

Rexroth IndraMotion MLC CamBuilder

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Functional Description



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1 CamBuilder

1.1 General

The CamBuilder is an integrated tool in IndraWorks for creating easy and comfortable Cams.

With direct sending the Cams to the drive controller of Bosch Rexroth this tool is specialized and predestinated for your requirements and special features.

The basic properties of the CamBuilder are:

- Easy creation of Cams with the help of graphical objects
- Comfortable handling of existing Cams
- Handling of several Cams at the same time
- Use of motion laws according to VDI 2143
- Sending and receiving the Cams in, resp. to BRC-Drives and controls
- Automatic display of position, acceleration, velocity and jerk
- Support of frequently occurred requirements (e.g. cross cutter functionality) by wizards
- Import of point tables for a sub-range of the Cam
- Automatic identification and calculation of boundary conditions of the Cam
- Zoom functionality
- Change-over between normalized and rated view
- Import / Export-Functionality in several formats (*.par, *.csv, *.ipf)

In general it can be differed between several Cam types:

- **Endless Cam** - the position commanded value rises continuous. This Cam is also used for the default Cam. Here the Cam table starts at 0% and ends at 100%. Generally with rotatory following axes the 0% matches 0 degree and 100% 360 degree. But 100 % may correspond to an other value, this depends on the setting of drive parameter Cam Shaft distance.
- **Recurring Cam** - the position commanded value at the beginning and at the end is the same, a fallback movement takes place when processing the table (example filling installation: up-synchronization - filling - down-synchronization - fallback movement to start position - up-synchronization ...). Start point and end point may be different of 0 % or 100 %. The greatest position value there matches 100 %, that means, the value specified in parameter Cam Shaft distance is reached in this point.
- **Automatic completed Cam** - this type is used, if the user cannot or will not specify the start and end value of the master axis at 0 degree and 360 degree. For this type of Cam only a part of the profile is relevant, the rest is calculated by the CamBuilder self-dependent. Thereby the polynom 5. class is used.

All Cam types can be created by the CamBuilder; a type can be changed anytime to an other by changing the parameters.

First Steps with the CamBuilder

To create a Cam in IndraWorks, first a project must be created. If the CamBuilder is installed, the Cam Pool is created automatically when creating a project.

Now you can create a Cam by several possibilities. For that purpose select in the context menu of the Cam Pool under entry "New" one of the following points:

- **Default Cam Profile** - for all necessary inputs standard values are set.
- **Cam Profile Wizard...** – the inputs for generating a Cam can be entered on several dialog pages.
- **Application Cam Profile...** – thereby inputs are prompted which are relevant for the chosen application (e.g. feed rate).

After the wizard was completed, the Cam appears in the working area of IndraWorks. The Cam may now be followed up.

In the CamBuilder the working sheet is subdivided in sections. A section is exactly determined by the left and the right interpolation point. The standard Cam profile is 0...360 degree. To insert more sections, you can:

- doubleclick with the mouse in the graphical representation of the Cam at the desired place (the position can be modified later in the Section Editor).
- click to switch "Edit CamBuilder" in the symbolbar (toolbar).
- select in the context menu of the graphical representation the entry "Insert new section".

A section is defined by:

- **Left Interpolation point**
- **Right Interpolation point**
- **Curve type** (mathematical function for connecting both interpolation points)
- **Limit Values** (velocity and acceleration at an interpolation point)

Furthermore the following Desktop-Elements to edit a Cam are available:

- **Project**
- **Section Editor**
- **Graphical Representation**
- **Graph-Manager**
- **Profile Limits List** of the Cam
- **Sections List**
- **Profile Points** of the Cam
- **Profile Point Editor**
- **Options Dialog**
- **Symbolbars** (Toolbars)

All Desktop-Elements can be optionally moved, arranged and shown/hide by the user. Each change of the layout is permanently stored and consequently the layout is restored at a restart of the CamBuilder.

From the Conceptual Formulation to the Completed Profile

Following steps must be performed to create and to load a Cam into the target device:

- **Start IndraWorks**
- **Create New Project**

- **Create New Cam**
 - Select in the context menu of the Cam Pool the entry "New", then select the wizard for creating a new Cam and insert the necessary values in the wizard pages.
- **Edit the Cam**
 - Add sections, delete or modify the values of a section in the Section Editor as long as the desired curve progression of following axis position, velocity, acceleration and jerk matches the requirements.
- **Drag the desired target device from the device library into the project**
 - Thereby enter the required communication settings
- **Go online with the target device** (via toolbar switch)
- **Select the desired Cam in the Cam Pool**
- **Select in the context menu the Item "Download to Device"**
- **Select in the following dialog the desired Cam table or the electronic movement profile in the target device**
- **Send the Cam to the target device by pressing "OK".**

1.2 Working with the CamBuilder

Cam Pool

The Cam Pool is in the IndraWorks-Project and shows all Cams in the project.

Following operations can be made in the Cam Pool:

- Create a New
- Edit an Existing Cam
- Delete a Cam
- Rename a
- Download and Upload Cams
- Import and Export
- Print a Cam

Note: For a better overview you can create additional folders below the Cam Pool.

Create a New Cam

A new Cam can be created anytime via the context menu of the Cam Pool. Thereby you can choose between 3 variants:

- **Create a new Default Cam** – a new Cam of 0 - 100%, normalized view and a section with polynom 5. class is created. All parameters may be modified later.
- **Create a new Cam with the New Cam-Wizard** - the inputs for generating a Cam can be entered on several wizard pages.
- **Create a new Cam with the Application-Wizard** - thereby inputs are prompted which are relevant for the chosen application (e.g. feed rate).

Edit an Existing Cam

Change Cam Properties

The properties dialog of a Cam is called up by the context menu of the Cam. Here the settings for the actual (focused) Cam can be made.

Note: The context menu entry "Properties" is only available, if the Cam is load (by a doubleclick to the Cam in the Project).

The properties of a Cam are:

- **Name** – the name of the Cam defined by the user. If a new Cam is created, the default name "Cam #" is assigned.
- **Description** – a description edited by the user.
- **Use Cam profile in normalized view** – it is selected, if the **Cam** is displayed in normalized (%) or scaling view.
- **Measurement units of the following axis** - damit wird auch automatisch festgelegt ob der Antrieb rotatorisch oder translatorisch betrieben wird. Default ist Grad (und damit rotatorisch) (nur bei bewerteter Ansicht relevant).
- **Master axis velocity** – is always specified in rounds per minute (rpm) (only relevant with scaled view).
- **Cam Shaft Distance** – the factor by which the value of the cam table is multiplied (only relevant with scaled view).
- **Default curve type** - here the motion law is specified which is used at the insertion of a section by a doubleclick. These property has an affect to all cams!
- **Boundary points** - for the start and end point of the cam the position of the master axis and the **following** axis as well as velocity and acceleration of the **following** axis can be entered.
- **Velocity and acceleration in start and end point identical** - for the start and end point of the cam the velocity and acceleration is set equal automatically.

Add Section

This dialog is used to insert a new interpolation point between two existing points. The dialog can be called up either in the Edit menu "Add Section" or from the context menu of the graphical representation (Insert new section).

If the dialog is called up from the context menu, the coordinates of the position are overtaken where the mouseclick was made.

At the call from the Edit-menu the center of the selected section is preselected as the x-coordinate. All other parameters are initialized with zero.

Possible inputs for the new section are:

- Position master axis, position following axis, velocity and acceleration of the to be insert interpolation points,
- Description of the new section (as well as the existing),
- Curve type of the new section (as well as the existing), as well as
- The point of inflection parameters (symmetry).

Note: Due to the used curve types, several parameters may be write protected, because otherwise boundary conditions can not be kept!

Import a Point Table into a Cam section

The CamBuilder allows to insert a point table as a section of the Cam. For that purpose select in the Section Editor as the curve type the point "Load Points Table...". In the following dialog the desired table can be selected and imported.

Delete a Cam

A cam can be deleted in the project in the following way:

- Select the to be deleted Cam in the Project with the mouse or keyboard, subsequently press the "Remove" key and quit the following safety query.
- Select the to be deleted Cam in the Project with the mouse or keyboard, subsequently open the context menu with the right mouse button or keyboard and select the menu item "Delete" and quit the following safety query.
- Select the to be deleted Cam in the Project with the mouse or keyboard, subsequently select in the main menu <name of the Cam> the menu item "Delete" and quit the following safety query.

Rename a Cam

A Cam can be renamed in a project in the following way:

- Select the to be renamed Cam in the Project with the mouse or keyboard. Subsequently click to the already selected cam with the left mouse button again. Now the actual name is marked and can be renamed. Quit the change with the Return-key.
- Select the to be renamed Cam in the Project with the mouse or keyboard. Subsequently open the context menu with the right mouse button or keyboard and select the item "Rename". Now the actual name is marked and can be renamed. Quit the change with the Return-key.
- Select the to be renamed Cam in the Project with the mouse or keyboard. Subsequently select in the main menu <name of the Cam>. Now the actual name is marked and can be renamed. Quit the change with the Return-key.

Comparison of two Cams

In IndraWorks you can compare two Cams visual. For that purpose select one of the two Cams in IndraWorks and select in the menu "Window" the item "New horizontal tab group". Thereupon the selected Cam is opened in a separate window below the existing window. Both Cams can now be compared visual.

Download and Upload Cams

Cams can be send with the CamBuilder directly to the drive or received by the drive. For that purpose it is necessary to have a drive with Cam support in the project and the project must be Online. If both conditions are fulfilled, you can

- Select the item "Download to Device" in the context menu of the Cam in the Project and then select the target device and the desired Cam in the following list of the available devices.
- Select the item "Upload from Device" in the context menu of the Cam Pool in the Project and then select the target device and the desired Cam in the following list. After receiving the new Cam is created in the Cam Pool and then opened.

Note: If a Cam table is load from the drive, it is only possible to edit the several interpolation points in the Section Editor!

Import and Export Cams

Cams can be imported into an IndraWorks-Project or exported from an IndraWorks-Project by the CamBuilder. For these Import- / Export-Functionality the following formats are supported:

- Comma Seperated Value Format (*.csv Fileformat)
 - Sercos ASCII Format (*.par Fileformat)
 - Internal file format CamBuilder Version 01VRS (*.ipf) –only with import
- For further informations see Data Management

Print a Cam

CamBuilder allows to print the different Cams data selective:

Via menu item "Print" in the context menu of a Cam in the Project the following options are selectable:

- **Print 'Description' of Profile** - the description for the Cam will be print.
- **Print 'Graphical Representation' of Profile** - the actual graphical representation will be print (a Cam must be opened in the working area so that this function works).
- **Print 'Interpolation Points' of Profile** - the data of the several interpolation points (position, velocity, curve type, description, ..) will be print.
- Profile Limits List of the Cam – the contents of the profile limit list will be print.
- Profile Points of the Cam - e.g. 1024 values of alle 4 profiles + master axis position will be print.

1.3 Desktop-Elements

Project Explorer

The project explorer is the navigation center of IndraWorks. The explorer displays the projects and all elements of the several projects (e.g. the Cam Pool or a drive). With a doubleclick to the several nodes editors are started; if available, a context menu is displayed when you click with the right mouse button to the node. Furthermore an entry is insert for the selected node in the main menu of the Project.

Section Editor

In window "Section Editor" the graphical representation of the selected section can be edited. After input the data, the profiles in the graphical representation are automatically updated by "Return" resp. by key 'Apply'.

With buttons << and >> a quick change between the section is possible.

Define the input fields for 'Left Point' and 'Right Point':

- x= Position of the master axis in the left, resp. right interpolation point of the section

- y = Position of the following axis in the left, resp. right interpolation point of the section
- v = Velocity of the following axis in the left, resp. right interpolation point of the section
- a = Acceleration of the following axis in the left, resp. right interpolation point of the section

Note: Depending on the chosen curve type (motion law) of the section or the Cam type, boundary conditions may be predetermined. For this reason the according parameter is calculated automatically and write protected.

Furthermore the following inputs are available fo the section:

- the curve type (motion law) to connect the 2 interpolation points of a section,
- the point of inflection parameter for this section (symmetry)
- a description of the section (optional)

Note: If a new Cam is created with the Application-Wizard (in menu "File" -> "New -> Application Wizard"), a second page with all relevant parameters of the application is available. Each section can then be edited further on with the Section Editor.

If a application parameter (on the second page) is changed and accepted, the profiles are re-calculated and the changes in the Section Editor will be discarded.

Graphical Representation of the Cam

This Desktop-Element represents the created Cam in a graphical form. Thereby the following elements are displayed:

- **Cam Profile** - for each created Cam four profiles are displayed, the position profile (displays the following axis position), the velocity profile, the acceleration profile and the jerk profile. What profiles are displayed can be determined in the Graph-Manager. The color of the drawn profile can be adjusted in the Options Dialog.
- **Section boundaries** - vertical lines which mark the boundaries of the sections
- **Profile boundaries** - vertical lines which mark the boundaries of the **Profiles** (normally 0 Grad - 360 degree, but not with an automatic completed Cam)
- **Coordinate system** - the axes of the coordinate system have always the color of the selected profile, the grid serves for an implemental to enhance the clearness

Following actions may be performed in the graphic:

Action	Result
Left mouseclick to a profile	Section and profile will be selected. All parameters of the section are displayed in the Section Editor.
Right mouseclick to a graphic	The context menu is displayed (see below).
Drag & Drop of an interpolation point of the selected section	The interpolation point can be moved by the mouse. If it is dropped, the profile is re-calculated.
Left mousedoubleclick within the profile boundaries	A new interpolation point (and there a new section) is inserted. The used curve type for the calculation of the profile section is the Default curve type.
Left mousedoubleclick to an interpolation point	The dialog for editing the section is called up.

Fig. 1-1: Edit the graphical representation

Note: The scaling of the y - coordinate is always related to the active profile.

The context menu (right mouseclick to auf graphic) has the following entries:

- **Insert New Section** - starts the dialog for inserting a section. The coordinates of the new interpolation point have been overtaken at the place where the mouseclick was executed
- **Edit Section** - starts the Section Editor. The selected section is that, in which the mouseclick was executed
- **Delete Section** – deletes the selected section. Subsequently the profiles will be re-calculated
- **Show All** – displays the complete profile (Default mode). All zoom actions will be discarded.
- **Zoom Rectangle** – a rectangle section can be marked with the mouse. Subsequently this section is scaled up.
- **Panning** – a scaled up section can be moved
- **Copy Graph to Clipboard** - copies the actual graphical representation to the clipboard. So you can insert it again e.g. in MS Paint or MS Word
- **Undo** - the last change will be discarded

Graph-Manager

This Desktop-Element contains the settings for the graphical representation of the Cam. It contains the following elements:

- **Profiles** - the four profiles for position, velocity, acceleration and jerk can separately be displayed or hide. Also the active profile can be selected
- **Zoom** - the several zoom methods can be selected here (see Graphical Representation of the Cam)
- **Coordinates** - the mouse coordinates, related to the actual profile, are displayed
- **Show** - the section boundaries, coordinates of the section boundaries and the mouse position can be displayed or hide

The settings in the Graph-Manager affect directly the graphical representation.

Note: This Desktop-Element can be displayed or hide via menu 'View - CamBuilder - Graph-Manager'.

Profile Limits List of the Cam

In this list the minimal and maximal values of the complete position profile, position profile, velocity profile, acceleration profile and jerk profile as well as the dynamic moment characteristic is displayed.

The dynamic moment characteristic is calculated by the following equation:

$$C_{\text{dyn}} = \text{MaxValue}(\mathbf{v} * \mathbf{a})$$

with \mathbf{v} = velocity and \mathbf{a} = acceleration.

For further help see Characteristics of the Standardized Motion Law

Note: This Desktop-Element can be displayed or hide via menu 'View - CamBuilder-Profile Extremums'.

Sections List

In this list the informations about the several sections of the Cam are centralized.

A line in the list contains the informations of a section. By clicking to a line in the section list this section is automatically activated in all other desktop elements.

Note: This Desktop-Element can be displayed or hide via menu 'View - CamBuilder – Sections List'.

Profile Points of the Cam

The profile points are values (e.g. 1024), which will be send to a BRC-Drive or BRC-Control. But only the values for the following axis will be send! All other columns serve only for check and documentation (e.g. it is possible by this table to detect the exactly velocity at a determined position).

The values of the following axis are standardized related to 100% calculated and send.

The Cam table consists thereby of e.g. 1024 values in equidistant sections $d(j)$. The distance between 2 values results in

$$d(j) = 360^\circ / 1024 = 0.35^\circ,$$

at which the first value begins at $j(0) = 0^\circ$ and

the last ends at $j(1023) = 360^\circ - d(j)$.

Further informations you find in the function description of the used device.

Note: The calculation and display of the profile points requires a specific part of the calculating capacity of the PC. If the display of the profile points is hidden, this calculating capacity can be saved and the graphical representation is accelerated. This Desktop-Element can be displayed or hide via menu "View - CamBuilder – Profil Points".

Profile Point Editor

The Profile Point Editor allows to edit the following axis position of imported Cams. For display the profile, the "Apply"-key must be pressed.

Changes in the Profile Point Editor can not be canceled by the standard "Undo"-key; use the "Undo"-key in the Profile Point Editor. When pressing this key all changes are discarded since the 'Apply'-key was pressed. If the 'Apply'-key was pressed, it is not possible to undo the changes.

The values of the following axis are standardized related to 100% calculated and send. The Cam table consists thereby of e.g. 1024 values in equidistant sections $d(j)$.

The distance between two values results in

$$d(j) = 360^\circ / 1024 = 0.35^\circ,$$

at which the first value begins at $j(0) = 0^\circ$ and

the last ends at $j(1023) = 360^\circ - d(j)$.

Note: This Desktop-Element can be displayed or hide via menu 'View - CamBuilder – Profil Points Editor'. The Profil Points Editor is only available for imported Cams (csv Fileformat or par Fileformat) or for received Cams of devices (see Upload from Device).

Further informations you find in the function description of the used device.

Options Dialog

In the options dialog general settings can be made which affect the whole CamBuilder.

Following options are available:

- **General**
 - **Mouse Sensitivity** - Resolution at a mousedoubleclick. Here the value for the master axis and the following axis is specified to which it is round up, resp round down at a mousedoubleclick.
 - **Active Profile Thickness** - changes the thickness of the active profile.
 - **Inactive Profile Thickness** - changes the thickness of the inactive profile.
 - **Active Profile Brightness** - changes the brightness of the active profile.
 - **Inactive Profile Brightness** - changes the brightness of the inactive profile.
 - **Grid Line Style** - changes the line type of the background grid.
- **Colors**
 - **Background** – Color of the background.
 - **Grid** – Color of the background grid.
 - **Profile Colors** – Colors for the different Cam profiles.

Note: Every change is stored persistent and thus restored at a restart of the CamBuilder.

Symbolbars (Toolbars)

With the toolbars "CamBuilderGeneral" and "CamBuilder Edit" the frequently used commands can be reached easy.

Note: Via main menu item "View - Toolbars" the toolbars can be displayed or hide.

1.4 Motion Laws supported by the CamBuilder

The CamBuilder offers the following motion laws (curve types) to connect the two interpolation points of a section:

- Linear Rest
- Straight Line - Linear Interpolation
- Quadratic Parabol
- Polynom 2nd
- Polynom 3rd
- Polynom 4th
- Polynom 4th Order (S)
- Polynom 5th
- Polynom 7th
- Polynom 8th
- Tilted Sinus
- Basic Sinus Lin
- Modified Sinus
- Modified Acceleration Trapez
- V-Cam Linear
- V-Cam 2nd Order (1)
- A-Cam 2nd Order (2)
- A-Cam Linear
- Analytic G-G
- Analytic G-G (5th Order)
- Analytic G-R (5th Order)
- Analytic R-G (5th Order)
- Analytic R-R (5th Order)
- Analytic R-R (Tilted Sinus Line)
- Import a Points Table
- User defined Motion

The curve linearity is determined by the boundary conditions of the interpolation points. Depending on the used motion laws it may happen that not all parameters can be set. These parameters are calculated automatically by the CamBuilder.

The desired motion law (curve type) can be adjusted in the Section Editor. If a new section is insert by a mousedoubleclick, the motion law adjusted as default curve type in the properties dialog is used.

Linear Rest

The "Linear Rest" is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The motion law "Linear Rest" is characterized by the constant position profile (velocity and acceleration are 0) between the two interpolation points.

The range which stretches across the section and applies to the motion law, is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = z$ (<i>konstant</i>)

The boundary conditions of the motion law for the interpolation points of the section are referred to the following axis:

	Start point	End point
Position	<i>user defined</i>	<i>automatically calculated</i>
Velocity	0	0
Acceleration	0	0

Fig. 1-2: Boundary conditions "Linear Rest"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Note: The linear rest is a special characteristic of the linear interpolation, at which the start and end point of the following axis are identical.

Straight Line - Linear Interpolation

The "Straight Line" ist one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The motion law "Straight Line" is characterized by the linear position profile (velocity is constant and acceleration is 0) between the two interpolation points.

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = A_1 x$ (<i>with A₁ constant</i>)

The boundary conditions of the motion law for the interpolation points of the section are referred to the following axis:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>automatically calculated</i>	<i>automatically calculated</i>
Acceleration	0	0

Fig. 1-3: Boundary conditions "Straight line - linear Interpolation"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Quadratic Parabola

The quadratic parabola is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law

The curve consists of two parts. The below displayed equations are used for calculating the standardized values. The motion law "Quadratic Parabola" is characterized by two consecutive parabolic position profiles between the two interpolation points.

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 0.5$	$y = 2x$
$0.5 \leq x < 1$	$y = 1 - 2(x - 1)^2$

The boundary conditions of the motion law for the interpolation points of the section are referred to the following axis:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	0	0
Acceleration	<i>automatically calculated</i>	<i>automatically calculated</i>

Fig. 1-4: Boundary conditions "Quadratic Parabola"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Polynom 2nd Order

The Polynom 2nd Order is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = A_0 + A_1x + A_2x^2$

The boundary conditions of the motion law for the interpolation points of the section are referred to the following axis:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>automatically calculated</i>
Acceleration	<i>automatically calculated</i>	<i>automatically calculated</i>

Fig. 1-5: Boundary conditions "Polynom 2nd Order"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

The desired motion law (curve type) can be adjusted in the Section Editor.

Polynom 3rd Order

The Polynom 3rd Order is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3$

The boundary conditions of the motion law for the interpolation points of the section are referred to the following axis:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	<i>automatically calculated</i>	<i>automatically calculated</i>

Fig. 1-6: Boundary conditions "Polynom 3rd Order"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

The desired motion law (curve type) can be adjusted in the Section Editor.

Polynom 4th Order

The Polynom 4th Order is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law Unlike Polynom 4th Order (S), the point of inflection parameter can be changed.

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$Y = A_0 + A_1 x + A_2 x^2 + A_3 x^3 + A_4 x^4$

The boundary conditions of the motion law for the interpolation points of the section are referred to the following axis:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	<i>automatically calculated</i>	<i>automatically calculated</i>

Fig. 1-7: Boundary conditions "Polynom 4th Order"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

The desired motion law (curve type) can be adjusted in the Section Editor.

Polynom 4th Order (S)

The Polynom 4th Order (Simple) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law Unlike Polynom 4th Order, the point of inflection parameter cannot be changed.

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3 + A_4 x^4$

The boundary conditions of the motion law for the interpolation points of the section are referred to the following axis:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	<i>automatically calculated</i>	<i>automatically calculated</i>

Fig. 1-8: Boundary conditions "Polynom 4th Order (Simple)"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

The desired motion law (curve type) can be adjusted in the Section Editor.

Polynom 5th Order

The Polynom 5th is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law With this motion law it is possible to adjust position, velocity and acceleration in both interpolation points. So it is applicable for all motion requirements.

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3 + A_4 x^4 + A_5 x^5$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	<i>user defined</i>	<i>user defined</i>

Fig. 1-9: Boundary conditions "Polynom 5th Order"

user defined - Parameter can be set by the user

The desired motion law (curve type) can be adjusted in the Section Editor.

Polynom 7th Order

The Polynom 7th is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law With this motion law position, velocity and acceleration is adjustable in both interpolation points. So it is applicable for all motion requirements.

The jerk value is both at start and end point 0.

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3 + A_4 x^4 + A_5 x^5 + A_6 x^6 + A_7 x^7$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	<i>user defined</i>	<i>user defined</i>

Fig. 1-10: Boundary conditions "Polynom 7th Order"

user defined - Parameter can be set by the user

The desired motion law (curve type) can be adjusted in the Section Editor.

Polynom 8th Order

The Polynom 8th Order is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law With this motion law position, velocity and acceleration is adjustable in both interpolation points. So it is applicable for all motion requirements.

The jerk value is both at start and end point 0.

The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3 + A_4 x^4 + A_5 x^5 + A_6 x^6 + A_7 x^7 + A_8 x^8$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	<i>user defined</i>	<i>user defined</i>

Fig. 1-11: Boundary conditions "Polynom 8th Order"

user defined - Parameter can be set by the user

The desired motion law (curve type) can be adjusted in the Section Editor.

Basic Sinus Line

The basic sinus line is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = (1 - \cos(\pi x)) / 2$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	0	0
Acceleration	<i>automatically calculated</i>	<i>automatically calculated</i>

Fig. 1-12: Boundary conditions "Basic Sinus Line"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Tilted Sinus Line

The tilted sinus line (Anti-Schwab-Profile, Helling-Bestehorn) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The range which stretches across the section and applies to the motion law is always standardized.

Range	Equation
$0 \leq x \leq 1$	$y = x - \sin(2\pi x) / 2\pi$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	0	0
Acceleration	0	0

Fig. 1-13: Boundary conditions "Tilted Sinus Line"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Modified Sinus Line

The modified sinus line is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The motion law "Modified Sinus Line" has an acceleration of 0 in both interpolation points.

The range which stretches across the section and applies to the motion law is always standardized.

Bereich	Gleichung
$0 \leq x \leq \lambda/4$	$C_a \frac{\lambda}{2\pi} (x - \frac{\lambda}{2\pi} \sin \frac{2\pi x}{\lambda}) + f'(0)x$
$\lambda/4 \leq x \leq \lambda$	$C_a \frac{\lambda}{2\pi} (x - \frac{9\lambda}{2\pi} \sin(2\pi \frac{x + \lambda/2}{3\lambda}) + \frac{4\lambda}{\pi}) + f'(0)x$
$\lambda \leq x \leq 1 - (1-\lambda)/4$	$-C_a \frac{1-\lambda}{2\pi} (x - \frac{9(1-\lambda)}{2\pi} \sin[2\pi \frac{x + \frac{3-5\lambda}{2}}{3(1-\lambda)}] + \frac{4\lambda}{\pi}) + f'(1)x + [f'(0) - f'(1)](\frac{3}{4} - \frac{1}{\pi})\lambda$
$1 - (1-\lambda)/4 \leq x \leq 1$	$-C_a \frac{1-\lambda}{2\pi} (x - \frac{1-\lambda}{2\pi} \sin(2\pi \frac{x-\lambda}{1-\lambda}) - 1) + 1 + f'(1)(x-1)$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	0	0

Fig. 1-14: Boundary conditions "Modified Sinus Line"

user defined - Parameter can be set by the user

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Modified Acceleration Trapezoid

The modified acceleration trapezoid (for Rest-in-Rest movement steps) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The motion law "Modified Acceleration Trapezoid" is characterized by a rest point (velocity and acceleration are 0) between both interpolation points. The jerk value is both at start and end point 0.

The range which stretches across the section and applies to the motion law is always standardized.

Bereich	Gleichung
$0 \leq x \leq 1/8$	$f_1 = \frac{2}{\pi+2} \left[x - \frac{1}{4\pi} \sin(4\pi x) \right]$
$1/8 \leq x \leq 3/8$	$f_2 = \frac{1}{\pi+2} \left[4\pi x^2 + (2-\pi)x + \frac{\pi^2-8}{16\pi} \right]$
$3/8 \leq x \leq 0,5$	$f_3 = \frac{2}{\pi+2} \left\{ (\pi+1)x - \frac{1}{4\pi} \sin \left[4\pi \left(x - \frac{1}{4} \right) \right] - \frac{\pi}{4} \right\}$
$0,5 \leq x \leq 5/8$	$f_4 = 1 - f_3(1-x)$
$5/8 \leq x \leq 7/8$	$f_5 = 1 - f_2(1-x)$
$7/8 \leq x \leq 1$	$f_6 = 1 - f_1(1-x)$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	0	0
Acceleration	0	0

Fig. 1-15: Boundary conditions "Modified Acceleration Trapezoid"

user defined - Parameter can be set by the user

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

A-Cam Linear

A-Cam Linear (linear acceleration) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law A-Cam Linear is characterized by a linear acceleration profile between both interpolation points.

Range	Equation
Start point - End point	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>automatically calculated</i>
Velocity	<i>user defined</i>	<i>automatically calculated</i>
Acceleration	<i>user defined</i>	<i>user defined</i>

Fig. 1-16: Boundary conditions "A-Cam Linear"

user defined - Parameter can be set by the user

automatically calculated - Parameter calculated is automatically

The desired motion law (curve type) can be adjusted in the Section Editor.

V-Cam Linear

V-Cam Linear is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law With V-Cam Linear only the velocity is entered. A linear velocity profile is created.

Range	Equation
Start point - End point	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>automatically calculated</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	<i>automatically calculated</i>	<i>automatically calculated</i>

Fig. 1-17: Boundary conditions "V-Cam Linear"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

The desired motion law (curve type) can be adjusted in the Section Editor.

V-Cam 2nd Order (1)

V-Cam 2nd Order (1) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law With V-Cam 2nd Order (1) only the velocity is entered, a quadratic velocity profile is created.

The acceleration in the start point is 0.

Range	Equation
Start point - End point	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>User defined</i>	<i>automatically calculated</i>
Velocity	<i>User defined</i>	<i>user defined</i>
Acceleration	0	<i>automatically calculated</i>

Fig. 1-18: Boundary conditions "V-Cam 2nd Order (1)"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

V-Cam 2nd Order (2)

V-Cam 2nd Order (2) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law

With V-Cam 2nd Order (2) only the velocity is entered, a quadratic velocity profile is created.

The acceleration in the end point is 0.

Range	Equation
Start point - End point	$y = A_0 + A_1 x + A_2 x^2 + A_3 x^3$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>User defined</i>	<i>automatically calculated</i>
Velocity	<i>User defined</i>	<i>user defined</i>
Acceleration	<i>automatically calculated</i>	0

Fig. 1-19: Boundary conditions " V-Cam 2nd Order (2)"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always thsi value

The desired motion law (curve type) can be adjusted in the Section Editor.

Analytic G-G

Analytic G-G is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law

The motion law "Analytic G-G" is characterized by a linear position profile (constant velocity and acceleration 0) between the two interpolation points.

Range	Equation
Start point - End point	$y = x$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>automatically calculated</i>	<i>automatically calculated</i>
Acceleration	0	0

Fig. 1-20: Boundary conditions "Analytic G-G"

user defined - Parameter can be set by the user

automatically calculated - Parameter is calculated automatically

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Note: This motion law is supported by operating mode "Electronic motion profile" of the IndraDrive Firmware MPx 03VRS and higher (only with Firmware-Performance "Advanced" available!)

Analytic G-G (5th Order)

Analytic G-G (5th Order) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law

Range	Equation
Start point - End point	$y = A_5 x^5 + A_4 x^4 + A_3 x^3 + A_2 x^2 + A_1 x$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	<i>user defined</i>
Acceleration	0	0

Fig. 1-21: Boundary conditions "Analytic G-G (5th Order)"

user defined - Parameter can be set by the user

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Note: This motion law is supported by operating mode "Electronic motion profile" of the IndraDrive Firmware MPx 03VRS and higher (only with Firmware-Performance "Advanced" available!)

Analytic G-R (5th Order)

Analytic G-R (5th Order) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law

Range	Equation
Start point - End point	$y = A_5 x^5 + A_4 x^4 + A_3 x^3 + A_1 x$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	<i>user defined</i>	0
Acceleration	0	0

Fig. 1-22: Boundary conditions "Analytic G-R (5th Order)"

user defined - Parameter can be set by the user

"Wert" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Note: This motion law is supported by operating mode "Electronic motion profile" of the IndraDrive Firmware MPx 03VRS and higher (only with Firmware-Performance "Advanced" available!)

Analytic R-G (5th Order)

Analytic R-G (5th Order) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law

Range	Equation
Start point - End point	$y = A_5 x^5 + A_4 x^4 + A_3 x^3$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	0	<i>user defined</i>
Acceleration	0	0

Fig. 1-23: Boundary conditions "Analytic R-G (5th Order)"

user defined - Parameter can be set by the user

"Value" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Note: This motion law is supported by operating mode "Electronic motion profile" of the IndraDrive Firmware MPx 03VRS and higher (only with Firmware-Performance "Advanced" available!)

Analytic R-R (5th Order)

Analytic R-R (5th Order) is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary

conditions are given in an interpolation point, so they are considered automatically.

Motion law The motion law "Analytic R-R (5th Order)" is characterized by the two rest point at the beginning and at the end (velocity and acceleration are 0).

Range	Equation
Start point - End point	$y = 6 x^5 - 15 x^4 + 10 x^3$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	0	0
Acceleration	0	0

Fig. 1-24: Boundary conditions "Analytic R-R (5th Order)"

user defined - Parameter can be set by the user

"**value**" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Note: This motion law is supported by operating mode "Electronic motion profile" of the IndraDrive Firmware MPx 03VRS and higher (only with Firmware-Performance "Advanced" available!)

Analytic R-R (Tilted Sinus Line)

Analytic R-R Tilted Sinus Line is one of the motion laws (curve type) which can be used to connect the two interpolation points of a section. If boundary conditions are given in an interpolation point, so they are considered automatically.

Motion law The motion law "Analytic R-R (Tilted Sinus Line)" is characterized by the two rest point at the beginning and at the end (velocity and acceleration are 0).

Range	Equation
Start point - End point	$y = x - (1/2\pi) \sin (2\pi x)$

The possible boundary conditions of the motion law for the interpolation points of the section are:

	Start point	End point
Position	<i>user defined</i>	<i>user defined</i>
Velocity	0	0
Acceleration	0	0

Fig. 1-25: Boundary conditions "Analytic R-R (Tilted Sinus Line)"

user defined - Parameter can be set by the user

"**Value**" - Parameter has always this value

The desired motion law (curve type) can be adjusted in the Section Editor.

Note: This motion law is supported by operating mode "Electronic motion profile" of the IndraDrive Firmware MPx 03VRS and higher (only with Firmware-Performance "Advanced" available!)

Import a Points Table

The CamBuilder supports the insertion of a point table as a section of the Cam. For that purpose choose in the Section Editor as curve type the item "Load Points Table...". In the following dialog the desired table can be imported.

Table of Motion Laws Supported by the CamBuilder

Motion law	Start point			End point			Point of inflection parameter	
	Position	Velocity	Acceleration	Position	Velocity	Acceleration	Conditions	Input range
Linear Rest	<i>user-defined</i>	0	0	<i>automatically calculated</i>	0	0	none	none
Straight Line - Linear Interpolation	<i>user-defined</i>	<i>automatically calculated</i>	0	<i>user-defined</i>	<i>automatically calculated</i>	0	none	none
Polynom 2 nd Order	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>automatically calculated</i>	none	none
Polynom 3 rd Order	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	$v_0 = 0, v_1 = 0$	$0 < \lambda < 1$
Polynom 4 th Order	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	$v_0 = 0, v_1 = 0$	$0 < \lambda < 1$
Polynom 4 th Order (S)	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	none	none
Polynom 5 th Order	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	$v_0 = 0, v_1 = 0$ $a_0 = 0, a_1 = 0$	$0 < \lambda < 1$
Polynom 7 th Order	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	none	none
Polynom 8 th Order	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	none	none
Quadratic Parabola	<i>user-defined</i>	0	<i>automatically calculated</i>	<i>user-defined</i>	0	<i>automatically calculated</i>	none	none
Basic Sinus Line	<i>user-defined</i>	0	<i>automatically calculated</i>	<i>user-defined</i>	0	<i>automatically calculated</i>	always	$0 < \lambda < 1$
Tilted Sinus Line	<i>user-defined</i>	0	0	<i>user-defined</i>	0	0	always	$0 < \lambda < 1$
Modified Sinus Line	<i>user-defined</i>	<i>user-defined</i>	0	<i>user-defined</i>	<i>user-defined</i>	0	always	$0 < \lambda < 1$
Modified Acceleration Trapezoid	<i>user-defined</i>	0	0	<i>user-defined</i>	0	0	none	none
V-Cam Linear	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>automatically calculated</i>	<i>user-defined</i>	<i>automatically calculated</i>	none	none
V-Cam 2 nd Order (1)	<i>user-defined</i>	<i>user-defined</i>	0	<i>automatically calculated</i>	<i>user-defined</i>	<i>automatically calculated</i>	none	none
A-Cam 2 nd Order (2)	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>automatically calculated</i>	<i>user-defined</i>	0	none	none
A-Cam Linear	<i>user-defined</i>	<i>user-defined</i>	<i>user-defined</i>	<i>automatically calculated</i>	<i>automatically calculated</i>	<i>user-defined</i>	none	none
Analytic G-G	<i>user-defined</i>	<i>automatically calculated</i>	0	<i>user-defined</i>	<i>automatically calculated</i>	0	none	none
Analytic G-G (5 th Order)	<i>user-defined</i>	<i>user-defined</i>	0	<i>user-defined</i>	<i>user-defined</i>	0	none	none
Analytic G-R (5 th Order)	<i>user-defined</i>	<i>user-defined</i>	0	<i>user-defined</i>	0	0	none	none
Analytic R-G (5 th Order)	<i>user-defined</i>	0	0	<i>user-defined</i>	<i>user-defined</i>	0	none	none
Analytic R-R (5 th Order)	<i>user-defined</i>	0	0	<i>user-defined</i>	0	0	none	none
Analytic R-R (Tilted Sinus Line)	<i>user-defined</i>	0	0	<i>user-defined</i>	0	0	none	none

Fig. 1-26: Table of supported motion laws

Comparison of the Motion Laws

Motion Law	Advantages	Disadvantages
Linear Rest	Velocity = 0, Acceleration = 0	
Straight Line - Linear Interpolation	Constant velocity, acceleration = 0	Velocity ≠ 0 in both boundary points (possible stroke-afflicted movement in the boundary points)
Polynom 2 nd	Low Ca – value, constant acceleration	Acceleration ≠ 0 in both boundary points (possible stroke-afflicted movement in the boundary points)
Polynom 3 rd	Low Cv -, Ca -, Cmdyn – values, velocity can be set in both boundary points	Acceleration ≠ 0 in both boundary points (possible stroke-afflicted movement in the boundary points)
Polynom 4 th	Lower Cj – Value	High Cmdyn – Value
Polynom 4 th Order (S)	Lower Cj – Value	High Cmdyn – Value
Polynom 5 th	Jerk-free, relatively low Cv -, Ca -, Cmdyn – Values (depending on the end conditions), can be used for all motion jobs, velocity and acceleration can be set in both boundary points	High Cj – Value
Polynom 7 th	Lower Cj – Value	High Cv -, Ca – and Cmdyn – Values
Polynom 8 th	Lower Ca – Value	High Cj -, Cmdyn-Values
Quadratic Parabol	Lower Ca – Value	3 jerks (one in the middle of the curve and one at each boundary point)
Basic Sinus Lin	Low Cv -, Ca -, Cmdyn – Values	High acceleration in both boundary points (possible acceleration jumps in both boundary points)
Tilted Sinus	Jerk-free, very low Cj - Value, well for high velocities	Low Cv -, Ca -, Cmdyn - Values
Modified Sinus	Jerk-free, relatively low Cv -, Ca -, Cmdyn - Values, well for high velocities, velocity can be set in both boundary points	High Cj - Values
Modified Acceleration Trapez	Especially low Ca - Value, low inertness forces	Cv -, Cj – and Cmdyn are relatively high
V-Cam Linear	constant acceleration	Acceleration ≠ 0 in both boundary points (possible stroke-afflicted movement in the boundary points), position at end point can not be set
V-Cam 2 nd Order (1)	Acceleration = 0 at start point (jerk-free at start point)	Acceleration ≠ 0 at end point (possible stroke-afflicted movement at the end point), position at end point can not be set
A-Cam 2 nd Order (2)	Acceleration = 0 at end point (jerk-free at end point)	Acceleration ≠ 0 at start point (possible stroke-afflicted movement at start point), position at end point can not be set
A-Cam Linear	Velocity can be set at start point	Position at end point can not be set
Analytic G-G	Is supported in operating mode "Electronic movement profile" of the IndraDrive Firmware MPx 03VRS and higher	Limited opposite to the general motion laws
Analytic G-G (5 th Order)	Is supported in operating mode "Electronic movement profile" of the IndraDrive Firmware MPx 03VRS and higher	Limited opposite to the general motion laws
Analytic G-R (5 th Order)	Is supported in operating mode "Electronic movement profile" of the IndraDrive Firmware MPx 03VRS and higher	Limited opposite to the general motion laws
Analytic R-G (5 th Order)	Is supported in operating mode "Electronic movement profile" of the IndraDrive Firmware MPx 03VRS and higher	Limited opposite to the general motion laws
Analytic R-R (5 th Order)	Is supported in operating mode "Electronic movement profile" of the IndraDrive Firmware MPx 03VRS and higher	Limited opposite to the general motion laws
Analytic R-R (Tilted Sinus Line)	Is supported in operating mode "Electronic movement profile" of the IndraDrive Firmware MPx 03VRS and higher	Limited opposite to the general motion laws

Fig. 1-27: Comparison of the supported motion laws

Note: All comparisons in this table are related to identical end point conditions.

The real C_v -, C_a -, C_j - and C_{mdyn} – are dependent on the conditions of this end point (see also Characteristics of the Standardized Motion Law).

Characteristics of the Standardized Motion Laws

Each motion law has the following characteristics:

1. **Velocity boundary value C_v** = Maximal value of the normalized motion law 1st order (normalized velocity)
2. **Acceleration characteristics C_a** = Maximal value of the normalized motion law 2nd order (normalized acceleration)
3. **Jerk characteristics C_j** = Maximal value of the normalized motion law 3rd order (normalized jerk function)
4. **Dynamic torque characteristics C_{mdyn}** = Maximal value of the dynamic torque characteristics

The dynamic torque characteristics is calculated by following formula:

$$C_{\text{mdyn}} = \text{MaxValue}(\mathbf{v} * \mathbf{a})$$

with \mathbf{v} = Velocity and \mathbf{a} = Acceleration.

The characteristics of the actual section are displayed in the Section Editor.

The characteristics of the complete cam are displayed in Profile Limits List of the Cam.

1.5 User defined Motion Laws

Is only supported in a later version of the CamBuilder.

1.6 Wizards

New Cam-Wizard

CamBuilder offers a wizard for the creation of a new Cam to support the user on the development. Requirements and specialties are prompted dialog-guided.

The inputs are:

- **Cam Name** – name of the Cam defined by the user. This is also the name displayed in the project explorer.
- **Description** – description entered by the user.
- **Cam Type** – defines whether the Cam is designed for the electronic motion profile of an IndraDrive. So the selection of the available motion profiles is restricted.
- **Display cam in normalized view** - the Cam is displayed with standardized values.
- **Display Cam in stated view** - the Cam is displayed with real values. Getting the same Cam on the target device like in the CamBuilder, the entered parameters must match the parameters on the target device.
 - **Velocity of the master axis** – this value is specified in rounds per minute (r.p.m.).
 - **Measuring unit of the slave axis** – determines whether the drive operates rotatory or translatory. Default is degree (rotatory).
 - **Cam Shaft Distance** – the factor, by that the value of the cam table is multiplied.
- **Cam Boundary Points** - for the start- and end point of the Cam the positions of the master- and slave axis as well as the velocity and acceleration of the slave axis can be entered.

- **Same Start and End Profile Points** – this is the normal case, so it is the default setting.
- **Number of Sections** - the number of sections of the motion profile.
- **Insert Section** - for each section the required parameters are prompted.

Note: These settings can be changed again in the section editor at a later point.

Application-Wizard

CamBuilder offers wizards for frequently occurred requirements (e.g. crosscutter functionality), to support the user on the development of the Cam. All requirements and specialties of the application are covered dialog-guided.

The first page of all wizards is identical and allows the following inputs:

- **Cam Name** – name of the Cam defined by the user. This is also the name displayed in the project explorer.
- **Description** – description entered by the user.
- **ApplicationType** - Type of the application which should be covered (e.g. crosscutter functionality).

Crosscutter-Wizard

CamBuilder offers wizards for frequently occurred requirements like crosscutter functionality, to support the user on the development of the Cam. All requirements and specialties of the application are covered dialog-guided.

Specific inputs for the crosscutter functionality are:

- Format length
- Roller diameter
- Cut angle
- Velocity of the master axis

The profile of the crosscutter functionality is calculated automatically after finishing the input. Thereupon a second page with all application-relevant parameters is available beside the section editor.

Note: Further on each section can also be edited by the section editor. But if an application parameter is changed or accepted in the wizard window, so the profiles are recalculated and the changes in the section editor are discarded.

Feed-Wizard

CamBuilder offers wizards for frequently occurred requirements like feed functionality, to support the user on the development of the Cam. All requirements and specialties of the application are covered by dialog-guided inputs.

Specific inputs for the feed functionality are:

- Format length
- Roller diameter
- Maximal deceleration
- Acceleration distance

- Roller position
- Distance between two products
- Velocity of the master axis

The profile of the feed functionality is calculated automatically after finishing the input. Thereupon a second page with all application-relevant parameters is available beside the section editor.

Note: Further on each section can also be edited by the section editor. But if an application parameter is changed or accepted in the wizard window, so the profiles are recalculated and the changes in the section editor are discarded.

Printlength-Correction-Wizard

CamBuilder offers wizards for frequently occurred requirements like printlength correction, to support the user on the development of the Cam. All requirements and specialties of the application are covered dialog-guided.

Specific inputs for the printlength correction functionality are:

- Diameter of the print cylinder
- Printing plate length
- Correction value
- Velocity of the master axis

More parameters are calculated by the wizard:

- Gradient in the synchron range – this parameter is displayed in the output data area of the wizard window.

The profiles for the printlength correction are calculated automatically after finishing the input. Thereupon a second page with all application-relevant parameters is available beside the section editor.

Note: Further on each section can also be edited by the section editor. But if an application parameter is changed or accepted in the wizard window, so the profiles are recalculated and the changes in the section editor are discarded.

Cross-Seal-Wizard

CamBuilder offers wizards for frequently occurred requirements like cross-seal, to support the user on the development of the Cam. All requirements and specialties of the application are covered dialog-guided.

Specific inputs for the cross-seal functionality are:

- Synchron range - range in which the sealing takes place
- Curve type (motion law) in the crossover range – the curve types Modified Sinus line, Polynomial 3rd order, Polynomial 5th order and Polynomial 7th order are offered.

Another parameter is calculated by the wizard:

- Gradient in the synchron range - this parameter is displayed in the output data area of the wizard window.

The profiles for the cross-seal functionality are calculated automatically after finishing the input. Thereupon a second page with all application-relevant parameters is available beside the section editor.

Note: Further on each section can also be edited by the section editor. But if an application parameter is changed or accepted in the wizard window, so the profiles are recalculated and the changes in the section editor are discarded.

1.7 Data Management

Cams created in an IndraWorks-Project belong to its project and will be archived with the project.

If a Cam shall be used outside the project, so the Cam must be exported. Depending on the application one format will be more suitable than others (see also Export Cams).

It is also possible to import already existing Cams into a project. Like with the export it also can be chosen between different formats that are suitable for the respective application (see also Import Cams).

Note: Regarding of send and receive Cams to and from Bosch Rexroth drives and controls, see Download to Device and Upload from Device.

Export Cams

Cams can be exported from an IndraWorks-Project by the CamBuilder. For this export functionality the following formats are supported:

- xml Fileformat - internal format of the CamBuilder that allows a further processing of the Cam
- csv Fileformat (Comma Separated Value) - the position-, velocity-, acceleration- and jerk-values of the Cam are stored in an Excel-readable fileformat.
- par Fileformat (Sercos ASCII Format) – the common fileformat for drives and controls.

- Examples:**
- If a Cam also shall be used in an other project, the Cam must be exported from the project and imported in the other. If the imported Cam shall be modified in the new project, so the xml Fileformat must be selected for export.
 - If a Cam shall be send via DriveTop to a drive, so the par Fileformat or csv Fileformat is suitable. First the Cam must be exported and then the Export-File must be read in with DriveTop and send the Cam to the drive.
 - If position-, velocity-, acceleration- and jerk-values of a Cam should be analyzed, so the csv Fileformat is suitable.

Note: The export functionality is callable in the project explorer via the context menu of the Cam.

Import Cams

Cams can be imported into an IndraWorks-Project by the CamBuilder. For this import functionality the following formats are supported:

- xml Fileformat (internal Format des CamBuilder)- allows further processing of the Cam

- csv Fileformat (Comma Seperated Value) - the position-, velocity-, acceleration- and jerk-values of the Cam are stored in an Excel-readable fileformat
 - par Fileformat (Sercos ASCII Format) – the common fileformat for Bosch Rexroth drives and controls
 - ipf Fileformat (internal fileformat CamBuilder Version 01VRS) – only available at import
- Examples:**
- If for example, a Cam also shall be used in an other project, the Cam must be exported from the project and imported in the other. If the imported Cam shall be modified in the new project, so the xml Fileformat must be selected for export.
 - If an Excel-created Cam shall be imported, so the csv Fileformat is suitable.
 - If a Cam, stored by DriveTop or VisualMotion shall be imported, so the par Fileformat is suitable.
 - If a Cam, created with CamBuilder Version 01VRS shall be imported, so the ipf fileformat should be used.

Note: The import functionality is callable in the project explorer via the context menu of the Cam Pool.

Supported Fileformats

xml Fileformat

This is the internal fileformat of the CamBuilder. It allows to store, load and modify a Cam at an later date.

Note: The file extension of version CamBuilder 01VRS is *.ipf (Interpolation Point File) and is supported with the import functionality.

The informations in the xml – File are:

- Creation date
- Version of the CamBuilder
- User defined name
- Number of points in the point table
- Velocity of the master axis
- Cam type
- Measuring unit of the slave axis
- Cam shaft distance of the slave axis
- Interpolation points
(each interpolation point has the following informations)
 - Curve type
 - Position master axis
 - Position slave axis
 - Velocity of the slave axis
 - Acceleration of the slave axis
 - Turning point parameter
 - Section description

Example of a *.xml File

```

<?xml version="1.0" encoding="utf-8"?>
<CamSaver xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <CommonCamData>
    <Unit>grad</Unit>
    <Sections>
      <CamSectionDescription>
        <StartPoint>
          <x>0</x>
          <y>0</y>
          <v>0</v>
          <a>0</a>
          <j>0.006</j>
          <Description />
        </StartPoint>
        <CurveTypeGUID>2E3EF69C-9A43-49ef-B064-
B4E86DCD9535</CurveTypeGUID>
        <Description />
        <CurveParameters>
          <CamCurveParameter Name="Lambda" Value="0.5"
/>
        </CurveParameters>
      </CamSectionDescription>
      <CamSectionDescription>
        <StartPoint>
          <x>100</x>
          <y>100</y>
          <v>0</v>
          <a>0</a>
          <j>0.006</j>
          <Description />
        </StartPoint>
        <CurveTypeGUID>2E3EF69C-9A43-49ef-B064-
B4E86DCD9535</CurveTypeGUID>
        <Description />
        <CurveParameters>
          <CamCurveParameter Name="Lambda" Value="0.5"
/>
        </CurveParameters>
      </CamSectionDescription>
    </Sections>
    <NormalisationData>
      <ScaleX>360</ScaleX>
      <ScaleY>360</ScaleY>
      <MasterVelocity>6</MasterVelocity>
      <AxisType>Any</AxisType>
    </NormalisationData>
    <Header>
      <CreationDate>2005-05-
17T07:59:52.4218750+02:00</CreationDate>

```

```

    <LastChangeDate>2005-05-
17T07:59:52.4843750+02:00</LastChangeDate>
    <ApplicationName>CamBuilder 2</ApplicationName>
    <ApplicationVersion>02V06</ApplicationVersion>
    <CamPackageVersion />
    <Description />
    <Name>Cam0</Name>
    <GUID>cafc11d3-9f15-4dc5-97ce-
24746c99aa0b</GUID>
  </Header>
</CommonCamData>
<AdditionalCamData>
  <NumberOfPoints>1024</NumberOfPoints>
  <StartEndConnected>>true</StartEndConnected>
  <DefaultProfileGUID>2E3EF69C-9A43-49ef-B064-
B4E86DCD9535</DefaultProfileGUID>
  <MasterVelocity>6</MasterVelocity>
  <Hub>360</Hub>
  <LastViewNormal>>true</LastViewNormal>
</AdditionalCamData>
</CamSaver>

```

par Fileformat

The point tables of the Cams are exported to a file with the Sercos-ASCII-Format.

A *.par file can be read e.g. by DriveTop or VisualMotion, and so the Cam can be send to a drive or a control. Also a *.par file can be imported into the CamBuilder.

Note: A Cam that is imported from a *.par file, can only be modified by the Profile Point Editor!

Following settings at export a Cam to a par-File are available:

- **Device-Type** - the drive- or control-type to which the Cam shall be stored.
- **Cam-Table Parameter** - the parameter to which the Cam shall be stored, e.g. drives of the ECODRIVE family support two Cams (P-0-0072 and P-0-0092).
- **Use Crosscutter Functionality of Drive** – if this function is enabled, the send data are modified. This functionality is only available with drives which have specific firmware versions. Further informations are available in the function description of the used device.
- **Drive Address** - Address of the drive or control to which the Cam shall be stored.

Files with the Sercos ASCII-Format may have more than one parameter that contain a Cam. If at the import a *.par file is chosen that contains more than one Cam, all found Cam parameters are offered for selection to the user. The user has to select the desired Cam from this list.

Example of a *.par File

SERCOS-ASCII

15.03.2004 09:11:29

Crosscutter

Cam description

1

```

|
P-0-0072 Cam table 1
00000110001001100000000000000001
%
-199.999999
199.999999
4096
4096
0.000000
0.000001
0.000007
0.000025
0.000059
0.000116
0.000199
...
99.999884
99.999941
99.999975
99.999993
99.999999

```

csv Fileformat

The CamBuilder allows to import or export a Cam in the *.csv (Comma Separated Value) format. This *.csv file can be read by DriveTop and so the Cam can be send to a drive (direct link between PC and drive).

Note: A Cam that was imported from a *.csv file, can only be modified in the Profile Point Editor!

Following settings at export a Cam table in a *.csv-File are available:

- **Add Informations** – if this setting is enabled, only the point table will be exported. Otherwise the following informations are added:
 - Creation date
 - Version of the CamBuilder
 - Target device (control or drive)
 - User defined name
 - Header
- **Use Crosscutter Functionality of the Drive** – if this setting is enabled, the point table is corrected accordingly.
- **Save in VisualMotion 8 Format** – uses automatically the VisualMotion-8-csv-File-Format for export. This setting automatically resets all other settings.
- **Table contains the last Interpolation Point of the Profile**
- **Number of exported Interpolation Points**
- **Include Position Derivatives** – this setting allows to include the data of the velocity-, acceleration- and jerk-profile at export.

Note: The values of the position derivatives are exported normalized.

Example of a csv File ;24.09.2002 16:51:58
 ;CamBuilder 01VRS
 ;GPP9
 ;Crosscutter
 +0.0000000000e+000, +0.0000000000e+000 (1)
 +3.5156250000e-001, +1.3951425041e-002 (2)
 +7.0312500000e-001, +2.7906043189e-002 (3)
 +1.0546875000e+000, +4.1867047548e-002 (4)
 ...
 +3.5859375000e+002, +9.9274587631e+001 (1021)
 +3.5894531250e+002, +9.9455929548e+001 (1022)
 +3.5929687500e+002, +9.9637281043e+001 (1023)
 +3.5964843750e+002, +9.9818638925e+001 (1024)

1.8 Communication

General

The communication with the field devices in IndraWorks take place via the associated field devices in the project. With this devices the communication parameters (serial, Com-Port, Ethernet, IP, ...) are adjusted. So if a Cam shall be send or received to or from a field device, you have to create an according device in your IndraWorks-Project.

Download to Device

With the CamBuilder Cams can be send directly to the drive. For that purpose it is necessary to be Online and having a drive with Cam support in the project. If these two conditions are fulfilled, you can select the command "Download to Device" in the context menu of a Cam in your Project and then the target device and the desired Cam in the following list of the available devices. By pressing the "OK"-Button the Cam is send to the drive.

Upload from Device

With the CamBuilder Cams can be received directly from the drive. For that purpose it is necessary to be Online and having a drive with Cam support in the project. If these two conditions are fulfilled, you can select the command "Upload from Device" in the context menu of the CamPool in your Project and then the target device and the desired Cam in the following list of the available devices. By pressing the "OK"-Button the Cam is read from the drive and after receiving, the new Cam is stored in the CamPool and opened.

Note: If a Cam table is load from the drive, only the several interpolation points can be modified by the Profile Point Editor!

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3 Service & Support

3.1 Helpdesk

Unser Kundendienst-Helpdesk im Hauptwerk Lohr am Main steht Ihnen mit Rat und Tat zur Seite. Sie erreichen uns

Our service helpdesk at our headquarters in Lohr am Main, Germany can assist you in all kinds of inquiries. Contact us

- telefonisch - by phone:
über Service Call Entry Center
- via Service Call Entry Center
- per Fax - by fax:
- per e-Mail - by e-mail: service.svc@boschrexroth.de

49 (0) 9352 40 50 60

Mo-Fr 07:00-18:00
Mo-Fr 7:00 am - 6:00 pm

+49 (0) 9352 40 49 41

3.2 Service-Hotline

Außerhalb der Helpdesk-Zeiten ist der Service direkt ansprechbar unter

After helpdesk hours, contact our service department directly at

+49 (0) 171 333 88 26

oder - or

+49 (0) 172 660 04 06

3.3 Internet

Unter www.boschrexroth.com finden Sie ergänzende Hinweise zu Service, Reparatur und Training sowie die **aktuellen** Adressen *) unserer auf den folgenden Seiten aufgeführten Vertriebs- und Servicebüros.

At www.boschrexroth.com you may find additional notes about service, repairs and training in the Internet, as well as the **actual** addresses *) of our sales- and service facilities figuring on the following pages.



Verkaufsniederlassungen



Niederlassungen mit Kundendienst

Außerhalb Deutschlands nehmen Sie bitte zuerst Kontakt mit unserem für Sie nächstgelegenen Ansprechpartner auf.



sales agencies



offices providing service

Please contact our sales / service office in your area first.

*) Die Angaben in der vorliegenden Dokumentation können seit Drucklegung überholt sein.

*) Data in the present documentation may have become obsolete since printing.

3.4 Vor der Kontaktaufnahme... - Before contacting us...

Wir können Ihnen schnell und effizient helfen wenn Sie folgende Informationen bereithalten:

For quick and efficient help, please have the following information ready:

1. detaillierte Beschreibung der Störung und der Umstände.
2. Angaben auf dem Typenschild der betreffenden Produkte, insbesondere Typenschlüssel und Seriennummern.
3. Tel./Faxnummern und e-Mail-Adresse, unter denen Sie für Rückfragen zu erreichen sind.

1. Detailed description of the failure and circumstances.
2. Information on the type plate of the affected products, especially type codes and serial numbers.
3. Your phone/fax numbers and e-mail address, so we can contact you in case of questions.

3.5 Kundenbetreuungsstellen - Sales & Service Facilities

Deutschland – Germany

vom Ausland:

(0) nach Landeskennziffer weglassen!

from abroad:

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