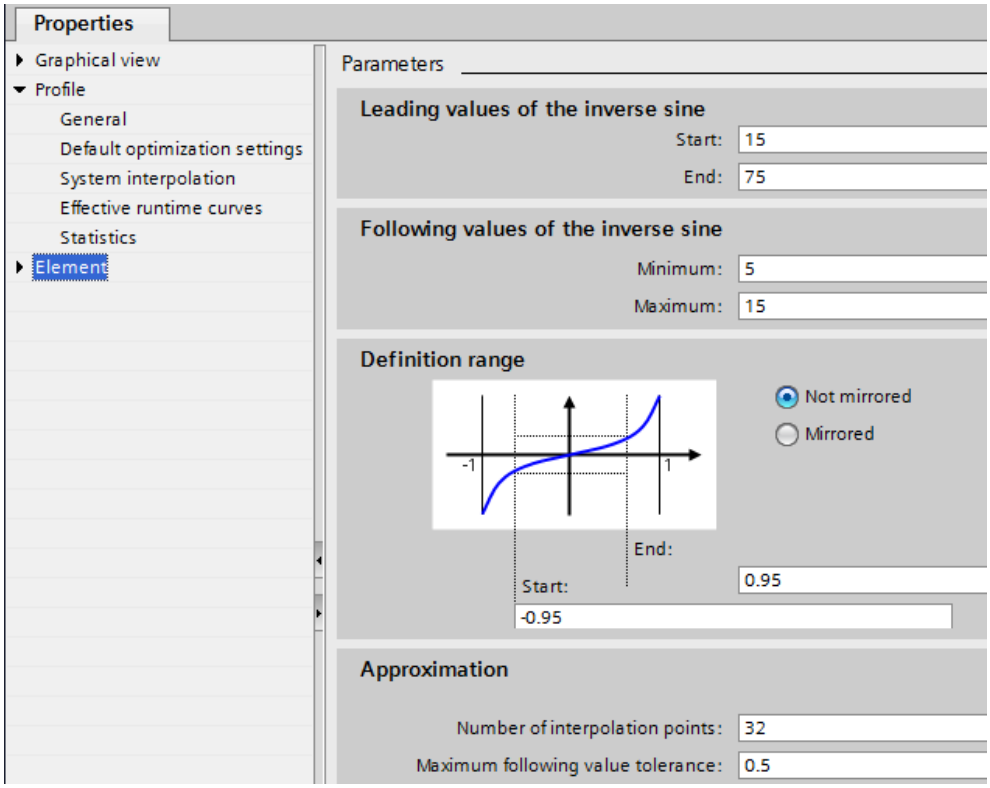
Figure 2-12: "Inverse sine" cam element



		Start			End			
	Element type	Leading value	Following value	Position	Leading value	Following value	Position	Co
1	Inverse sine	15.000000	5.000000	5.000000	75.000000	15.000000	15.000000	

In the properties of the cam element you define the starting point and end point of the leading value as well as the minimum and maximum following values. In the settings of the definition range you have the option of mirroring the function to have a rising or falling curve. For the approximation you can specify the number of interpolation points with which the arc sine function is approximated.

Figure 2-13: "Inverse sine" properties

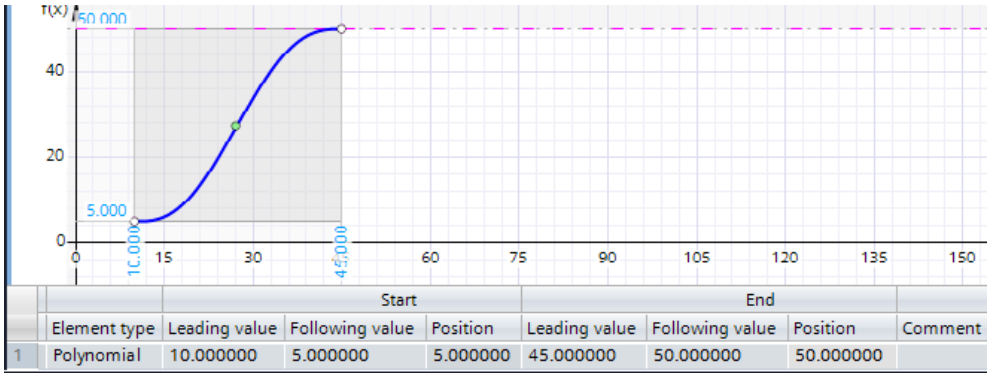


2.6 Polynomial

The "Polynomial" cam element describes a movement according to a polynomial function of the 6th degree maximum with trigonometric portion. By selecting the definition type you can define a polynomial by the following input options:

- Input of boundary values (see Figure 2-14)
- Input of polynomial coefficients (see Figure 2-16)

Figure 2-14: "Polynomial" cam element

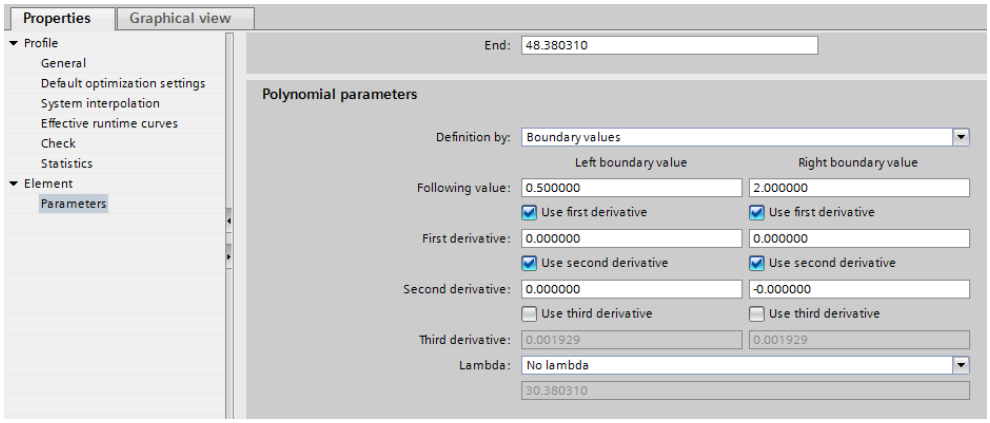


		Start			End			
	Element type	Leading value	Following value	Position	Leading value	Following value	Position	Comment
1	Polynomial	10.000000	5.000000	5.000000	45.000000	50.000000	50.000000	

Boundary values

In the properties you can specify the first, second and third derivatives (velocity, acceleration and jerk) for the boundary values (starting point and end point) of the polynomial.

Figure 2-15 "Polynomial" properties

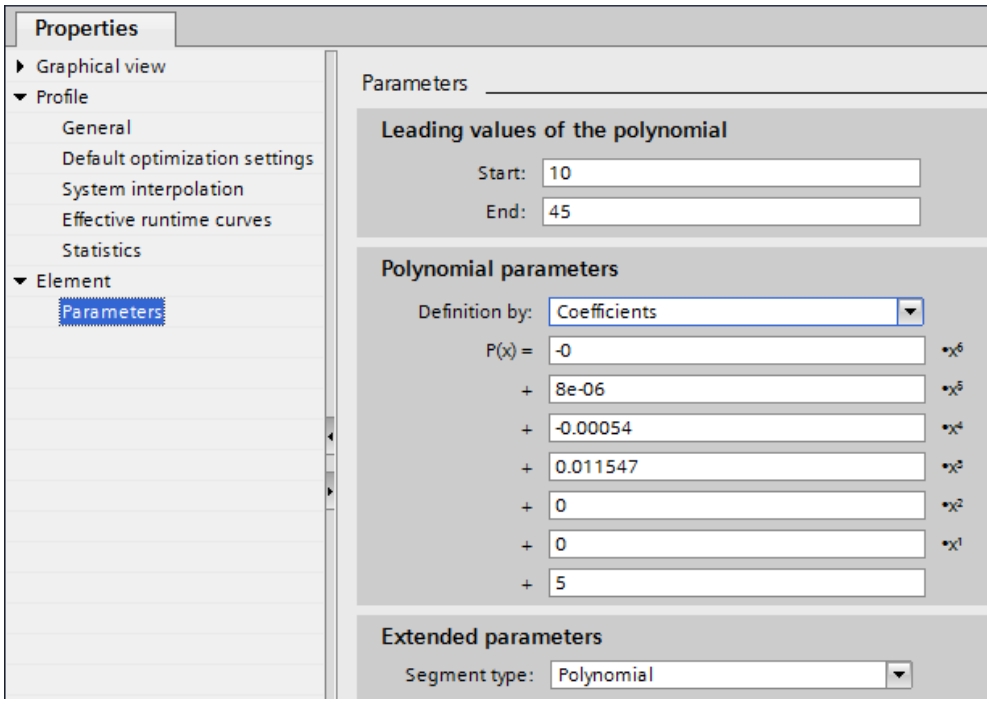


Polynomial coefficients

You enter polynomial coefficients to define the "Polynomial" cam element according to the following formula:

$$Y(x) = a_0 + a_1x^1 + a_2x^2 + a_3x^3 + a_4x^4 + a_5x^5 + a_6x^6$$

Figure 2-16: Input as coefficients



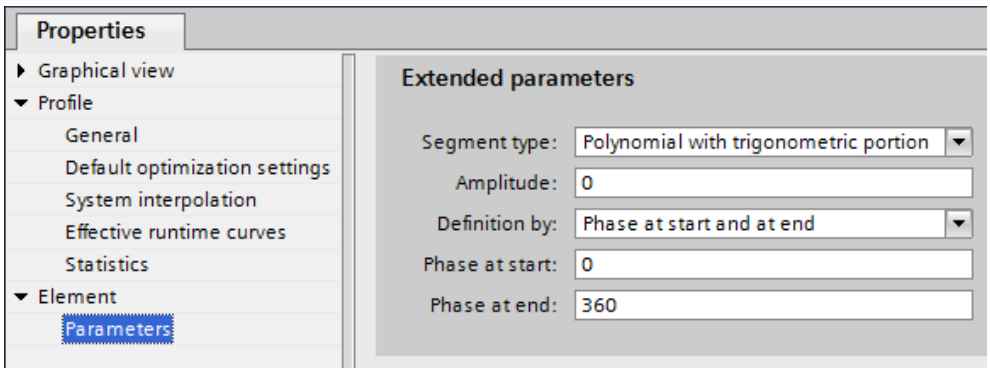
Extended parameters

Select the segment type "Polynomial with trigonometric portion" to activate the extended parameters. Then you can define the trigonometric portion according to the following formula:

$$Y(x) = a_0 + a_1x^1 + a_2x^2 + a_3x^3 + a_4x^4 + a_5x^5 + a_6x^6 + b_0 \sin\left((b_1x) + b_2\right)$$

$a_{0..6}$ = Coefficient of the order 0..6 of the polynomial
b_0 = Amplitude of the trignometric portion
b_1 = Period of the trignometric portion
b_2 = Phase offset of the trignometric portion

Figure 2-17: Extended parameters



3 Interpolation Types

If a curve is defined via segments, the gaps in the definition range can be closed through interpolation. The following actions are performed in the interpolation of a cam:

- The cam is checked for plausibility (double values in the definition range, for example).
- Missing areas of the cam are completed (interpolated).
- The continuity and the connection conditions at the boundary points of the individual elements are checked.

The cam editor shows the interpolated transitions between the segments as they are calculated for the interpolation of the cam in the user program. The technology data block contains only the elements defined by the user. A cam must be interpolated in the user program before it is used.

Note The cam is interpolated in the user program with the Motion Control instruction "MC_InterpolateCam". A description of this instruction is available in the Motion Control function manual:

https://support.industry.siemens.com/cs/ww/en/view/109749263/101549847307

One of the following interpolation types can be specified for each transition:

- System interpolation
- Interpolation in compliance with VDI guideline 2143

3.1 System Interpolation

With system interpolation the transitions between the elements are interpolated according to the interpolation type and behavior at the boundary points. At this point the connections between the segments of the cam are designated as transitions.

The following interpolation types are possible:

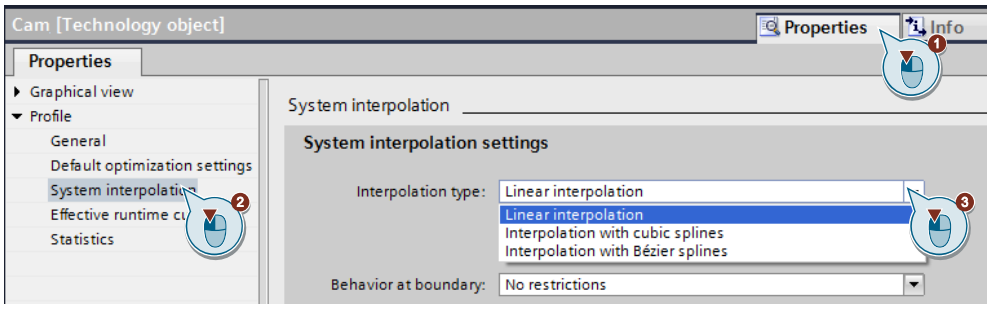
- Linear interpolation
- Interpolation with cubic splines
- Interpolation with Bézier splines

The behavior at the boundary points can be defined as follows:

- No restrictions
  The areas between the elements are closed.
- First derivative constant (constant velocity)
  The cam is interpolated so that no velocity jumps occur at the start and end of the transition.

You select the system interpolation in the properties of the "Cam" technology object. This setting applies to all transitions of the curve with the "System interpolation" setting.

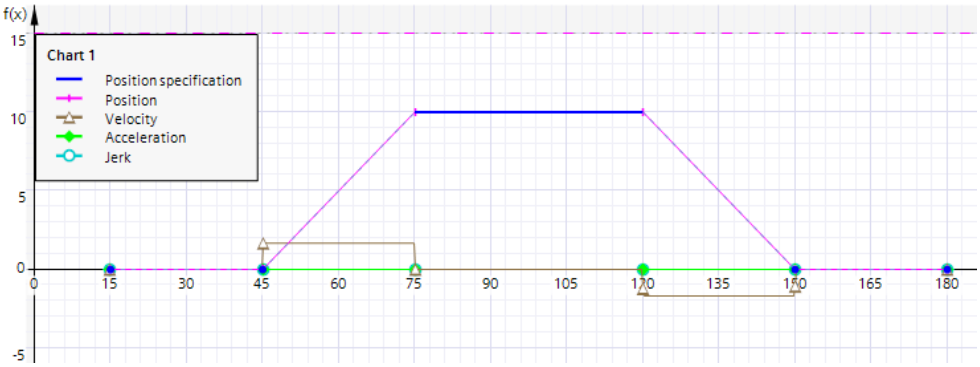
Figure 3-1: Interpolation setting



Linear interpolation

With linear interpolation the transitions (magenta) between the cam elements (blue) are defined by a line.

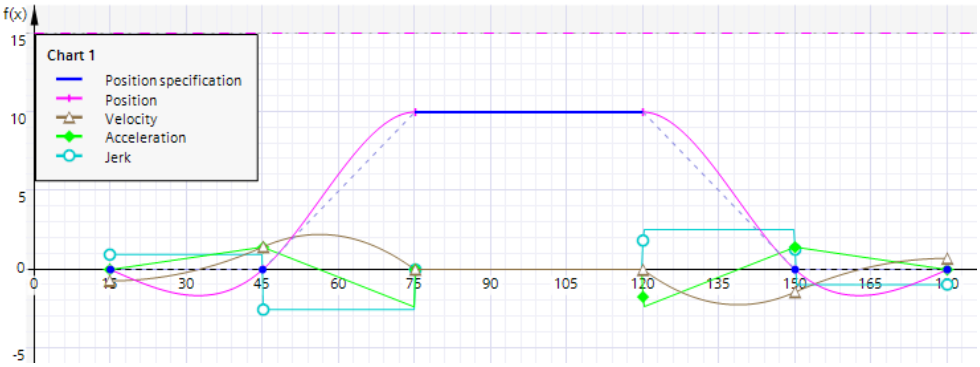
Figure 3-2 Linear interpolation



Interpolation with cubic splines

With interpolation with cubic splines the transitions (magenta) between the cam elements (blue) are defined so that the interpolated curve runs through all the cam elements. The acceleration (green) in the transition is linear.

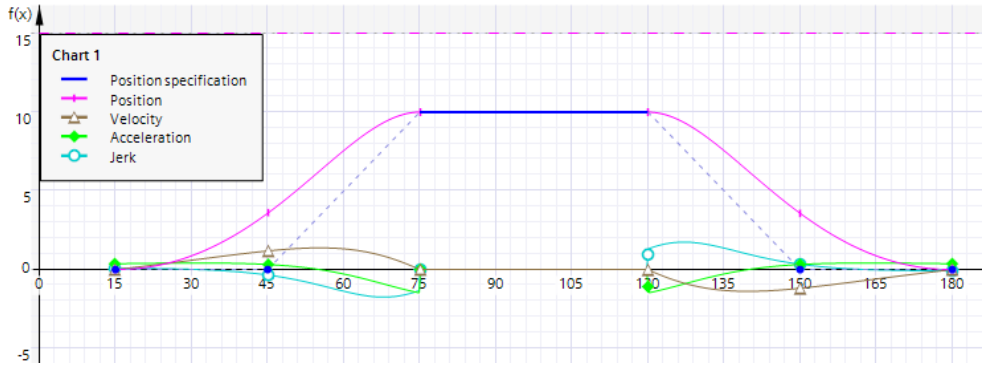
Figure 3-3 Interpolation with cubic splines



Interpolation with Bézier splines

With interpolation with Bézier splines the transitions (magenta) between the cam elements (blue) are defined so that the interpolated curve is oriented on the specified points and runs through other cam element types.

Figure 3-4 Interpolation with Bézier splines



Differences

With interpolation with cubic splines high dynamics might arise depending on the definition of the cam, because the interpolated curve always runs through the specified points. Where necessary choose an interpolation with Bézier splines to obtain a smoothed, slower interpolated curve. In the following figures you can compare the dynamic values from the measuring lines. The curve with interpolation with cubic splines runs through all the specified points whereas the curve with interpolation with Bézier splines is only oriented on the points and there are therefore less dynamic values.

Figure 3-5 Interpolation with cubic splines with dynamic values

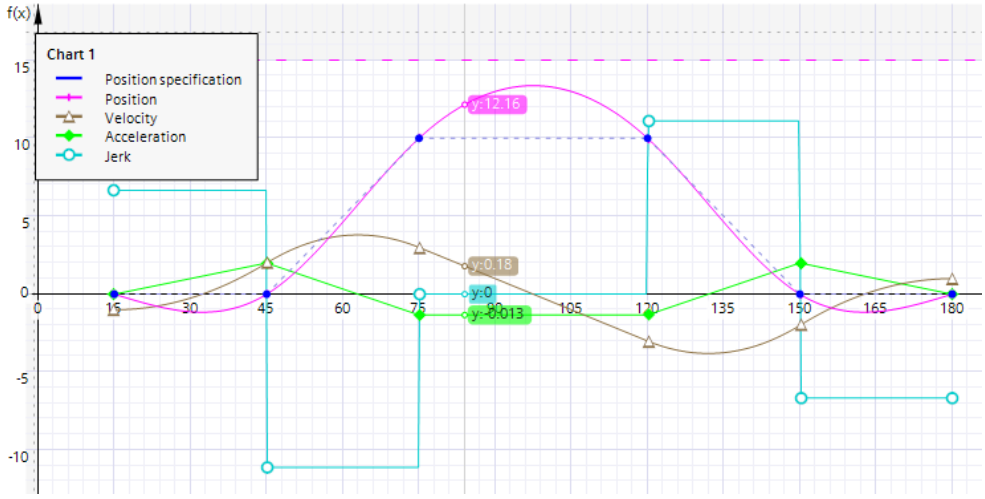
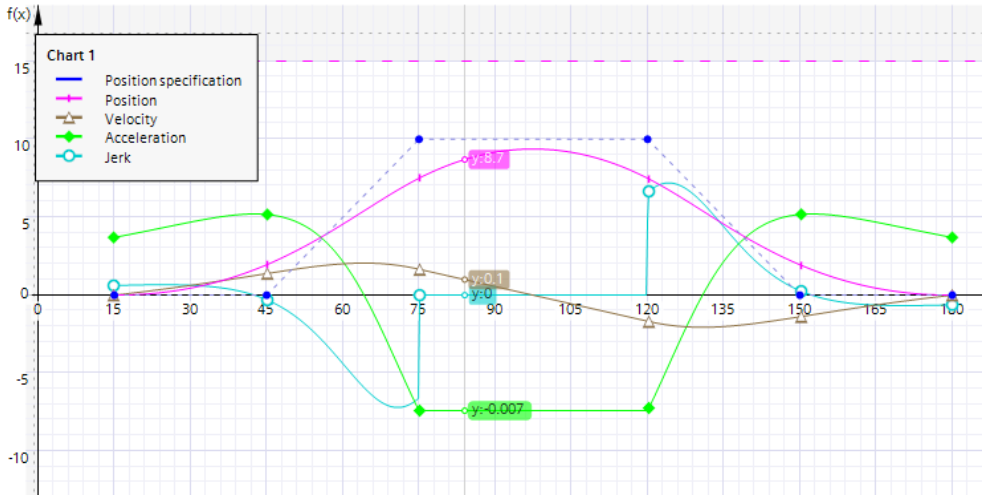


Figure 3-6 Interpolation with Bézier splines with dynamic values



Note If you change the interpolation type, this might change the value range of the cam. After changing the interpolation types always check the minimum and maximum values of the effective curve (see section 5.2).

3.2 Interpolation in Compliance with VDI Guideline 2143

The VDI Guideline 2143 covers motion rules for cam mechanisms. The aim of these motion rules is to achieve high running smoothness and diminish jogs and jerks.

In the cam editor a difference is made between areas of usage and motion transitions:

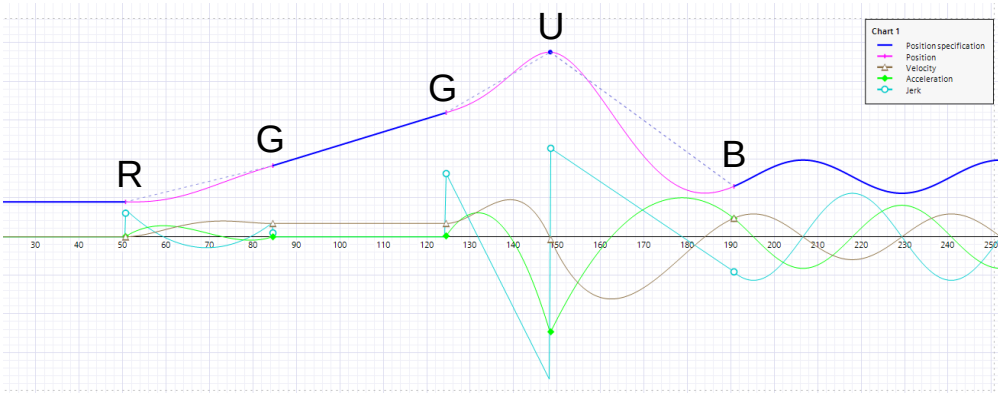
- Areas of usage are elements of the cam added by the user (see chapter 2).
- Motion transitions are the areas that are calculated by the system between the boundary points of two areas of usage.

At the boundary points of a cam element the following motion tasks are given depending on the velocity (v) and acceleration (a):

Table 3-1: Motion tasks according to VDI 2143

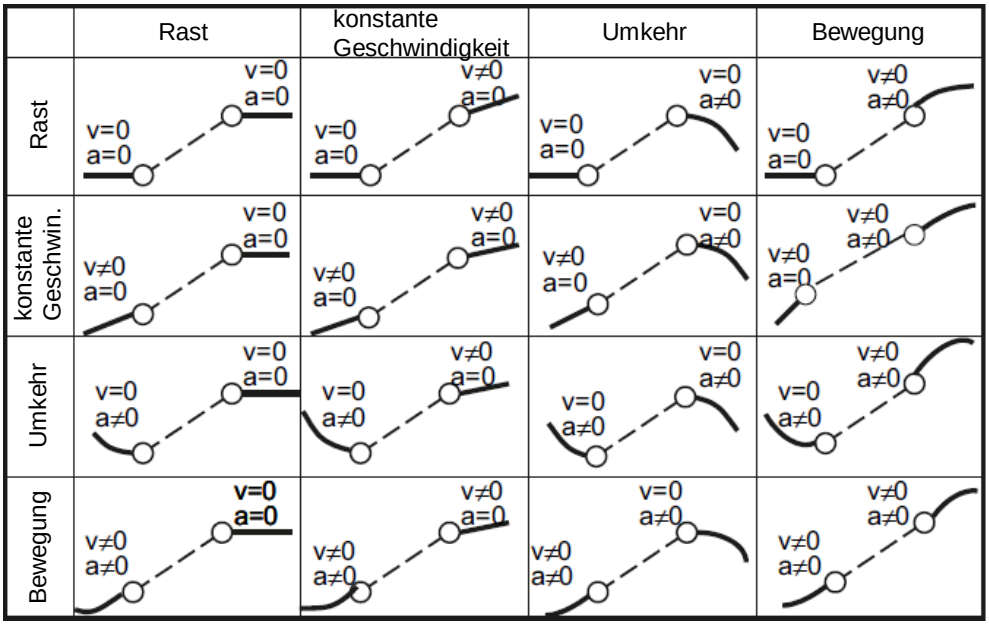
Motion tasks	Designation	Properties
Rest	R	$a = 0$ $v = 0$
Constant velocity	G	$a = 0$ $v \neq 0$
Reverse	U	$a \neq 0$ $v = 0$
Motion	B	$a \neq 0$ $v \neq 0$

Figure 3-7 Examples of motion tasks at the boundary points



The following combinations of motion tasks result between two boundary points:

Figure 3-8 Combination of motion tasks according to VDI 2143



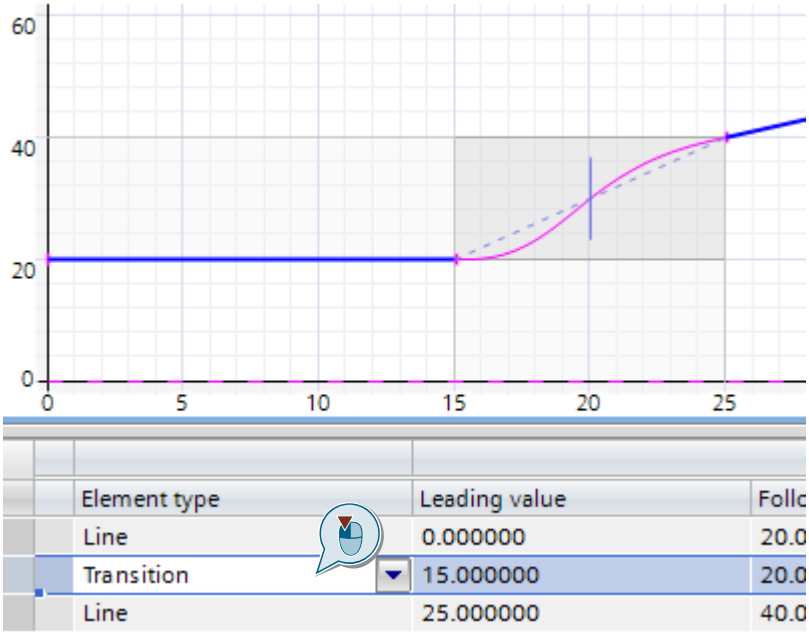
The VDI Guideline 2143 provides multiple standardized motion rules (see Table 3-2) which can be used to calculate transitions free of jogs and jerks for each combination. Depending on what is required of the cam, an appropriate law of motion can be selected and parameterized. If changes are made to a transition, the cam editor shows all the settings of the optimization immediately in the graphical editor and you can read the characteristic values of a transition. Only those motion rules are proposed that are possible for the combination of motion tasks.

The settings of a transition according to the VDI Guideline 2143 can be specified individually for each transition.

Selection of interpolation in compliance with VDI Guideline 2143

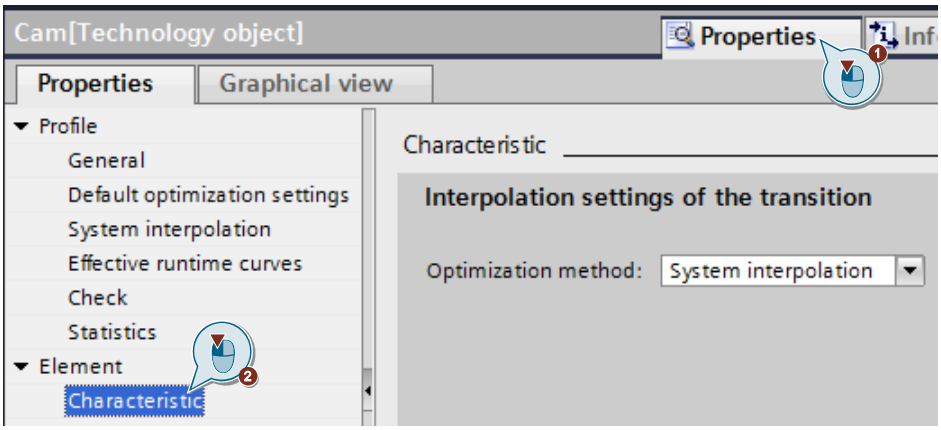
1. Select a transition in the graphical editor or the tabular editor.

   Figure 3-9: Selection of the transition



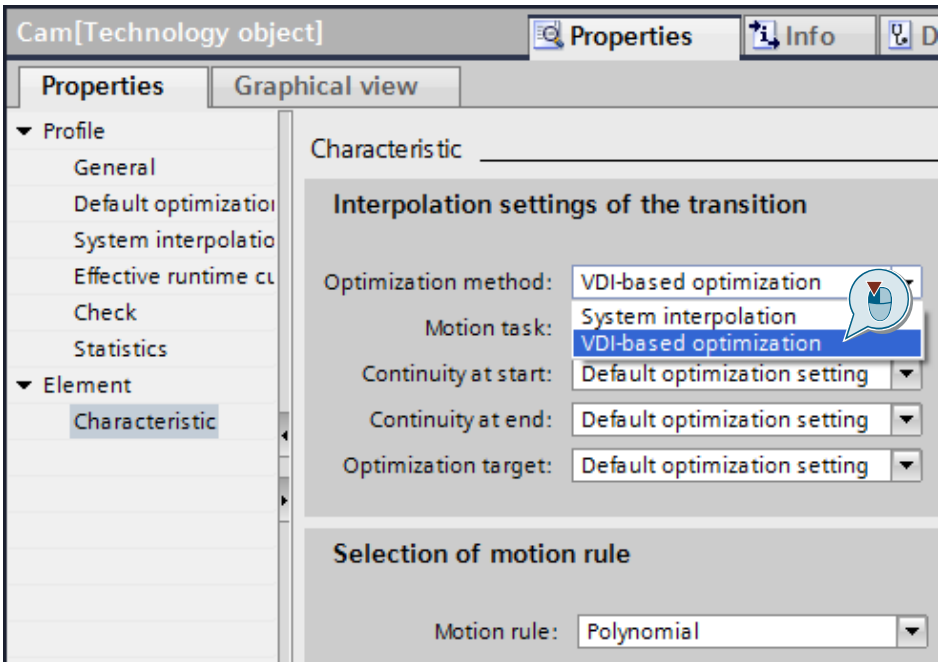
2. In the properties you open the overview window of the characteristic.

   Figure 3-10: Overview of the characteristic



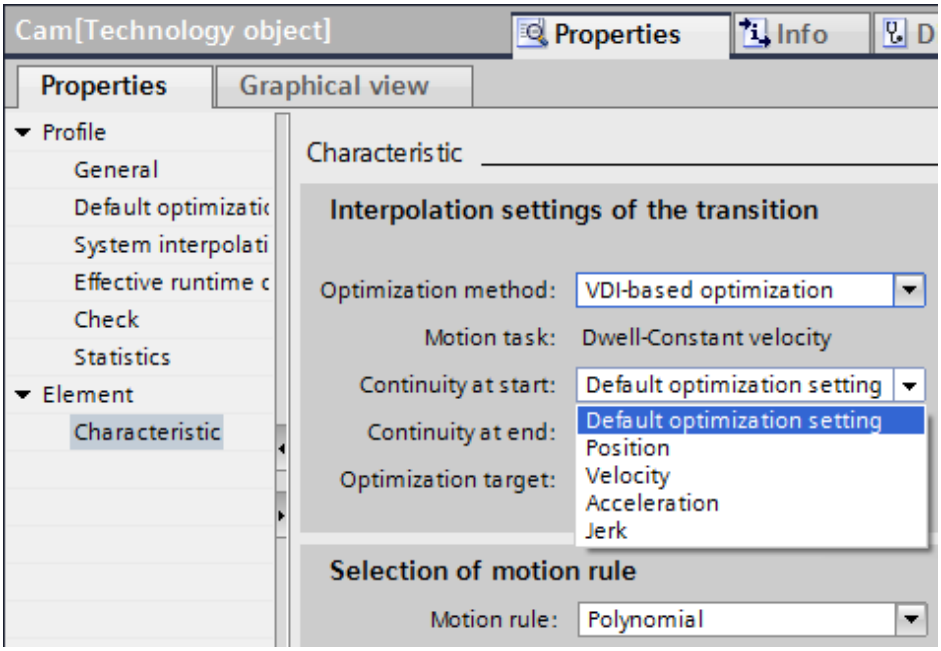
3. In the "Optimization method" drop-down list box you select "VDI-based optimization" as the optimization method.

Figure 3-11: Optimization method



4. Where necessary, change the default settings.

Figure 3-12: Default settings



Default settings

In the "Default optimization settings" configuration window you configure the default settings for the VDI-based optimization of transitions. The default settings are used if you select "VDI-based optimization" as the optimization method for a transition and the "Default optimization setting" for the continuity or the optimization target. The corresponding motion rules according to VDI Guideline 2143 are proposed based on these settings and the associated boundary conditions.

Table 3-2: Setting options

Parameter	Description
Continuity at start Continuity at end	Position
	Velocity
	Acceleration
	Jerk
Optimization target	Velocity
	Acceleration
	Jerk
	Minimum dynamic moment
Motion rule	Line
	Quadratic parabola
	Sine
	Polynomial
	Inclined sine
	Modified acceleration trapezoid
	Modified sine
	Harmonic combination
	Double-harmonic transition
	Sine-line combination

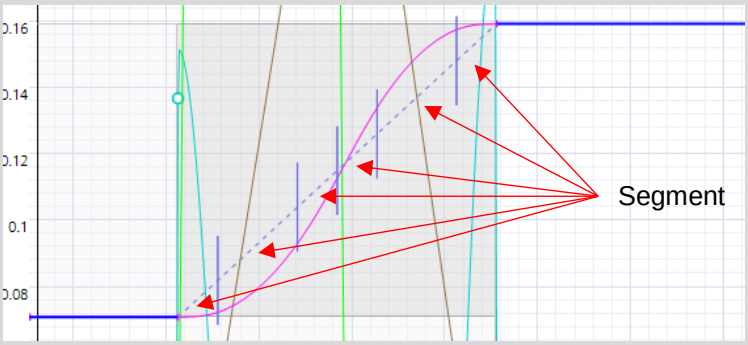
With the continuity settings you select which parameter is constant at the boundary points of the transition and should be considered for optimization.

The possible motion rules are proposed based on the default settings. The maximum values and normalized values are displayed in the "Characteristic values of the transition" overview. Depending on the motion target you select an optimum motion rule and compare it with the displayed characteristic values. If the selected motion rule offers degrees of freedom (boundary conditions and position of lambda), these are changed to meet the required optimization target.

Note

The optimization of transitions according to VDI Guideline 2143 compared to system interpolation might occupy multiple segments in the technology object data block (see also section 5.2), because certain transitions can no longer be mapped by a single 6th-degree polynomial.

Figure 3-13 Transition according to VDI Guideline 2143

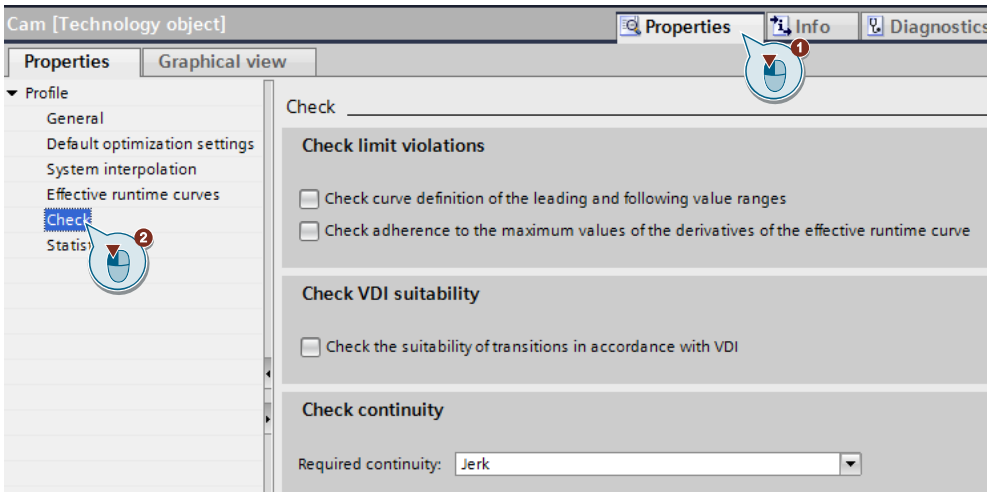


4 Checking and Diagnostics

4.1 Checking the Cam

In the "Check" configuration window you set the criteria that the cam editor checks when the curve is entered.

Figure 4-1: "Check" configuration window



The following check options are available to you:

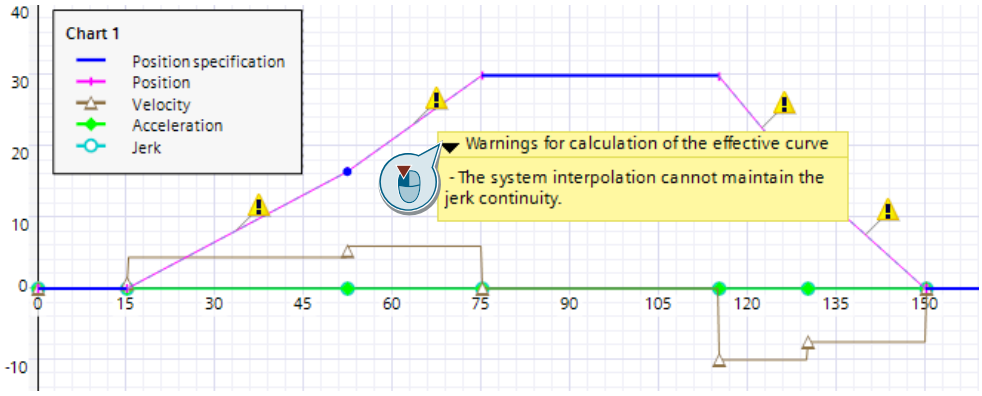
- **Check limit violations**
  - Check the curve definition of the leading and following value ranges (see Properties → Profile → Check)
  - Check adherence to the maximum values of the derivatives of the effective runtime curve (see chapter 5)
- **Check VDI suitability**
  Check that the transition classification of the currently selected VDI transition is maintained and check the boundary value changes according to the VDI Guideline.
- **Check continuity**
  With "Required continuity" you select the parameters the cam editor should check for continuity:
  - Position
  - Velocity
  - Acceleration
  - Jerk

  If a function or a derivative is not continuous, all higher-level derivatives are also not continuous.

Note Use the check options for the final check of the cam and activate all checks before completion of the cam. If necessary, change the cam profile.

When you activate one of the cam checks, the graphical and tabular editors display corresponding messages via a warning triangle on the element. Use the tooltip on the warning triangle to show the message text.

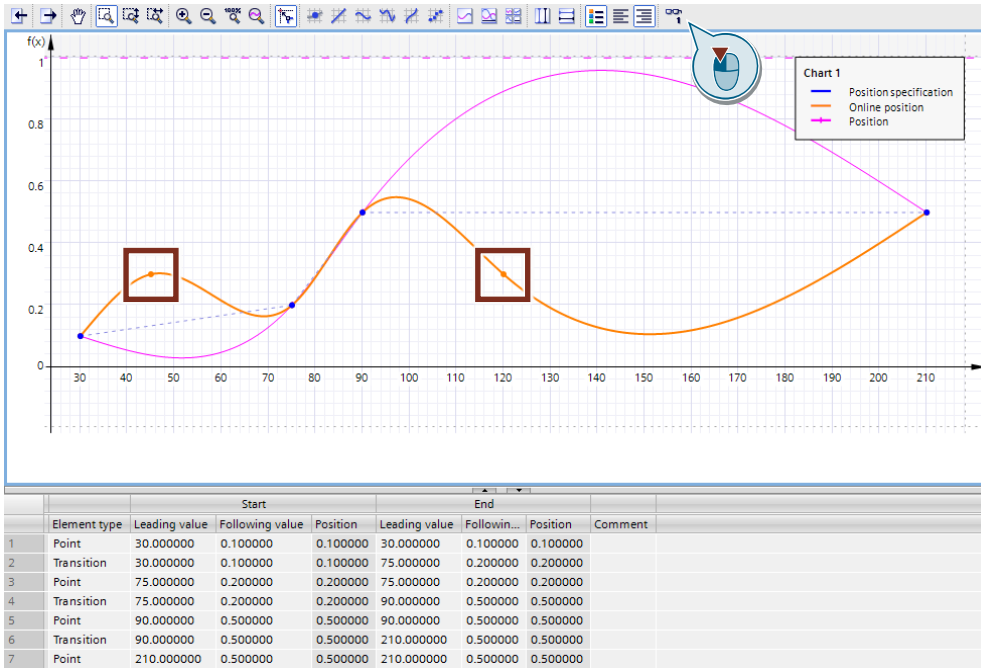
Figure 4-2: Display of faults in the editor



4.2 Show Online Curve

The graphical editor also provides the option of displaying the cam during runtime. If you click the "Show online curve" button, the data is uploaded once from the technology object data block and displayed (orange) if changes and/or an interpolation have been made. Two more points have been added to the online curve in Figure 4-3 before the upload.

Figure 4-3 Interpolated cam at runtime



		Start			End			
	Element type	Leading value	Following value	Position	Leading value	Followin...	Position	Comment
1	Point	30.000000	0.100000	0.100000	30.000000	0.100000	0.100000	
2	Transition	30.000000	0.100000	0.100000	75.000000	0.200000	0.200000	
3	Point	75.000000	0.200000	0.200000	75.000000	0.200000	0.200000	
4	Transition	75.000000	0.200000	0.200000	90.000000	0.500000	0.500000	
5	Point	90.000000	0.500000	0.500000	90.000000	0.500000	0.500000	
6	Transition	90.000000	0.500000	0.500000	210.000000	0.500000	0.500000	
7	Point	210.000000	0.500000	0.500000	210.000000	0.500000	0.500000	

Different online states of the curve are displayed depending on the status bits of the cam (<TO>.StatusWord):

Table 4-1 Status bits of the cam

Status word Bit 4 "CamDataChanged"	Status word Bit 5 "Interpolated"	Description
0	0	No changes made on the cam.
0	1	No data has been changed on the cam, the cam has been interpolated.
1	0	Data has been changed on the cam.
1	1	Data has been changed on the cam, the cam has been interpolated.

This produces the following displays in the graphical editor:

Figure 4-4 Online – no change of data, no interpolation

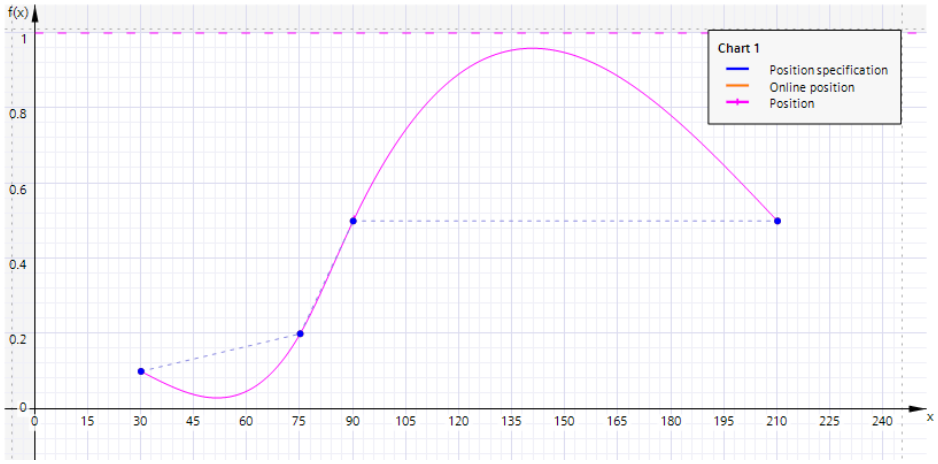


Figure 4-5 Online – no change of data, but interpolation

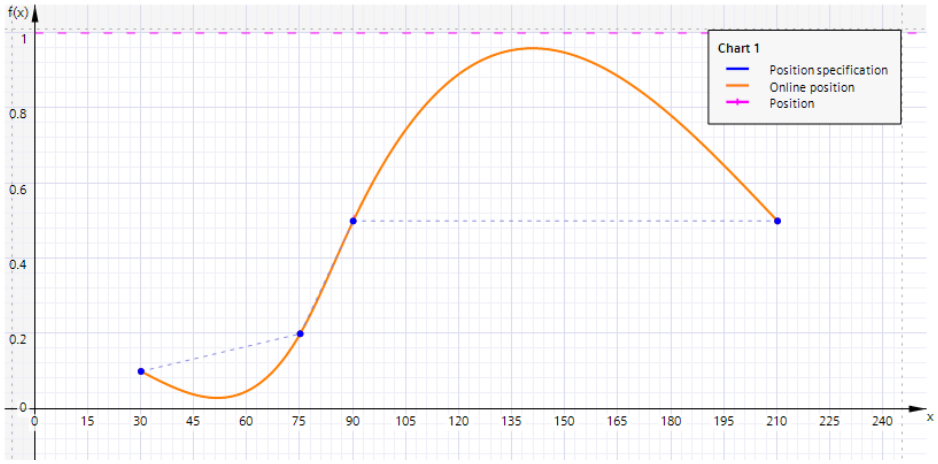


Figure 4-6 Online – change of data, no interpolation

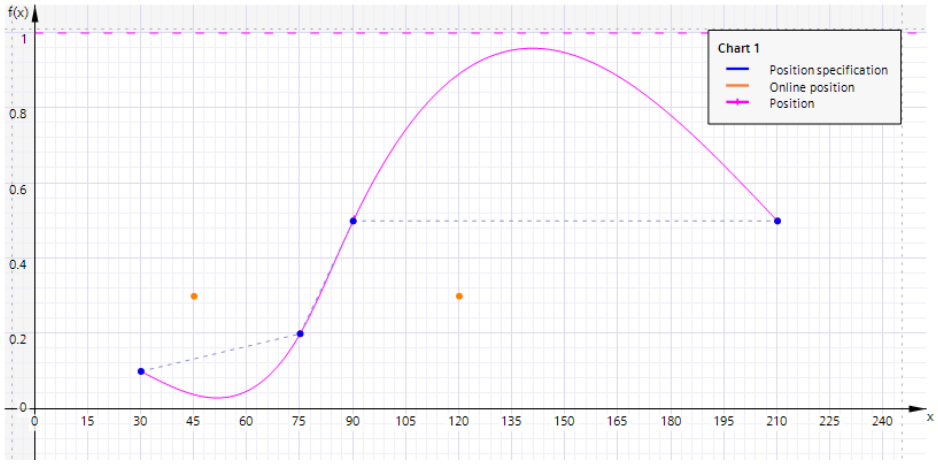
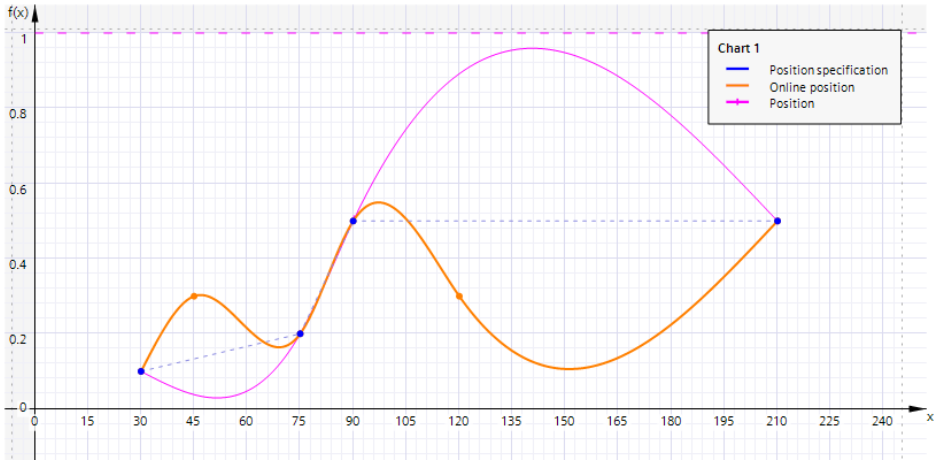


Figure 4-7 Online – change of data and interpolation



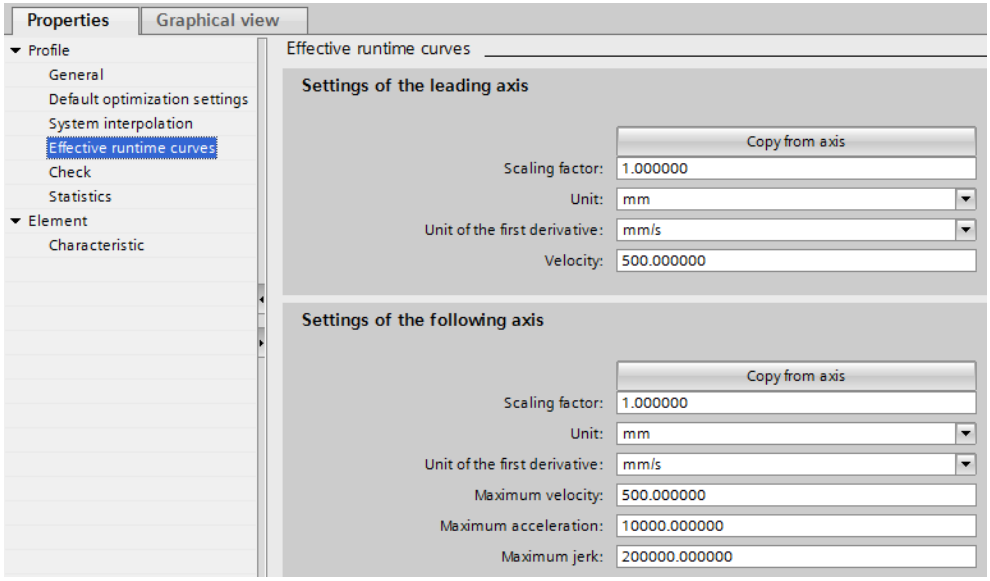
Note The online curve shows only the online values of the technology object data block in the graphical editor. Scaling or offsets parameterized during cam synchronization via the Motion Control instruction "MC_CamIn" cannot be displayed.

5 Notes and Auxiliary Functions

5.1 Effective Runtime Curves

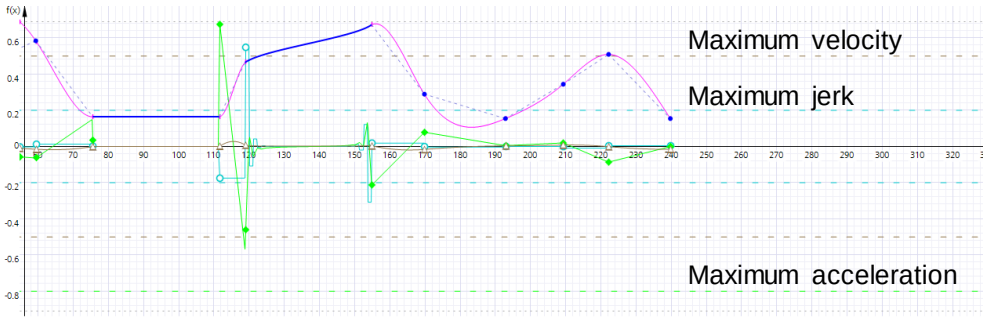
In the "Effective runtime curves" configuration window, for the display of the cam you can copy from a technology object the units and dynamic settings for leading and following axes. The runtime emulation calculates the effective curve with these assumptions and displays them in the graphical editor with the configured boundary values. If settings from a technology object have been used, the specified limit values are checked when the "Check adherence to the maximum values of the derivatives of the effective runtime curve" check has been activated. Alternatively, you can also enter the settings manually.

Figure 5-1 "Effective runtime curve" configuration window



The limit values of the following axis are highlighted in color in the graphical editor.

Figure 5-2 Limit values of the following axis in the graphical editor

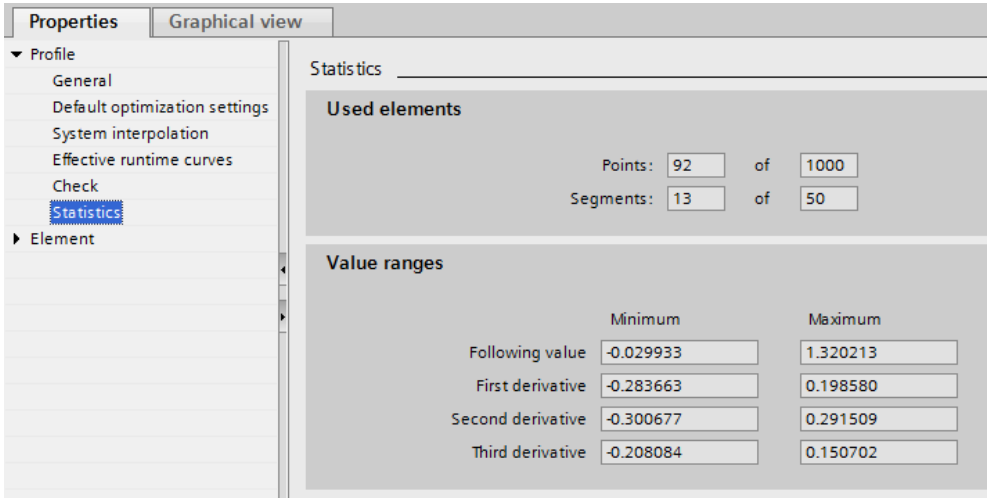


The inputs are not loaded into the CPU; they are just for the visual check in the editor at the time when the cam is created. The cam is therefore interpolated without these settings. With the assumed values you can test and visualize how the cam behaves during operation, for example when specifying a scaling on the Motion Control instruction "MC_CamIn".

5.2 Statistics

The cam statistics give an overview of the number of elements used as well as the minimum and maximum values of the effective curves for the following value and derivatives. One cam can consist of a maximum of 1000 points and a maximum of 50 segments.

Figure 5-3 Statistics of a cam



Used elements

In the statistics a difference is made between points and segments.

- **Point**
  A following value/leading value coordinate on the cam through which the curve runs.
- **Segments**
  All elements and transitions that are calculated through a 6th-degree polynomial with trigonometric portion.

If an element or a transition is defined via one point or multiple interpolation points, the number of specified interpolation points defines the number of points used. The following elements and transitions are calculated via interpolation points:

- "Point" element
- "Inverse sine" element
- "Point group" element with "Point approximation" mapping option
- The "Double harmonic transition" motion rule according to the VDI Guideline

All other elements and transitions according to the VDI Guideline are defined via 6th-degree polynomials with trigonometric portion and for the statistics are therefore counted as segments.

Note A tabular overview of the number of points or segments used of a cam element is available in the section entitled "Profile – Statistics" in function manual "S7-1500T Motion Control V4.0 in the TIA Portal V15".

https://support.industry.siemens.com/cs/ww/en/view/109749263/104835251339

Value ranges

This area shows the minimum and maximum values of the effective curves for the following value and the derivatives.

Boundary conditions

The following conditions hold for the input and usage of points and segments:

- **Points**
  In the case of points with the same leading values a warning symbol is displayed in the editor and only one of the points is effective.
- **Segments**
  - Gaps between segments are filled with a transition segment.
  - In the case of gaps in the leading value range less than 1.0E-4, the segment end point and segment starting point are contracted.
  - In the case of gaps in the leading value range greater than 1.0E-4, a new transition segment is added.
  - If there are overlaps, the new segment is inserted at the starting point and used completely. If the previous segment is defined beyond the new segment, at the end point of the new segment the previous segment continues to be used.
- **Interpolation points and segments**
  If points are defined in the same area as segments, the segment is used.

5.3 Import and Export of Cams

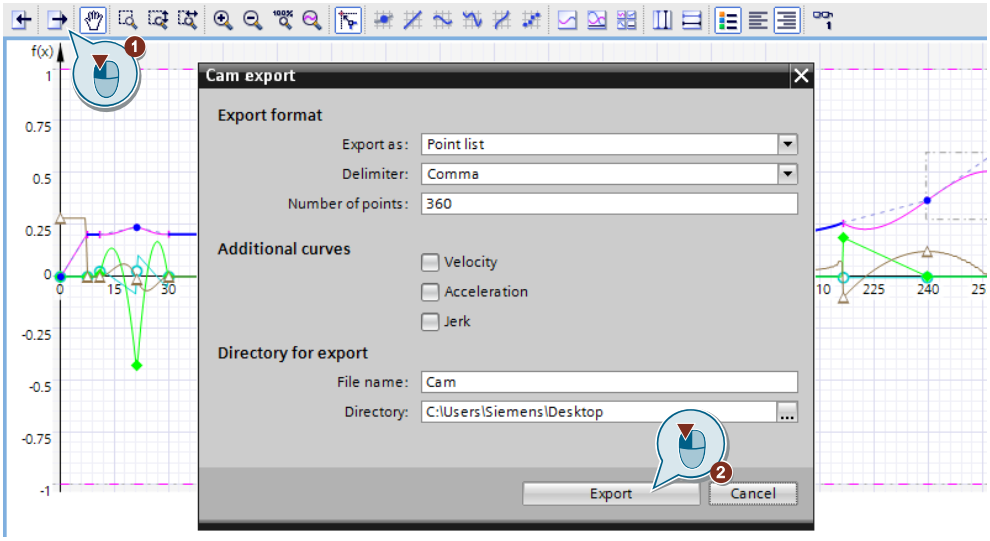
Via the toolbar you can import and export cams from the cam editor.

Export a cam

The following file formats are available for cam export:

- MCD Exchange
- SIMOTION Scout
- Point list
- Binary

Figure 5-4 Cam export dialog in point list format



The SIMOTION Scout, MCD-Exchange and point list formats support export with comma or tab separator. Furthermore, when exporting in the point list format you can specify the number of points and export the derivatives.

The binary format is for exchanging cams between multiple TIA Portal installations and external applications. In this case, the user data of the cam as well as all the settings of the cam editor are exported/imported.

Note

The "Point list" cam element has been added as a new element in TIA Portal V15. If a cam export in the binary format includes the cam element "point list" and is imported into the TIA Portal V14, it is transformed into one or more polynomials.

Import a cam

For cam import you select one of the following file formats: *.txt, *.csv or *.bin. The cam editor identifies the format automatically and imports the cam data in the right format.

WARNING

Machine damage

The import of defective files (.txt, .csv) can lead to unwanted behavior of the axes.

Each time you import a cam from a file you should check the integrity of the imported data (see chapter 4).

5.4 Data Storage in the Technology Object Data Block

When compiling cams, the points and segments are transferred to the technology object data block and stored there in the "Point" and "Segment" arrays.

The positions of the cam elements are arranged according to the x-coordinate (leading value) when interpolating the cam. The order of the segments and points in the corresponding arrays is therefore not of relevance.

In the user program you can add or change points and segments regardless of the order. If you interpolate a cam with the Motion Control instruction "MC_InterpolateCam", the changes are made usable for the technology object.

Note

If you add elements during runtime, their transitions are interpolated via the interpolation type "System interpolation". An interpolation according to VDI Guideline 2143 cannot be set via the user program.

The LCamHdl library for SIMATIC and SIMOTION provides function blocks that support the user in creating jerk-free cams according to the VDI Guideline 2143. The required calculations of the segments for different profile types, for example the polynomial coefficients including any necessary standardization, are done by the blocks.

https://support.industry.siemens.com/cs/ww/en/view/105644659

Data structure for points in the technology object data block

Figure 5-5 Point in the technology object data block

Cam_1

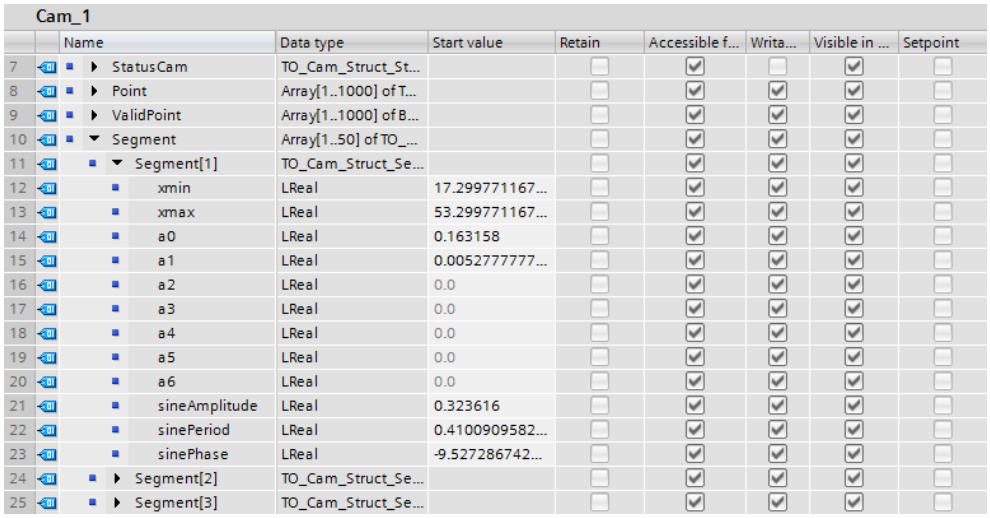
	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint
1	Base	TO_Object			☑	☑	☑	
2	Input							
3	Output							
4	InOut							
5	Static							
6	InterpolationSettings	TO_Cam_Struct_Int...			☑	☑	☑	
7	StatusCam	TO_Cam_Struct_St...			☑		☑	
8	Point	Array[1..1000] of T...			☑	☑	☑	
9	Point[1]	TO_Cam_Struct_Po...			☑	☑	☑	
10	x	LReal	10.160183066...		☑	☑	☑	
11	y	LReal	0.5719298245...		☑	☑	☑	
12	Point[2]	TO_Cam_Struct_Po...			☑	☑	☑	
13	Point[3]	TO_Cam_Struct_Po...			☑	☑	☑	
14	Point[4]	TO_Cam_Struct_Po...			☑	☑	☑	
15	Point[5]	TO_Cam_Struct_Po...			☑	☑	☑	
16	Point[6]	TO_Cam_Struct_Po...			☑	☑	☑	
17	Point[7]	TO_Cam_Struct_Po...			☑	☑	☑	
18	Point[8]	TO_Cam_Struct_Po...			☑	☑	☑	
19	Point[9]	TO_Cam_Struct_Po...			☑	☑	☑	

Table 5-1 Structure of a point

Variable	Data type	Explanation
x	LReal	Leading value
y	LReal	Following value

Data structure for segments in the technology object data block

Figure 5-6 Segment in the technology object data block



Cam_1

	Name	Data type	Start value	Retain	Accessible f...	Writa...	Visible in ...	Setpoint
7	StatusCam	TO_Cam_Struct_St...		☐	☑	☐	☑	☐
8	Point	Array[1..1000] of T...		☐	☑	☑	☑	☐
9	ValidPoint	Array[1..1000] of B...		☐	☑	☑	☑	☐
10	Segment	Array[1..50] of TO_...		☐	☑	☑	☑	☐
11	Segment[1]	TO_Cam_Struct_Se...		☐	☑	☑	☑	☐
12	xmin	LReal	17.299771167...	☐	☑	☑	☑	☐
13	xmax	LReal	53.299771167...	☐	☑	☑	☑	☐
14	a0	LReal	0.163158	☐	☑	☑	☑	☐
15	a1	LReal	0.0052777777...	☐	☑	☑	☑	☐
16	a2	LReal	0.0	☐	☑	☑	☑	☐
17	a3	LReal	0.0	☐	☑	☑	☑	☐
18	a4	LReal	0.0	☐	☑	☑	☑	☐
19	a5	LReal	0.0	☐	☑	☑	☑	☐
20	a6	LReal	0.0	☐	☑	☑	☑	☐
21	sineAmplitude	LReal	0.323616	☐	☑	☑	☑	☐
22	sinePeriod	LReal	0.4100909582...	☐	☑	☑	☑	☐
23	sinePhase	LReal	-9.527286742...	☐	☑	☑	☑	☐
24	Segment[2]	TO_Cam_Struct_Se...		☐	☑	☑	☑	☐
25	Segment[3]	TO_Cam_Struct_Se...		☐	☑	☑	☑	☐

Table 5-2 Structure of a segment

Variable	Data type	Explanation
xmin	LReal	Start leading value X-coordinate
xmax	LReal	End leading value X-coordinate
a0	LReal	Coefficient of the order 0
a1	LReal	Coefficient of the order 1
a2	LReal	Coefficient of the order 2
a3	LReal	Coefficient of the order 3
a4	LReal	Coefficient of the order 4
a5	LReal	Coefficient of the order 5
a6	LReal	Coefficient of the order 6
sineAmplitude	LReal	Amplitude of the trigonometric portion
sinePeriod	LReal	Period of the trigonometric portion
sinePhase	LReal	Phase of the trigonometric portion

Activate the array entries

For each entry in the "Point" array and in the "Segment" array there is an entry in the "ValidPoint" array and in the "ValidSegment" array. The validity of each element is defined in these Boolean arrays. The cam editor automatically sets the corresponding "ValidPoint" or "ValidSegment" for each element to the value "true". If you add elements via the user program during runtime, then you must set the "ValidPoint" or "ValidSegment" manually to "true". Only elements whose ValidPoint or ValidSegment have been set to "true" are interpolated.

Programming example

The following sample code shows how to add a new point to a cam, activate the point and interpolate the cam.

```
#Cam.Point[5].x := 45.0;
#Cam.Point[5].y := 0.3;
#Cam.ValidPoint[5] := true;
#MC_INTERPOLATECAM_Instance(Cam := #Cam,
                           Execute := true);
```

Note After changing the elements used in the cam you must interpolate the cam again. To do this you use the Motion Control instruction "MC_InterpolateCam".

6 Links and Literature

Table 6-1 Links and literature

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/109749820
\3\	Function Manual S7-1500T Motion Control V4.0 in TIA Portal V15 Edition: 12/2017 Document ID number: A5E37577583-AB https://support.industry.siemens.com/cs/ww/en/view/109749263
\4\	Library LCamHdl – Creation of cam disks at runtime https://support.industry.siemens.com/cs/ww/en/view/105644659