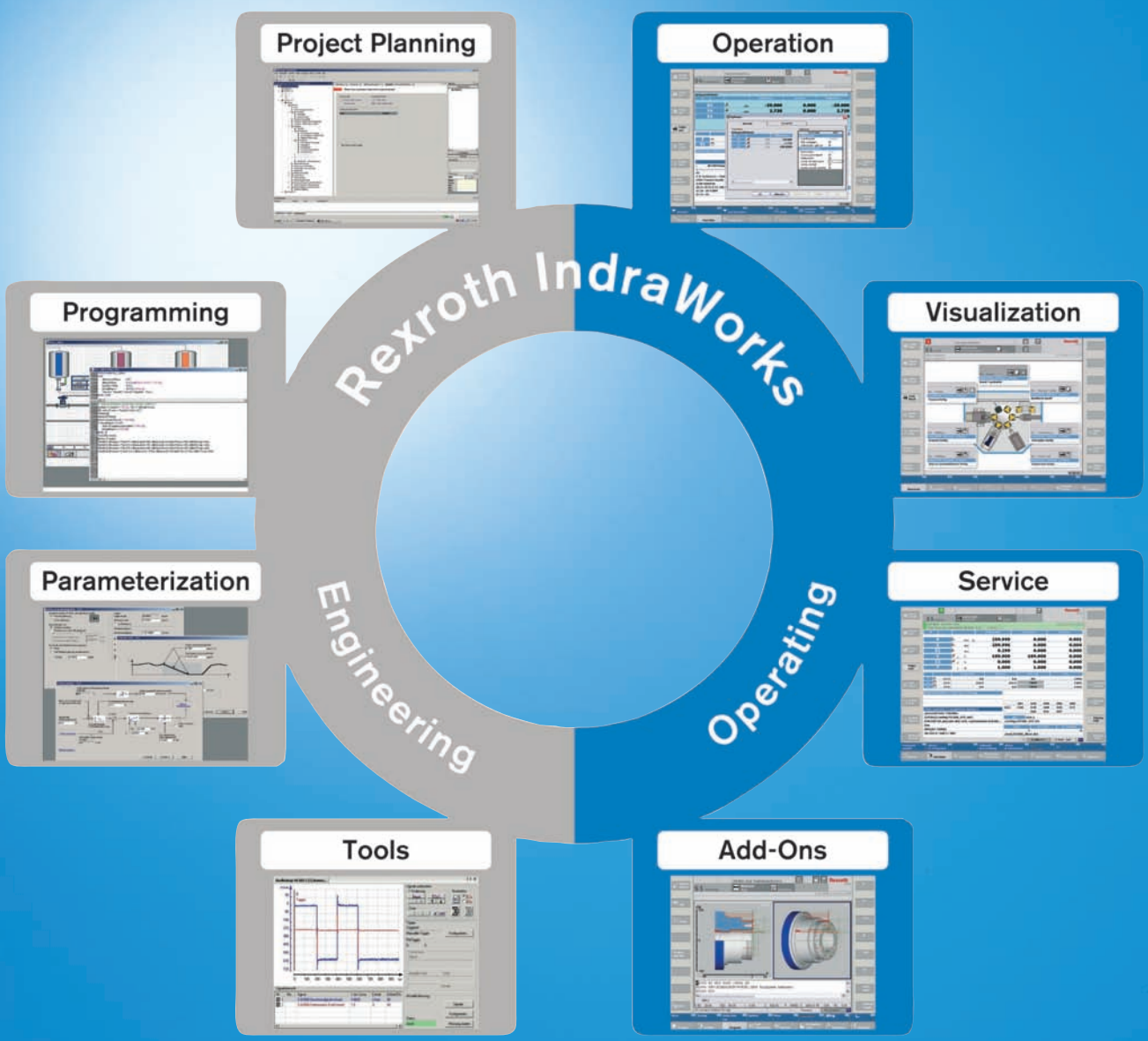
Electric Drives and Controls | Hydraulics | Linear Motion and Assembly Technologies | Pneumatics | Service

Rexroth Bosch Group

Rexroth IndraWorks CamBuilder 12VRS

R911333842
Edition 01

Application Manual



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Purpose of Documentation This documentation describes the basic principles and operation of the CamBuilder, the cam editing tool.

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Edition 01	02.2011	First edition for 12VRS

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1 About this Documentation

1.1 Validity of the Documentation

Target group This documentation is intended for users that like to create electronic cams using the CamBuilder.

This documentation supports the user during the following phases:

- Engineering
- Commissioning

1.2 Required and Supplementing Documentations

Documentation titles with type designation codes and parts numbers

IndraWorks		MLC	XLC
/36/	**Rexroth IndraWorks 12VRS Software Installation** DOK-IWORKS-SOFTINS*V12-COxx-EN-P, R911334396 This documentation describes the IndraWorks installation.	X	X
/5/	**Rexroth IndraWorks 12VRS Engineering** DOK-IWORKS-ENGINEE*V12-APxx-EN-P, R911334388 This documentation describes the application of IndraWorks in which the Rexroth Engineering tools are integrated. It includes instructions on how to work with IndraWorks and how to operate the oscilloscope function.	X	X
/20/	**Rexroth IndraMotion MLC 12VRS Functional Description** DOK-MLC***-FUNC****V12-APxx-EN-P, R911333848 This documentation describes wizards, context menus, dialogs, control commissioning, device configuration and functionalities of the IndraMotion MLC.	X	
/20/	**Rexroth IndraLogic XLC 12VRS Functional Description** DOK-XLC***-FUNC****V12-APxx-EN-P, R911333878 This documentation describes wizards, context menus, dialogs, control commissioning, device configuration and functionalities of the IndraLogic XLC.		X
/7/	**Rexroth IndraWorks 12VRS CamBuilder** DOK-IWORKS-CAMBUIL*V12-APxx-EN-P, R911333842 This documentation describes the basic principles and operation of the CamBuilder, the cam editing tool.	X	X
/37/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS Automation Interface** DOK-XLCMLC-AUT*INT*V12-APxx-EN-P, R911334178 This documentation describes the script-based access to IndraWorks project data via the interface of the Automation Interface.	X	X
/38/	**Rexroth IndraWorks 12VRS FDT Container** DOK-IWORKS-FDT*CON*V12-APxx-EN-P, R911334398 This documentation describes the IndraWorks FDT Container functionality. It includes the activation of the functionality in the project and working with DTMs.	X	X

About this Documentation

/29/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS Project Conversion** DOK-XLCMLC-PROCONV*V12-APxx-EN-P, R911334187 This documentation describes the project conversion from IndraWorks version 7 projects with IndraLogic 1.x to IndraWorks version 12 with IndraLogic 2G. It especially focuses on changes in the field of Motion and PLC.	X	X
/28/	**Rexroth IndraMotion MLC 12VRS Commissioning** DOK-MLC***-STARTUP*V12-COxx-EN-P, R911333858 This documentation describes the steps required for commissioning and performing service on the IndraMotion MLC system. It includes checklists for tasks to be frequently performed and a detailed description of the steps.	X	

Motion		**MLC**	**XLC**
/23/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS PLCopen Libraries** DOK-XLCMLC-FUNLIB**V12-LIxx-EN-P, R911334182 This documentation describes the function blocks, functions and data types of the RIL_CommonTypes, ML_Base and ML_PLCopen libraries for the IndraLogic XLC/IndraMotion MLC. It also includes the error reactions of function blocks.	X	X
/27/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS Generic Application Template** DOK-XLCMLC-TF*GAT**V12-APxx-EN-P, R911334191 This documentation provides a structured template to the IndraLogic PLC programmer. This template can be used to add and edit the PLC programming code. It includes the template, the template wizard and example applications.	X	X
/31/	**Rexroth IndraMotion MLC 12VRS RCL Programming Instruction** DOK-MLC***-RCL*PRO*V12-APxx-EN-P, R911333852 This documentation provides information on the RobotControl. It is given most importance to the programming language RCL (RobotControl Language). The program structure, variables, functions, motion statements and the required system parameters are described.	X	
/21/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS Parameters** DOK-XLCMLC-PARAM***V12-RExx-EN-P, R911334176 This documentation describes the parameters of the XLC/MLC systems as well as the interaction between parameterization and programming. It includes the axis parameters, control parameters, kinematic parameters, touch probe parameters and programmable limit switch parameters.	X	X
/10/	**Rexroth IndraDrive; Firmware for Drive Controllers MPH, MPB, MPD, MPC-07** DOK-INDRV*-MP*-07VRS**-FKxx-EN-P, R911328670		
/11/	**Rexroth IndraDrive MPx-16 Functions** DOK-INDRV*-MP*-16VRS**-APxx-EN-P, R911326767		

Field Buses		**MLC**	**XLC**
/39/	**Rexroth IndraMotion MLC 11VRS PLCopen Field Bus** DOK-IM*ML*-PLCFBUS*V11-APxx-EN-P, R911333896 This documentation describes the creation of field bus drives in an IndraWorks project, function blocks, functions and data types of the libraries RIL_CommonTypes.library (excerpt for field bus drives), RMB_PLCopenFieldBus.library, RIL_Utilities.library (excerpt for field bus drives). It also includes the error reactions of function blocks.	X	X
/4/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS Field Buses** DOK-XLCMLC-FB******V12-APxx-EN-P, R911334394 This documentation describes the supported field buses and their diagnostic function blocks.	X	X

HMI		MLC	XLC
/8/	**Rexroth IndraWorks 12VRS HMI** DOK-IWORKS-HMI*****V12-APxx-EN-P, R911334392 This documentation describes the functions, configuration and operation of the user interfaces IndraWorks HMI Engineering and IndraWorks HMI Operation.	X	X
/6/	**Rexroth IndraWorks 12VRS WinStudio** DOK-IWORKS-WINSTUD*V12-APxx-EN-P, R911333844 This documentation describes the installation of the software, working with WinStudio and the creation and operation of applications.	X	X
/50/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS HMI Connection** DOK-XLCMLC-HMI*****V12-APxx-EN-P, R911334184 This documentation describes the visualization systems supported by the IndraLogic XLC and IndraMotion MLC and their connection.	X	X

PLC		MLC	XLC
/3/	**Rexroth IndraWorks 12VRS IndraLogic 2G Programming Instruction** DOK-IWORKS-IL2GPRO*V12-APxx-EN-P, R911334390 This documentation describes the PLC programming tool IndraLogic 2G and its usage. It includes the basic usage, first steps, visualization, menu items and editors.	X	X
/33/	**Rexroth IndraWorks 12VRS, Basic Libraries, IndraLogic 2G** DOK-IL*2G*-BASLIB**V12-LIxx-EN-P, R911333835 This documentation describes the system-comprehensive PLC libraries.	X	X

Technology			
/30/	**Rexroth IndraMotion MLC 12VRS Technology Libraries** DOK-MLC***-TF*LIB**V12-LIxx-EN-P, R911333868 This documentation describes the function blocks, functions and data types of the libraries "ML_TechInterface.library", "ML_TechMotion.library", "RMB_TechCam.library" and "ML_TechBase.library". It also includes libraries for the winder functionality, register controller functionality and CrossCutter functionality.	X	
/60/	**Rexroth IndraMotion MLC 12VRS RegisterControl (Library)** DOK-MLC***-REGI*CO*V12-LIxx-EN-P, R911333856 This documentation describes the inputs and outputs of the individual function blocks and provides information on their usage.	X	
/62/	**Rexroth IndraMotion MLC 12VRS RegisterControl (Application Manual)** DOK-MLC***-REGI*CO*V12-APxx-EN-P, R911333854 This documentation describes the application of the integrated register control for a rotogravure printing machine. The components of the mark stream sensor, the HMI application and the error recovery options are described. This instruction provides information on how to operate the register control, react on errors and query diagnostics. This documentation is written for machine setters and machine operators.	X	
/49/	**Rexroth IndraMotion MLC 12VRS Application of Winder Functions** DOK-MLC***-TF*WIND*V12-APxx-EN-P, R911333870 This application-related system documentation describes the usage of the winder technology functions.	X	

About this Documentation

Hardware		MLC	XLC
/1/	**Rexroth IndraControl L45/L65** DOK-CONTRL-IC*L45*L65*-PRxx-EN-P, R911324661	X	X
/2/	**Rexroth IndraControl L25** DOK-CONTRL-IC*L25*****-PRxx-EN-P, R911328474	X	X
/24/	**Rexroth IndraControl Lxx 12VRS Function Modules** DOK-CONTRL-FM*LXX**V12-APxx-EN-P, R911333830 This documentation describes all function modules of the Lxx controls including engineering and diagnostics.	X	
/12/	**Rexroth IndraDrive Drive Controllers MPx-02 to MPx-07** DOK-INDRV*-GEN-**VRS**-PAxx-EN-P, R911297317		
/13/	**Rexroth IndraDrive MPx-02 to MPx-07 and HMV** DOK-INDRV*-GEN-**VRS**-WAxx-EN-P, R911297319		
/35/	**Rexroth IndraDrive Drive Controller Control Units CSB01, CSH01, CDB01** DOK-INDRV*-CSH********-PR08-EN-P, R911295012		

Diagnostics and Service		MLC	XLC
/26/	**Rexroth IndraMotion MLC/XLC 11VRS Service Tool** DOK-IM*ML*-IMST****V11-RExx-EN-P, R911331940	X	X
/22/	**Rexroth IndraLogic XLC IndraMotion MLC 12VRS Diagnostics** DOK-XLCMLC-DIAG****V12-RExx-EN-P, R911334180 This documentation includes all control parameters implemented in the control systems IndraLogic XLC and IndraMotion MLC.	X	X

System Overview		MLC	XLC
/48/	**Rexroth IndraMotion for Printing 12VRS System Overview** DOK-IM*PR*-SYSTEM**V11-PRxx-EN-P, R911333840 This documentation describes the product IndraMotion for Packaging. It introduces the control systems, drive systems and I/O systems as well as the commissioning and programming.	X	
/48/	**Rexroth IndraMotion for Packaging 12VRS System Overview** DOK-IM*PA*-SYSTEM**V12-PRxx-EN-P, R911333838 This documentation describes the product IndraMotion for Packaging. It introduces the control systems, drive systems and I/O systems as well as the commissioning and programming.	X	
/9/	**Rexroth IndraMotion MLC 12VRS System Overview** DOK-MLC***-SYSTEM**V12-PRxx-EN-P, R911333860 This documentation provides an overview on the possible hardware/software components of the automation system IndraMotion MLC of the named version. It helps assembling a system.	X	
/9/	**Rexroth IndraLogic XLC 12VRS System Overview** DOK-XLC***-SYSTEM**V12-PRxx-EN-P, R911333880 This documentation provides an overview on the possible hardware/software components of the automation system IndraLogic XLC of the named version. It helps assembling a system.		X

First Steps		MLC	XLC
/25/	**Rexroth IndraMotion MLC 12VRS First Steps** DOK-MLC***-F*STEP**V12-COxx-EN-P, R911333846 This documentation describes the first steps of the IndraMotion MLC and the RobotControl. It includes the hardware and software prerequisites as well as the creation of a project.	X	
/25/	**Rexroth IndraLogic XLC 12VRS First Steps** DOK-XLC***-F*STEP**V12-COxx-EN-P, R911333876 This documentation describes the first steps of the IndraLogic XLC. It includes the hardware and software prerequisites as well as the creation of a project.		X

xx Respective edition
Fig. 1-1: XCL/MLC documentation overview

1.3 Information Representation

1.3.1 Safety Instructions

Structure for safety instructions for electric drives and controls:

1.3.2 Symbols

Representation

The representation of different symbols can be found in the chapter 3.4 Explanation of Signal Words and the Safety Alert Symbol, page 22.

1.3.3 Descriptions

Description	Explanation
Cam Pool	Folder in IndraWorks (to store the created cams)
Function block	To provide application-specific functionalities
Chart	Graphic representation of a function

VisualMotion	Programmable multi-axis motion control system
IndraMotion MLC	Compact Motion Logic systems with Motion, Robot and Logic Control functionalities
IndraLogic XLC	Compact PLC system with integrated Motion functionality
IndraWorks	Project planning and commissioning tool of Bosch Rexroth
IndraDrive	Drive control unit
IndraSize	Software tool to determine the drive design
Wizard	Wizard guiding the user through several dialogs for an ergonomic data input

Fig. 1-2: Designations used

1.3.4 Abbreviations

Abbreviation	Meaning
IEC	International Electrotechnical Commission
XML	Extensible Markup Language (XML). It is a markup language to represent hierarchical structured data as text data
CSV	This file format describes the structure of a text file to save or exchange simply structured data. The file extension .csv is an abbreviation for Comma-"Separated Values"
PAR	Parameter file in ASCII format to save data
I.e.	This means
E.g.	For example
ms	Millisecond
mm	Millimeter
%	Percent
Rad/s	Angular velocity
rpm	Speed
Degrees	Angular size

Fig. 1-3: Abbreviations used

2 Important Instructions on Use

2.1 Appropriate Use

2.1.1 Introduction

Rexroth products represent state-of-the-art developments and manufacturing. They are tested prior to delivery to ensure operating safety and reliability.

The products may only be used in the appropriate way. If they are not used in the appropriate way, situations resulting in property damage and personal injury can occur.

☞ Bosch Rexroth as manufacturer is not liable for any damages resulting from inappropriate use. In such cases, the guarantee and the right to payment of damages resulting from inappropriate use are forfeited. The user alone carries all responsibility of the risks.

Before using Rexroth products, make sure that all the pre-requisites for an appropriate use of the products are satisfied:

- Personnel that in any way, shape or form uses our products must first read and understand the relevant safety instructions and be familiar with appropriate use.
- If the products take the form of hardware, then they must remain in their original state, in other words, no structural changes are permitted. It is not permitted to decompile software products or alter source codes.
- Do not mount damaged or faulty products or use them in operation.
- Ensure that the products have been installed in the manner described in the relevant documentation.

2.1.2 Areas of Use and Application

Rexroth IndraMotion MLC/ IndraLogic XLC

IndraMotion MLC/IndraLogic XLC and its function modules are intended for Motion/Logic applications.

☞ The IndraMotion MLC/IndraLogic XLC and its function modules may only be used with the accessories and mounting parts listed in this documentation. Components that are not expressly mentioned must neither be attached nor connected. The same is valid for cables and lines.

The operation must only be carried out with the hardware component configurations and combinations that were expressly mentioned and with the software and firmware indicated and specified in the respective documentations and functional descriptions.

IndraMotion MLC/IndraLogic XLC and its function modules have been developed for use in single and multi-axis drive and control tasks.

For the application-specific use of the machine operating and visualization terminals, device models featuring different equipments and different interfaces are available.

Typical scopes of use where IndraMotion MLC/IndraLogic XLC and its function modules can be applied are:

- [Handling and mounting systems]
- [Packaging and food machines]

- [Printing and paper-processing machines]

Rexroth IndraMotion MLC/IndraLogic XLC and the function modules must only be operated under the mounting and installation conditions, the position, and the ambient conditions (temperature, type of protection, moisture, EMC, etc.) specified in the related documentations.

2.2 Inappropriate Use

The use of Rexroth IndraMotion MLC/IndraLogic XLC and its function modules in applications other than those specified or described in the documentation and the technical data is considered as "improper".

The Rexroth IndraMotion MLC/IndraLogic XLC and its function modules may not be used if it is

- exposed to operating conditions which do not correspond to the specified ambient conditions. Operation under water, extreme temperature fluctuations or extreme maximum temperatures etc. is prohibited.
- Furthermore, the IndraMotion MLC/IndraLogic XLC and its function modules must not be used in any applications not expressly approved by Bosch Rexroth. Therefore, read the statements given in the general safety instructions!

3 Safety Instructions for Electric Drives and Controls

3.1 Definitions of Terms

Application Documentation Application documentation comprises the entire documentation used to inform the user of the product about the use and safety-relevant features for configuring, integrating, installing, mounting, commissioning, operating, maintaining, repairing and decommissioning the product. The following terms are also used for this kind of documentation: User Guide, Operation Manual, Commissioning Manual, Instruction Manual, Project Planning Manual, Application Manual, etc.

Component A component is a combination of elements with a specified function, which are part of a piece of equipment, device or system. Components of the electric drive and control system are, for example, supply units, drive controllers, mains choke, mains filter, motors, cables, etc.

Control System A control system comprises several interconnected control components placed on the market as a single functional unit.

Device A device is a finished product with a defined function, intended for users and placed on the market as an individual piece of merchandise.

Electrical Equipment Electrical equipment encompasses all devices used to generate, convert, transmit, distribute or apply electrical energy, such as electric motors, transformers, switching devices, cables, lines, power-consuming devices, circuit board assemblies, plug-in units, control cabinets, etc.

Electric Drive System An electric drive system comprises all components from mains supply to motor shaft; this includes, for example, electric motor(s), motor encoder(s), supply units and drive controllers, as well as auxiliary and additional components, such as mains filter, mains choke and the corresponding lines and cables.

Installation An installation consists of several devices or systems interconnected for a defined purpose and on a defined site which, however, are not intended to be placed on the market as a single functional unit.

Machine A machine is the entirety of interconnected parts or units at least one of which is movable. Thus, a machine consists of the appropriate machine drive elements, as well as control and power circuits, which have been assembled for a specific application. A machine is, for example, intended for processing, treatment, movement or packaging of a material. The term "machine" also covers a combination of machines which are arranged and controlled in such a way that they function as a unified whole.

Manufacturer The manufacturer is an individual or legal entity bearing responsibility for the design and manufacture of a product which is placed on the market in the individual's or legal entity's name. The manufacturer can use finished products, finished parts or finished elements, or contract out work to subcontractors. However, the manufacturer must always have overall control and possess the required authority to take responsibility for the product.

Product Examples of a product: Device, component, part, system, software, firmware, among other things.

Project Planning Manual A project planning manual is part of the application documentation used to support the sizing and planning of systems, machines or installations.

Qualified Persons In terms of this application documentation, qualified persons are those persons who are familiar with the installation, mounting, commissioning and operation of the components of the electric drive and control system, as well as with the hazards this implies, and who possess the qualifications their work requires. To comply with these qualifications, it is necessary, among other things,

1) to be trained, instructed or authorized to switch electric circuits and devices safely on and off, to ground them and to mark them

2) to be trained or instructed to maintain and use adequate safety equipment

3) to attend a course of instruction in first aid

User A user is a person installing, commissioning or using a product which has been placed on the market.

3.2 General Information

3.2.1 Using the Safety Instructions and Passing Them on to Others

Do not attempt to install and operate the components of the electric drive and control system without first reading all documentation provided with the product. Read and understand these safety instructions and all user documentation prior to working with these components. If you do not have the user documentation for the components, contact your responsible Bosch Rexroth sales partner. Ask for these documents to be sent immediately to the person or persons responsible for the safe operation of the components.

If the component is resold, rented and/or passed on to others in any other form, these safety instructions must be delivered with the component in the official language of the user's country.

Improper use of these components, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, could result in property damage, injury, electric shock or even death.

3.2.2 Requirements for Safe Use

Read the following instructions before initial commissioning of the components of the electric drive and control system in order to eliminate the risk of injury and/or property damage. You must follow these safety instructions.

- Bosch Rexroth is not liable for damages resulting from failure to observe the safety instructions.
- Read the operating, maintenance and safety instructions in your language before commissioning. If you find that you cannot completely understand the application documentation in the available language, please ask your supplier to clarify.
- Proper and correct transport, storage, mounting and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of the component.
- Only qualified persons may work with components of the electric drive and control system or within its proximity.
- Only use accessories and spare parts approved by Bosch Rexroth.
- Follow the safety regulations and requirements of the country in which the components of the electric drive and control system are operated.
- Only use the components of the electric drive and control system in the manner that is defined as appropriate. See chapter "Appropriate Use".
- The ambient and operating conditions given in the available application documentation must be observed.
- Applications for functional safety are only allowed if clearly and explicitly specified in the application documentation "Integrated Safety Technology". If this is not the case, they are excluded. Functional safety is a safety

concept in which measures of risk reduction for personal safety depend on electrical, electronic or programmable control systems.

- The information given in the application documentation with regard to the use of the delivered components contains only examples of applications and suggestions.

  The machine and installation manufacturers must

  – make sure that the delivered components are suited for their individual application and check the information given in this application documentation with regard to the use of the components,

  – make sure that their individual application complies with the applicable safety regulations and standards and carry out the required measures, modifications and complements.

- Commissioning of the delivered components is only allowed once it is sure that the machine or installation in which the components are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only allowed if the national EMC regulations for the application are met.
- The instructions for installation in accordance with EMC requirements can be found in the section on EMC in the respective application documentation.

  The machine or installation manufacturer is responsible for compliance with the limit values as prescribed in the national regulations.

- The technical data, connection and installation conditions of the components are specified in the respective application documentations and must be followed at all times.

National regulations which the user must take into account

- European countries: In accordance with European EN standards
- United States of America (USA):
  – National Electrical Code (NEC)
  – National Electrical Manufacturers Association (NEMA), as well as local engineering regulations
  – Regulations of the National Fire Protection Association (NFPA)
- Canada: Canadian Standards Association (CSA)
- Other countries:
  – International Organization for Standardization (ISO)
  – International Electrotechnical Commission (IEC)

3.2.3 Hazards by Improper Use

- High electrical voltage and high working current! Danger to life or serious injury by electric shock!
- High electrical voltage by incorrect connection! Danger to life or injury by electric shock!
- Dangerous movements! Danger to life, serious injury or property damage by unintended motor movements!
- Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric drive systems!
- Risk of burns by hot housing surfaces!

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- Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!
- Risk of injury by improper handling of batteries!
- Risk of injury by improper handling of pressurized lines!

3.3 Instructions with Regard to Specific Dangers

3.3.1 Protection Against Contact With Electrical Parts and Housings

☞ This section concerns components of the electric drive and control system with voltages of **more than 50 volts**.

Contact with parts conducting voltages above 50 volts can cause personal danger and electric shock. When operating components of the electric drive and control system, it is unavoidable that some parts of these components conduct dangerous voltage.

High electrical voltage! Danger to life, risk of injury by electric shock or serious injury!

- Only qualified persons are allowed to operate, maintain and/or repair the components of the electric drive and control system.
- Follow the general installation and safety regulations when working on power installations.
- Before switching on, the equipment grounding conductor must have been permanently connected to all electric components in accordance with the connection diagram.
- Even for brief measurements or tests, operation is only allowed if the equipment grounding conductor has been permanently connected to the points of the components provided for this purpose.
- Before accessing electrical parts with voltage potentials higher than 50 V, you must disconnect electric components from the mains or from the power supply unit. Secure the electric component from reconnection.
- With electric components, observe the following aspects:

  Always wait **30 minutes** after switching off power to allow live capacitors to discharge before accessing an electric component. Measure the electrical voltage of live parts before beginning to work to make sure that the equipment is safe to touch.
- Install the covers and guards provided for this purpose before switching on.
- Never touch electrical connection points of the components while power is turned on.
- Do not remove or plug in connectors when the component has been powered.
- Under specific conditions, electric drive systems can be operated at mains protected by residual-current-operated circuit-breakers sensitive to universal current (RCDs/RCMs).
- Secure built-in devices from penetrating foreign objects and water, as well as from direct contact, by providing an external housing, for example a control cabinet.

High housing voltage and high leakage current! Danger to life, risk of injury by electric shock!

- Before switching on and before commissioning, ground or connect the components of the electric drive and control system to the equipment grounding conductor at the grounding points.

- Connect the equipment grounding conductor of the components of the electric drive and control system permanently to the main power supply at all times. The leakage current is greater than 3.5 mA.
- Establish an equipment grounding connection with a minimum cross section according to the table below. With an outer conductor cross section smaller than 10 mm^2 (8 AWG), the alternative connection of two equipment grounding conductors is allowed, each having the same cross section as the outer conductors.

Cross section outer conductor	Minimum cross section equipment grounding conductor Leakage current ≥ 3.5 mA	
	1 equipment grounding conductor	2 equipment grounding conductors
1.5 mm^2 (16 AWG)	10 mm^2 (8 AWG)	2 × 1.5 mm^2 (16 AWG)
2.5 mm^2 (14 AWG)		2 × 2.5 mm^2 (14 AWG)
4 mm^2 (12 AWG)		2 × 4 mm^2 (12 AWG)
6 mm^2 (10 AWG)		2 × 6 mm^2 (10 AWG)
10 mm^2 (8 AWG)		-
16 mm^2 (6 AWG)	16 mm^2 (6 AWG)	-
25 mm^2 (4 AWG)		-
35 mm^2 (2 AWG)		-
50 mm^2 (1/0 AWG)	25 mm^2 (4 AWG)	-
70 mm^2 (2/0 AWG)	35 mm^2 (2 AWG)	-
...	...	...

Fig.3-1: Minimum Cross Section of the Equipment Grounding Connection

3.3.2 Protective Extra-Low Voltage as Protection Against Electric Shock

Protective extra-low voltage is used to allow connecting devices with basic insulation to extra-low voltage circuits.

On components of an electric drive and control system provided by Bosch Rexroth, all connections and terminals with voltages between 5 and 50 volts are PELV ("Protective Extra-Low Voltage") systems. It is allowed to connect devices equipped with basic insulation (such as programming devices, PCs, notebooks, display units) to these connections.

Danger to life, risk of injury by electric shock! High electrical voltage by incorrect connection!

If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volts (e.g., the mains connection) are connected to Bosch Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV ("Protective Extra-Low Voltage").

3.3.3 Protection Against Dangerous Movements

Dangerous movements can be caused by faulty control of connected motors. Some common examples are:

- Improper or wrong wiring or cable connection
- Operator errors
- Wrong input of parameters before commissioning
- Malfunction of sensors and encoders
- Defective components
- Software or firmware errors

These errors can occur immediately after equipment is switched on or even after an unspecified time of trouble-free operation.

The monitoring functions in the components of the electric drive and control system will normally be sufficient to avoid malfunction in the connected drives. Regarding personal safety, especially the danger of injury and/or property damage, this alone cannot be relied upon to ensure complete safety. Until the integrated monitoring functions become effective, it must be assumed in any case that faulty drive movements will occur. The extent of faulty drive movements depends upon the type of control and the state of operation.

Dangerous movements! Danger to life, risk of injury, serious injury or property damage!

A **risk assessment** must be prepared for the installation or machine, with its specific conditions, in which the components of the electric drive and control system are installed.

As a result of the risk assessment, the user must provide for monitoring functions and higher-level measures on the installation side for personal safety. The safety regulations applicable to the installation or machine must be taken into consideration. Unintended machine movements or other malfunctions are possible if safety devices are disabled, bypassed or not activated.

To avoid accidents, injury and/or property damage:

- Keep free and clear of the machine's range of motion and moving machine parts. Prevent personnel from accidentally entering the machine's range of motion by using, for example:
  - Safety fences
  - Safety guards
  - Protective coverings
  - Light barriers
- Make sure the safety fences and protective coverings are strong enough to resist maximum possible kinetic energy.
- Mount emergency stopping switches in the immediate reach of the operator. Before commissioning, verify that the emergency stopping equipment works. Do not operate the machine if the emergency stopping switch is not working.
- Prevent unintended start-up. Isolate the drive power connection by means of OFF switches/OFF buttons or use a safe starting lockout.
- Make sure that the drives are brought to safe standstill before accessing or entering the danger zone.
- Additionally secure vertical axes against falling or dropping after switching off the motor power by, for example,
  - mechanically securing the vertical axes,
  - adding an external braking/arrester/clamping mechanism or
  - ensuring sufficient counterbalancing of the vertical axes.

- The standard equipment **motor holding brake** or an external holding brake controlled by the drive controller is **not sufficient to guarantee personal safety**!
- Disconnect electrical power to the components of the electric drive and control system using the master switch and secure them from reconnection ("lock out") for:
  - Maintenance and repair work
  - Cleaning of equipment
  - Long periods of discontinued equipment use
- Prevent the operation of high-frequency, remote control and radio equipment near components of the electric drive and control system and their supply leads. If the use of these devices cannot be avoided, check the machine or installation, at initial commissioning of the electric drive and control system, for possible malfunctions when operating such high-frequency, remote control and radio equipment in its possible positions of normal use. It might possibly be necessary to perform a special electromagnetic compatibility (EMC) test.

3.3.4 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated by current-carrying conductors or permanent magnets of electric motors represent a serious danger to persons with heart pacemakers, metal implants and hearing aids.

Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electric components!

- Persons with heart pacemakers and metal implants are not allowed to enter the following areas:
  - Areas in which components of the electric drive and control systems are mounted, commissioned and operated.
  - Areas in which parts of motors with permanent magnets are stored, repaired or mounted.
- If it is necessary for somebody with a heart pacemaker to enter such an area, a doctor must be consulted prior to doing so. The noise immunity of implanted heart pacemakers differs so greatly that no general rules can be given.
- Those with metal implants or metal pieces, as well as with hearing aids, must consult a doctor before they enter the areas described above.

3.3.5 Protection Against Contact With Hot Parts

Hot surfaces of components of the electric drive and control system. Risk of burns!

- Do not touch hot surfaces of, for example, braking resistors, heat sinks, supply units and drive controllers, motors, windings and laminated cores!
- According to the operating conditions, temperatures of the surfaces can be **higher than 60 °C** (140 °F) during or after operation.
- Before touching motors after having switched them off, let them cool down for a sufficient period of time. Cooling down can require **up to 140 minutes**! The time required for cooling down is approximately five times the thermal time constant specified in the technical data.

- After switching chokes, supply units and drive controllers off, wait **15 minutes** to allow them to cool down before touching them.
- Wear safety gloves or do not work at hot surfaces.
- For certain applications, and in accordance with the respective safety regulations, the manufacturer of the machine or installation must take measures to avoid injuries caused by burns in the final application. These measures can be, for example: Warnings at the machine or installation, guards (shieldings or barriers) or safety instructions in the application documentation.

3.3.6 Protection During Handling and Mounting

Risk of injury by improper handling! Injury by crushing, shearing, cutting, hitting!

- Observe the relevant statutory regulations of accident prevention.
- Use suitable equipment for mounting and transport.
- Avoid jamming and crushing by appropriate measures.
- Always use suitable tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- Use suitable protective equipment (hard hat, safety goggles, safety shoes, safety gloves, for example).
- Do not stand under hanging loads.
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

3.3.7 Battery Safety

Batteries consist of active chemicals in a solid housing. Therefore, improper handling can cause injury or property damage.

Risk of injury by improper handling!

- Do not attempt to reactivate low batteries by heating or other methods (risk of explosion and cauterization).
- Do not attempt to recharge the batteries as this may cause leakage or explosion.
- Do not throw batteries into open flames.
- Do not dismantle batteries.
- When replacing the battery/batteries, do not damage the electrical parts installed in the devices.
- Only use the battery types specified for the product.

☞ Environmental protection and disposal! The batteries contained in the product are considered dangerous goods during land, air, and sea transport (risk of explosion) in the sense of the legal regulations. Dispose of used batteries separately from other waste. Observe the national regulations of your country.

3.3.8 Protection Against Pressurized Systems

According to the information given in the Project Planning Manuals, motors and components cooled with liquids and compressed air can be partially supplied with externally fed, pressurized media, such as compressed air, hydraulics oil, cooling liquids and cooling lubricants. Improper handling of the connected supply systems, supply lines or connections can cause injuries or property damage.

Risk of injury by improper handling of pressurized lines!

- Do not attempt to disconnect, open or cut pressurized lines (risk of explosion).
- Observe the respective manufacturer's operating instructions.
- Before dismounting lines, relieve pressure and empty medium.
- Use suitable protective equipment (safety goggles, safety shoes, safety gloves, for example).
- Immediately clean up any spilled liquids from the floor due to the risk of falling!

☞ Environmental protection and disposal! The agents (e.g., fluids) used to operate the product might not be environmentally friendly. Dispose of agents harmful to the environment separately from other waste. Observe the national regulations of your country.

3.4 Explanation of Signal Words and the Safety Alert Symbol

The Safety Instructions in the available application documentation contain specific signal words (DANGER, WARNING, CAUTION or NOTICE) and, where required, a safety alert symbol (in accordance with ANSI Z535.6-2006).

The signal word is meant to draw the reader's attention to the safety instruction and identifies the hazard severity.

The safety alert symbol (a triangle with an exclamation point), which precedes the signal words DANGER, WARNING and CAUTION, is used to alert the reader to personal injury hazards.

⚠ DANGER

In case of non-compliance with this safety instruction, death or serious injury **will** occur.

⚠ WARNING

In case of non-compliance with this safety instruction, death or serious injury **could** occur.

⚠ CAUTION

In case of non-compliance with this safety instruction, minor or moderate injury could occur.

NOTICE

In case of non-compliance with this safety instruction, property damage could occur.

4 Introduction

4.1 General

The CamBuilder is a tool integrated into the IndraWorks Engineering Desktop for the simple and convenient creation of electronic cams. The CamBuilder supports the direct download of cams to Bosch Rexroth drive controllers as well as the generation of cam PLC function blocks for parameterizing FlexProfiles. Thanks to these features, this tool is customized to meet the requirements and characteristics of the Bosch Rexroth drive controller.

4.2 Cams and Synchronization Modes

Electronic cams control the motion sequences of slave axes in relation to master axes.

The Bosch Rexroth driver controllers have different synchronization modes for executing cams.

Cam table The position of the slave axis is calculated during its runtime using the distance and the percentage values from the table.

MotionProfile The position of the slave axis is calculated during its runtime using analytical functions or cam tables.

FlexProfile The FlexProfile corresponds to an extension of the MotionProfile (the time can optionally be used as a reference variable for the slave axis; it has a larger choice of motion laws and an event controller).

The CamBuilder is a higher-level tool and, during creation and editing, does not differentiate between the various operation modes. Only if the user decides to download a cam onto a device, he has to specify the corresponding operation mode.

4.3 CamBuilder - Characteristics

The essential features of the CamBuilder are as follows:

- Simple creation of cams using graphic tools
- Convenient editing of existing cams
- Open several cams parallel in a preview and analyze them with different master axis velocities
- Use of VDI 2143-compliant motion laws
- Upload and download cams to Bosch Rexroth drives and controls
- Generating an PLC code to change the cam in the PLC program at runtime.
- Entering variables, formula and references in the cam editor to to generate flexible cam definitions.
- Automatic display of position, acceleration, velocity and jerk.
- Support for common requirements (application-specific cams, such as CrossCutter) with wizards.
- Import of cam tables as motion laws
- Automatic detection and calculation of the limit conditions of the individual motion steps of the cam.
- Zoom functions
- Import / export functionality in different formats (*.XML, *.PAR, *.CSV).

4.4 Definition of Terms

Cam

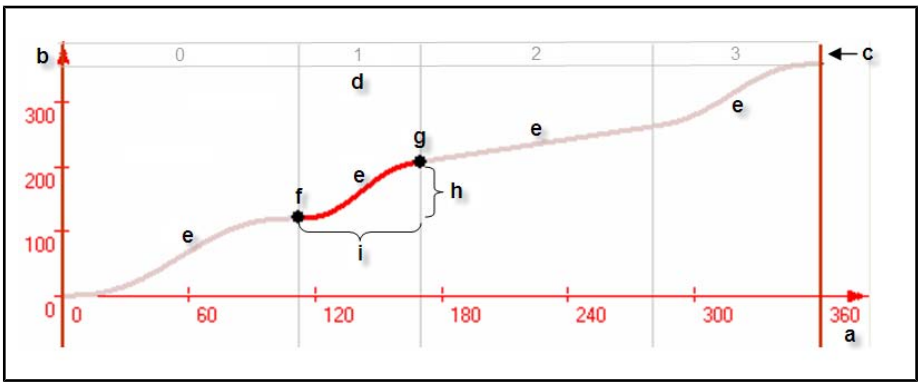

Fig.4-1: Diagram of a cam graph to provide a definition of terms

a **Master axis** (X-axis)

b **Slave axis** (Y-axis)

c **Motion steps** (0 – n)

d **Focused motion step**

e **Motion law** (analytical function or cam table)

f **Starting point** of the focused motion step (X_n,Y_n)

g **End point** of the focused motion step (X_{n+1},Y_{n+1})

h **Distance** of the focused motion step (ΔY)

i **Range** of the focused motion step, which can either be the time duration (ΔT) or the master axis range (ΔX).

A cam defines the position of a slave axis in relation to a master axis or in relation to the the time. A cam comprises one or more motion steps. Each motion step has a motion law that specifies the connection between the master axis or time and the slave axis. The individual motions of the steps combined create a cam.

In the CamBuilder, the focused motion step of a cam is always edited. This can either take place via a graphic diagram or via numerical inputs. Depending on the editing mode and the type of change, the preceding or subsequent motion steps can also change.

From the second motion step on, all motion steps begin with the end point of the preceding step.

5 CamBuilder – First Steps

5.1 Preparation

Installation and Start

The CamBuilder is integrated in the IndraWorks Suite installation package and is installed automatically.

If the CamBuilder is licensed, it starts automatically with IndraWorks Engineering.

Licensing

1. A full license key has to be purchased in order to use all CamBuilder functions.
2. The license overview opens via the **Tools** ▸ **Options** ▸ **General** ▸ **Software Licenses** menu.

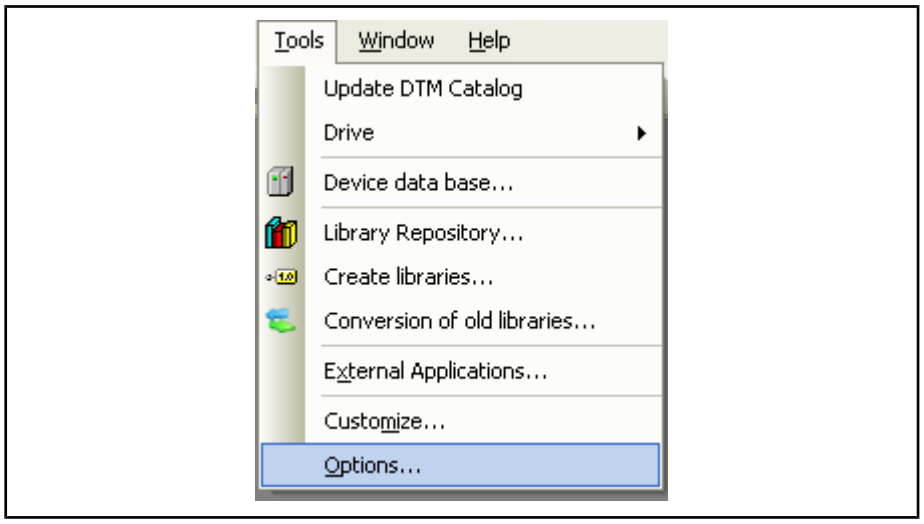

Fig.5-1: Menu: Tools

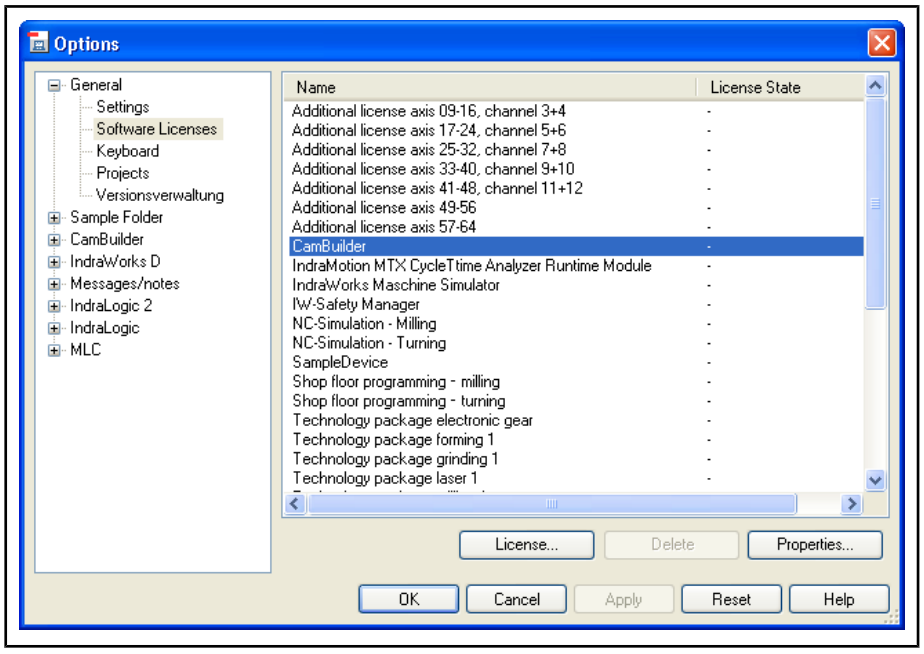

Fig.5-2: Dialog: Options (software licenses)

3. The CamBuilder license can be activated via the "License…" button.

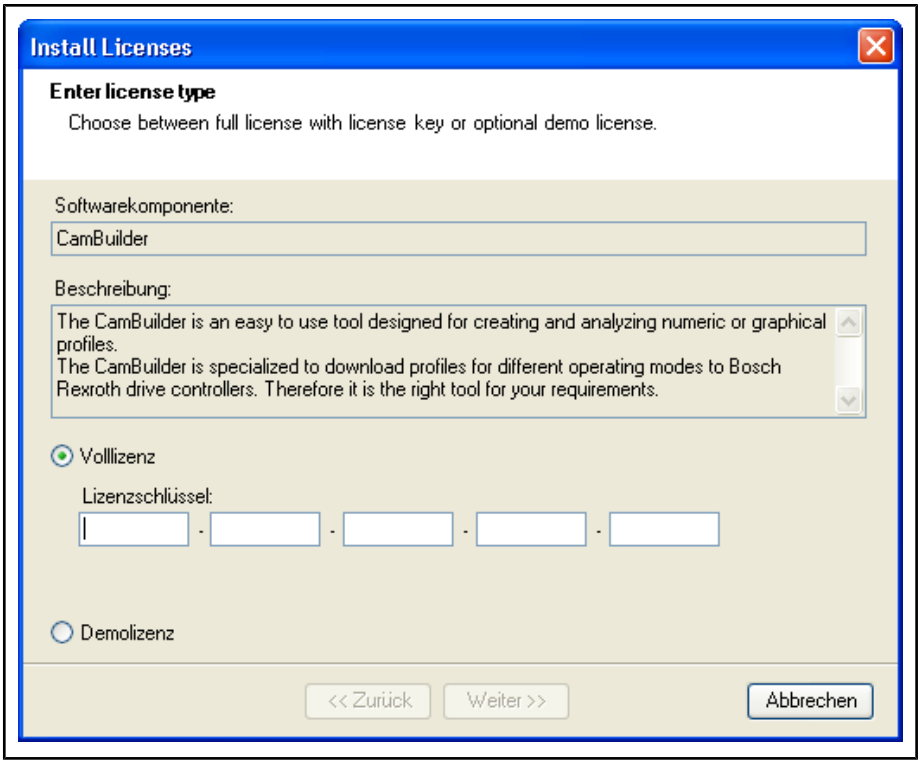

Fig.5-3: Dialog: Install Licenses

A demo license valid for 30 days is available without an activation key. After 30 days, the objects managed by the CamBuilder are deactivated in IndraWorks projects. The CamBuilder can be licensed to continue using the cams created. Otherwise, the deactivated objects can be deleted from existing projects.

Library All CamBuilder objects can be found in the IndraWorks library under "CamBuilder". These objects can be inserted via Drag&Drop (it is focused on individual elements in the following examples).

The following objects are available:

Cam Pool All cams generated with the CamBuilder in the current project can be managed in a "Cam Pool" folder.

A new cam can also be created via a "Cam Pool" node context menu.

Cam A cam in the CamBuilder is defined by one or several motion steps.

The cam can be opened for editing by double-click.

Preview A preview in the CamBuilder shows one or several cams of a master axis.

Open the preview with double-click. Add more cams to the preview using Drag&Drop.

5.2 Creating and Downloading Cams

This chapter explains, how to create and download a cam consisting of 3 motion steps.

Topic The master and slave axis are rotary. The master axis rotates at a velocity of 100 rotations per minute.

The slave axis starts at 0 degrees and should be moved on a fixed axis range of 180 degrees from standstill to 120 degrees. It should pause for 100 millisec-

onds (independent of the master axis velocity) and then travel up to the master axis end position of 360 degrees return to 0 degrees at standstill.

The cam created is then downloaded to an IndraMotion MLC or IndraLogic XLC control.

Operating sequence

1. Creating the cam

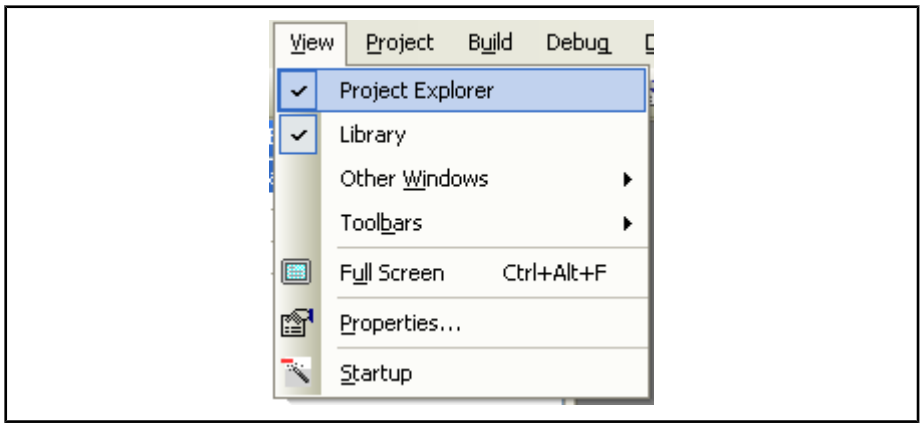

Fig.5-4: Menu: View

Via the menu "View", the "Project Explorer" and the "Library" are activated.

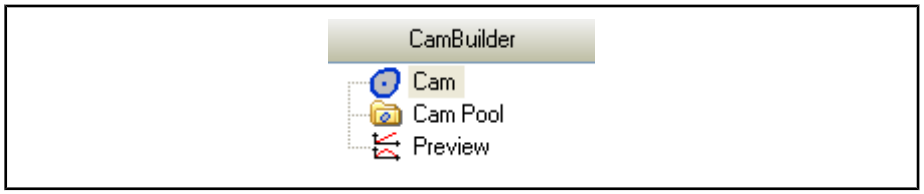

Fig.5-5: Library: CamBuilder section

A "Cam Pool" is added from the IndraWorks library in the "CamBuilder" section with drag&drop.

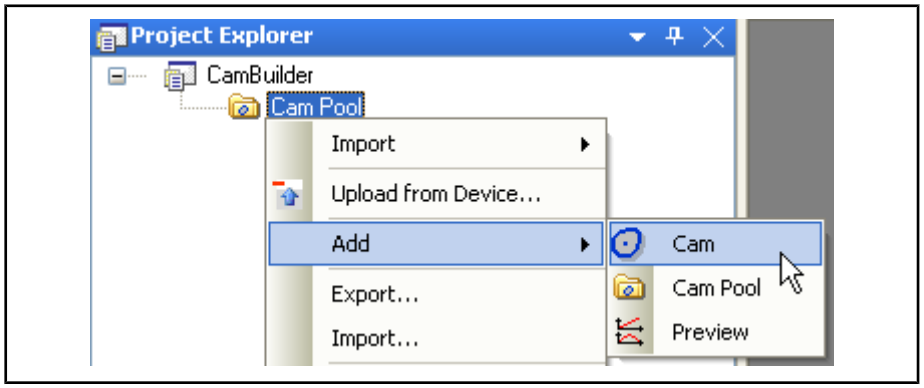

Fig.5-6: Context menu: Cam Pool

In the Project Explorer, right click on the "Cam Pool" node and select the **Add ▸ Cam** context menu item.

2. Wizard

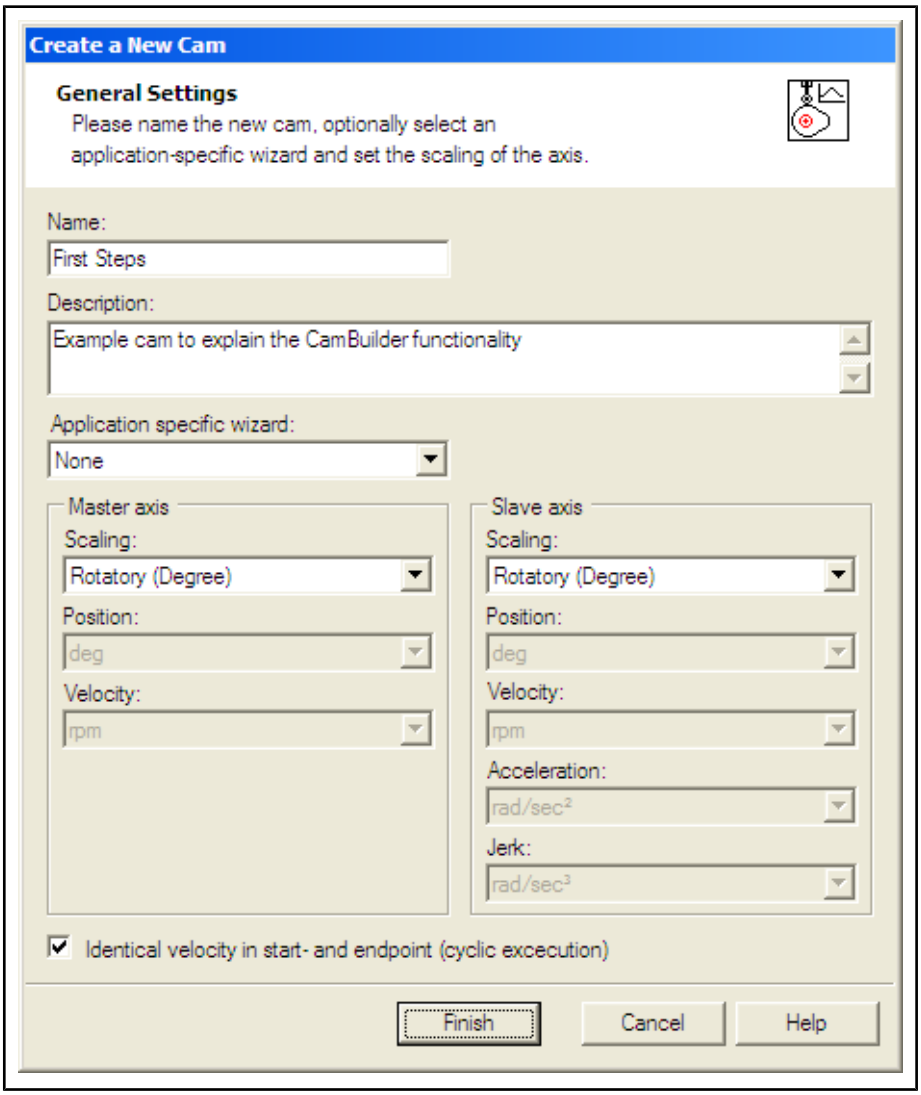

Fig.5-7: Dialog: Creating a new cam (Wizard)

Enter a specific name and optionally a description for the new cam in the wizard. To create a freely-defined cam, select "none" under "Application-specific Wizard".

The scalings of master and slave axis are set to "Rotary (degree)."

To execute the cam cyclically, the option "Identical velocity in starting and end point (cyclic execution)" is selected.

The "Finish" button creates a default cam, saves it in the IndraWorks project and automatically opens a graph window.

3. Edit motion step 0

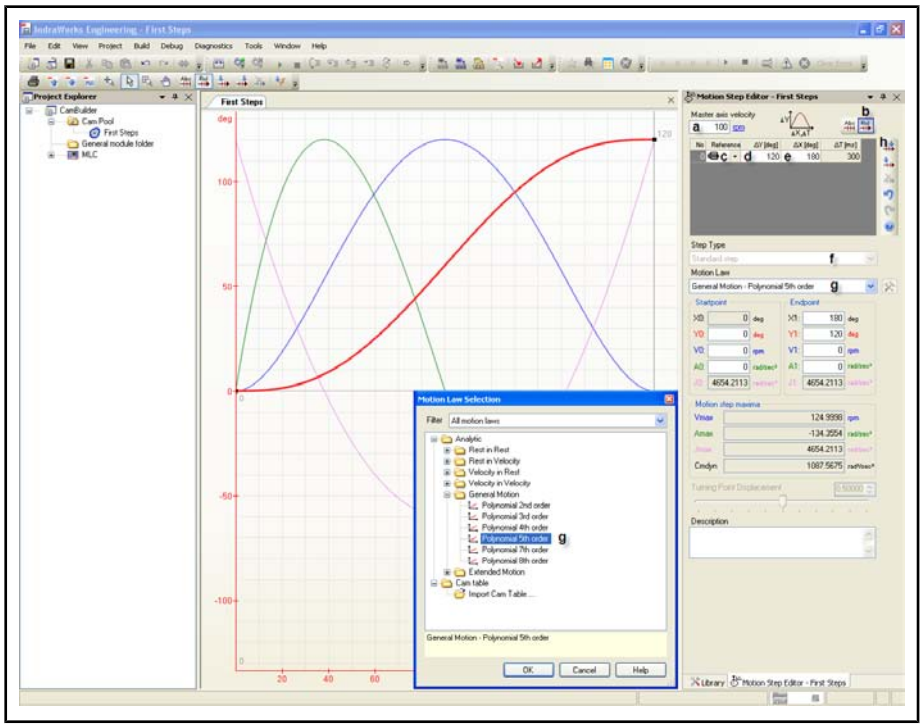

Fig.5-8: Dialog: IndraWorks Engineering – First steps (cam)

The Motion Step Editor opens at the same time as the graph window. The first motion step has been automatically generated and is entered with default values. Depending on the motion law and mathematical degrees of freedom, not all the motion fields can be edited. To facilitate entering values, all editable fields are provided with a white background.

a The master axis rotates at 100 rpm.

b As all steps have to be input consecutively, the editing mode shows "Relative."

c The slave axis should follow the master axis, therefore the reference should be set to the motor symbol.

d The relative distance of the slave axis is defined at 120 degrees (ΔY).

e The distance is based on a master axis range of 180 degrees (ΔX).

f If the cam only consists of one step, the step type is automatically defined as "Default step".

g The "Rest-in-rest - Polynomial 5th order" is selected as the motion law. All other fields are automatically completed.

h Another step is added to the end of the focused step with the "Add motion step after focused step" button.

If focused, the graph view can be modified using the following keys:

- <Pos1> Show all
- <Arrow keys> Move view
- <+ / -> Zoom in view / Zoom out view

The zoom factor can be changed using the wheel of the mouse. The view can be moved when the <space> key / or the mouse key in the middle is pressed.

Special tool for changing the graph view are contained in the CamBuilder tool bar.

Fig.5-9: CamBuilder Tool bar, graph

4. Edit Motion Step 1

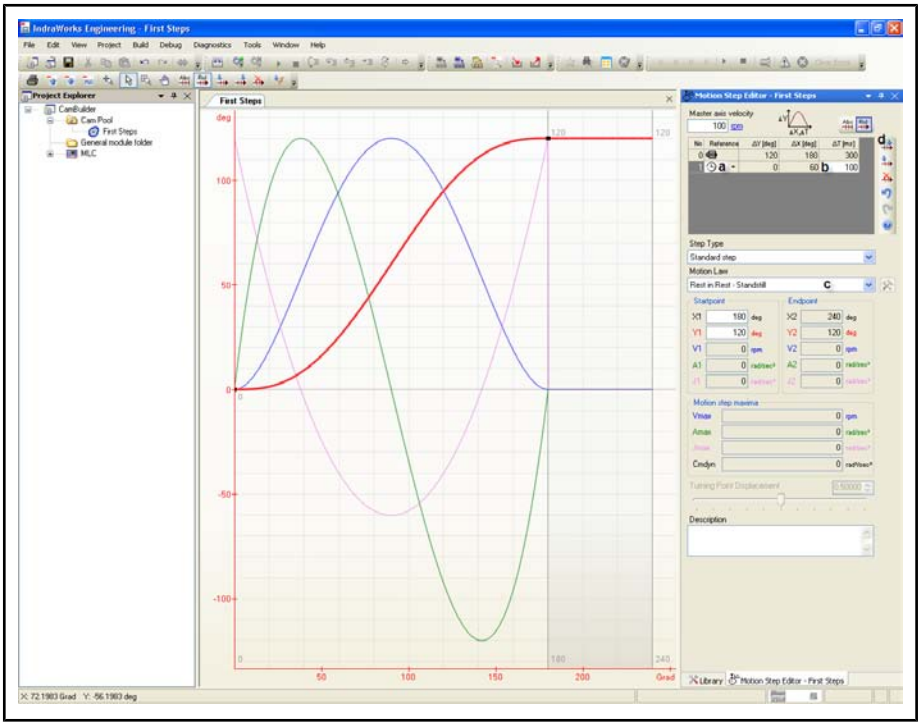

Fig.5-10: Dialog: IndraWorks Engineering – First steps (cam)

The fields of the second motion step are pre-assigned with standard values from the CamBuilder options.

a The reference of the slave axis is changed from the master axis to the time, deactivating the input fields ΔX and X_2.

b Now, the duration of the step in milliseconds has to be entered in column ΔT (100 ms).

c Following the changeover of the motion law to "Rest-in-Rest - Standstill", all automatically calculated fields are deactivated.

After every input, the cam is automatically recalculated, and in doing so rechecks whether all the values are valid. In case of incorrect values, the

relevant input field is highlighted and a message is displayed.

By clicking on the first row of the table, it can be switched to the first motion step. If the active step includes input errors, it is not possible to change to another step. There is an option to undo the last changes to the cam using the "Undo" button.

d Another step is added to the end of the focused step with the "Add motion step after focused step" button.

5. Edit motion step 2

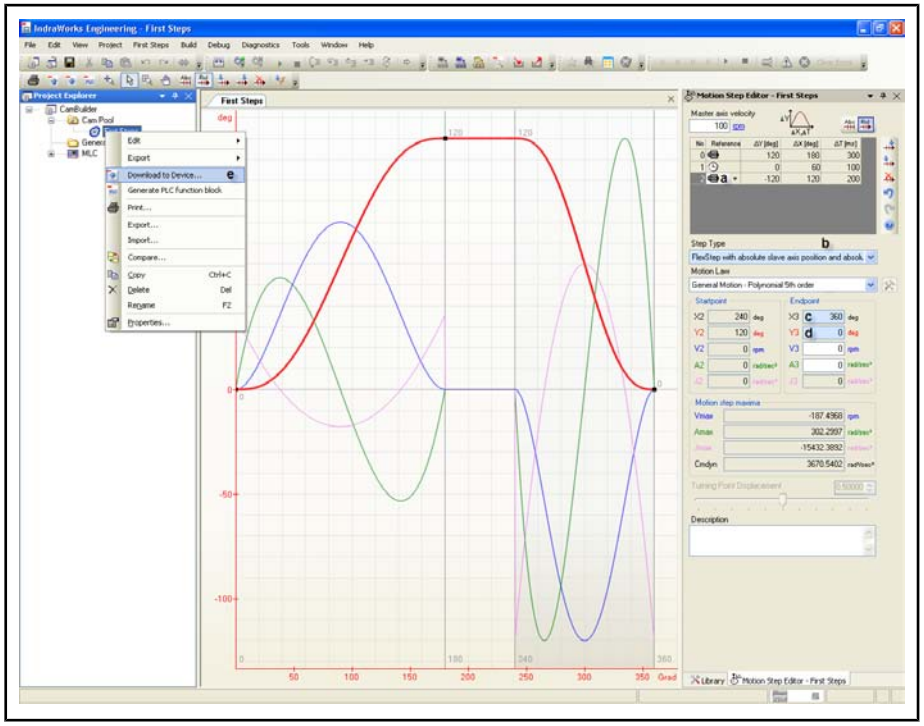

Fig.5-11: Dialog: IndraWorks Engineering – First steps (cam)

a The last step should relate to the master axis and, to this end, the slave axis reference is set to the motor symbol.

b In order to relate the slave axis absolutely to the master axis, the step type is set to "FlexStep with absolute slave axis position and absolute master axis position".

c The master axis end position X_3 is set to 360 degrees.

d The slave axis end position Y_3 is set to 0 degrees.

e The new cam is now displayed as a node below the "Cam Pool" node in the Project Explorer.

If the IndraMotion MLC/IndraLogic XLC in the project is online or is in offline-parameterization mode, the cam can be downloaded to the control via its context menu in the Project Explorer.

6. Downloading the cam

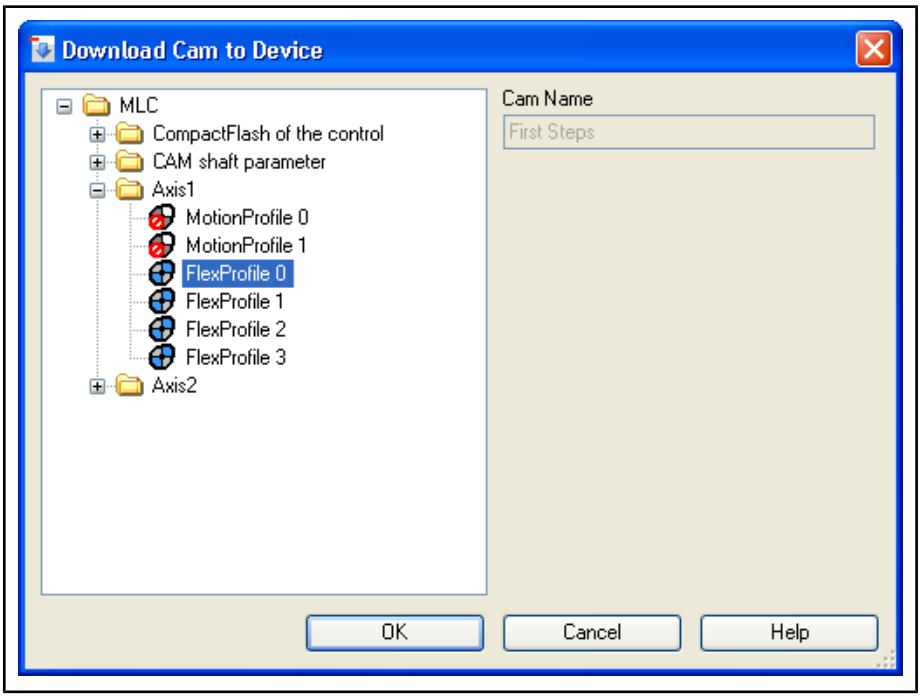

Fig.5-12: Dialog: Download Cam to Device

The target "FlexProfile 0" of "Axis 1" is selected. Confirming the dialog with **OK** downloads the cam "First steps" to the parameters of the control. A message confirms that the process has been completed successfully.

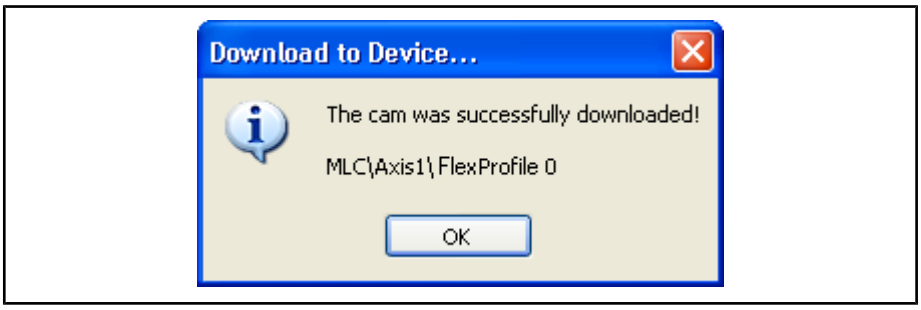

Fig.5-13: Dialog: Download to Device

☞ If there a FlexProfile is already on the axis and if the FlexProfile is currently in use (axis in motion), the FlexProfile is write-protected and cannot be replaced. Close the operation mode and write the FlexProfile to another empty profile set.

5.3 Analyzing the Cam

This chapter describes the analysis of the cam from the previous chapter 5.2 "Creating and Downloading Cams" on page 28.

Topic The cam behavior of the master axis velocities is to be analyzed.

Operating sequence

1. Creating preview

   In the Project Explorer, right click on the "Cam Pool" node and select the **New ▸ Preview...** context menu item.

2. Adding cams to the preview

   The cam "First steps" can be moved to the preview window by keeping the left mouse key pressed and dropping it.

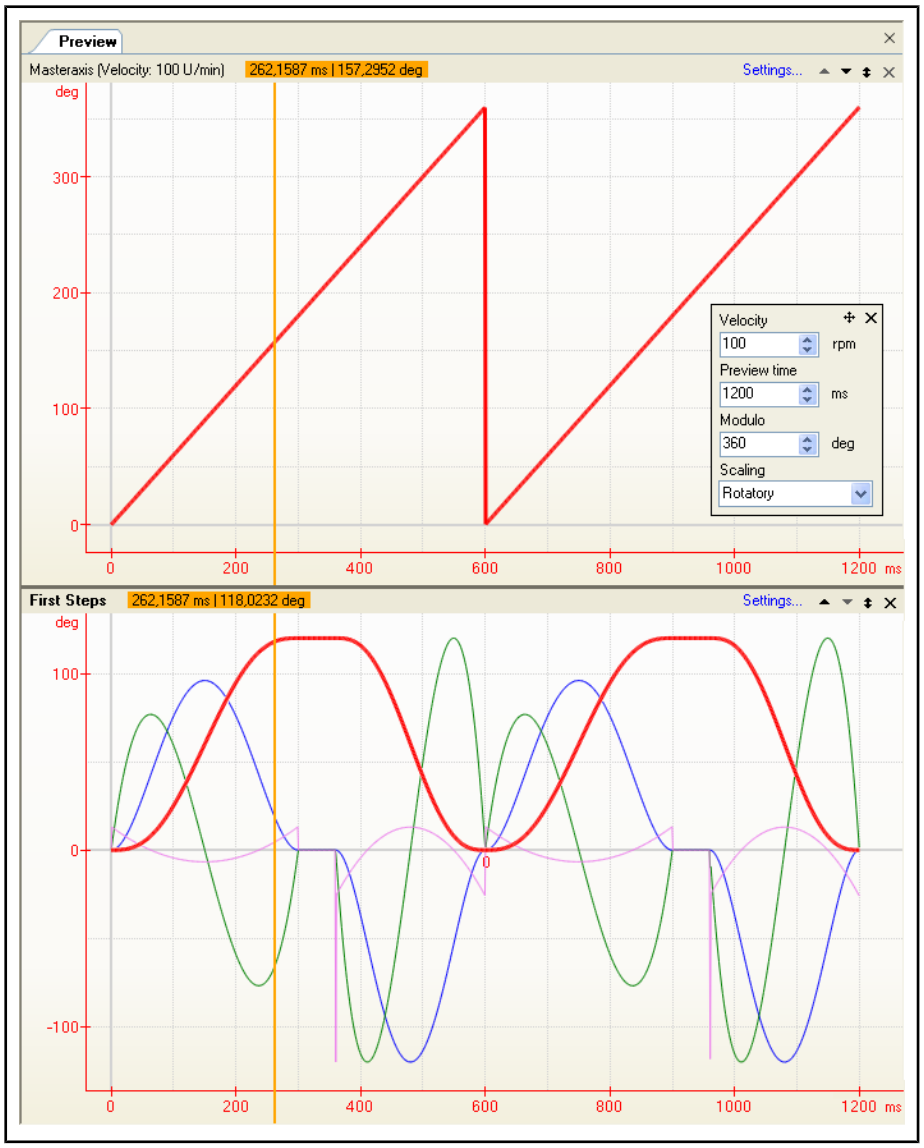

Fig.5-14: Position preview of the cam at a master axis velocity of 100 rpm

3. Change master axis velocity

   By clicking on "Settings...", the master axis velocity can be changed to e.g. 300 rpm.

   As the 2nd cam motion step does not have a master axis range but it refers to the time, there is less time for the 3rd motion step (FlexStep) to return to the home position.

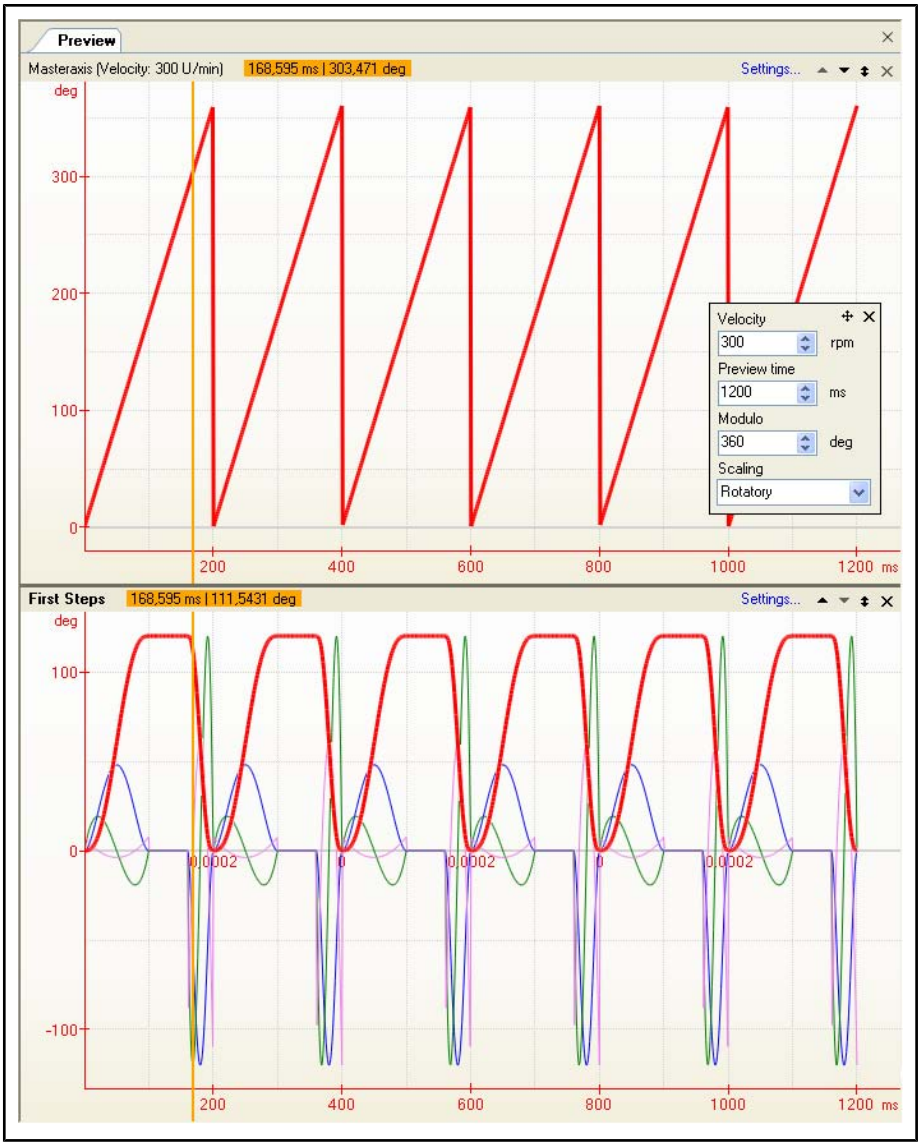

Fig.5-15: Position preview of the cam at a master axis velocity of 300 rpm

The measuring line can be moved using the mouse.

The view of a preview window can be changed in the CamBuilder tool bar via the graph tools.

4. Analyzing the slave axis velocity

   By clicking on the blue position profile of the cam, the position preview of the cam changes to a velocity preview. The velocity can be analyzed using a measuring tool.

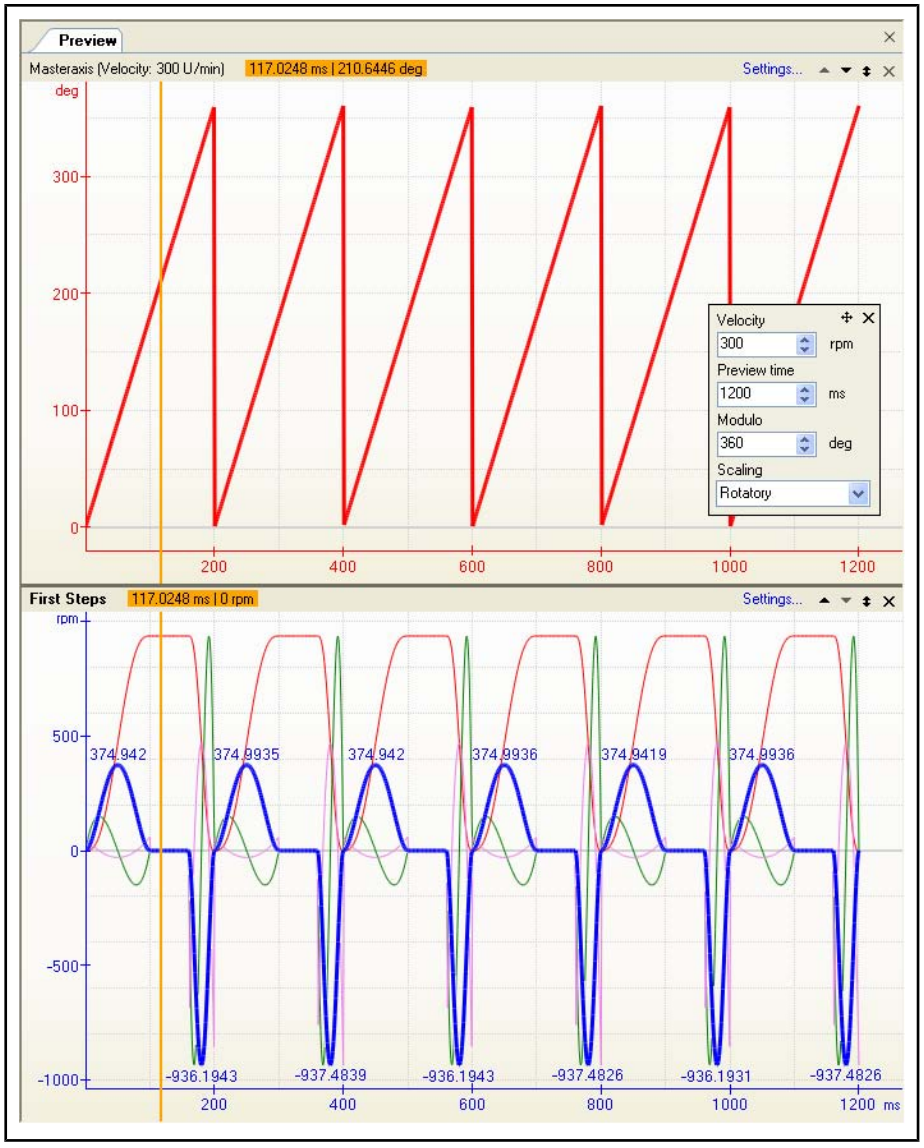

Fig.5-16: Velocity preview of the cam at a master axis velocity of 300 rpm

Several cams can be added to a preview using Drag&Drop. The cams can be analyzed simultaneously, referring to the same master axis.

5.4 Creating a Variable Cam and a PLC Function Block

This chapter explains how to create and download a variable cam consisting of 2 motion steps.

Topic

The master and slave axis are rotary. The master axis rotates at a velocity of 100 rotations per minute.

The slave axis starts at 0 degrees and is to be moved to a variable position (Variable "Distance") from standstill on a variable master axis section (sum of 10 and a variable "Range"). From this position, the slave axis has to be traveled from a defined master axis end position of 360 degrees to 0 degrees at standstill.

A PLC function block is to be generated from the cam. With this function block, the FlexProfile of an axis can be parameterized in an IndraMotion MLC/ IndraLogic XLC PLC application.

Operating sequence

1. Creating the cam

   A new cam with default settings is created under the name Cam1, as described in chapter chapter 5 "CamBuilder – First Steps" on page 27.

2. Edit motion step 0

   The cam is defined without a formula in the first draft. The following requirements have to be met:

   The master axis velocity is 100 rpm.

   The editing mode is set to "Relative".

   Recommended relative slave axis distance: 120 degrees (ΔY).

   Recommended master axis section: 180 degrees (ΔX).

   Another step is added to the end of the focused step with the **Add motion step after focused step** button.

3. Edit Motion Step 1.

   The master axis end position X_2 is set to 360 degrees.

   The slave axis end position Y_2 is set to 0 degrees.

4. Variable distance of first step

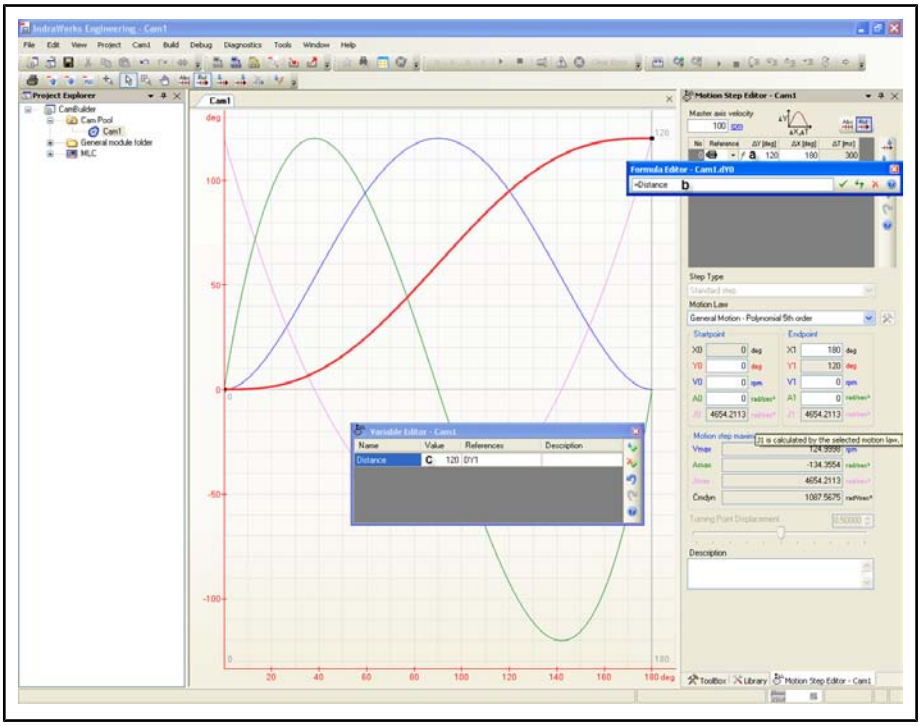

Fig.5-17: Dialog: IndraWorks Engineering – Cam1 (variable cam)

a The distance of the first motion step is to be defined via the "Distance" variable. No number is entered in the [ΔY] input field of the motion step editor but a "=" character as in a table calculation.

b A formula editor window opens in which the "=Distance" formula can be entered in the current field.

The formula is applied when acknowledging the formula. A prompt is displayed, asking if the unknown

"Distance" variable should be automatically created using a default value. The prompt is acknowledged with "Yes".

c A value of e.g. 120 degrees can now be entered in the new variable window for the "Distance" variable.

5. Variable master axis range of first step

   The master axis range of the first motion step is defined by the sum of 10 and a "Range" variable. No number is entered in the [ΔY] input field of the motion step editor but a "=" character as in a table calculation.

   The formula "=10 + Range" is entered in the formula editor for the current field.

   This variable is created automatically with a default value.

   A value of e.g. 170 degrees can now be entered in the new variable window for the "Distance" variable.

6. Variable distance of second step

   The slave axis end position of the second motion law has to be 0 degrees. The distance of the second step has to be equal to the negative distance of the first step. This is achieved by entering the formula "= - DY0" in the formula editor for the [ΔY] input field. DY0 stands for the distance of the first motion step.

7. Variable master axis range of the second step

   The master axis end position of the second motion law has to be 360 degrees. Consequently, the master axis range of the second step has to be 360 degrees less the master axis range of the first step. This is achieved by entering the formula "=360 - DX0" in the formula editor for the [ΔY] input field. "DX0" stands for the master axis range of the first motion step.

8. Generating PLC function blocks

   The generation of the PLC function block is started via the context menu of the cam in the Project Explorer or the CamBuilder tool bar.

   In case of an IndraMotion MLC/IndraLogic XLC in the project, the function block is created in the "General Block Part" folder.

9. Generating PLC function blocks

   The block can be instanced and executed in the PLC application of the IndraMotion MLC/IndraLogic XLC. The parameterization of the FlexProfile can be changed via the "Range" and "Distance" inputs.

Example ST code:

Program:

```
PROGRAM PlcProg
VAR
    fbCam1       : ChangeFlexSet_Cam1;
    bExecute     : BOOL    := TRUE;
    uiSetNumber : UINT    := 0;
    lrDistance   : LREAL   := 180;
    lrRange      : LREAL   := 170;
END_VAR
-------------------------------------------------
fbCam1(
    Execute      := bExecute,
```

```
SetNumber    := uiSetNumber,
Distance     := lrDistance,
Range        := lrRange,
Axis         := SlaveAxis,
Done=> ,
Active=> ,
Error=> ,
ErrorID=> ,
ErrorIdent=> );
```

Example CFC code:

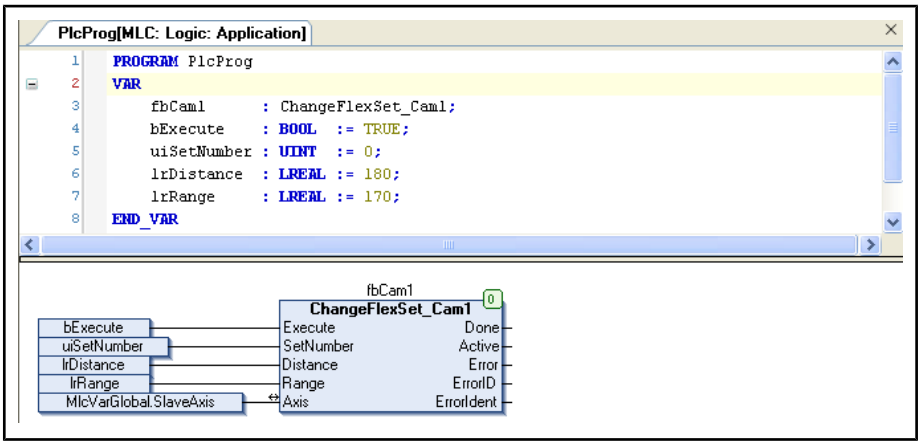

Fig.5-18: Example CFC code

Result:

The FlexProfile of the "SlaveAxis" of the IndraMotion MLC/IndraLogic XLC is parameterized according to the block inputs and can be executed by executing the generated cam function block in the PLC program on the IndraMotion MLC/ IndraLogic XLC.

6 Creating Cams and Preview Objects

6.1 Creating New Cams

Starting wizard

A new cam can be created in one step using the wizard.

The wizard is started via the context menu item **Add ▸ Cam** of the "Cam Pool" node in the Project Explorer. Optionally, a "cam" is copied from the IndraWorks library from the "CamBuilder" section into the project.

General settings

Multiple attributes of the cam are preset in the wizard.

The wizard suggests a default **name** ("Cam#") for the cam that can be changed by the user.

The user can also enter a short **description** for the cam.

The **application-specific wizard** determines whether a wizard is to be used for a specific application.

The CamBuilder provides wizards for common technologies (CrossCutter, feed, print length correction, cross seal) which assist the user when creating a cam. All requirements and unique features of the application are dialog-controlled.

No application-specific wizard is set by default. The user can freely specify the individual motion steps in the Motion Step Editor.

This property is set once when creating a cam and can no longer be changed thereafter.

Additionally, the **scalings of the master and slave axis** can be set. These settings are automatically entered and deactivated when an application-specific wizard is selected.

Three standards can be selected for the scaling of an axis:

1. Rotary (degree)
   - Position = degree
   - Velocity = rpm
   - Acceleration = rad/s^2
   - Jerk = rad/s^3
2. Translatory (mm)
   - Position = mm
   - Velocity = mm/min
   - Acceleration = mm/s^2
   - Jerk = mm/s^3
3. Translatory (inch)
   - Position = inch
   - Velocity = inch/min
   - Acceleration = inch/s^2
   - Jerk = inch/s^3

The selection of the units position, velocity, acceleration and jerk can be modified individually. By the position unit, it is specified whether the axis is rotary or translatory. For the other variables, only the respective units can be selected.

1. Rotary
   - Position = degree; radiant

- Velocity = rpm; rps; degrees/min; degrees/s; rad/min; rad/s
- Acceleration = rpm^2; rps^2; $degree/min^2$; $degree/s^2$; rad/min^2; rad/s^2
- Jerk = rpm^3; rps^3; $degree/min^3$; $degree/s^3$; rad/min^3; rad/s^3

2. Translatory
   - Position = mm; inch
   - Velocity = mm/min; mm/s; inch/min; inch/s
   - Acceleration = mm/min^2; mm/s^2; $inch/min^2$; $inch/s^2$
   - Jerk = mm/min^3; mm/s^3; $inch/min^3$; $inch/s^3$

Complete or cancel

Once the entries are input, a cam is generated by the wizard after clicking on "Finish".

Each cam can either be edited after "Completion" using the Motion Step Editor or it can be edited via the graph.

The wizard can be closed at any time by using the "Cancel" function. All entries for the new cam are cancelled.

Application-specific cams can still be edited by the same wizard. If an application parameter is changed and applied in the wizard window, the complete cam is recalculated and any Motion Step Editor or graph changes are overwritten.

To edit cams, see chapter 7 "Editing and Analyzing Cams" on page 43.

6.2 Creating Preview Objects

Creating preview

An empty new preview is created via the context menu item **Add ▸ Preview** of the "Cam Pool" node in the Project Explorer. Optionally, a "preview" is copied from the IndraWorks library from the "CamBuilder" section into the project.

The Wizard suggests a unique name ("preview#") for the preview which can be changed by the user.

Adding cams to the preview

One or several cams can be taken from the current project via Drag&Drop and can be added to a preview. Therefore, the desired cams are highlighted in the Project Explorer, dragged with the left mouse button via the preview and dropped.

Removing cams from the preview

A cam opened in preview can be removed from the preview via the **X** interface of its title bar.

To analyze cams in the preview, see chapter 7.9 "Cam Preview" on page 69.

7 Editing and Analyzing Cams

7.1 Graph Editor

7.1.1 General

The graph window is the core element of the CamBuilder. By opening a graph (by double clicking on a cam of a "Cam Pool" node), the graph is displayed in the IndraWorks main screen. Only one cam is always "focused" in the CamBuilder and can be edited via the graph or the Motion Step Editor. If another cam is opened, this cam is "focused." By focusing (clicking the cursor on a cam window), the cam is automatically registered as focused by the CamBuilder. All CamBuilder inputs and displays relate to the focused cam.

7.1.2 Design

A CamBuilder graph consists of a cam in a **coordinate system**.

In the coordinate system, up to 4 different slave axis profiles are displayed at the same time (**Position profile**, **Velocity profile**, **Acceleration profile** and **Jerk profile**).

The different profile diagrams can be shown and hidden using the Graph Manager (refer to chapter 7.1.5 "Graph Manager Settings" on page 45). The color in which the profiles are displayed can be set using the Options dialog (see chapter 11.1 "CamBuilder Options" on page 79).

The **X-axis unit** is the unit of the master axis.

The **Y-axis unit** corresponds to the respective focused profile diagram. A profile diagram can be focused by clicking on the respective profile.

The **axes of the coordinate system** always have the color of the focused diagram; the grid helps to make the graph clearer.

The **motion step limits** are vertical lines which mark the limits of the motion steps.

The **focused motion step** is highlighted by a different background color.

Another step can be focused by clicking in the area of this motion step.

The **limit points** of a **focused motion step** are highlighted by a black dot.

The section of the cam displayed in the coordinate system can be zoomed in and out or can be moved.

7.1.3 Editing a Cam Graphically

Moving the starting or end point

The starting and end points of the focused profile (position, velocity, acceleration or jerk) of the focused motion step are shown as black squares.

If a point can be moved, this is shown as a symbol with arrows when the cursor hovers over the point.


Data point can be moved horizontally and vertically


Data point can only be moved horizontally


Data point can only be moved vertically

The data points of the **Position diagram** can be moved vertically and horizontally, depending on the editability of the values defined by the selected motion law.

The cam changes in different ways depending on the editing mode (relative or absolute) which has been set. The behavior of the cam, when the limit values are changed, is described in more detail in chapter 7.2.9 "Absolute Editing of the Master Axis Range (X-Values)" on page 54 and chapter 7.2.10 "Relative Editing of the Master Axis Range (X-Values)" on page 55.

The data points of the **Velocity, Acceleration** and **Jerk diagrams** can only be offset vertically, in line with the editability of the values defined by the selected motion law.

Deleting a focused motion step

A motion step is deleted using the graph context menu in the same way as described under chapter 7.2.14 "Deleting a Focused Motion Step" on page 59.

7.1.4 Changing the View

Via the tool bar, a graph can be set to different modes. By default, a selection tool (arrow) is activated.

Fig.7-1: Icons: Tools for the CamBuilder graph window

Show All

The entire cam is drawn with the **Show all** function in the context menu.

Optionally, this function is triggered via the "tool bar", the "Graph Manager" and the <Pos1> key.

Selection

The context menu item **Zoom In** activates an arrow as mouse cursor. Points can be moved and profiles can be activated in this mode.

Optionally, this function is activated via the "tool bar", the "Graph Manager" and the <ESC> key.

Zoom In

The context menu item **Zoom In** activates a magnifying symbol as mouse cursor. By clicking in the coordinate system and marking a rectangle, the area to be zoomed can be specified.

Optionally, this mode is activated via the "tool bar" and the "Graph Manager".

The mouse wheel also controls the zoom level.

The keys <+>/<-> zoom the view in/out by 25%.

Pan View

The context menu item **Pan View** activates a hand symbol as mouse cursor. By clicking in the coordinate system and dragging, the section can be panned.

Optionally, this mode is activated via the "tool bar" and the "Graph Manager".

The graph can also be panned using the mouse key in the middle or using the <space> key.

Copying the graph to clipboard

The section of the cam currently being displayed can be copied to the clipboard via the context menu and used in other applications, such as word processing.

Show tool window

The main graph window context menu has a menu to activate all other CamBuilder Tools windows.

Furthermore, in the IndraWorks **View ▸ Other Windows** menu, there is an option to show and hide all other tool windows created by the CamBuilder.

Restore default layout

The **Restore Default Layout** menu hides all CamBuilder tools, with the exception of the Motion Step Editor and the Graph Manager and activates the Toolbar.

All windows can be arranged arbitrarily and shown or hidden by the user. Each layout change is permanently saved. The last used layout is preset during a CamBuilder restart.

7.1.5 Graph Manager Settings

The Graph Manager can be opened via the context menu of a graph or a preview: **Tool window** ▸ **Graph Manager**. It can also be shown and hidden via **View** ▸ **Other windows** ▸ **Graph Manager** on the main menu.

The Graph Manager is used to focus, show and hide the different profile diagrams.

- **Slave axis position** (shown/hidden and focused/not focused)
- **Velocity** (shown/hidden and focused/not focused)
- **Acceleration** (shown/hidden and focused/not focused)
- **Jerk** (shown/hidden and focused/not focused)

Different actions on the graph window can be started via the "Graph tool selection" buttons

- **Show All**
- **Selection**
- **Zoom In**
- **Pan**

The cursor coordinates in relation to the focused profile diagram of all units are shown in the cursor coordinates area.

Via the advanced options, the visibility of different data can be set in the Graph window.

- **Coordinate axes** (shown/hidden)
- **Coordinate net** (shown/hidden)
- **Motion step limits** (shown/hidden)
- **Border Coordinates** (shown/hidden)

The settings in the Graph Manager directly affect the graphic output.

Cross-project settings, such as colors and line thickness of the graph window, can be set via **Tools** ▸ **Options** ▸ **CamBuilder** ▸ **Graph** in the main menu (see chapter 11.1 "CamBuilder Options" on page 79).

7.2 Motion Step Editor

7.2.1 Overview

A cam can consists of any number of motion steps. The Motion Step Editor serves to configure the individual motion steps.

The "MotionProfile" and "FlexProfile" operation modes of the devices are limited to a maximum number of motion steps! If too many steps are defined, the cam can no longer be downloaded for the corresponding operation mode.

Editing and Analyzing Cams

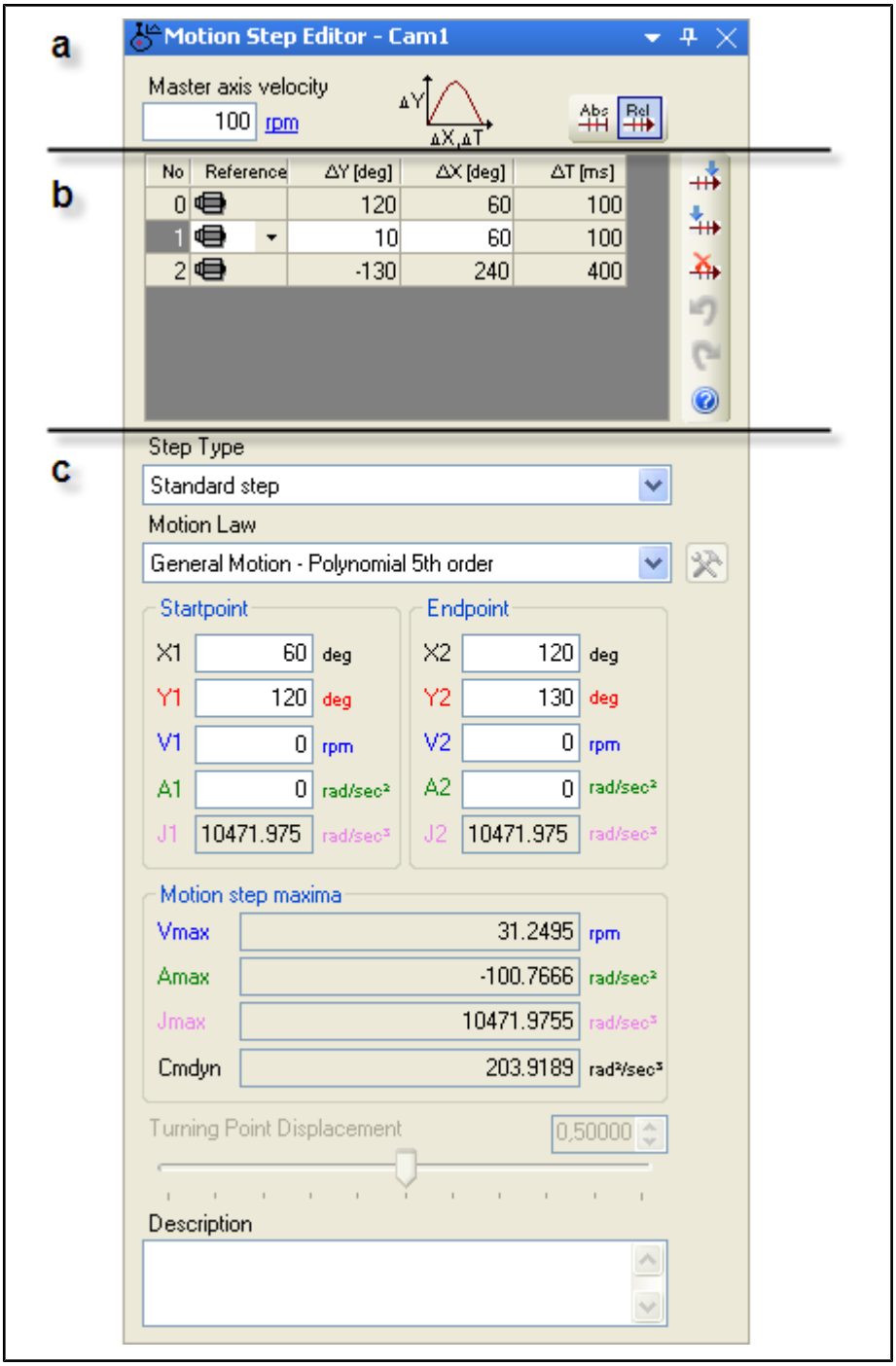

Fig.7-2: Dialog: Motion Step Editor

The Editor is divided into three areas.

a The **superordinate** part relates to all the cam motion steps.

b The **tabular** part provides, on the one hand, an overview and navigation between the individual motion steps and, on the other hand, allows to change single attributes.

c The **form-based** section provides the option of editing other attributes of the motion step focused in the tabular part.

A motion step is set as default.

Not all attributes can always be edited. Some attributes are automatically calculated depending on the choice of other attributes. All deactivated attributes

are always calculated after a property has been changed (after clicking on the <Enter> key or by changing the cursor to another attribute.) If a non-numerical value is entered into a numerical entry field, the value is automatically reset. Other incorrect entry fields are marked by an error symbol and a message appears.

The previous 50 changes to a cam can be undone providing the cam has not been saved.

Formula can also be entered in almost all fields to calculate values instead of constant values (see chapter 7.5 "Formula Editor" on page 63).

7.2.2 High-Level Attributes

The high-level attributes relate to the entire cam.

Master axis velocity

A cam is defined with reference to a master axis velocity. All limit values of the motion steps refer to the master axis velocity in the editor.

A "preview" can be created (see chapter 6.2 "Creating Preview Objects" on page 42) in order to analyze the cam behavior during different master axis velocities.

The master axis velocity is set depending on the preset master axis scaling.

This attribute can always be edited.

Minimum

- Master axis velocity > 0
- The master axis velocity has to be high enough that no ΔX of a time-related motion step is lower than the minimum step size (see chapter 11.1 "CamBuilder Options" on page 79)

Maximum

- The master axis velocity has an upper limit, in case there are time-related motion steps in front of a FlexStep with an absolute master axis end position and these would extend beyond the absolute master axis end position

Editing mode

The "relative" or "absolute" editing mode determines the behavior of the subsequent motion steps when ΔY, ΔX, ΔT, Y1 or X2 are edited (see also chapter 7.2.9 "Absolute Editing of the Master Axis Range (X-Values)" on page 54 and chapter 7.2.10 "Relative Editing of the Master Axis Range (X-Values)" on page 55).

7.2.3 Attributes of the Tabular Section

The attributes of the tabular section show the values of all cam motion steps. Only the values of the focused motion step can be edited.

Reference

The reference defines the reference values of the slave axis. There are two options:

- The motion of the slave axis should follow the master axis; this option is displayed by a motor symbol (default)
- The motion of the slave axis should follow the time; this option is displayed by a clock symbol

This attribute can always be edited.

ΔY

ΔY represents the relative distance of the slave axis within the focused motion step and is specified as a unit of the slave axis.

Changing ΔY immediately results in a calculation of Y_2.

This attribute cannot be edited if the step type is a "FlexStep with absolute slave axis position" or if the current motion law defines the distance.

ΔX ΔX represents the relative master axis range of the focused motion step in relation to the master axis and is given as a unit of the master axis.

Changing ΔX immediately results in the calculation of X_2 and ΔT.

This attribute cannot be edited if the reference of the slave axis is time (the value is then calculated by the master axis velocity and ΔT.)

This attribute cannot be edited if the step type is a "FlexStep with an absolute master axis position" or if the current motion law defines the master axis range.

Minimum

- ΔX >= minimum step size

Maximum

- ΔX has an upper limit if a FlexStep with an absolute master axis end position follows and ΔX would extend the focused step beyond the absolute master axis end position

ΔT ΔT represents the relative duration of the focused motion step measured in milliseconds.

Changing ΔT immediately results in the calculation ΔX and X_2 .

This attribute cannot be edited if the reference of the slave axis is the master axis position (the value is then calculated by the master axis velocity and ΔX.)

This attribute cannot be edited if the step type is a "FlexStep with an absolute master axis position" or if the current motion law defines the master axis range.

Minimum

- ΔT >= 1 millisecond

Maximum

- ΔT has an upper limit if a FlexStep with an absolute master axis end position follows and ΔT would extend the focused step beyond the absolute master axis end position

7.2.4 Attributes of the Form-Based Section

The attributes of the form-based section relate to the focused motion step.

Step type There are 2 categories of step types.

- **Default step**

  At the time of creation, a default step has defined boundary values (X_1, Y_1, V_1, A_1, J_1, X_2, Y_2, V_2, A_2, J_2). The motion path is calculated on the basis of these values The motion path of a default step is thus rigid and does not change during runtime.

  Any motion law can be used for this step type.

- **FlexStep**

  A FlexStep is an active step. I.e, it applies the starting point boundary values during runtime from the real values (X_1, Y_1, V_1, A_1, J_1) and the boundary values of the end point from the pre-defined values (ΔX or X_2, ΔY or Y_2, V_2, A_2, J_2). The motion path is calculated during runtime. Thus, no velocity jumps occur.

  There are four different FlexStep types

  – **FlexStep with relative distance and relative master axis range**

    ΔX and ΔY are user-defined.

    X_2 is calculated from X_1 + ΔX

Y_2 is calculated from $Y_1 + \Delta Y$

- **FlexStep with absolute slave axis end position and relative master axis range**

  Y_2 and ΔX are user-defined

  ΔY is calculated from $Y_2 - Y_1$

  X_2 is calculated from $X_1 + \Delta X$

- **FlexStep with relative distance and absolute master axis end position**

  This step type cannot be selected for time-dependent motion steps.

  X_2 and ΔX are user-defined

  ΔX is calculated from $X_2 – X_1$

  Y_2 is calculated from $Y_1 + \Delta Y$

- **FlexStep with absolute slave axis end position and absolute master axis end position**

  This step type cannot be selected for time-dependent motion steps.

  Y_2 and X_2 are user-defined

  ΔX is calculated from $X_2 – X_1$

  ΔY is calculated from $Y_2 - Y_1$

Only motion laws of the "General motion type" (polynomial 5th order or polynomial 7th order) can be used for a FlexStep.

If a FlexStep is selected, and the current motion law does not match, there is an automatic changeover to a polynomial 5th order.

The step type attribute can be edited if the subsequent step is a default step. If the last step is focused and the starting velocity and the starting acceleration are identical to the end velocity and the end acceleration of the cam (cyclical design of cam), the first step of the cam is used as subsequent step.

Motion law

The motion law defines the **motion of the slave axis**, to be performed between the starting and end points of the focused motion step.

The different motion laws are described in detail in chapter 13 "Motion Laws" on page 83.

The motion law is selected using the following dialog:

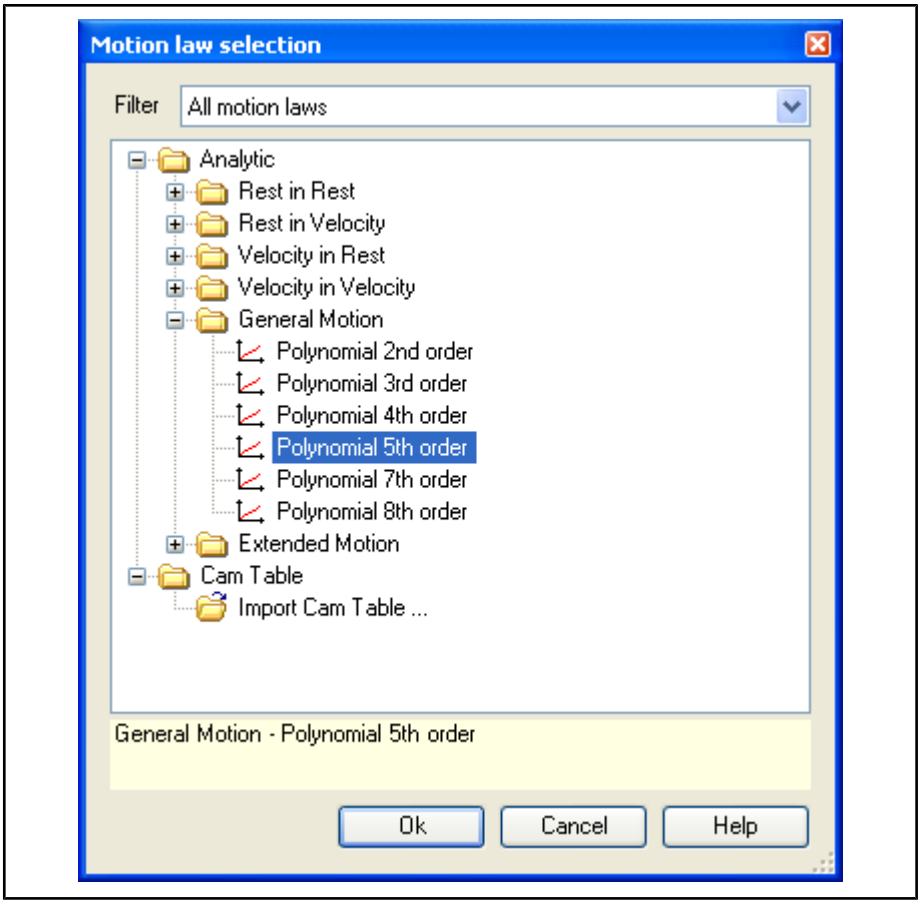

Fig.7-3: Dialog: Motion law selection

The dialog is sub-divided into two sections:

At the top, there is a filter option which is used to display only specific motion laws, e.g. only for MotionProfile.

The lower sections displays the motion laws.

Existing cam tables for the focused cam can be uploaded as a motion law under the category "Cam Table". Only the cam tables used as motion law are saved together with the cam. Imported cam tables which are not used are no longer accessible once the cam has been closed and reopened.

Not all motion laws can always be selected. If the preceding step ends in rest, the focused motion step has to be continued with rest or a general motion law. If the step type is not a default step, only two motion laws of the general motion type (polynomial 5th order and 7th order) are available.

Starting point X1 X_1 is the master axis position at the starting point of the focused motion step in the master axis unit.

Minimum

- X_1 >= 0

Maximum

- X_1 has an upper limit if a FlexStep with an absolute master axis end position follows and X_1 would extend the focused step beyond the absolute master axis end position

Y1 X_1 is the **slave axis position at the starting point** of the focused motion step in the slave axis unit.

This attribute cannot be edited if Y_2 of the preceding step cannot be edited.

☞ Y_1, the offset of the first motion step, serves only for the purpose of illustration in the CamBuilder and is deducted during transmission into the devices.

V1 V_1 is the **velocity at the starting point** of the focused motion step. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the selected motion law or if V_2 of the preceding step cannot be edited.

A1 A_1 is the **acceleration at the starting point** of the focused motion step. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the selected motion law or if A_2 of the preceding step cannot be edited.

J1 A_1 is the **jerk at the starting point** of the focused motion step. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the selected motion law or if J_2 of the preceding step cannot be edited.

End point X2 X_2 is the master axis position at the end point of the focused motion step in the master axis unit.

In case of a motion step in the cam including an absolute master axis end position as its step type, the X_2 change of the other motion steps is limited by this point.

The following applies if the focused motion step lies before the step with an absolute master axis end position:

($X_{1\ focus}$ + minimum step size <= $X_{2\ focus}$ <= $X_{2\ fix}$ + minimum step size)

This attribute X_2 cannot be edited if the reference of the slave axis is the time (the value is then calculated by the master axis velocity and ΔT.)

The attribute X_2 cannot be edited if the step type is a FlexStep with a relative master axis range or if the motion law is an extended motion law with acceleration-limited motion trapezoid profile, with an acceleration-limited motion sinusoid profile or with a jerk-limited motion.

Minimum

- X_2 >= X_1 + minimum step size

Maximum

- X_2 has an upper limit if a FlexStep with an absolute master axis end position follows and if X_2 would extend the focused step beyond the absolute master axis end position.

Y2 Y_2 is the **slave axis position at the end point** of the focused motion step in the slave axis unit.

This attribute cannot be edited if it is automatically calculated by the selected motion law or if Y_1 of the preceding step cannot be edited.

V2 V_2 is the **velocity at the end point** of the focused motion step. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the selected motion law or if Y_1 of the preceding step cannot be edited.

A2 A_2 is the **acceleration at the end point** of the focused motion step. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the selected motion law or if Y_1 of the preceding step cannot be edited.

J2 J_2 is the **jerk at the end point** of the focused motion step. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the selected motion law or if Y_1 of the preceding step cannot be edited.

Maximum values Vmax V_{max} is the **maximum velocity of the focused motion step**. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the motion law selected in the focused motion step.

Amax A_{max} is the **maximum acceleration of the focused motion step**. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the motion law selected in the focused motion step.

Jmax J_{max} is the **maximum jerk of the focused motion step**. The unit depends on the selected slave axis scaling.

This attribute cannot be edited if it is automatically calculated by the motion law selected in the focused motion step.

Cmdyn The dynamic torque characteristic value C_{mdyn} is calculated on the basis of the following equation:

C_{mdyn}= Maximum value (V * A)

The unit depends on the selected slave axis scaling.

This attribute can never be edited and is always calculated automatically.

Turning point displacement The turning point displacement specifies at which point the curving behavior changes for a symmetrical motion law.

The turning point displacement can either be changed with the slider or by entering a percentage value between 0 and 1.

This attribute can be edited for all symmetric "Rest-in-rest" motion laws.

Description The description includes brief user-defined information on the focused motion step.

This attribute can always be edited.

7.2.5 Calculating the Motion Step

The cam is recalculated after each entry (changing to another input field or confirming by means of the <Enter> key). If the calculation is not possible, the incorrect input fields are highlighted and detailed information is provided. The motion step is only applied if all entries are correct.

By means of the "Undo motion step" function, all changes that have been made since the motion step was successfully calculated the last time can be undone.

If an action is to be performed, which requires the focused motion step in a calculated format, e.g. another motion step is highlighted in the table as an active motion step or a new motion step is to be inserted, the active motion step has to be error-free.

In case of incorrect entries, the last focused motion step remains active until all the inputs are correct or have been undone.

7.2.6 Undo / Redo Editing

The **Edit** ▸ **Undo** menu allows the last 50 processes, which have been performed on the focused cam since the last save, to be undone.

Once editing has been undone, it can still be redone providing no further changes have been made to the cam.

7.2.7 Absolute Editing of the Slave Axis Position (Y-Values)

If the Y-value or ΔY in a motion step is changed in the **"Absolute edit mode"**, only this individual value is changed and the rest of the position profile remains at the original position.

If the change to a motion step results in the limit values of the subsequent step no longer matching its motion law, the distance of the subsequent step is regarded as a fixed value and the motion law is sporadically set to a Polynomial 5th order.

In the following example, the distance of the 3rd motion step cannot be edited that. That is why the distance of the 4th motion step is adjusted.

Example:

Absolute editing of ΔY

Fig.7-4: Absolute edit mode

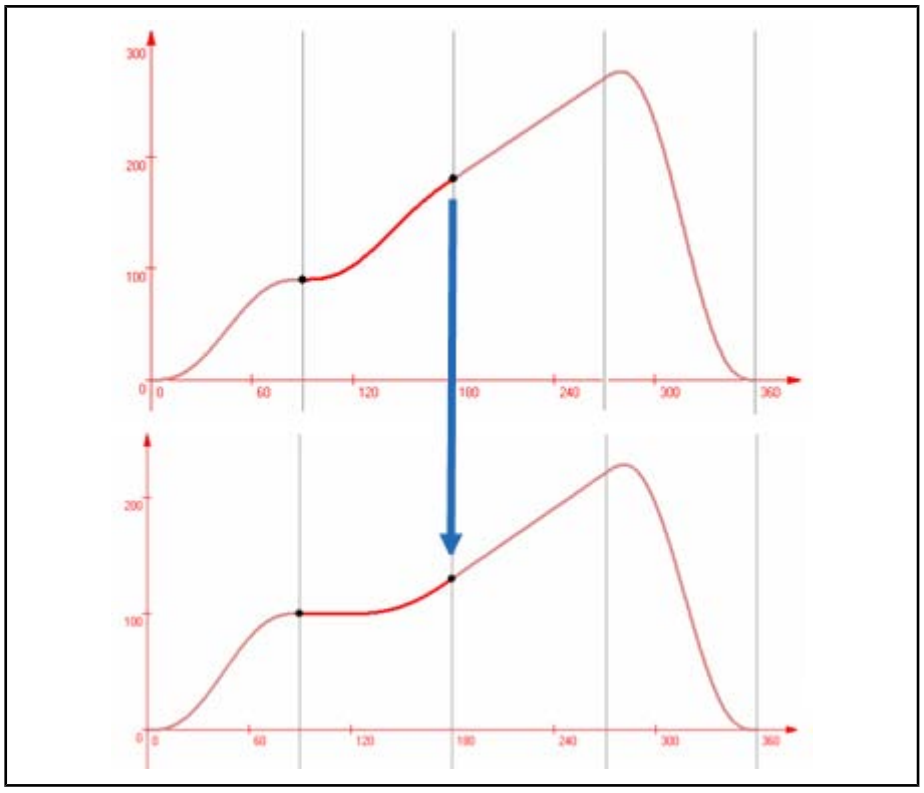

Fig.7-5: Changing ΔY in the second motion step by -50 degrees

7.2.8 Relative Editing of th Slave Axis Position (Y-Values)

If the Y-value or ΔY in a motion step is changed in the **"Relative edit mode"**, the remainder of the position profile is displaced in the Y-direction by the value of the change.

☞ If the change to a motion step results in the limit values of the subsequent step no longer matching its motion law, the distance of the subsequent step is regarded as a fixed value and the motion law is sporadically set to a Polynomial 5th order.

Example:

Relative editing of ΔY

Fig.7-6: Relative edit mode

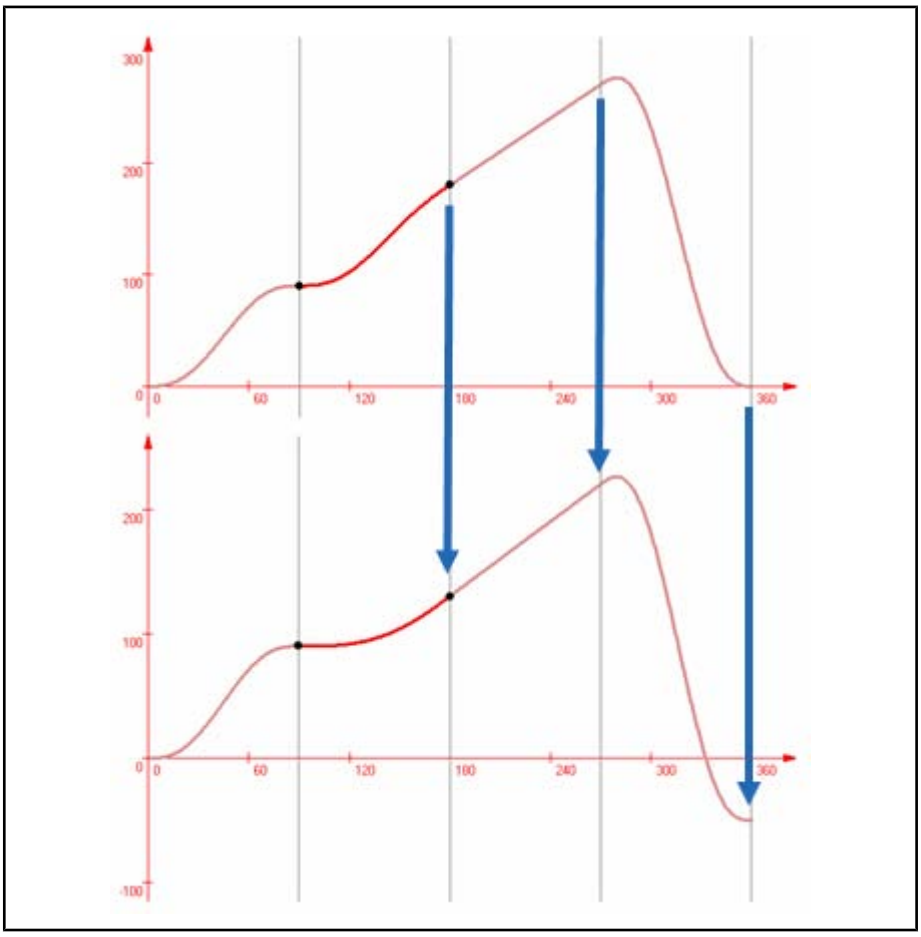

Fig.7-7: Changing ΔY in the second motion step by -50 degrees

7.2.9 Absolute Editing of the Master Axis Range (X-Values)

In case of changes to the master axis range (ΔX, ΔT, X1 or X2) of individual motion steps in the **"Absolute edit mode"**, the total length of the cam is retained. This means that the change to the length of an individual motion step changes the length of the preceding or subsequent motion step.

This mode is recommended if, for example, a cam with a fixed length of 360 degrees is to be edited and a motion step in the cam has to be shortened or extended, but the total length of the cam has to be retained.

If, in the "Absolute edit mode", a (new) motion step extends in the X-direction beyond one or more subsequent steps, these steps are overwritten.

Example:

Absolute editing of ΔX or Xn

Fig.7-8: Absolute edit mode

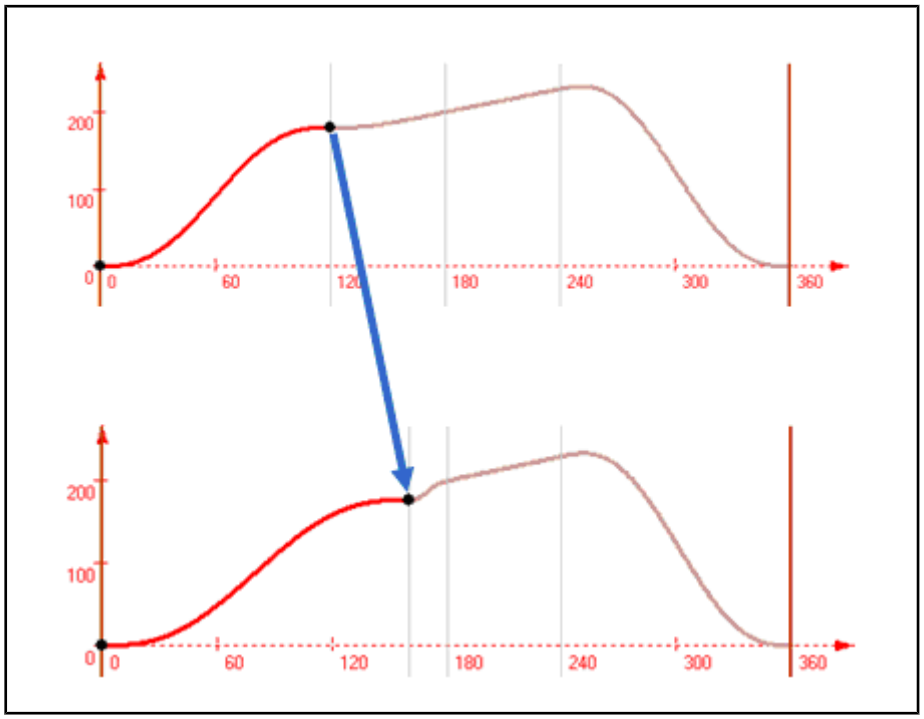

Fig.7-9: Changing ΔX in the second motion step by +40 degrees

7.2.10 Relative Editing of the Master Axis Range (X-Values)

The total length of the cam changes with a change to the master axis range (ΔX, ΔT, X1 or X2) of individual motion steps in the **"Relative edit mode"**. The ΔX or ΔT values of the preceding and subsequent motion steps are not changed.

This mode is recommended if, for example, a cam is being created for the first time or if time-dependent motion steps have to be identified. If, for example, the duration of a motion step is shortened, the duration of the total cam is also shortened.

Example:

Relative editing of ΔX or Xn

Fig.7-10: Relative edit mode

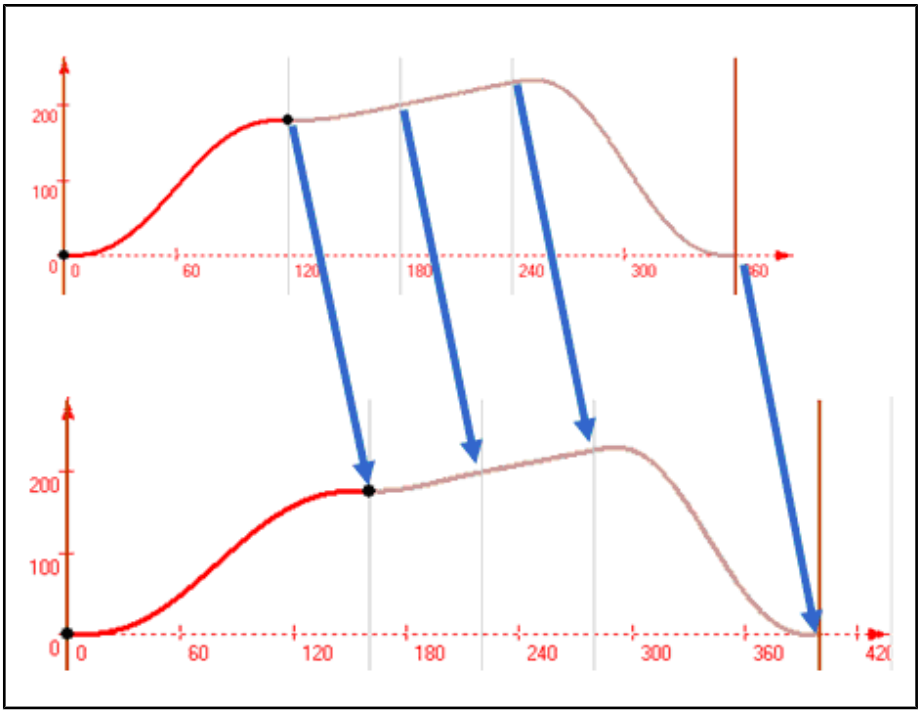

Fig.7-11: Changing ΔX in the second motion step by +40 degrees

7.2.11 Editing the Motion Step Cam Table

If the focused motion step includes a cam table as motion law, in addition to selecting the motion law, a modal window can be opened via an interface for editing the cam table.

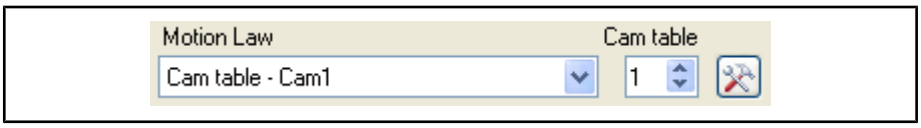

Fig.7-12: Icon: Edit cam table

All **% values** of the cam table can be **edited** in this window.

Points can be **deleted**. In this case, the X-values are recalculated and the existing Y-values retain their values. At least 3 points have to remain.

New points will be **added** after the focused line, the X-values are recalculated and the existing Y-values retain their value. At least 3 and max. 1024 points can be entered.

The X-values are always specified as a unit of the master axis and the Y-values are recorded as a percentage value. In the cam table, the first X-value always corresponds to the first master axis position of the motion step and the last X-value corresponds to the last master axis position of the motion step.

7.2.12 Adding a New Step after the Focused Step

This function adds a new motion step at the end of the focused motion step and gives ΔX the default step size from the options and the motion law "General motion - Polynomial 5th order".

The limit values of the starting point of the new motion step are applied from the focused end point.

If the **"Relative edit mode"** is active, the total length of the cam increases.

The limit values of the end point are, if available, applied by the starting point of the subsequent motion step. If there is no subsequent motion step, the limit values are assigned "0" values.

If the **"Absolute edit mode"** is active, the total length of the cam is retained.

The boundary values of the end point are assigned the values of the previous subsequent step at its point (X_1 + default step size) and the subsequent step is shortened by the default step size. If this is not possible, a clear and understandable message appears explaining why a step cannot be inserted at this position. If there is no subsequent motion step, the limit values are assigned "0" values.

The inserted motion step is activated following the insertion.

Example:

Fig.7-13: Absolute edit mode

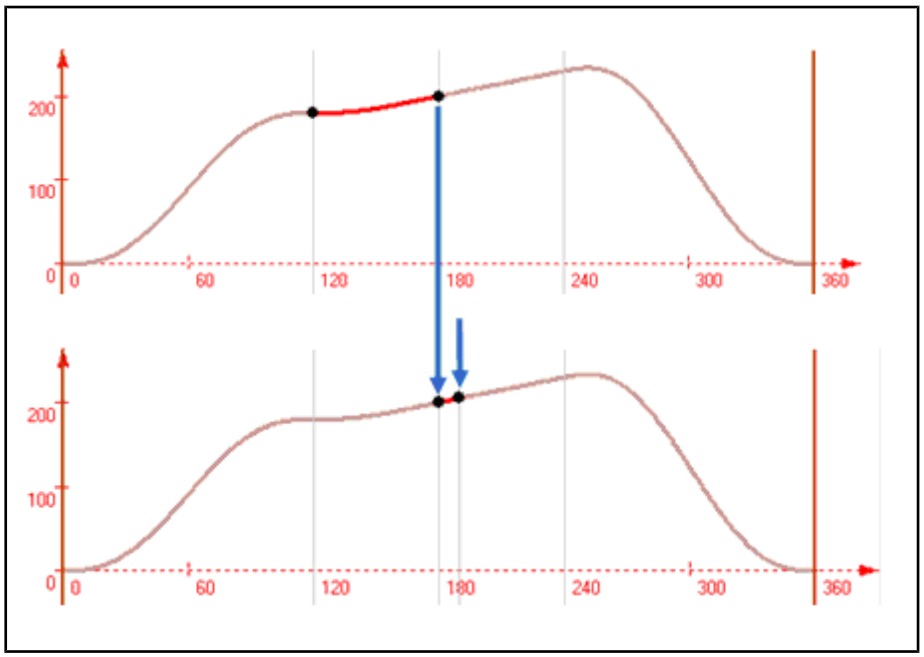

Fig.7-14: A new step is added at the end of the 2nd motion step.

Example:

Fig.7-15: Relative edit mode

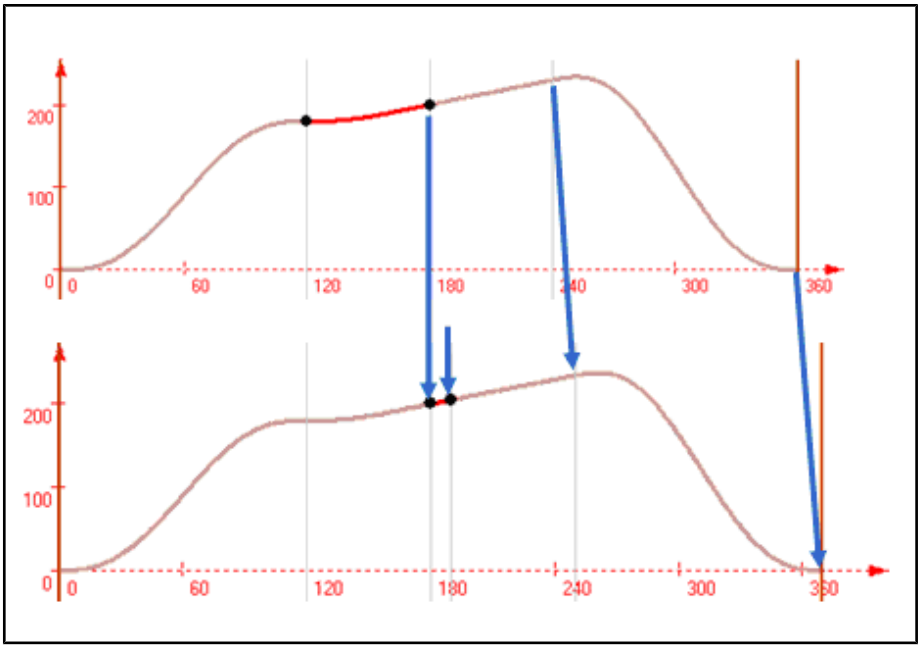

Fig.7-16: A new step is added at the end of the 2nd motion step.

7.2.13 Adding a New Step before the Focused Step

The "Add before" function adds a new motion step before the focused motion step and gives ΔX the default step size and gives the motion law the Polynomial 5th order.

The limit values of the starting point of the new motion step are applied from the end point of the preceding step.

If the **"Relative edit mode"** is active, the total length of the cam increases.

All subsequent steps are displaced backwards by ΔX.

If the **"Absolute edit mode"** is active, the total length of the cam is retained. The limit values of the end point are assigned the values of the previous step focused at its point (X_1 + default step size) and the previous step is shortened by the default step size. If this is not possible, a clear and understandable message appears explaining why a step cannot be inserted at this position.

The new inserted step is activated after the insertion.

Example:

Fig.7-17: Absolute edit mode

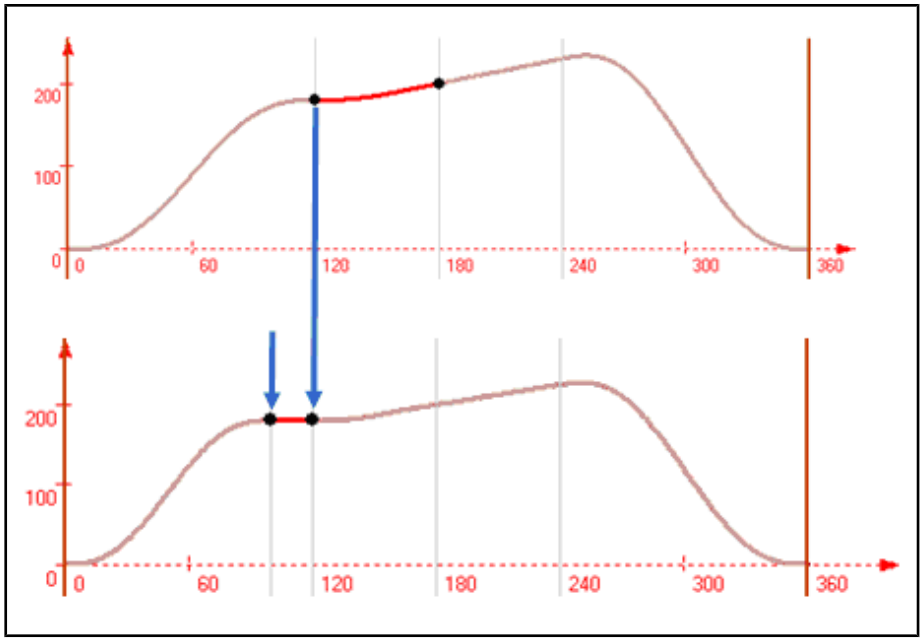

Fig.7-18: A new step is added at the end of the 2nd motion step

Example:

Fig.7-19: Relative edit mode

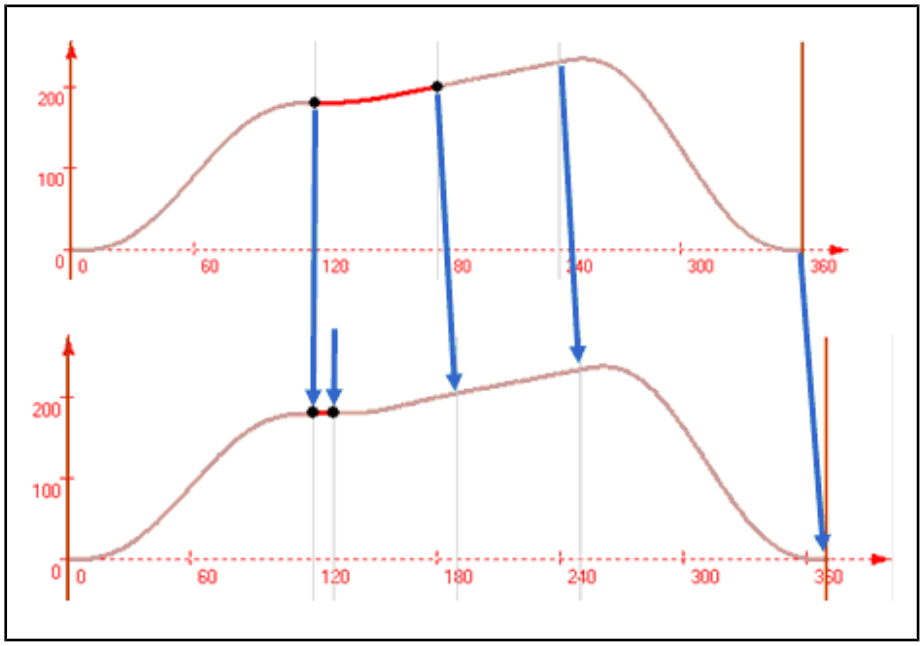

Fig.7-20: A new step is added at the start of the 2nd motion step

7.2.14 Deleting a Focused Motion Step

A cam requires at least one motion step. If a cam consists of more than one motion step, the focused motion step can be deleted.

If the **"Relative edit mode"** is active, the total length of the cam decreases.

If the **"Absolute edit mode"** is active, the total length of the cam is retained.

The total length is retained by the subsequent motion step (if not available, by the preceding step), extended by ΔX of the step to be deleted. If this is not possible, the motion step cannot be deleted.

Example:

Fig.7-21: Absolute edit mode

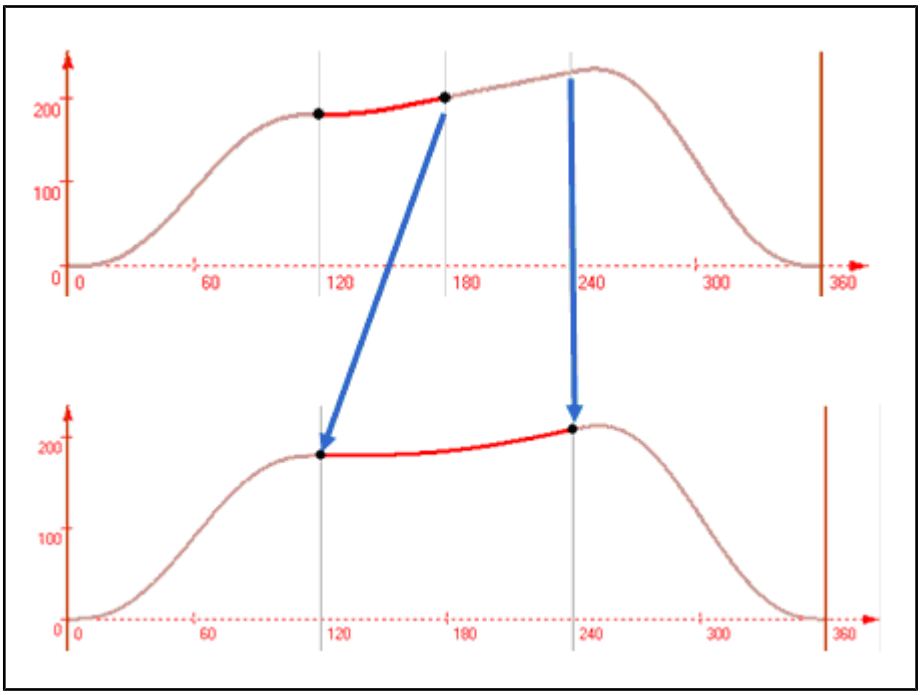

Fig.7-22: Deleting motion step 2

Example:

Fig.7-23: Relative edit mode

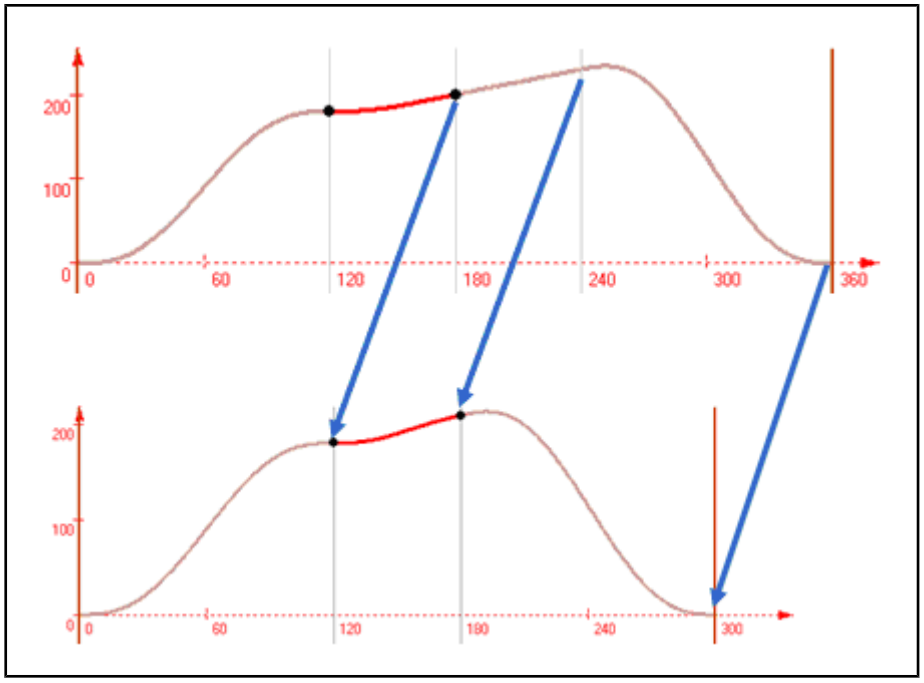

Fig.7-24: Deleting motion step 2

7.3 Event Editor

7.3.1 Overview

The event editor is used to define events.

The **FlexProfile** supports the event control. **Events** can be assigned to motion steps. Events consist of a **trigger** and an **action**. Bits of the AxisData structure can be set during the execution time of the FlexProfile via the action of an event. The PLC offers solutions to react to these events.

An event can be added to a focused motion step via the tool bar in the CamBuilder.

Fig.7-25: Icon: Add event

7.3.2

Events can be added to each motion step of a cam. An event consists of a trigger and an action.

No. The number is assigned automatically and serves to identify the event.

Motion step Each event is assigned to a certain motion step (Selection option: All motion steps of the focused cam).

Trigger The trigger is the criteria when the event is triggered:

- Absolute master axis position reached

  The event is triggered when the master axis position entered in the assigned motion step is reached.

  Similarly to a programmable limit switch, the current position of an axis can be monitored. If it crosses a specified position in the current motion step, the event occurs.

- Relative master axis path traveled

  The event is triggered when the master axis position entered in the assigned motion step is reached.
- Absolute slave axis position reached

  The event is triggered when the master axis position entered in the assigned motion step is reached.
- Relative slave axis path traveled

  The event is triggered when the slave axis position entered in the assigned motion step is reached.
- PLC signal

  The event is triggered if the PLC signal is set during execution of the assigned motion step.
- Time lapsed

  The event is triggered when the time specified as value has lapsed during the execution of the assigned motion step.

Value The value depends on the trigger (position, travel distance or time).

Unit The unit is displayed depending on the selected trigger (position and travel distance, specified in the unit of the master or slave axis, time in s).

Bit If the trigger criteria is fulfilled during the execution of the assigned motion step, the selected bit of the AxisData structure is set. (Selection options: Bit0 to Bit15).

Action The action defines when the bit should be set:

- At the end of the profile

  The selected bit is set after executing the last motion step at the end of the profile.
- At the end of the motion step

  The selected bit is set after executing the selected motion step.
- Set immediately

  The selected bit is set immediately.
- Set immediately and connect next motion step immediately

  The selected bit is set immediately and the next motion step is executed. If the next motion is a FlexStep, the limit values can be applied dynamically during runtime and the transition can be started without jerks.

If one or more events are assigned to a motion step, they are displayed in the Graph editor in the lower right area as active lighting symbol. The event editor opens by clicking on the symbol.

If a cam with events is displayed in a preview, it is displayed at which time which bit is activated.

7.3.3 Functions

Creating a new event A standard event is inserted at the end of the event list. (Motion Step: focused step; trigger: PLC signal; bit: Bit0; action: set immediately).

Editing Events can be edited in this list.

Remove event The event focused in the list is removed.

Undo Undoes the most recent change.

Restore If a change has been undone, this function restores it again.

Help Opens the Event Editor chapter of the CamBuilder online help.

By downloading a cam, the events are written in the corresponding parameter.

If a cam contains events, they are generated using the PLC function block for the FlexProfile generation.

If a motion step number changes, as e.g. an additional step is inserted, events remain assigned to the originally assigned motion step. If a motion step is removed, the events belonging to the motion step are also removed.

7.4 Variable Editor

7.4.1 Overview

By means of the variable editor, cam definition variables can be defined.

Variables can be used in formula (see chapter 7.5 "Formula Editor" on page 63) of the cam input fields. When generating a PLC function block to parameterize a FlexProfile, these variables are displayed as inputs at the block.

7.4.2 Attributes

Name The variable name has to be IEC-compliant and unique.

If a variable value is changed, all references to this variable are renamed.

Variables can also be defined as variable fields. For example: "Range[1]" and "Range[2]". When generating a PLC function block, only the variable field is displayed at the input of the block.

Value The variable value can be defined user-specifically and is displayed as default value when generating a PLC function block.

References This field cannot be edited. All abbreviations of form fields referencing the variable are listed.

Description Variable descriptions are displayed as comment in the PLC function block when declaring the variable.

7.4.3 Functions

Creating a new variable A new variable is added to the variable list.

Editing Variables can be edited in this list.

Remove variable The variable focused in the list is removed unless it is not used anymore in the cam definition.

Undo Undoes the most recent change.

Restore If a change has been undone, this function restores it again.

Help Opens the Variable Editor chapter of the CamBuilder online help.

If values are calculated using formula or variables in a cam definitions, the relative editing mode is used for the recalculation.

7.5 Formula Editor

7.5.1 Overview

The formula editor is used to enter formula to calculate cam properties.

The use of formula instead of constant input values when defining cams makes it possible to define certain values of a cam definition variably. If a PLC function

block is generated using the CamBuilder definition using a "variable" cam definition, different cam variants can be parameterized as FlexProfile via variable inputs using this block.

The formula editor opens automatically if an "=" character was entered in an input field.

The following input fields support the input of a formula if they are not automatically calculated:

Motion step editor

- Distance of the slave axis (ΔY)
- Master axis range (ΔX)
- Duration of the motion step (ΔT)
- Velocity in the starting point of the motion step (V1)
- Velocity in the end point of the motion step (V2)
- Velocity limit value of motion step (Vmax)
- Acceleration in the starting point of the motion step (A1)
- Acceleration in the end point of the motion step (A2)
- Acceleration in the motion step (Amax)
- Jerk in the starting point of the motion step (J1)
- Jerk in the end point of the motion step (J2)
- Jerk limit value of motion step (Jmax)

Event Editor

- Motion step number
- Trigger value

☞ If the motion step number of an event is calculated with a formula, the result is rounded as integer.

7.5.2 Functions

Editing formula Formula can be edited via the formula text field.

Apply formula and close (OK) The formula is checked and if valid, the calculated formula result is applied to the cam definition. The formula editor is closed.

Applying the formula (refresh) The functionality is as described. Only the formula editor remains open.

Removing formula The formula of the current CamBuilder input field is removed and the last value is used as constant value of the input field instead.

Help Opens the Formula Editor chapter of the CamBuilder online help.

☞ Changes are not applied when clicking on <Esc> or closing the editor.

By clicking on <Enter> or exiting the editor by selecting a different input field, the changes are applied.

If values are calculated using formula in a cam definition, the relative editing mode is used for recalculation.

7.5.3 Keyword Formula

Mathematical Operators

+	Addition
-	Subtraction
*	Multiplication
/	Division
()	Brackets

Fig.7-26: Formula editor, mathematical operators

Constants

E	Euler number e
PI	Pi

Fig.7-27: Formula editor, constants

Mathematical Functions

ABS(n)	Returns the absolute value of the transferred number.
ACOS(n)	Returns an angle whose cosine is the specified number (radian).
ASIN(n)	Returns an angle whose sine is the specified number (radian).
ATAN(n)	Returns an angle whose tangent is the specified number (radian).
CEILING(n)	Returns the smallest integer number that is greater or equal to the specified number.
	The return value for n = 7.03 is 8.
	The return value for n = 7.64 is 8.
	The return value for n = 0.12 is 1.
	The return value for n = -0.12 is 0.
	The return value for n = -7.1 is -7.
	The return value for n = -7.6 is -7.
COS(n)	Returns the cosine of the specified angle (radian).
DEG_TO_RAD(n)	Converts an angle from degrees to radian.
EXP(n)	Returns the specified power of e.
EXPT(n1,n2)	Exponentiates a specified number with the specified exponent.
FLOOR(n)	Returns the largest integer number that is smaller or equal to the specified number.
	The return value for n = 7.03 is 7.
	The return value for n = 7.64 is 7.
	The return value for n = 0.12 is 0.
	The return value for n = -0.12 is -1.
	The return value for n = -7.1 is -8.
	The return value for n = -7.6 is -8.
LN(n)	Returns the natural logarithm of a specified number.
LOG(n)	Returns the logarithm for basis 10 of the specified number.
MAX(n1,n2)	Returns the greater number of two specified numbers.
MIN(n1,n2)	Returns the smaller number of two specified numbers.

RAD_TO_DEG(n)	Converts an angle from radian to degrees.
SIGN(n)	Returns a value that specifies the sign of a number.
	The return value is -1, if n is smaller than 0.
	The return value is 0, if n is equal to 0.
	The return value is 1, if n is greater than 0.
SIN(n)	Returns the sine of the specified angle (radian).
SQRT(n)	Returns the square root of a specified number.
TAN(n)	Returns the tangent of the specified angle (radian).
TRUNC(n)	Calculates the integer part of a number.

Fig.7-28: Formula editor, mathematical functions

Cam Attributes

MASTERVELOCITY	Master axis velocity
DYn	Slave axis range of motion step n
DXn	Master axis range of motion step n
DTn	Duration of motion step n
Vn	Initial velocity of the motion step n or end velocity of the motion step n+1
An	Initial acceleration of the motion step n or end acceleration of the motion step n+1
Jn	Initial jerk of the motion step n or end jerk of the motion step n+1
VMAXn	Velocity limit value of motion step n
AMAXn	Acceleration limit value of motion step n
JMAXn	Jerk limit value of motion step n
EVENT_STEPn	Assigned motion step of the event n
EVENT_VALUEn	Trigger value of event n

Fig.7-29: Formula editor, references to fields

☞ References to cam properties that are defined by motion laws are not supported! Only references to editable cam properties can be used in formula.

User Defined Variables

Variable1	Sample variable (see chapter 7.4 "Variable Editor" on page 63)
Variable2	Sample variable
ArrayVariable[1]	Sample variable array
ArrayVariable[2]	Sample variable array

Fig.7-30: Formula editor, references to variables

7.6 Application-Specific Wizard

7.6.1 General

Depending on its type of application, an application-specific cam has a special wizard with which the entire cam can be edited.

Single motion steps can be reedited later at any time using the Motion Step Editor (see chapter 7.2 "Motion Step Editor" on page 45). However, as soon as a change has been made using the wizard, all Motion Step Editor changes are overwritten.

7.6.2 CrossCutter Wizard

The CamBuilder provides a wizard for common requirements, such as the CrossCutter functionality, which supports the user in creating the cam. All requirements and unique features of the application are dialog-controlled.

The specific inputs for the CrossCutter functionality are:

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

7.6.3 Feeder Wizard

The CamBuilder provides a wizard for common requirements, such as the feed function, which supports the user in creating the cam. All requirements and special features of the application are set using dialog-controlled inputs.

The specific inputs for the feed function are as follows:

- Format length
- Roller diameter
- Maximum delay
- Acceleration path
- Roller position
- Distance between two products
- Velocity of the master axis

To attain the feed configured in the CamBuilder, the distance factor during the download as points table has to be set equal to the distance factor for executing the application.

7.6.4 Print Length Correction Wizard

The CamBuilder provides a Wizard for common requirements, such as the print length correction that supports the user in creating the cam. All requirements and unique features of the application are dialog-controlled.

The specific inputs for the print length correction are as follows:

- Diameter of the pressurized cylinder
- Length of the printing plate
- Correction value
- Velocity of the master axis

Another parameter is calculated by the wizard:

- Gradient in the synchronous range

7.6.5 Flying Shear Wizard

The CamBuilder provides a Wizard for common requirements, such as the print length correction that supports the user in creating the cam. All the requirements and unique features of the application are dialog-controlled.

Specific entries for the Flying Shear:

- Synchronous range - range within which the step is executed
- The motion law in the transition area - the modified sine curve, polynomial 3rd order, polynomial 5th order and polynomial 7th order motion laws are available.

Another parameter is calculated by the wizard:

- Gradient in the synchronous range

7.7 Cam Table

The cam table is an overview of the complete behavior of the cam.

The user can specify the **number of data points** for the entire position profile. It is also possible to define with which **distance** the percentage values are to be calculated.

The distribution of the points across the master axis range can be specified using the following option:

The last data point in the table belongs to X: 100% (Yes/No) (table format).

Assuming the number of data points is to be 1024:

Yes:	100% is divided between 1024 points		
	0,0000%	=	Point 1
	99,9023%	=	Point 1023
	100,0000%	=	Point 1024
No:	100% is divided between 1024 + 1 points		
	0,0000%	=	Point 1
	99,9024%	=	Point 1024
	100,0000%	=	Point 1

Fig.7-31: The units in the columns depend on the master and slave axis units

The table is write-protected and has the following columns:

Number, Y [%], Master axis position, Slave axis position, Velocity, Acceleration, Jerk. The values refer to the master axis velocity defined in the motion step editor.

The values of the table can be copied to the clipboard and can be applied via "Insert".

7.8 Extreme Values

The minimum and maximum values referred to the master axis velocity defined in the motion step editor for the entire cam are displayed in the extreme values list.

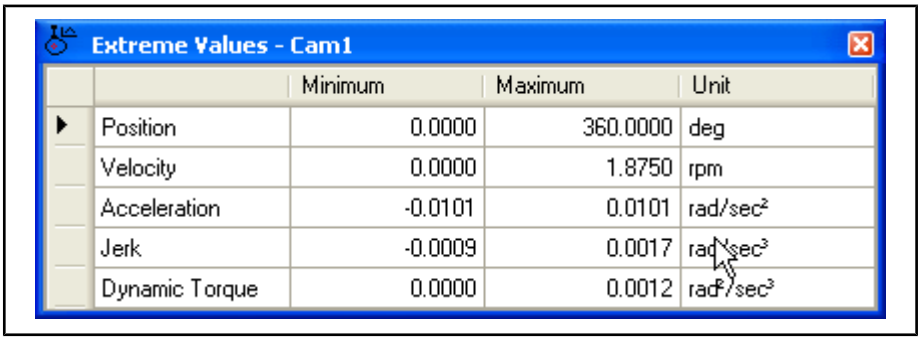

Fig.7-32: Example: Extreme Values List

The dynamic torque characteristic value is calculated on the basis of the following equation:

C_{mdyn} = maximum value (V_{max} * A_{max})

where V_{max} = maximum velocity and A_{max} = maximum acceleration.

This window can be displayed or hidden via the **View** ▸ **More Windows** ▸ **Extreme Values** menu.

7.9 Cam Preview

Cams are graphically edited in the "GraphEditor" (see chapter 7.1 "Graph Editor" on page 43).

In order to compare several cams with regard to a master axis, the cams can be opened in a preview and can be analyzed.

A new preview is added to the project via a "Cam Pool" or the IndraWorks library (see chapter 6.2 "Creating Preview Objects" on page 42).

Depending on the selected operation mode in the application, differences to the preview can occur. Cam tables and MotionProfiles do not support any time-dependent steps or events.

Slave axis and master axis offset have to be explicitly specified when enabling the respective synchronous operation mode in the user program via function blocks. (e.g. MB_PhasingSlave, MB_Phasing for all operation modes or via the corresponding inputs at the ML_FlexProfile block)

Preview window design

A preview window consists of time-dependent position representation of a master axis and the optional time-dependent profile representations (position / velocity / acceleration / jerk) of the slave axes.

The individual positions in the preview window can be moved upwards or downwards via a system menu in the upper right corner of the respective preview. The previews can be distributed in the preview window and individual previews can also be closed.

The height of the individual previews can be changed using the mouse. The line between two previews is "held" using the mouse and the size is adjusted by moving the mouse.

If the <Ctrl> key is pressed when changing the size, the entire size of the preview can be adjusted.

Measuring function

The measuring line can be moved in the selection mode (arrow) using the mouse. The measuring results are shown in the title bar of each preview. In order to measure another profile (position / velocity / acceleration / jerk), it can be selected using the mouse. The measuring results refer to this profile.

Changing the view

The view can be changed using the same tools as the Graph Editor (see chapter 7.1.4 "Changing the View" on page 44).

The individual views of the previews are synchronized on the X axis. The same time section is always displayed.

Master axis properties

The following attribute of the master axis representation can be changed via the link "Settings...":

- **Master axis velocity**

  The unit of the master axis velocity depends on the scaling

- **Preview of time**

  The unit of the preview time is milliseconds
- **Modulo**

  Defines the overflow for the graphic representation
- **Scaling**

  (rotary or translatory and unit)

Slave axes properties

The following attributes of the slave axis representation can be changed via the link "Settings..." of the slave axis:

- **Modulo**

  Defines the overflow for the graphic representation
- **Master axis offset**

  Defines the offset in the master axis range
- **Slave axis offset**

  Defines the offset in the slave axis range
- **Execution mode**

  Cyclical

  Cyclical with defined pause

  One-time

The cyclic representation with a defined pause is used to preview cams started with the processing type "One-time execution" by cyclic events (e.g. of other cams) .

The master axis offset can either be entered in the master axis unit or in ms.

8 Managing Cams and Preview Objects in the IndraWorks Project

General

Cams and preview objects are managed by the CamBuilder within the IndraWorks project and are also archived and restored using this project. They are managed in the Project Explorer below the **"Cam Pool"** node.

A cam can also be exported if it is to be used project-externally.

It is also possible to import existing cams into a project (refer to chapter 10 "Importing and Exporting Cams" on page 77).

Cams can also be used within the project if one or more devices are online or are in offline parameterization mode, can be downloaded to these or can be uploaded from these to the project (refer to chapter 9 "Interacting with Bosch Rexroth Devices" on page 73).

"Cam Pool" Create folder

A "Cam Pool" folder can be copied from the IndraWorks library from the "CamBuilder" section into the project using drag&drop.

Via the context menu of a "Cam Pool" node in the project explorer, a new folder can be created below this one. Cams and preview objects can also be created and edited within this folder. This folder can be renamed or deleted via the context menu.

A "Cam Pool" folder can be moved within the project. Several "Cam Pool" folders can exist in one project.

Opening a cam / preview

A cam and a preview is opened by double-clicking on the relevant symbol in the "Cam Pool" node in the Project Explorer. The relevant graphical view opens.

Saving a cam / preview

Once a cam was edited within the project and is focused, changes can be permanently applied in the project via the **File ▸ Save (Ctrl+S)** menu item.

The **File ▸ Save All** menu item also saves changes to cams and preview objects currently not focused.

If a preview is saved, all the cams in the preview are saved as well!

When closing a project, all open document are automatically saved (without confirmation)!

Copying a cam / preview

A cam or a preview can be copied in the Project Explorer by highlighting and selecting the menu item **File ▸ Edit ▸ Copy**.

Inserting a cam

A cam or a preview can also be reinserted into the project once it has been copied. Therefore, a "Cam Pool" node is highlighted and the copy of the cam is inserted via the **File ▸ Edit ▸ Insert** menu item.

Renaming

A Cam Pool, a cam or a preview can also be renamed by slowly clicking twice on its name in the Project Explorer. Optionally, the object is highlighted in the Project Explorer and renamed using the context menu. Another option is to access the "Properties" dialog via the cam context menu, when the cam is open and change the name.

Deleting

A Cam Pool, a cam or a preview can be deleted via the context menu by highlighting it in the Project Explorer. Optionally, the object is highlighted and deleted using the <Del> key.

9 Interacting with Bosch Rexroth Devices

9.1 Downloading Cams to Devices

9.1.1 General

The CamBuilder supports communication to different devices in the IndraWorks project.

The devices either have to be online or in an offline parameterization mode and require an interface to the CamBuilder in order to use the following functions.

The "Download cam" dialog is started via the cam context menu in the Project Explorer. The devices in the IndraWorks project that are either online or in an offline parameterizable mode and support the downloading of cams, provide an overview of the parameters for cams.

The parameters have different symbols for the different operation modes:

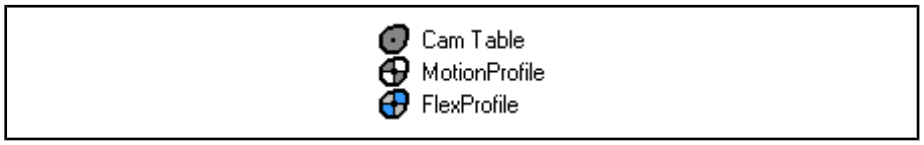

Fig.9-1: Device symbols for different operation modes

9.1.2 Downloading Cams to Cam Table Parameters

If the focused cam is to be downloaded to cam table parameters, a base point table, with percentage values with at least 3 and at most the number of points supported by the device, is created for the complete travel of the position profile.

The following information is required for downloading to a cam table:

- **Number of base points**
- **Distance** factor for calculating the percentage values
- **Removing linear sections of the cam** only applies to drives above a specific version
- **The last data point in the table corresponds to X = 100%** - (Yes / No) (table format)

  This setting only applies to drives; with control, the last data point always corresponds to X = 100%

  There are only two different formats on the drive for specifying the calculation of X-values.

Assuming the number of data points is to be 1024:

Historically:	100% is divided between 1024 + 1 points		
	0,0000%	=	Point 1
	99,9024%	=	Point 1024
	100,0000%	=	Point 1
Current:	100% is divided between 1024 points		
	0,0000%	=	Point 1
	99,9023%	=	Point 1023
	100,0000%	=	Point 1024

☞ If the cam contains motion steps with time reference, the slave axis motion is calculated using the entered master axis velocity. The dynamic function is lost here. The dynamics of the FlexSteps is also lost.

9.1.3 Downloading Cams to MotionProfile Parameters

If a cam is to be downloaded to MotionProfile parameters, it can only include motion laws supported by the MotionProfile operation mode. The master axis range has to be rotatorily fixed at 360 degrees.

No further settings can be made.

☞ If the cam contains motion steps with time reference, the slave axis motion is calculated using the entered master axis velocity. The dynamic limit values are lost here. The dynamics of the FlexSteps is also lost.

9.1.4 Downloading Cams to FlexProfile Parameters

If a cam is to be downloaded to FlexProfile parameters, it can only include motion laws supported by the FlexProfile operation mode.

No further settings can be made.

9.1.5 Downloading Cams to a CF Memory Card

If an IndraMotion MLC/IndraLogic XLC is online in the project, cams can also be stored on its Compact Flash card.

Unlike with parameters for cam tables, MotionProfiles and FlexProfiles, there is no predefined format for cams on the CF card. The user has to specify the desired format. The cam is saved as file with the name specified in the CamBuilder. If the file already exists, a query is displayed asking whether it should be overwritten.

9.2 Uploading Cams from Devices

The CamBuilder supports communication to different devices in the IndraWorks project.

The devices either have to be online or in an offline parameterization mode and require an interface to the CamBuilder in order to use the following functions.

The "Upload Cam" dialog is started via the context menu of a "Cam Pool" node in the Project Explorer via "Upload Cam from Device". The devices in the IndraWorks project that are either online or in an offline parameterizable mode and support uploading of cams, provide an overview of the cams ready for uploading.

The parameters have different symbols for the different operation modes:

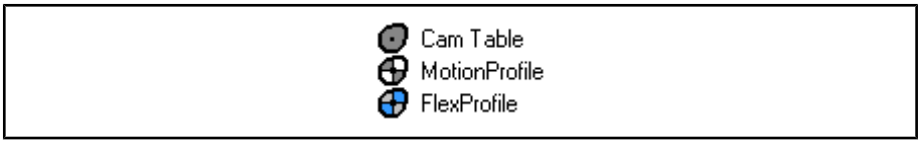

Fig.9-2: Device symbols for different operation modes

The process for uploading cams is identical for all cam types.

A specific name has to be entered when saving the cam in the IndraWorks project. The cam is converted to the neutral CamBuilder format. The editing of

the cam is thus always identical in the CamBuilder, the format of the cam is only of significance when downloading it onto a device.

9.3 Generating a PLC Function Block

The CamBuilder provides the option to generate a PLC code (in structured text) for an FB. This code writes the cam defined in the CamBuilder into the FlexProfile parameters of an IndraMotion MLC/IndraLogic XLC axis.

Generating a PLC code for a cam is started via its context menu in the Project Explorer via "Generate PLC function block". Optionally, the code generation is started via the "PLC" button when the cam is open.

Fig.9-3: Generating PLC function blocks

If a folder named "General module folder" (IndraLogic) is available in the current project, a new function block is automatically created for e.g. the selected "Cam1" under the name "ChangeFlexSet_Cam1". The function block name consists of a prefix specified in the options dialog (see chapter 11.1 "CamBuilder Options" on page 79) and the cam name (non-IEC conform characters are replaced by the character "_").

If the folder "General module folder" does not exist in the current project, the generated PLC code is only displayed in a display window. From this window, the code text can be copied into the clipboard and can be used in other applications.

In order to generate a variable function block, formula with references to variables can be recorded in the CamBuilder instead of constant values for cam properties (see chapter 7.5 "Formula Editor" on page 63).

Brief description of the function block

The generated "ChangeFlexSet_Cam1" function block is used to load the motion steps and events of the cam defined in the CamBuilder to a FlexProfile of an IndraMotion MLC/IndraLogic XLC axis.

Interface Description

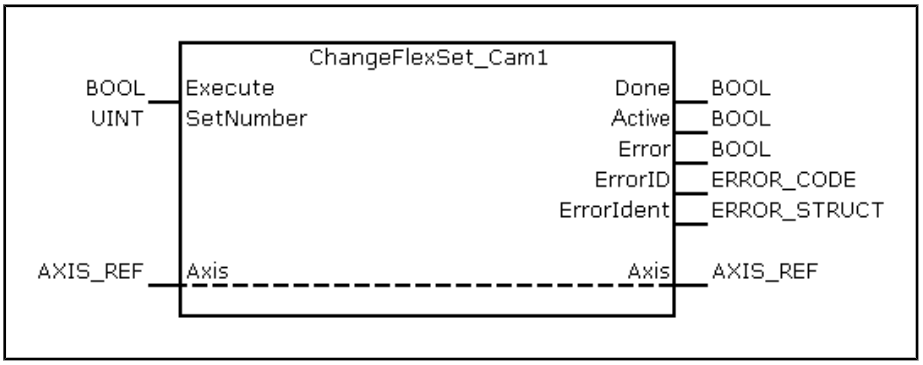

Fig.9-4: ChangeFlexSet_Cam1 function block

	Name	Type	Comment
VAR_IN_OUT	Axis	AXIS_REF	It contains information on the axis for which the FlexProfile set is to be exchanged.
VAR_INPUT	Execute	BOOL	Starts the action at a rising edge.
	SetNumber	UINT	Selecting FlexProfile (0 ... 3).
VAR_OUTPUT	Done	BOOL	Data were accepted.

Interacting with Bosch Rexroth Devices

	Name	Type	Comment
	Active	BOOL	Processing of data runs after preprocessing is completed.
	Error	BOOL	It indicates that an error has occurred in the FB instance.
	ErrorID	ERROR_CODE	Brief indication of the error cause.
	ErrorIdent	ERROR_STRUCT	Detailed information on the error.

Fig.9-5: Interface of the FB ChangeFlexSet_Cam1

☞ If formula with variables are used in cam definitions (see chapter 7.4 "Variable Editor" on page 63), the block contains the definitions as additional inputs of type "LREAL".

Signal-time diagram

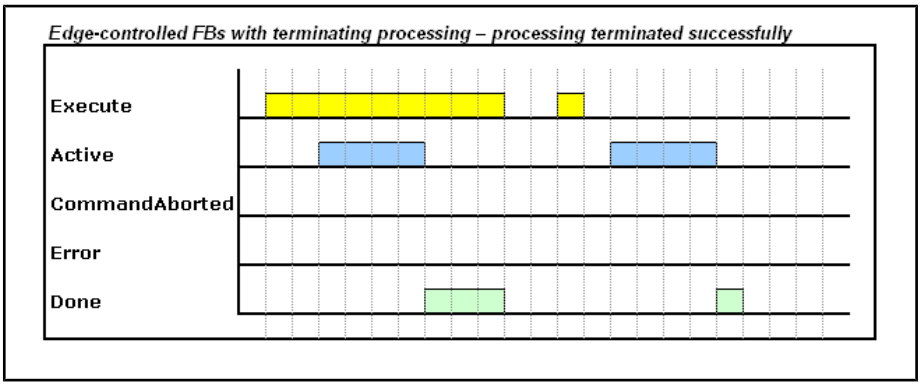

Fig.9-6: Signal-time diagram: MB_ChangeFlexProfileSet

10 Importing and Exporting Cams

10.1 General

Cams can be imported into an IndraWorks project or exported from an IndraWorks project using the CamBuilder. The following formats are supported for these Import / Export functions:

- **CamBuilder file (*.XML)**

  Internal CamBuilder format.

  Enables the unrestricted further editing of the cam in other CamBuilder projects.

- **Parameter file (*.PAR)**

  Parameter file for drives and controls (e.g. IndraDrive and IndraMotion MLC or IndraLogic XLC).

  Enables parameter files to be uploaded into the target device using IndraWorks or DriveTop for example. The cam is converted into a cam table.

- **Cam table (*.CSV)**

  The position values, velocity values, acceleration values and jerk values of the cam are saved in a file that can be read by Excel. The cam is converted into a cam table. This ensures that it can also be read via DriveTop.

10.2 Exporting Cams

The export of a cam is started via the cam context menu in the Project Explorer "Cam Pool" node.

If the cam is to be further edited in another project, it has to be exported in XML format and imported into the other project.

If the cam is to be analyzed with the **IndraSize** tool, it has to be exported in XML format and imported into IndraSize.

If the cam is to be sent to a drive using DriveTop, for example, the PAR format or the CSV format can be used. The cam is exported and the exported file is read with DriveTop and the cam table is send to the drive.

The CSV format is available for examining the position values, velocity values, acceleration values and jerk values of a cam more closely.

As CamBuilder file (*.xml) Only the target location of the file has to be specified.

As a parameter file (*.par) The following information has to be provided for export as a parameter file:

- **Device type** - the drive or control type, on which the cam is to be stored
- **Cam table** - the parameter, to which the cam is to be saved, e.g.drives of the ECODRIVE family support two cams (P-0-0072 and P-0-0092)
- **Remove linear components of the cam** - if this function is set, the data sent is modified. This function is only available with drives and also only with specific firmware versions. For further information, refer to the functional description of the device used
- **Address** - address of the drive or control on which the cam is to be saved (limited from 0 - 100)
- **The last data point in the table belongs to X: 100%** - (Yes/No) (table format)
- **Number of data points** (limited from 3 to 1,024)
- **Distance** - factor for calculating the % values of the data point table.

As a cam table (*.csv)

The following information has to be provided when exporting the cam in **CSV format**:

- **Adding information** - if this setting is not set, only the cam table will be exported. Otherwise the following information is added:
  - Date created
  - CamBuilder version
  - User-defined name
  - Column headings
- **Remove linear components of the cam** - if this function is set, the data sent is modified. This function is only available with drives and also only with specific firmware versions. For further information, refer to the functional description of the device used
- **Backup in VisualMotion-8 format** - automatically exports in VisualMotion-8-csv-file format. This setting automatically resets all other settings.
- **The last data point in the table belongs to X: 100%** - (Yes/No)
- **Number of data points** (limited from 3 to 1,024)
- **Distance** - factor for calculating the % values of the data point table.
- **Additional data** - this setting enables the velocity profile, acceleration profile and the jerk profile to be exported as well
- **Field separator** - specifies with which separator the values will be exported. It is possible to choose between a comma and a semicolon

10.3 Importing Cams

The import of a cam is started via the context menu in the Project Explorer "Cam Pool" node. The data to be imported has to be selected in an **Open File** dialog.

No further entries are required when importing the cam in XML format.

SERCOS ASCII format files can include more than one parameter, which includes a cam table. If a *.par file is selected for import, which includes more than one cam table, then the user will be offered a selection of all the cam table parameters found. The user can then select the cam table required from this list.

The CamBuilder internally requires cam tables, the last Y data point of which corresponds to X = 100%. If a CSV file or a PAR file is to be imported, then the table format still has to be given. If the last Y value equals 0.xxx % or +-99.xxx %, then a suggested last data point is automatically entered in the input field.

11 CamBuilder Options and Cam Properties

11.1 CamBuilder Options

The Options dialog is opened via the **Tools** ▸ **Options** ▸ **CamBuilder** menu.

All general settings affecting the entire CamBuilder (all opened cams) can be entered here.

The options are divided into two parts:

General options

- **Minimum rotary motion step length**
- **Minimum translatory motion step length**
- **Default rotary motion step length**
- **Default translatory motion step length**

  Minimum motion step lengths can be defined for the slave axis. When a change to a motion step is applied, the length of the focused step is checked to detect whether it is greater than this setting.

  The defined default values are used when inserting new motion steps.
- **FlexProfile FB name prefix**

  The name prefix is used to generate a PLC function block from a cam. The name of the function block consists of the prefix and the cam name.

Graph options

- **General**
  - **Snap radius**

    Radius in pixels around the mouse pointer to select objects
  - **Using grid positions during editing**

    This option can be deactivated during editing by clicking on the <Ctrl> key
  - **Line width of the focused profile**
  - **Line width of the inactive profiles**
  - **Brightness of the focused motion steps**
  - **Brightness of the inactive motion steps**
  - **Line type of the coordinate grid**
- **Colors**

  Predefined color schemes can be selected or changed.

  The following colors can be adapted:
  - **Color of the position profile**
  - **Color of the velocity profile**
  - **Color of the acceleration profile**
  - **Color of the jerk profile**
  - **Color of the selected step (top)**
  - **Color of the selected step (bottom)**
  - **Color of the motion step limits**
  - **Color of the coordinate grid**
  - **Color of the graph background (top)**
  - **Color of the graph background (bottom)**

☞ Every change is permanently saved and thus reproduced when the CamBuilder is preset.

11.2 Cam Properties

The "Properties" dialog of a cam is called via the context menu of the focused cam in the Project Explorer or via the CamBuilder toolbar. Settings for the focused cam can be input here.

☞ Opening Properties automatically loads the corresponding cam.

The properties to be edited here correspond to the first step of the wizard for a new cam (refer to chapter 6 "Creating Cams and Preview Objects" on page 41).

12 Printing Cams

The CamBuilder allows the user to print the different cams individually.

The following print settings can be selected via the "Print" context menu item in the Project Explorer.

- Print the **graphic output** of the cam (Yes/No) - the current graphic output will be printed. A cam has to be open in the workspace to allow this option to be selected
- Print the **description** of the cam (Yes/No) - the cam description will be printed. The cam has to have a description for this option to be chosen
- Print the **application data** of the cam (Yes/No) - the application data from the application wizard will be printed. The cam has to have an application wizard for this option to be chose
- Print the **motion steps** of the cam (Yes/No) - the data of the individual motion steps (position, velocity, motion law, description, ...) is printed
- Print the **extreme values** of the cam (Yes/No) - the content of the extreme values list will be printed
- Print the **cam table** of the cam (Yes/No) - e.g. 1,024 percentage values of the slave axis position is printed

To print or to view a preview, select at least one of the options.

13 Motion Laws

13.1 General

The CamBuilder supports 36 different motion laws to define the motion between the starting and end point of a motion step. Moreover, free cam tables can also be imported to define the motion.

Further information on motion laws is given in the FlexProfile documentation.

The different motion laws provide different degrees of freedom in terms of limit values and can be sub-divided into categories:

	Definition of the motion law at eth input MotionLaw (ProfileStepAdr)		Travel range		Boundary values left			Boundary value right			Max (not considered everywhere)			TPS possible	Flex step possible	Operation Modes
			Distance	Range	StVel	StAcc	StJerk	EndVel	EndAcc	EndJerk	MaxVel	MaxAcc	MaxJerk			
Rest-in-rest																
Standstill	REST_IN_REST_LINEAR	2048	0	*	0	0	0	0	0	0	=	=	=	x		CT, FP
Sine curve	REST_IN_REST_SINE	2560	*	*	0	0	=	0	0	=	=	=	=	x		CT, FP
Inclined sine curve	REST_IN_REST_INCLINEDSINE	0	*	*	0	0	=	0	0	=	=	=	=	x		CT, MP, FP
Accel.-opt. inclined sine curve	REST_IN_REST_SINEACC	3072	*	*	0	0	=	0	0	=	=	=	=	x		CT, FP
Torque-opt. inclined sine curve	REST_IN_REST_SINETORQUE	3328	*	*	0	0	=	0	0	=	=	=	=	x		CT, FP
Gutman sinoide	REST_IN_REST_GUTMANSINE	2816	*	*	0	0	=	0	0	=	=	=	=	x		CT, FP
Modified sine curve	REST_IN_REST_MOD_SINE	3840	*	*	0	0	=	0	0	=	=	=	=	x		CT, FP
Modified accel. trapez.	REST_IN_REST_MOD_TRAPEZE	3584	*	*	0	0	=	0	0	=	=	=	=	x		CT, FP
Quadratic parabola	REST_IN_REST_PARABOLA	4864	*	*	0	0	0	0	0	0	=	=	=	x		CT, FP
Polynomial 5th order	REST_IN_REST_POLY5	256	*	*	0	=	=	0	=	=	=	=	=	x		CT, FP
Polynomial 7th order	REST_IN_REST_POLY7	2304	*	*	0	0	=	0	0	=	=	=	=	x		CT, MP, FP
Polynomial 8th order	REST_IN_REST_POLY8	5120	*	*	0	0	0	0	0	0	=	=	=	x		CT, FP
Rest-in-velocity																

Motion Laws

	Definition of the motion law at eth input MotionLaw (ProfileStepAdr)		Travel range		Boundary values left			Boundary value right			Max (not considered everywhere)			TPS possible	Flex step possible	Operation Modes
			Distance	Range	StVel	StAcc	StJerk	EndVel	EndAcc	EndJerk	MaxVel	MaxAcc	MaxJerk			
Polynomial 5th order	REST_IN_VELOCITY_POLY5	512	*	*	0	0	=	*	0	=	=	=	=			CT, MP, FP
Polynomial 7th order	REST_IN_VELOCITY_POLY7	768	*	*	0	0	0	*	0	0	=	=	=			CT, FP
Velocity-in-velocity																
Constant velocity	CONSTANT_VELOCITY	1536	*	*	=	0	0	=	0	0	=	=	=			CT, MP, FP
Polynomial 5th order	VELOCITY_IN_VELOCITY_POLY5	1792	*	*	*	0	=	*	0	=	=	=	=			CT, MP, FP
Polynomial 7th order	VELOCITY_IN_VELOCITY_POLY7	4096	*	*	*	0	0	*	0	0	=	=	=			CT, FP
Modified sine curve	VELOCITY_IN_VELOCITY_MOD_SINE	4352	*	*	*	0	=	*	0	=	=	=	=			CT, FP
Velocity-in-rest																
Polynomial 5th order	VELOCITY_IN_REST_POLY5	1024	*	*	*	0	=	0	0	=	=	=	=			CT, MP, FP
Polynomial 7th order	VELOCITY_IN_REST_POLY7	1280	*	*	*	0	0	0	0	0	=	=	=			CT, FP
General motion																
Polynomial 2nd order	COMMON_POLY2	16896	*	*	*	=	=	=	=	=	=	=	=			CT, FP
Polynomial 3rd order	COMMON_POLY3	17152	*	*	*	=	=	*	=	=	=	=	=			CT, FP
Polynomial 4th order	COMMON_POLY4	17408	*	*	*	=	=	*	=	=	=	=	=	x		CT, FP
Polynomial 5th order	COMMON_POLY5	16384	*	*	*	*	=	*	*	=	=	=	=		x	CT, MP, FP
Polynomial 7th order	COMMON_POLY7	16640	*	*	*	*	*	*	*	*	=	=	=		x	CT, FP
Polynomial 8th order	COMMON_POLY8	17664	*	*	*	*	*	*	*	*	=	=	=			CT, FP
Extended motion																

	Definition of the motion law at eth input MotionLaw (ProfileStepAdr)		Travel range		Boundary values left			Boundary value right			Max (not considered everywhere)			TPS possible	Flex step possible	Operation Modes
			Distance	Range	StVel	StAcc	StJerk	EndVel	EndAcc	EndJerk	MaxVel	MaxAcc	MaxJerk			
- Resulting distance																
Vel. 2nd order (start acc. zero)	X_VEL_STARTACC	33280	=	*	*	0	=	*	=	=	=	=	=			CT, FP
Vel. 2nd order (end acc. zero)	X_VEL_ENDACC	33280	=	*	*	=	=	*	0	=	=	=	=			CT, FP
Linear velocity	X_LINEAR_VEL	33024	=	*	*	=	=	*	=	=	=	=	=			CT, FP
Linear acceleration	X_LINEAR_ACC	32768	=	*	*	*	=	=	*	=	=	=	=			CT, FP
- Resulting master axis range																
Acc.-lim. motion (trapezoid profile)	X_FIT_VEL_TRAPEZE_ALIM	7000	*	=	*	=	=	*	=	=	*	*	=			CT, FP
Accel.-lim. sine curve	X_FIT_SINE_TRAPEZE_ALIM	28928	*	=	*	=	=	*	=	=	*	*	=			CT, FP
Jerk-lim. motion (trapezoid profile)	X_FIT_ACC_TRAPEZE_JLIM	29184	*	=	*	=	=	*	=	=	*	*	*			CT, FP
- Others																
Vel.-lim. polynomial 5th order	X_MOTION_IN_MOTION_POLY5_VLIM	24576	*	*	*	*	=	*	*	=	*	=	=			CT, FP
No overshoot polynomial 5th order	X_MOTION_IN_MOTION_POLY5_SLIM	24832	*	*	*	0	=	*	0	=	=	=	=			CT, FP
Acc.-lim. (trapezoid profile)	X_VELOCITY_IN_VELOCITY_TRAPEZE_ALIM	20480	*	*	*	0	=	*	0	=	*	*	=			CT, FP
Cam table																
Cam table	CAMTABLE_1	1...99	*	*	=	=	=	=	=	=	=	=	=			CT, MP, FP

0	explicitly 0
*	User-defined
=	Calculated automatically

CT	Cam table
MP	MotionProfile
FP	FlexProfile

Fig.13-1: FlexProfile motion law boundary conditions

13.2 Analytic Functions

13.2.1 General

The following motion laws enable a selection to be made on the basis of different criteria.

A high throughflow of goods is achieved by reducing damaging vibrations and abrasion and noise is also minimized by this.

13.2.2 Rest-in-Rest

There are 12 rest-in-rest motion laws available. These motion laws are defined only by the distance and the master axis range. Starting and end velocity are 0.

Rest-in-rest, standstill

(up to CamBuilder 08VRS: linear rest)

$$f(z) = 0$$

Fig. 13-2: Function: Rest-in-rest, standstill

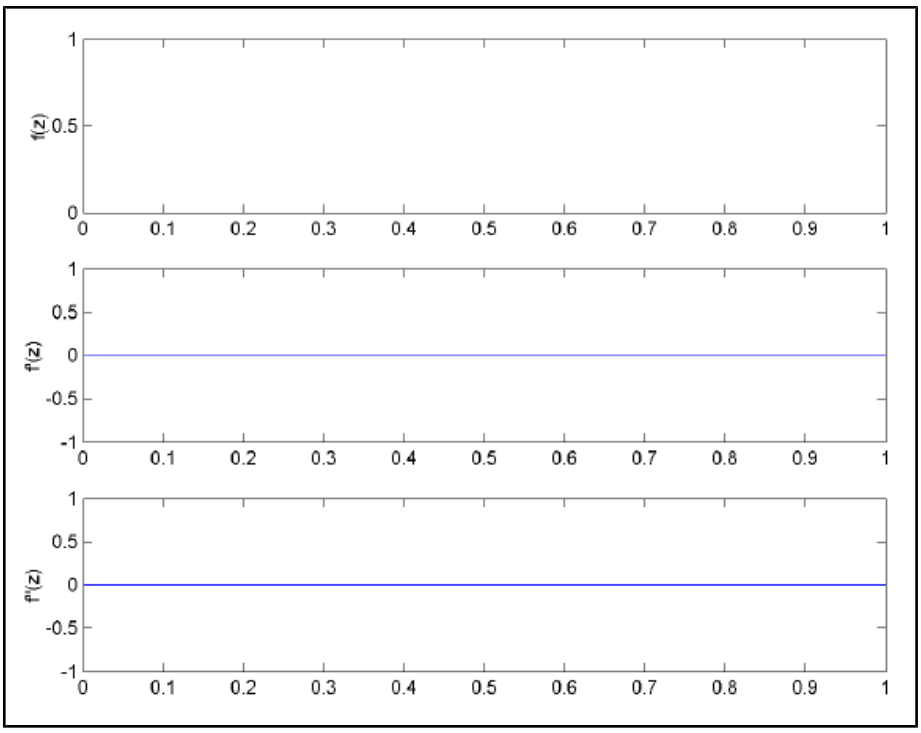

Fig. 13-3: Graph: Rest-in-rest, standstill

Rest-in-rest, simple sine curve

Advantages

- Low velocity characteristic value
- Low acceleration characteristic value
- Low dynamic torque characteristic value

Disadvantages

- Acceleration step
- Vibrations, noise, abrasion

$$f(z) = \frac{1}{2}\left[1 - \cos(\pi z)\right]$$

Fig. 13-4: Function: Rest-in-rest, simple sine curve

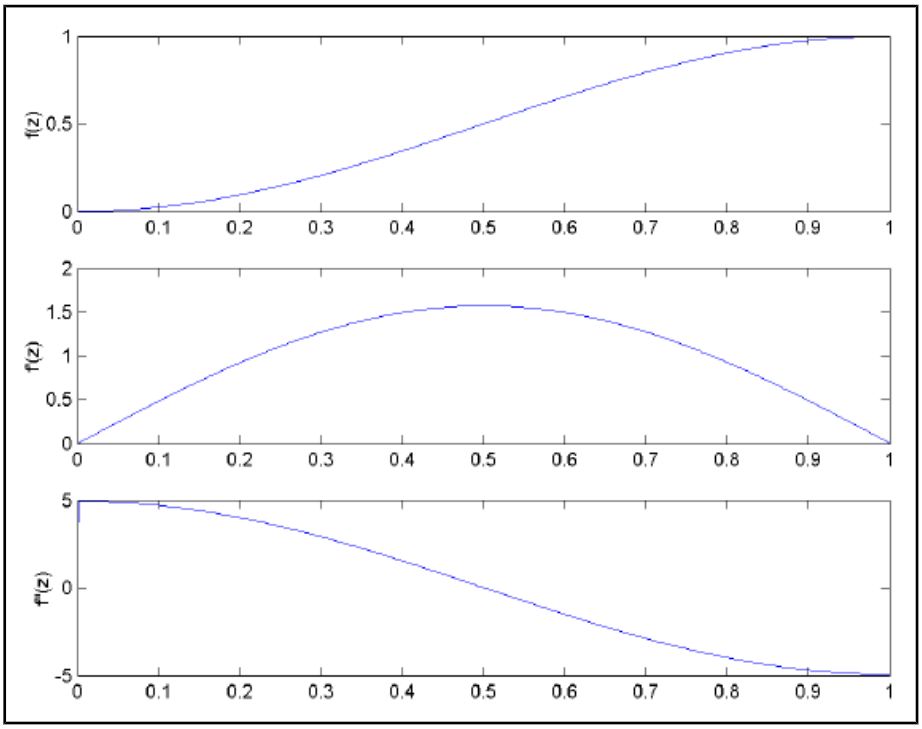

Fig. 13-5: Graph: Rest-in-rest, Sine curve (simple sinoide)

Rest-in-rest, inclined sine curve (Bestehorn sinoide)

Advantages

- Especially low jerk characteristic value
- Low vibration, ideal for high speeds

Disadvantages

- Velocity characteristic value, acceleration characteristic value and
- dynamic torque characteristic value are higher than with polynomial 5th order

$$f(z) = z - \frac{1}{2\pi}\sin(2\pi z)$$

Fig. 13-6: Function: Rest-in-rest, inclined sine curve (Bestehorn sinoide)

Motion Laws

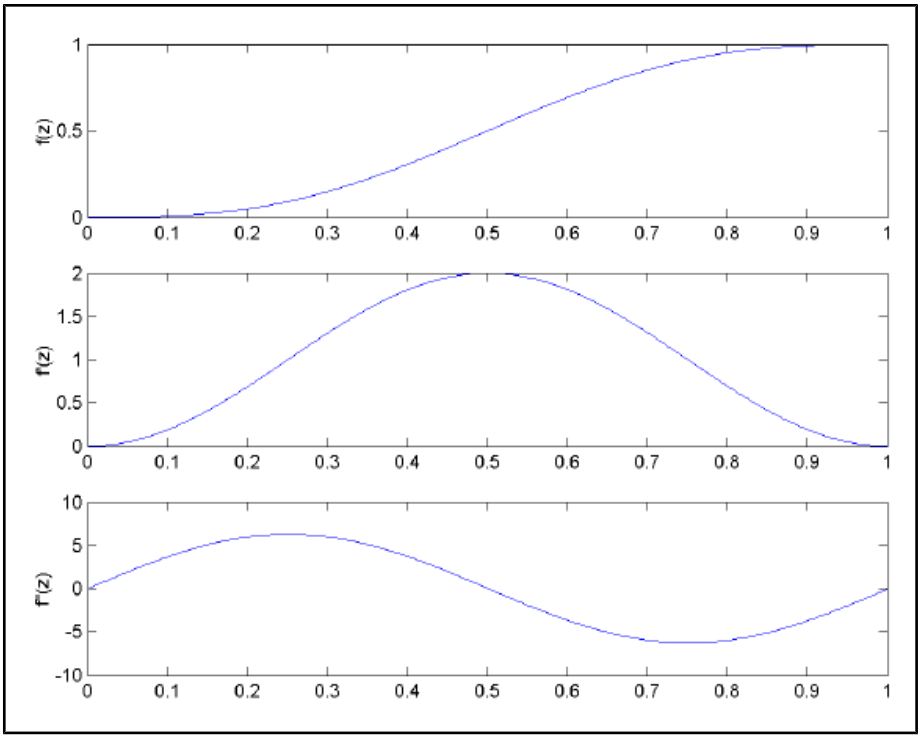

Fig.13-7: Graph: Rest-in-rest, inclined sine curve (Bestehorn sinoide)

Rest-in-rest, acceleration-optimal inclined sine curve

$$f(z) = z - \frac{1}{2\pi}\sin(2\pi z)$$

$$g(z) = z - \frac{0.41}{2\pi}\sin(2\pi z)$$

Fig.13-8: Function: Rest-in-rest, acceleration-optimal inclined sine curve

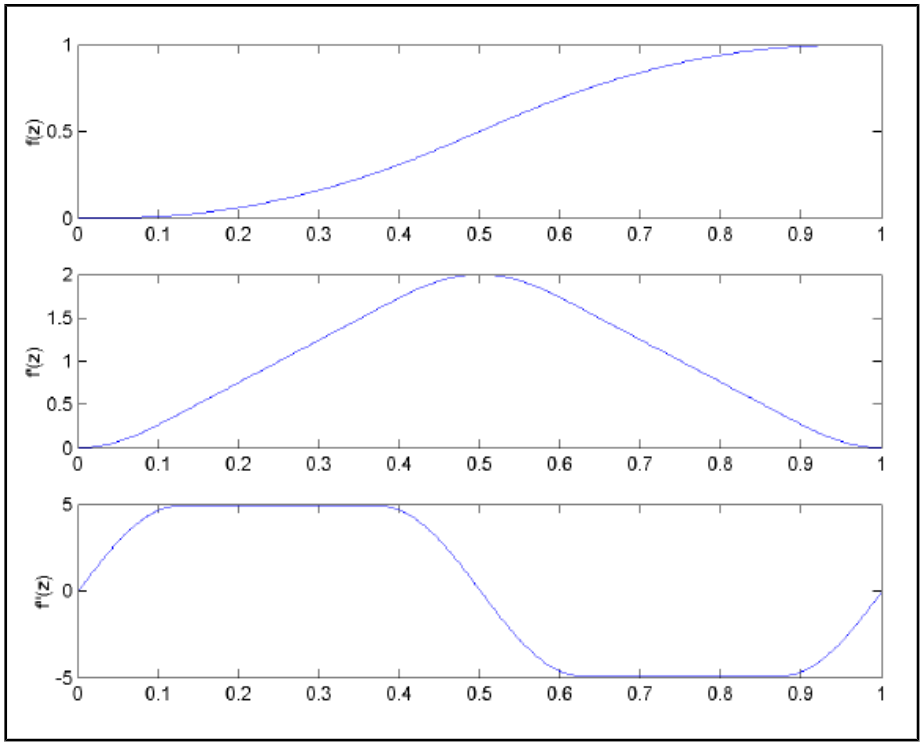

Fig. 13-9: Graph: Rest-in-rest, acceleration-optimal inclined sine curve

Rest-in-rest, moment-optimal inclined sine curve

$$f(z) = z - \frac{1}{2\pi}\sin(2\pi z)$$

$$g(z) = z - \frac{0.134}{2\pi}\sin(2\pi z)$$

Fig. 13-10: Function: Rest-in-rest, torque-optimum inclined sine curve

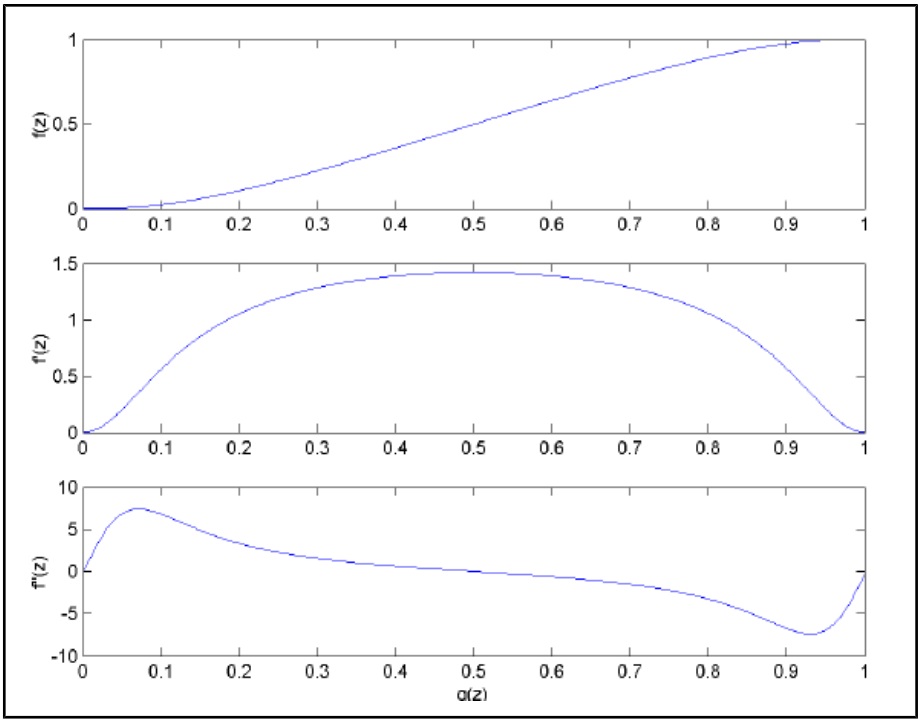

Fig.13-11: Graph: Rest-in-rest, torque-optimum inclined sine curve

Rest-in-rest, sinoide of Gutman

$$f(z) = z - \frac{15}{32\pi}\sin(2\pi z) - \frac{1}{96\pi}\sin(6\pi z)$$

Fig.13-12: Function: Rest-in-rest, Gutman sinoide

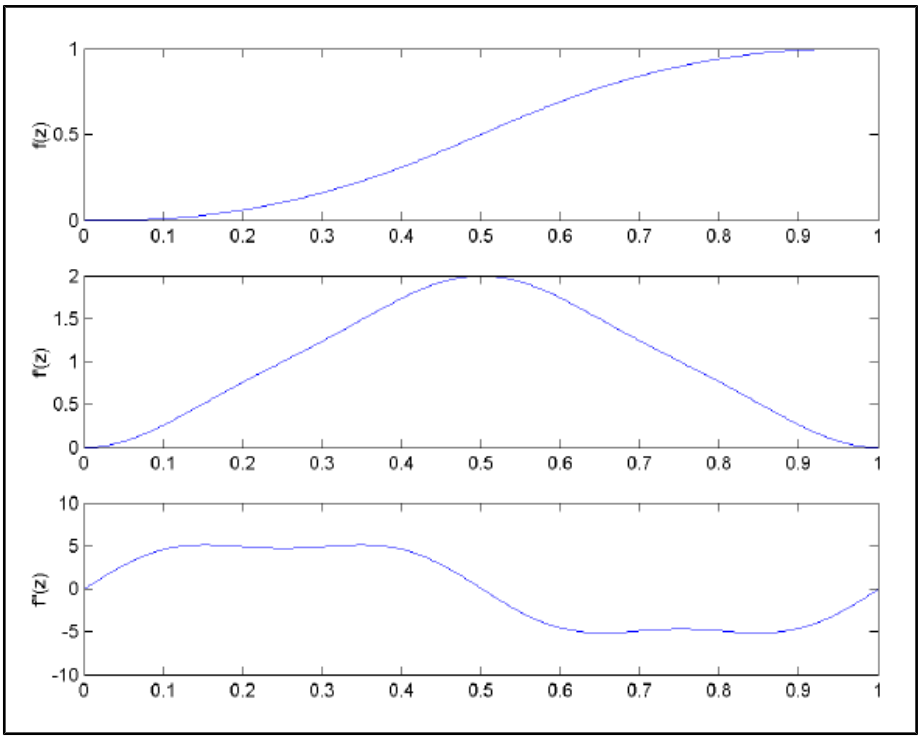

Fig.13-13: Graph: Rest-in-rest, Gutman sinoide

Rest-in-rest, modified sine curve

Advantages

- Ideal for high speeds
- Low velocity characteristic value
- Low acceleration characteristic value
- Low dynamic torque characteristic value

Disadvantages

- Jerk characteristic value is higher than with the inclined sine curve

$$0 \le z \le \frac{1}{8}: f(z) = \frac{1}{4+\pi}\left[\pi z - \frac{1}{4}\sin(4\pi z)\right]$$

$$\frac{1}{8} \le z \le \frac{7}{8}: f(z) = \frac{1}{4+\pi}\left[2 + \pi z - \frac{4}{9}\sin\left(\frac{4\pi}{3}z + \frac{\pi}{3}\right)\right]$$

$$\frac{7}{8} \le z \le 1: f(z) = \frac{1}{4+\pi}\left[4 + \pi z - \frac{1}{4}\sin(4\pi z)\right]$$

Fig.13-14: Function: Rest-in-rest, Modified sinoide

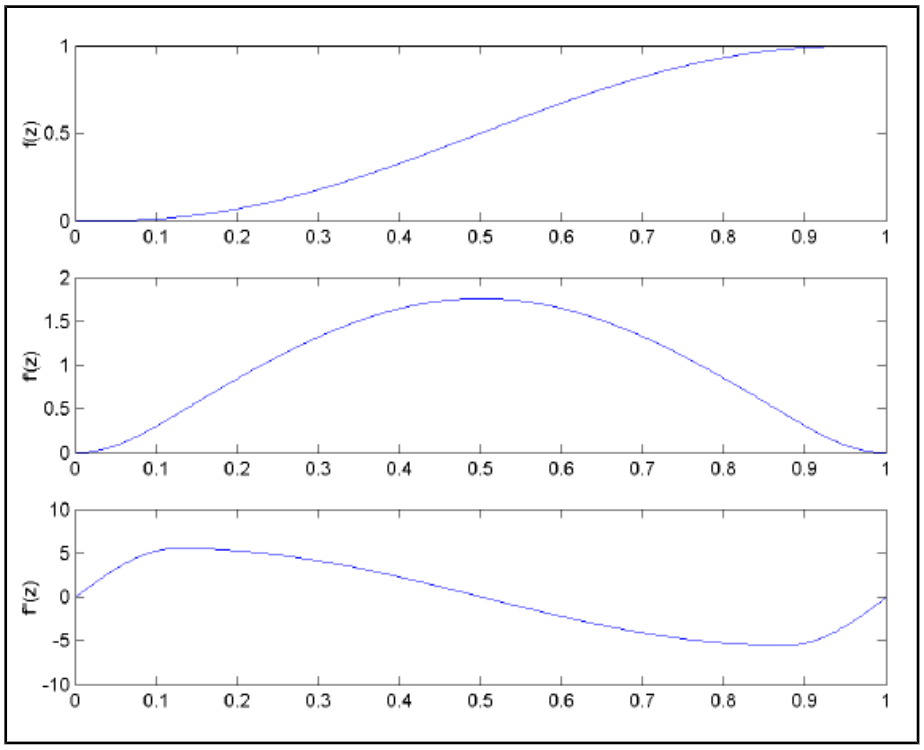

Fig.13-15: Graph: Rest-in-rest, Modified sinoide

Rest-in-rest, modified acceleration trapezoid

Advantages

- Especially low acceleration characteristic value
- Low inert forces

Disadvantages

- Jerk characteristic value is higher than with the inclined sine curve

Motion Laws

$$0 \le z \le \frac{1}{8}: f(z) = \frac{1}{2+\pi}\left[2z - \frac{1}{2\pi}\sin(4\pi z)\right]$$
$$\frac{1}{8} \le z \le \frac{3}{8}: f(z) = \frac{1}{2+\pi}\left[-\frac{1}{2\pi} + 2z + 4\pi\left(z + \frac{1}{8}\right)^2\right]$$
$$\frac{3}{8} \le z \le \frac{1}{2}: f(z) = \frac{1}{2+\pi}\left[-\frac{\pi}{2} + 2(1+\pi)z - \frac{1}{2\pi}\sin(4\pi z - \pi)\right]$$
$$\frac{1}{2} \le z \le 1: f(z) = 1 - f(1-z)$$

Fig.13-16: Function: Rest-in-rest, Modified acceleration trapezoid

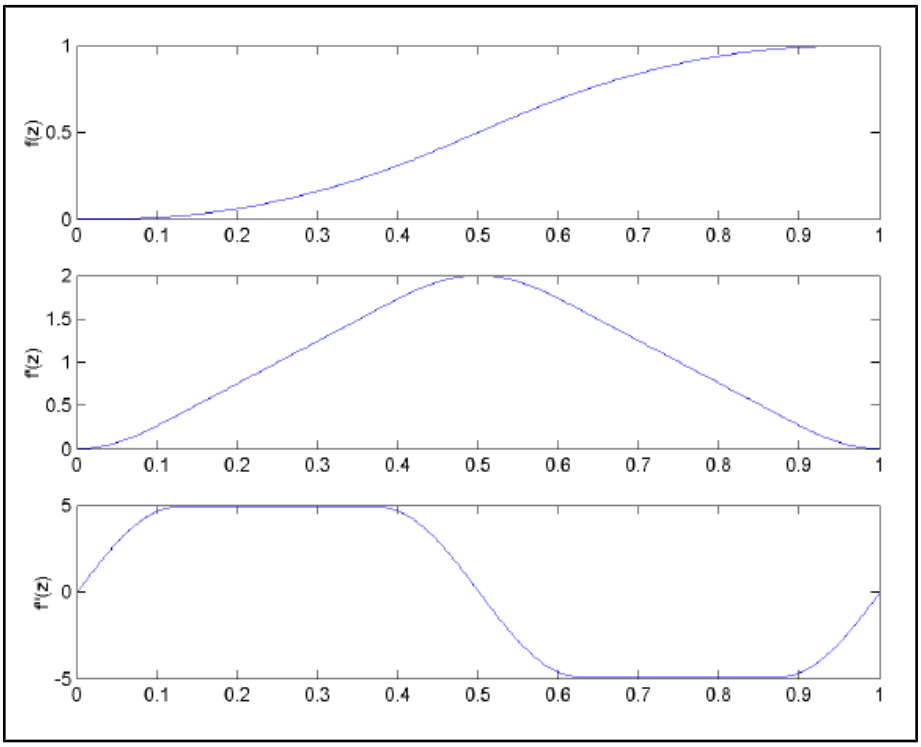

Fig.13-17: Graph: Rest-in-rest, Modified acceleration trapezoid

Rest-in-rest, quadratic parabola

$$0 \le z \le 0.5: f(z) = 2z^2$$
$$0 \le z \le 0.5: f(z) = 1 - 2(z-1)^2$$

Fig.13-18: Function: Rest-in-rest, quadratic parabola

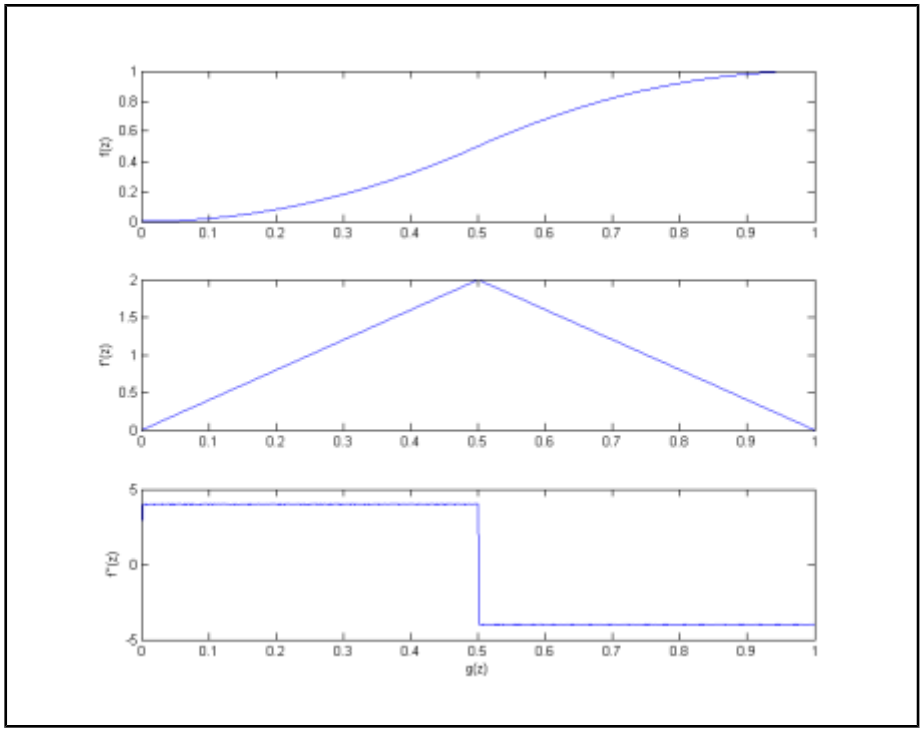

Fig. 13-19: Graph: Rest-in-rest, quadratic parabola

Rest-in-rest, polynomial 5th order

Advantages

- Low velocity characteristic value
- Low acceleration characteristic value
- Low dynamic torque characteristic value
- Low forces and torque

Disadvantages

- Jerk characteristic value is higher than with the inclined sine curve

$$f(z) = 6z^5 - 15z^4 + 10z^3$$

Fig. 13-20: Function: Rest-in-rest, polynomial 5th order

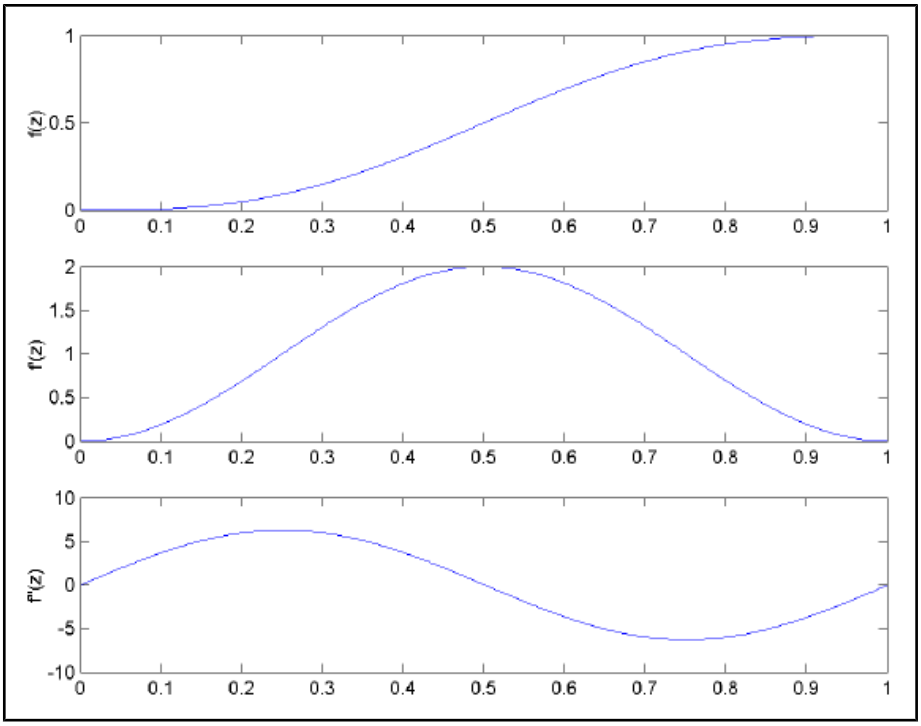

Fig.13-21: Graph: Rest-in-rest, polynomial 5th order

Rest-in-rest, polynomial 7th order

$$f(z) = -20z^7 + 70z^6 - 84z^5 - 35z^4$$

Fig.13-22: Function: Rest-in-rest, polynomial 7th order

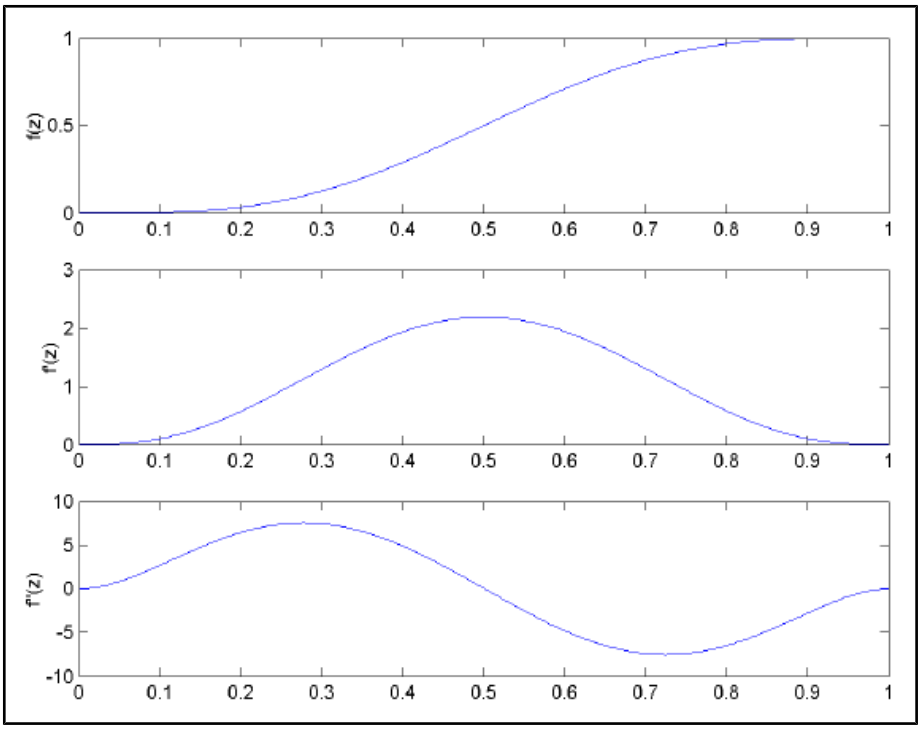

Fig.13-23: Graph: Rest-in-rest, polynomial 7th order

Rest-in-rest, polynomial 8th order

$$f(z) = A_8 z^8 + A_7 z^7 + A_6 z^6 + A_5 z^5 + A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig. 13-24: Function: Rest-in-rest, polynomial 8th order

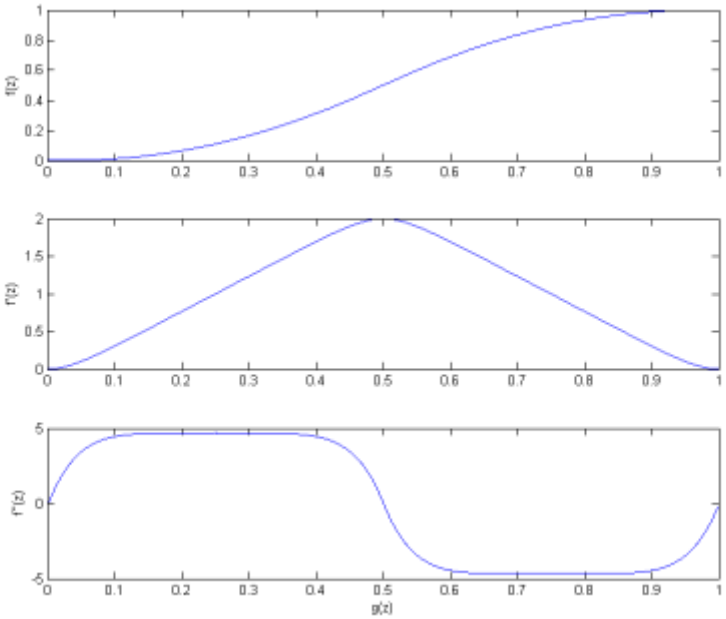

Fig. 13-25: Graph: Rest-in-rest, polynomial 8th order

13.2.3 Rest-in-Velocity

Rest-in-velocity motion laws are used for impact-free and jerk-free transition from standstill to defined velocities.

Rest-in-velocity, polynomial 5th order

$$f(z) = A_5 z^5 + A_4 z^4 + A_3 z^3$$

Fig. 13-26: Function: Rest-in-velocity, polynomial 5th order

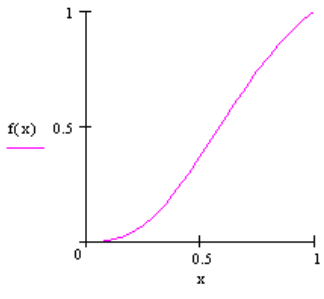

Fig. 13-27: Graph: Rest-in-velocity, polynomial 5th order

Rest-in-velocity, polynomial 7th order

$$f(z) = A_7 z^7 + A_6 z^6 + A_5 z^5 + A_4 z^4 + A_3 z^3$$

Fig. 13-28: Function: Rest-in-velocity, polynomial 7th order

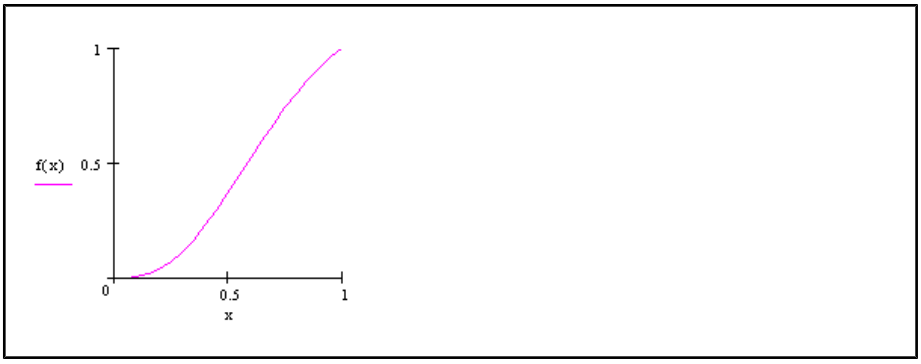

Fig.13-29: Graph: Rest-in-velocity, polynomial 7th order

13.2.4 Velocity-in-Rest

Velocity-in-rest motion laws are used for impact-free and jerk-free transition from defined velocities to standstill.

Velocity-in-rest, polynomial 5th order

$$f(z) = A_5 z^5 + A_4 z^4 + A_3 z^3 + A_1 z$$

Fig.13-30: Function: Velocity-in-rest, polynomial 5th order

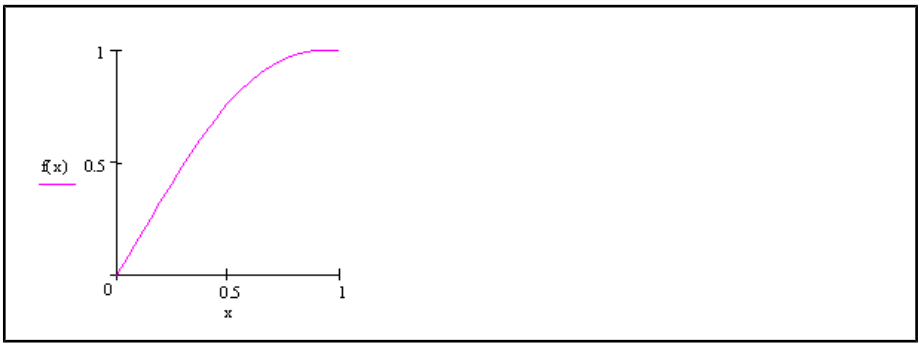

Fig.13-31: Graph: Velocity-in-rest, polynomial 5th order

Velocity-in-rest, polynomial 7th order

$$f(z) = A_7 z^7 + A_6 z^6 + A_5 z^5 + A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-32: Function: Velocity-in-rest, polynomial 7th order

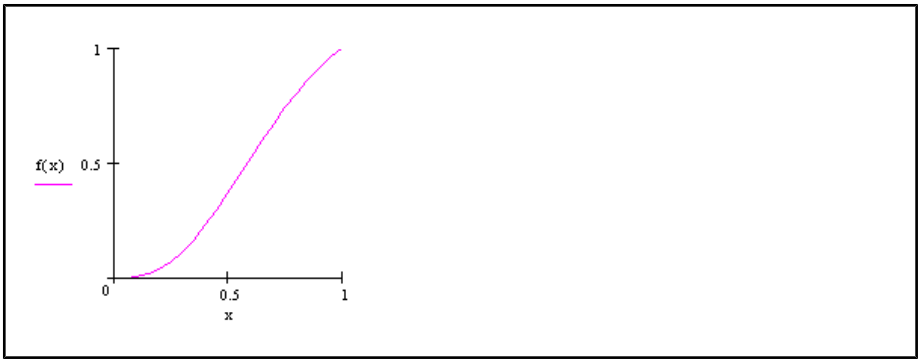

Fig.13-33: Graph: Velocity-in-rest, polynomial 7th order

13.2.5 Velocity-in-Velocity

Velocity-in-velocity motion laws are used for impact- and jerk-free transition from defined velocities to other defined velocities.

Velocity-in-velocity, Constant velocity

(up to CamBuilder 08VRS: Analytic G-G / Linear interpolation)

The velocity is calculated using the specified distance and the given master axis range. A constant velocity can be specified in the motion law "Extended, linear velocity" (see chapter "Resulting Distance" on page 103).

$$f(z) = z$$

Fig. 13-34: Function: Velocity-in-velocity, Constant velocity

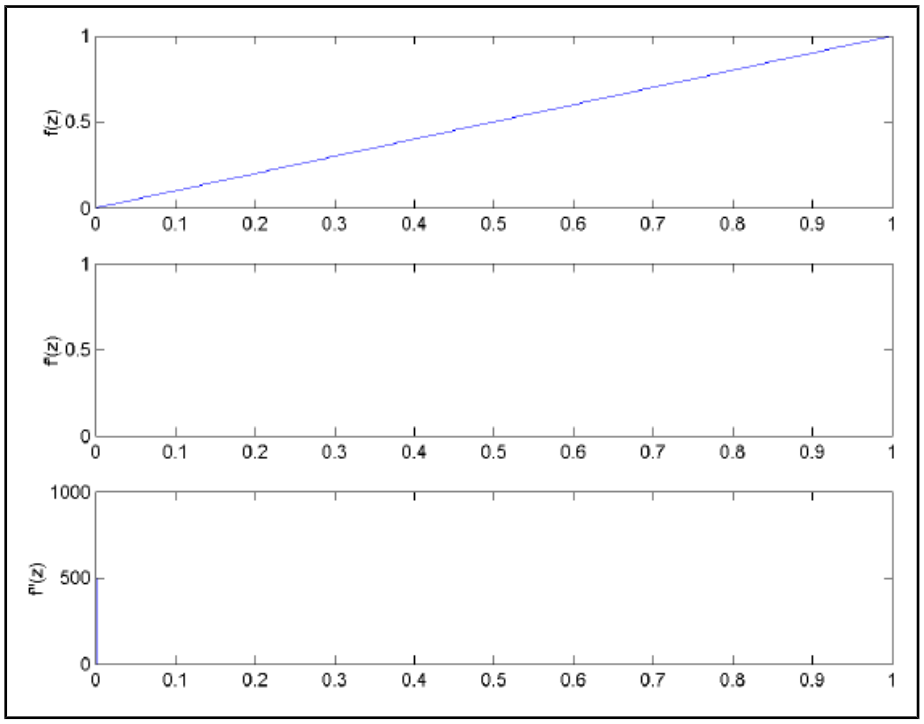

Fig. 13-35: Graph: Velocity-in-velocity, Constant velocity

Velocity-in-velocity, polynomial 5th order

$$f(z) = A_5 z^5 + A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig. 13-36: Function: Velocity-in-velocity, polynomial 5th order

Motion Laws

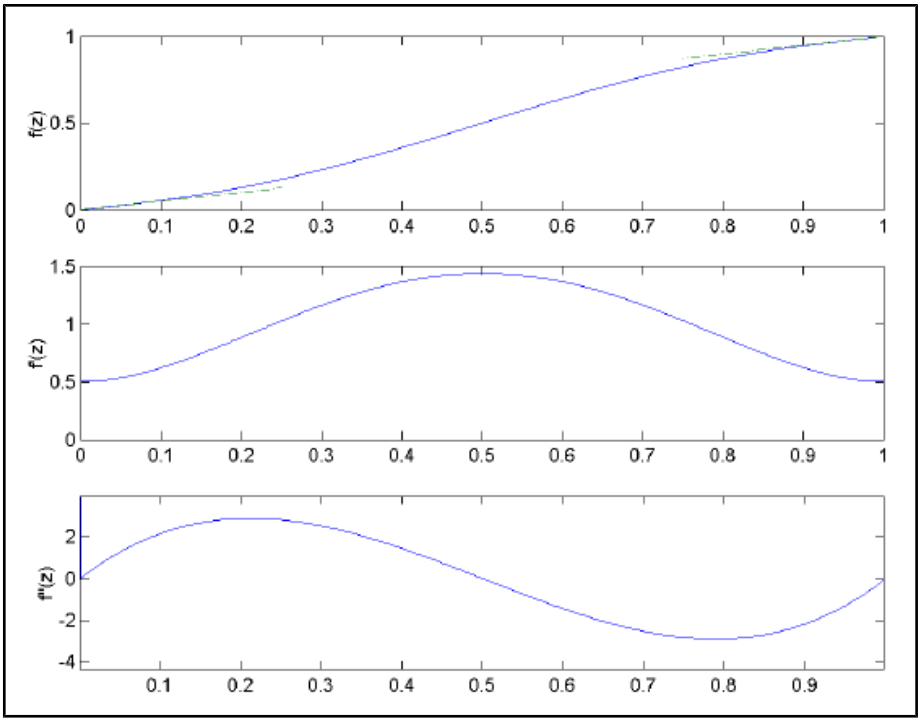

Fig.13-37: Graph: Velocity-in-velocity, polynomial 5th order

Velocity-in-velocity, polynomial 7th order

$$f(z) = A_7 z^7 + A_6 z^6 + A_5 z^5 + A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-38: Function: Velocity-in-velocity, polynomial 7th order

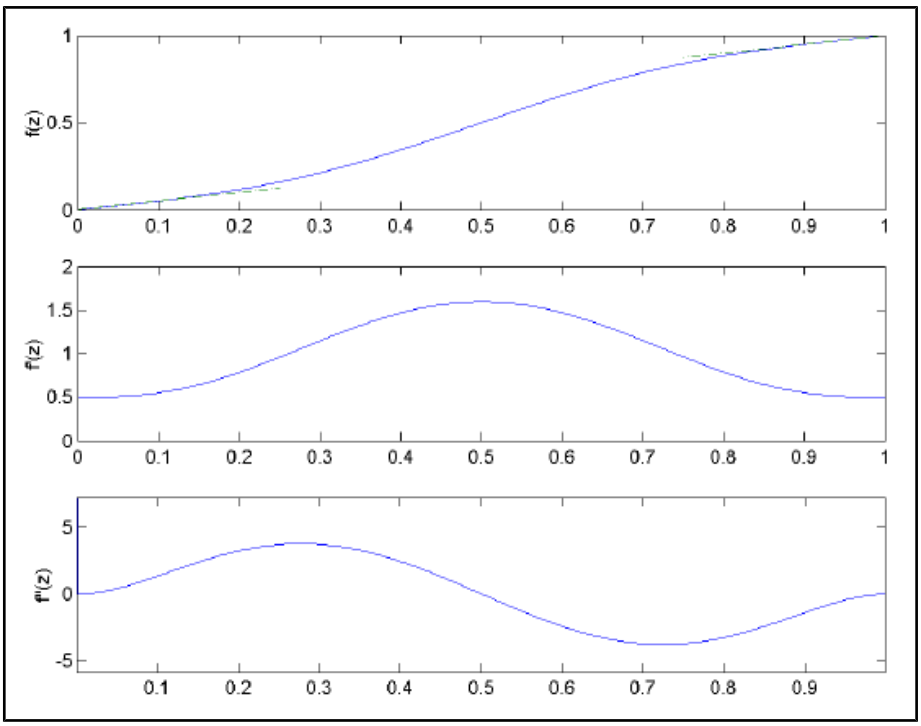

Fig.13-39: Graph: Velocity-in-velocity, polynomial 7th order

Velocity-in-velocity, Modified sine curve

$$0 \le z \le \frac{\lambda}{8} : f'(z) = C_a \frac{\lambda}{2\pi}\left(z - \frac{\lambda}{2\pi}\sin\left(2\pi\frac{z}{\lambda}\right)\right) + f'(0)z$$

$$\frac{\lambda}{8} \le z \le \lambda : f'(z) = C_a \frac{\lambda}{2\pi}\left(z - \frac{9\lambda}{2\pi}\sin\left(2\pi\frac{z+\frac{\lambda}{2}}{3\lambda}\right) + \frac{4\lambda}{\pi}\right) + f'(0)z$$

$$\lambda \le z \le 1 - \frac{1-\lambda}{4} : f'(z) = C_b \frac{1-\lambda}{2\pi}\left(z - \frac{9(1-\lambda)}{2\pi}\sin\left(2\pi\frac{z+\frac{3-5\lambda}{3(1-\lambda)}}{3\lambda}\right) + \frac{4\lambda}{\pi}\right)$$

$$+ f'(1) + \left(f'(0) - + f'(1)\right)\left(\frac{3}{4} - \frac{1}{\pi}\right) + \lambda$$

$$1 - \frac{1-\lambda}{4} \le z \le 1 : f'(z) = -C_b \frac{1-\lambda}{2\pi}\left(z - \frac{1-\lambda}{2\pi}\sin\left(2\pi\frac{z+\lambda}{1-\lambda}\right) - 1\right)$$

$$+1 + f'(1) + (z-1)$$

Fig. 13-40: Function: Velocity-in-velocity, Modified sine curve

13.2.6 General Motion

Motion laws for general motion can always be used.

General motion, polynomial 2nd order

$$f(z) = A_2 z^2 + A_1 z$$

Fig. 13-41: Function: General motion, polynomial 2nd order

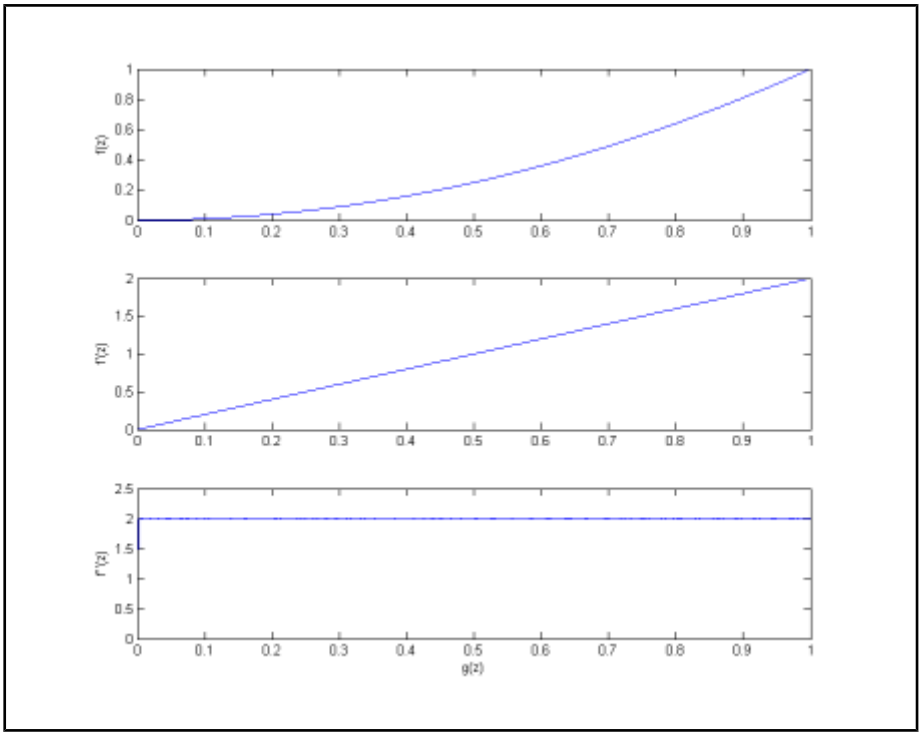

Fig. 13-42: Graph: General motion, polynomial 2nd order

General motion, polynomial 3rd order

$$f(z) = A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-43: Function: General motion, polynomial 3rd order

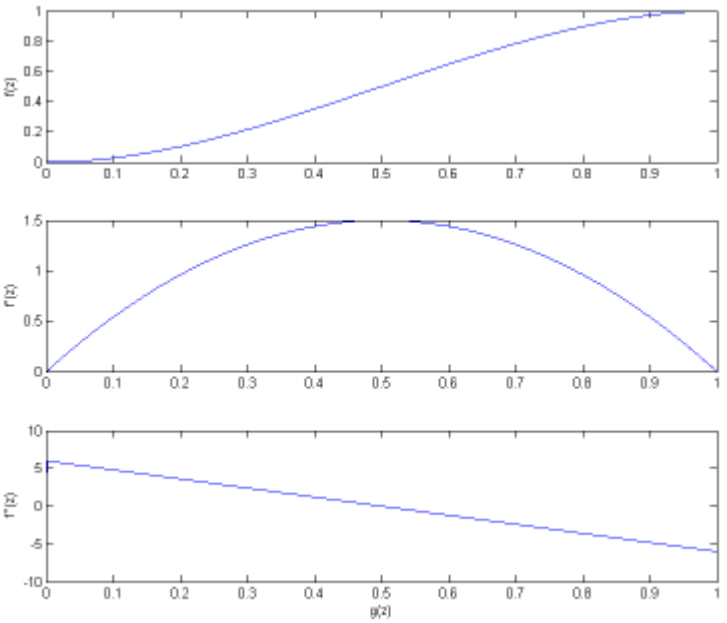

Fig.13-44: Graph: General motion, polynomial 3rd order

General motion, polynomial 4th order

(Special case with turning point displacement 0.57735 up to CamBuilder 08VRS: Polynomial 4th order (S))

$$f(z) = A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-45: Function: General motion, polynomial 4th order

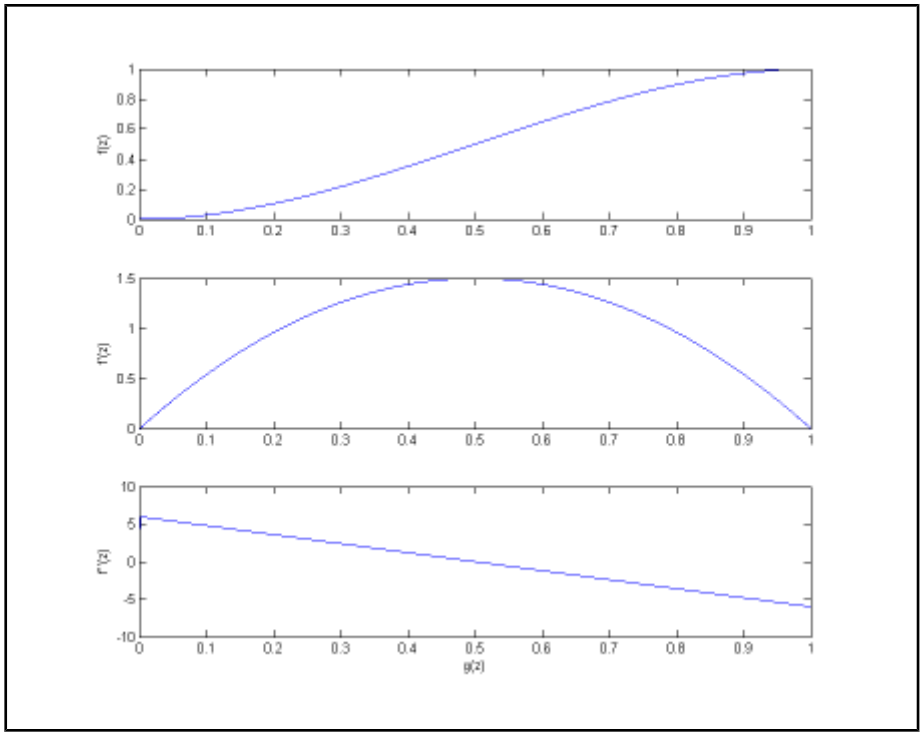

Fig.13-46: Graph: General motion, polynomial 4th order

General motion, polynomial 5th order

$$f(z) = A_5 z^5 + A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-47: Function: General motion, polynomial 5th order

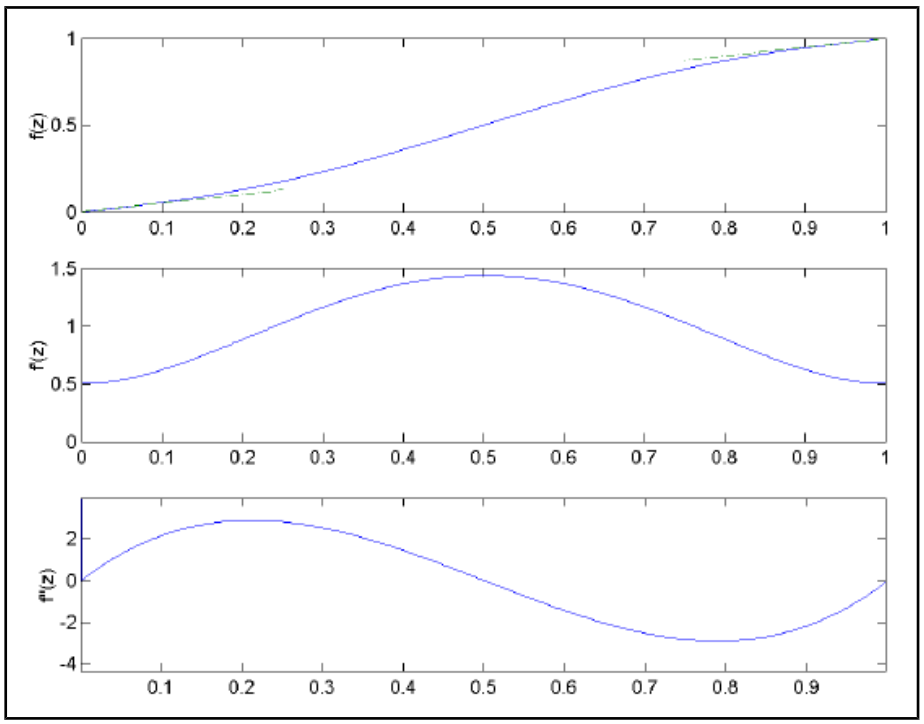

Fig.13-48: Graph: General motion, polynomial 5th order

General motion, polynomial 7th order

Motion Laws

$$f(z) = A_7 z^7 + A_6 z^6 + A_5 z^5 + A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-49: Function: General motion, polynomial 7th order

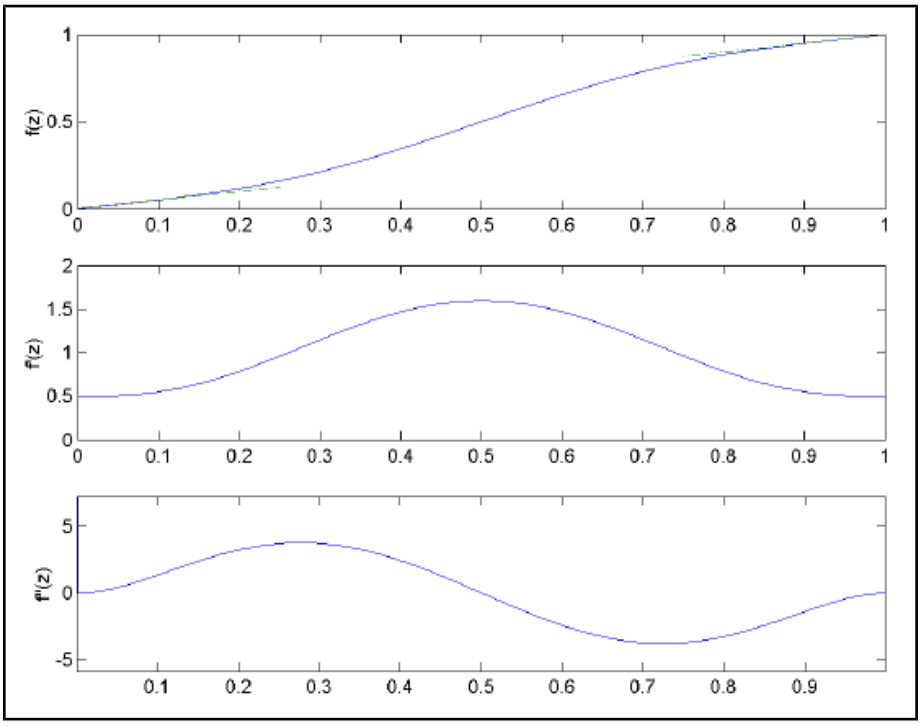

Fig.13-50: Graph: General motion, polynomial 7th order

General motion, polynomial 8th order

$$f(z) = A_8 z^8 + A_7 z^7 + A_6 z^6 + A_5 z^5 + A_4 z^4 + A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-51: Function: General motion, polynomial 8th order

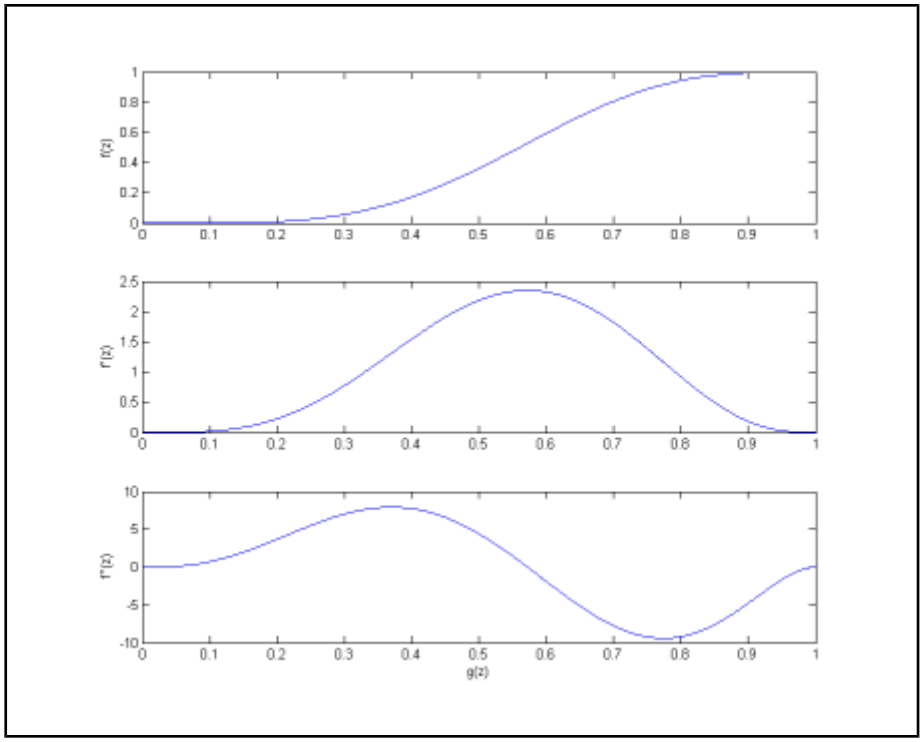

Fig. 13-52: Graph: General motion, polynomial 8th order

13.2.7 Extended Motion Laws

Resulting Distance

Extended, Linear velocity

(up to CamBuilder 08VRS: V-CAM Linear)

$$f(z) = A_3 z^3 + A_2 z^2 + A_1 z$$

Fig. 13-53: Function: Extended, Linear velocity

Motion Laws

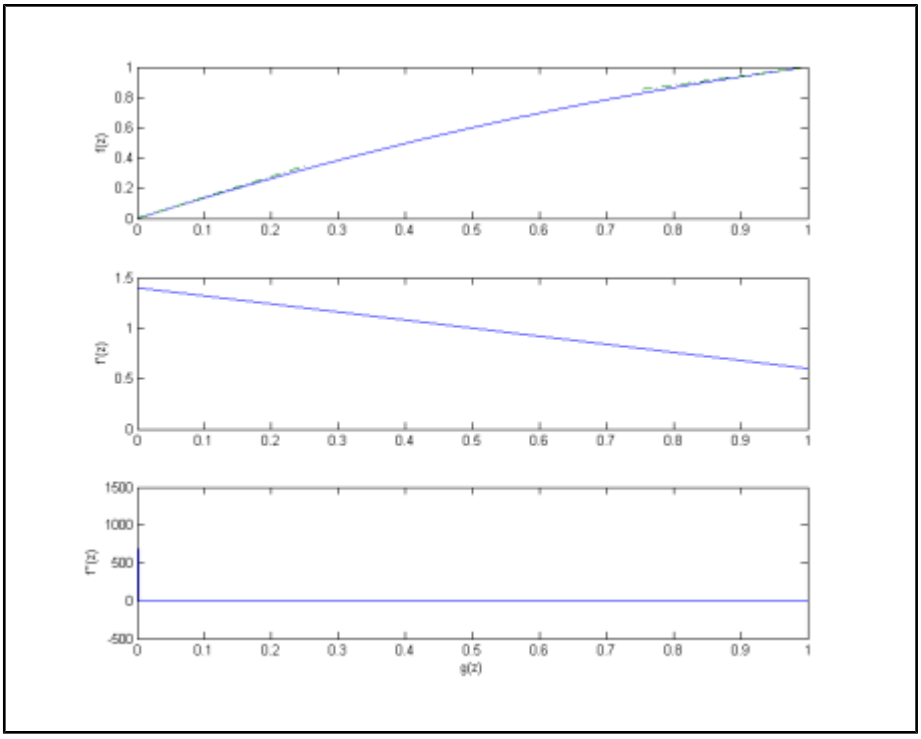

Fig.13-54: Graph: Extended, Linear velocity

Extended, Linear acceleration

(up to CamBuilder 08VRS: A-CAM Linear)

$$f(z) = A_3 z^3 + A_2 z^2 + A_1 z$$

Fig.13-55: Function: Extended, Linear acceleration

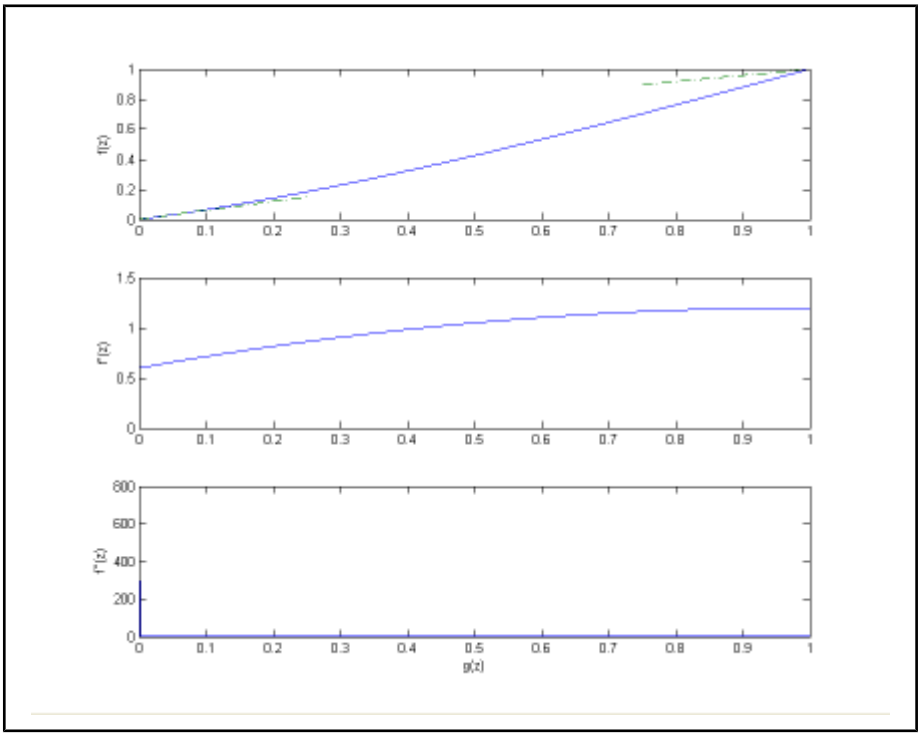

Fig.13-56: Graph: Extended, Linear acceleration

Extended, Velocity 2nd Order (Starting acc. zero)

(up to CamBuilder 08VRS: V-CAM 2nd order (1)

$$f(z) = A_3 z^3 + A_2 z^2 + A_1 z$$

Fig. 13-57: Function: Extended, Velocity 2nd Order (Starting acc. zero)

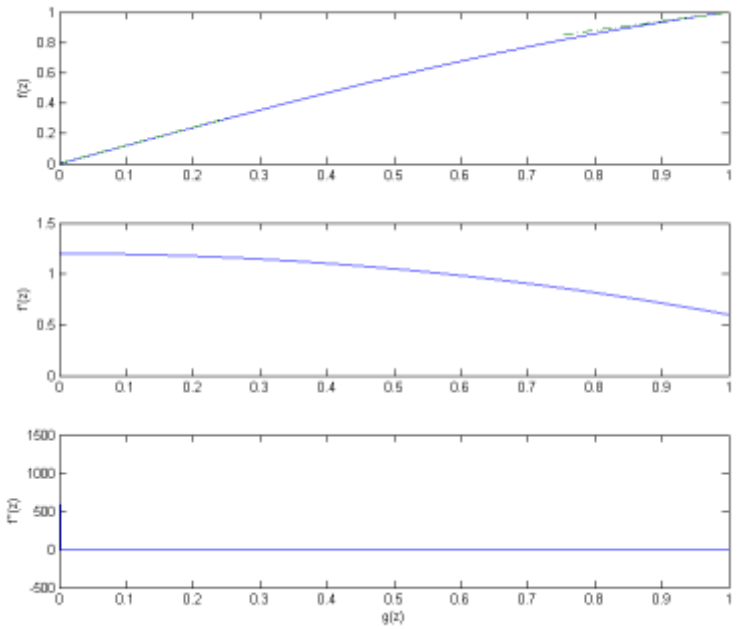

Fig. 13-58: Graph: Extended, Velocity 2nd Order (Starting acc. zero)

Extended, Velocity 2nd Order (End acc. zero)

(up to CamBuilder 08VRS: V-CAM 2nd order (2)

$$f(z) = A_3 z^3 + A_2 z^2 + A_1 z$$

Fig. 13-59: Function: Extended, Velocity 2nd Order (End acc. zero)

Motion Laws

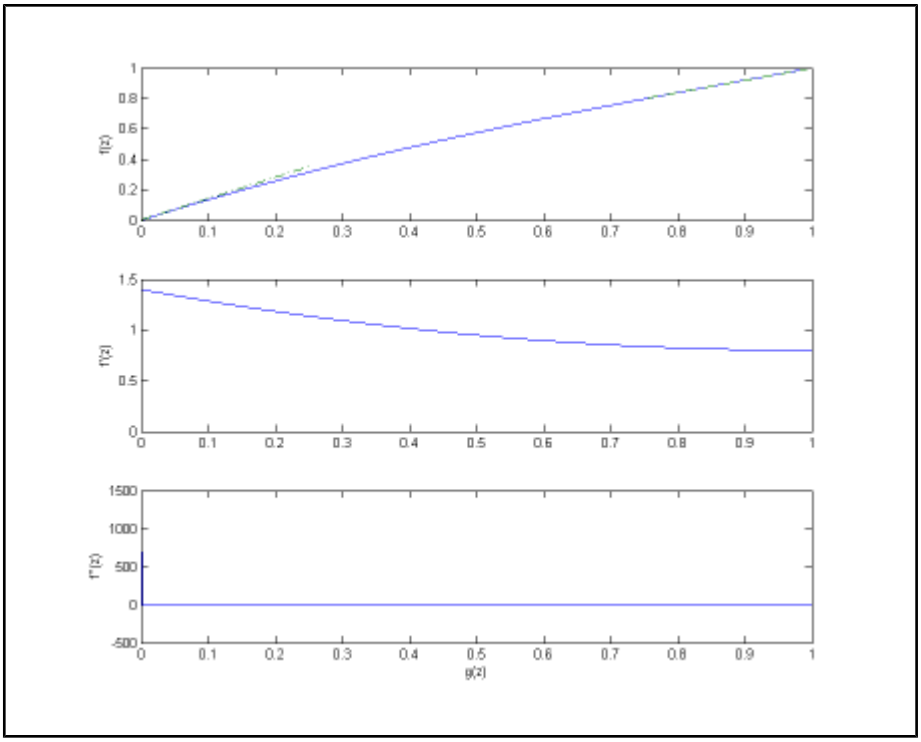

Fig.13-60: Graph: Extended, Velocity 2nd Order (End acc. zero)

Extended, Resulting Master Axis Range

These extended motion laws are special motion laws. They differ from the known motion laws from the VDI guidelines by their new degrees of freedom. While a standard motion law is clearly defined by the details of its left-hand and right-hand limit values, the motion laws shown here enable even further different setting options, such as a required maximum velocity. In this case the master axis range of the motion step is not required. Instead, this results from the parameterization of the motion law and the specification of characteristic values. Thus, for example, acceleration-limited motion allows the distance, starting and end velocity to be specified, but not the setting of a master axis range. The latter, and thus also the duration of the motion step, results from the maximum acceleration and maximum velocity values, which can also be specified.

Extended, Acceleration-limited motion (trapezoid profile)

The trapezoid profile, often also known as a ramp profile, can be regarded as the simplest form of path interpolation. If a path "s" should be traveled, it is accelerated up to a specified traveling velocity in the first phase (acceleration phase) using a given acceleration value. In the second phase (constant phase), it is traveled with a constant velocity and finally in the third phase (braking phase) it is decelerated with a predetermined delay. The role of path interpolation is to calculate the starting and end time points t1, t2 and t3 and the individual runtimes T1, T2 and T3 from the preset acceleration values a1 and a3 and the required velocity vm and the distance to be traveled "s". In the variation shown here, the required starting velocity v0 and end velocity v3 is also taken into consideration.

Extended, Acceleration-limited motion (sine curve)

With the sinoide profile, the starting and end velocity can be unequal to "0", and have different acceleration factors a1 and a3 for the acceleration and braking phase. Moreover, the special cases are also taken into consideration, in which the starting velocity v0 is already greater than the required travel velocity vm. The same also applies to the end velocity v3.

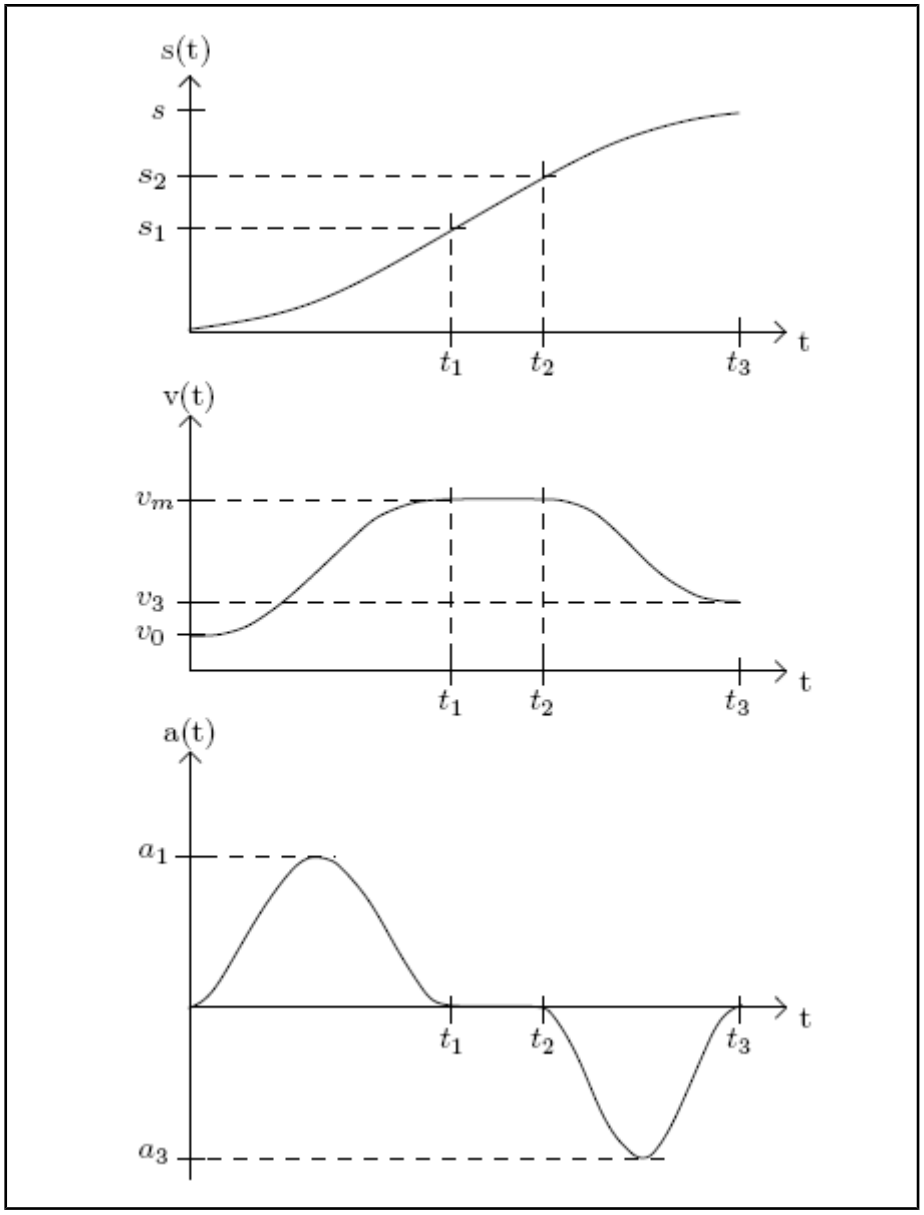

Fig.13-61: Graph: Acceleration-limited motion (sine curve)

Extended, Jerk-limited motion (trapezoid profile)

The acceleration with jerk limitation applies to many motion tasks, for example, to the transportation of fluids and to machines easily susceptible to vibration.

Motion Laws

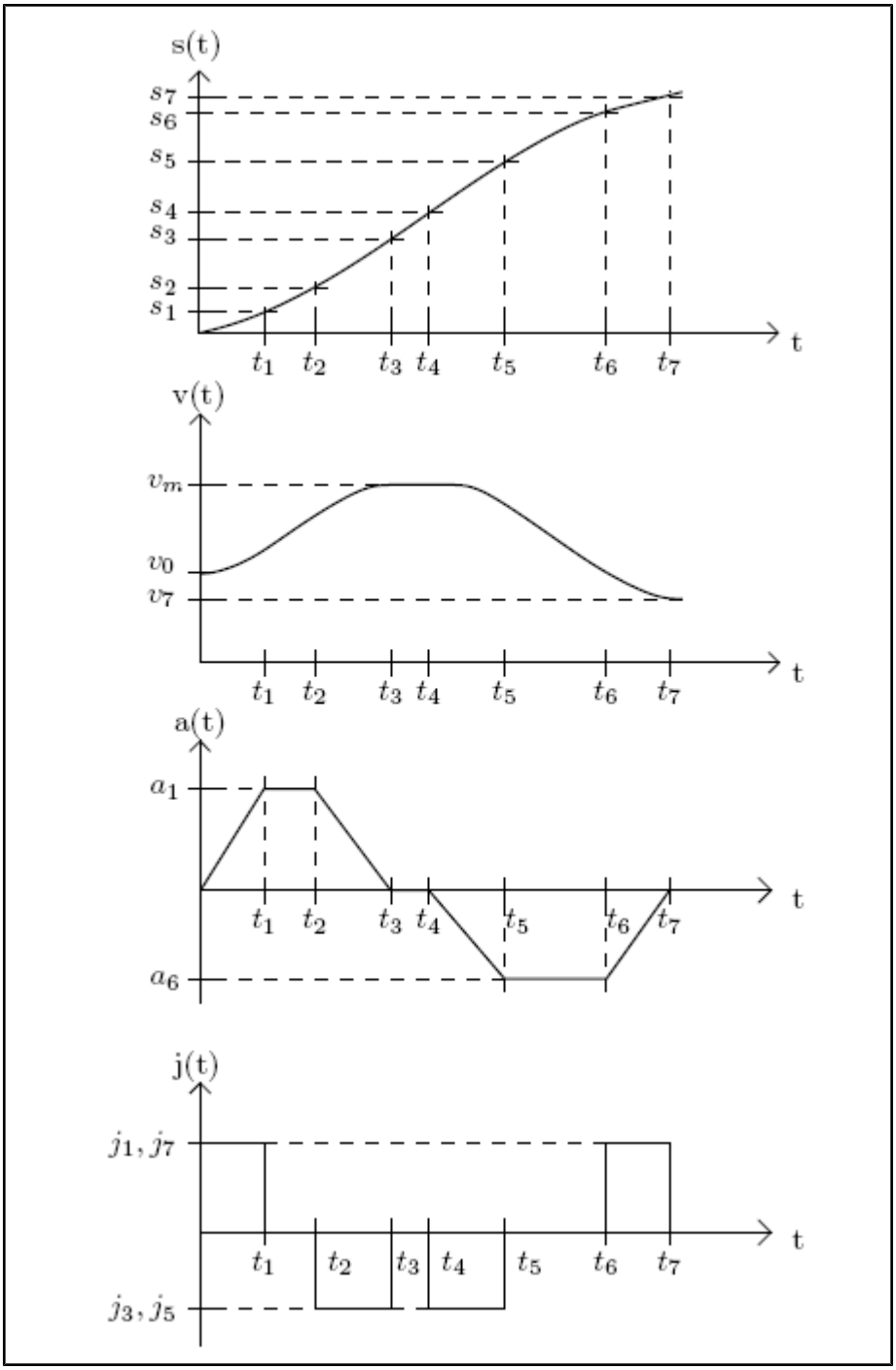

Fig.13-62: Graph: Jerk-limited motion

Miscellaneous

Extended, Velocity-limited Polynomial 5th order

The Polynomial 5th order, known from the VDI, allows no control of the maximum travel velocity. The motion law is subdivided into three sections to solve this problem. The middle section corresponds to a straight line with the required velocity. This is surrounded by two polynomials 5th order. This ensures a smooth transition from the start to the traveling velocity and from the traveling to the end velocity. The intersecting points between the first and second and the second and third sections have to be determined. The points are selected in such a way that no turning point is set for the two polynomials.

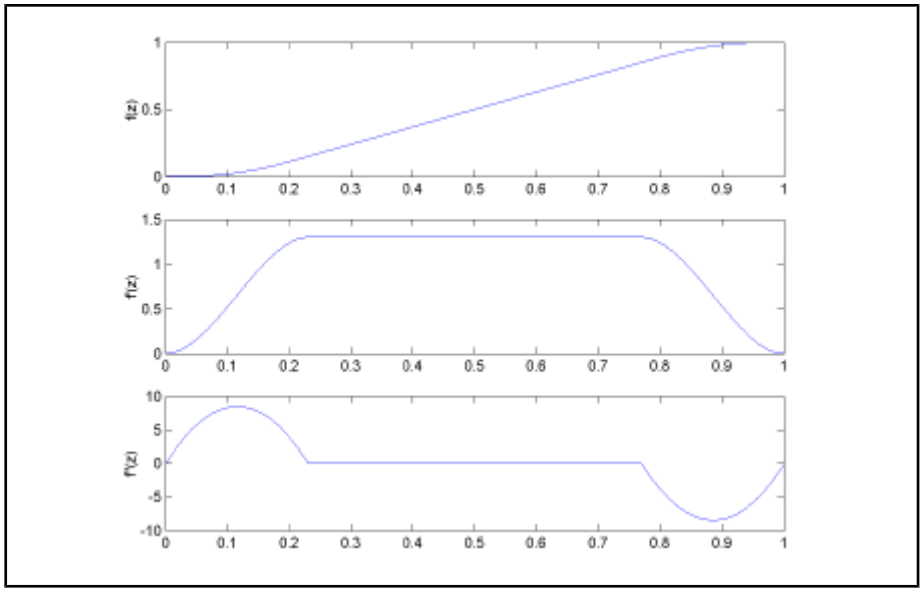

Fig.13-63: Graph: Velocity-limited polynomial 5th order

Extended, Free of harmonics polynomial 5th order

The Free of harmonics polynomial 5th order recognizes and prevents possible polynomial overshoot. The kind of modification depends on the combination of the standardized marginal velocity values. Four cases result. This motion law cannot be used for combinations in which the normalized starting velocity V_1 and the normalized end velocity V_2 have different signs. This would mean that the motion path would have a bend at a limit point, if it was not able to leave the normalized range of 0 <= z <=1 and 0 <=f(z) <= 1.

- Case 1:

  V_0<=1 and V_1<=1

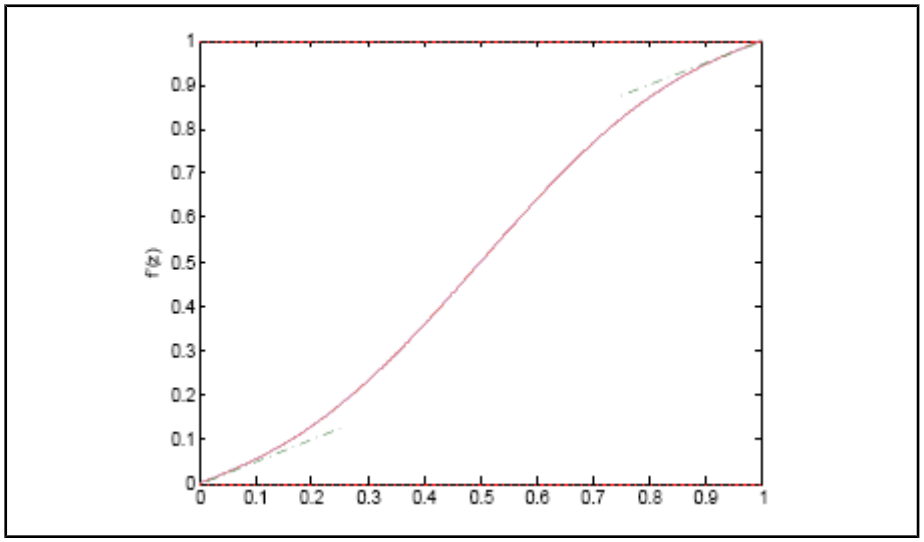

Fig.13-64: Case 1

- Case 2:

  V_0<=1 and V_1>1

Motion Laws

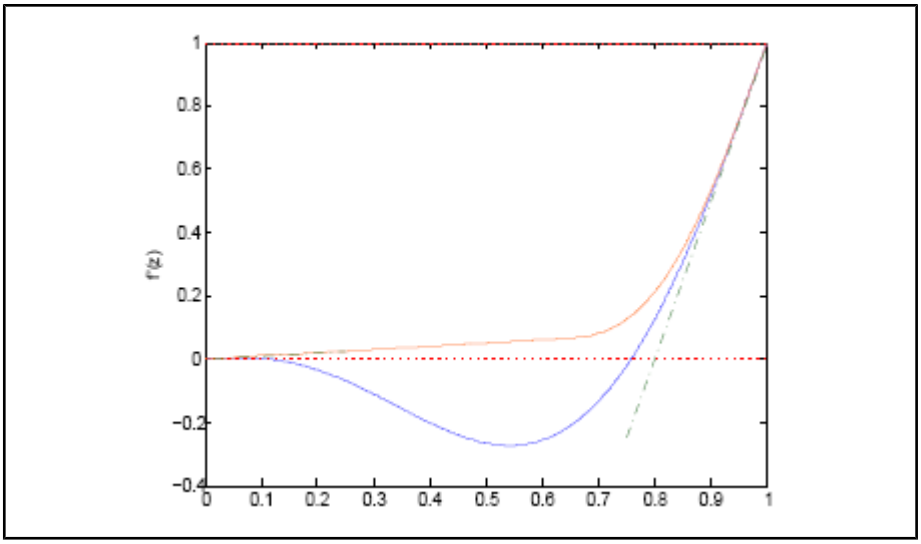

Fig. 13-65: Case 2

- Case 3:
  V_0>1 and V_1<=1

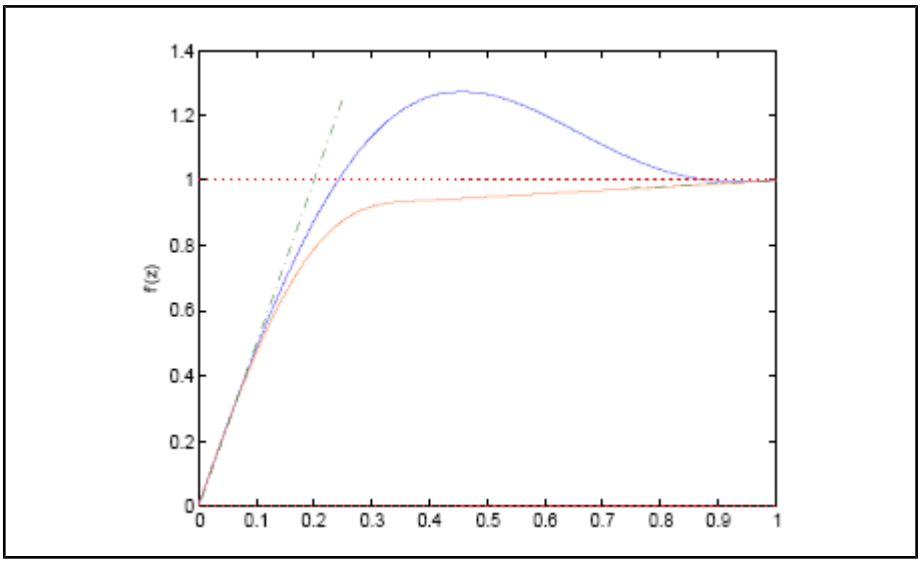

Fig. 13-66: Case 3

- Case 4:
  V_0>1 and V_1>1

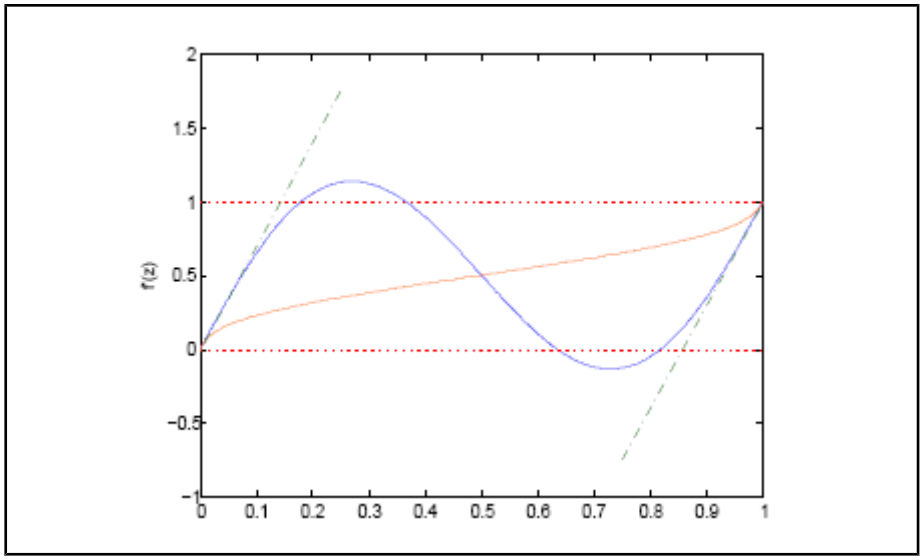

Fig. 13-67: Case 4

13.3 Cam Tables

The slave axis motion of a motion step can be defined by means of a cam table.

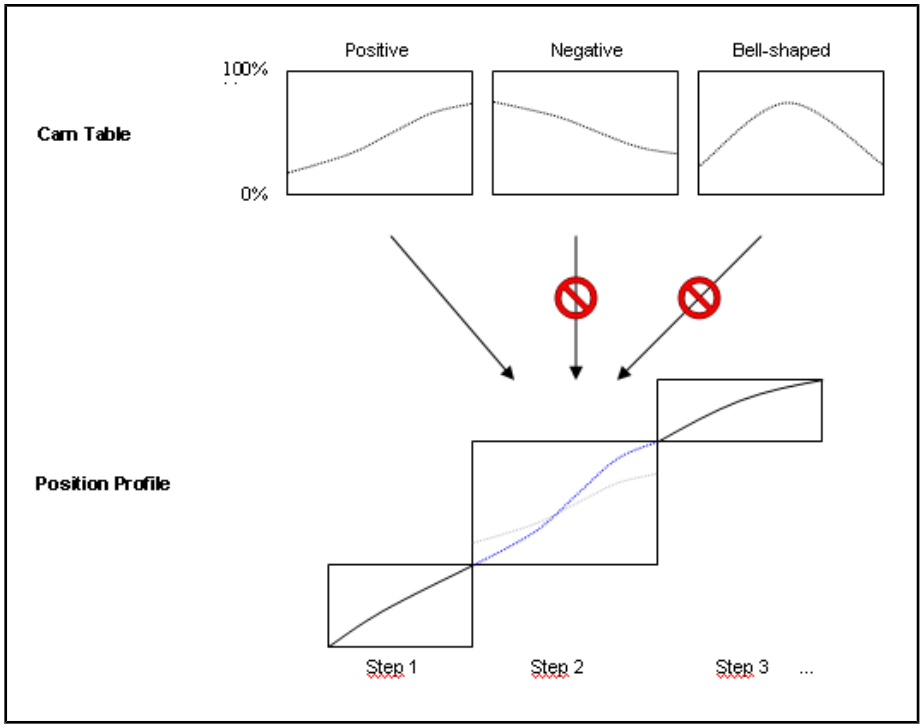

Fig. 13-68: Cam tables supported by the CamBuilder

In order to allocate a cam table to a motion step as a motion law using CamBuilder, the menu item **Cam Table ▸ Import Cam Table...** has to be selected as a motion law in the Motion Step Editor or an existing imported table will be selected. A new Import dialog opens if a new table is to be imported.

There are three different options to select a cam table:

1. Importing a cam table from a cam in the current project

   All the cams of the current project are listed and can be selected in a selection dialog.

2. Importing a cam table from a parameter file
3. Importing a cam table from a CSV file

With cams from the project, it is possible to state how many data points have to be created (at least 3, at most 1024.) Moreover, the distance can be specified for calculating the data points (0 corresponds to an automatic distance factor - base points from 0% to 100%.) Following the import, a memory space number has to be defined for the subsequent memory location on a device for this selected cam table.

A differentiation is made between cams, which consists of one or multiple motion steps, when processing cam tables in the CamBuilder.

Cams consisting of one motion step:

All cam table forms are supported here, that is to say cam tables whose end value is greater or less than the starting value. Starting values not equal to 0 are also allowed, as are cam tables with the same starting and end points (e.g. bell). The behavior here is identical to the MotionProfile, that is to say that points from the cam table are simply multiplied by the distance (no offset, no scaling).

Cams consisting of multiple motion steps:

Cam tables, the end point of which is greater than the starting point, are scaled in such a way that they end at 100%. A starting point, which is not equal to 0%, is offset to 0%. Thus, the entire cam table is automatically adapted to the distance preset for the respective motion step. Cam tables with the same or smaller end point than the starting point are not supported.

14 Service and Support

Our service helpdesk at our headquarters in Lohr, Germany and our worldwide service will assist you with all kinds of enquiries. You can reach us **around the clock - even on weekend and on holidays**.

	Helpdesk	Service Hotline Worldwide
Phone	**+49 (0) 9352 40 50 60**	Outwith Germany please contact our sales/service office in your area first. For hotline numbers refer to the sales office addresses on the Internet.
Fax	**+49 (0) 9352 40 49 41**	
E-mail	service.svc@boschrexroth.de	
Internet	http://www.boschrexroth.com You will also find additional notes regarding service, maintenance (e.g. delivery addresses) and training.	

Preparing Information

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

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

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