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Purpose of Documentation This documentation describes function modules, functions, and data types of the library "ML_TechCrank" in the design for the IndraMotion MLC 09VRS.

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1 Important Instructions on Use

1.1 Intended Use

1.1.1 Introduction

All Bosch Rexroth controls and drives are developed and tested in accordance with the state of the art technology.

It is not possible to track the continuous further improvement of all materials our controls and drives may come into contact with (e.g. lubricants at machine tools). Reactions with the materials used in the Bosch systems cannot generally be excluded.

Therefore, before using new lubricants, cleaning agents etc., must be checked for compatibility with the Bosch housing and device materials.

The products may only be used for the intended purpose. When they are not used as intended, situations may arise resulting in damage to person or material.



Bosch Rexroth, as the manufacturer of the products, shall not assume any warranty, liability or payment of damages in case of damage resulting from a non-intended use of the products. If the user fails to use the products as intended, the user shall assume sole responsibility for any resulting risks.

Before using Bosch Rexroth products, the following prerequisites must be fulfilled to ensure their proper use:

- Anyone using our products must read and understand the corresponding safety notes and intended use of the product.
- If the products are hardware, they must be kept in their original state, i.e. no constructional modifications should be made. Software products may not be decompiled; their source codes may not be modified.
- Damaged or defective products must not be installed or put into operation.
- It must be ensured that the products are installed according to the regulations specified in the documentation.

1.1.2 Scope of Use and Application

Bosch Rexroth drive controllers are intended to control electrical motors and monitor their operation.

To control and monitor the motor, it may be necessary to connect additional sensors and actuators.



The drive controllers must only be used with the accessories and mounting parts listed in this documentation. Do not install or connect components not expressly specified in this documentation. This also applies to cables and lines.



The unit may be operated only with the explicitly specified component configurations and combinations and only with the software and firmware specified in the appropriate functional description.

Before commissioning, every drive controller must be programmed to ensure that the motor executes the appropriate functions for the application.

Important Instructions on Use

The drive controllers have been developed for use in single and multi-axes drive and control tasks.

To allow for application-specific requirements in the drive controllers, our product range comprises various device types with different drive powers and interfaces.

The drive controller 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 this documentation.

1.2 Improper Use

The use of the drive controllers in applications other than those specified or described in the documentation and the technical data is considered as "improper".

Drive controllers must not be used if they ...

- are subjected to operating conditions not corresponding to the specified ambient conditions. They must not be operated under water, under extreme temperature fluctuations, or within extreme maximum temperatures.
- Furthermore, the drive controllers can only be used in applications approved by Bosch Rexroth. Please note the specifications outlined in the general safety instructions!

2 Safety Instructions for Electric Drives and Controls

2.1 Safety Instructions - General Information

2.1.1 Using the Safety Instructions and Passing them on to Others

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

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



WARNING

Improper use of these devices, failure to follow the safety instructions in this document or tampering with the product, including disabling of safety devices, may result in material damage, bodily harm, electric shock or even death!

Observe the safety instructions!

2.1.2 How to Employ the Safety Instructions

Read these instructions before initial commissioning of the equipment in order to eliminate the risk of bodily harm and/or material damage. Follow these safety instructions at all times.

- Bosch Rexroth AG is not liable for damages resulting from failure to observe the warnings provided in this documentation.
- Read the operating, maintenance and safety instructions in your language before commissioning the machine. If you find that you cannot completely understand the documentation for your product, please ask your supplier to clarify.
- Proper and correct transport, storage, assembly and installation, as well as care in operation and maintenance, are prerequisites for optimal and safe operation of this device.
- Only assign trained and qualified persons to work with electrical installations:
 - Only persons who are trained and qualified for the use and operation of the device may work on this device or within its proximity. The persons are qualified if they have sufficient knowledge of the assembly, installation and operation of the product, as well as an understanding of all warnings and precautionary measures noted in these instructions.
 - Furthermore, they must be trained, instructed and qualified to switch electrical circuits and devices on and off in accordance with technical safety regulations, to ground them and to mark them according to the requirements of safe work practices. They must have adequate safety equipment and be trained in first aid.
- Only use spare parts and accessories approved by the manufacturer.

Safety Instructions for Electric Drives and Controls

- Follow all safety regulations and requirements for the specific application as practiced in the country of use.
- The devices have been designed for installation in industrial machinery.
- The ambient conditions given in the product documentation must be observed.
- Only use safety-relevant applications that are clearly and explicitly approved in the Project Planning Manual. If this is not the case, they are excluded. Safety-relevant are all such applications which can cause danger to persons and material damage.
- The information given in the documentation of the product with regard to the use of the delivered components contains only examples of applications and suggestions.

The machine and installation manufacturer must

- make sure that the delivered components are suited for his individual application and check the information given in this documentation with regard to the use of the components,
- make sure that his 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 permitted once it is sure that the machine or installation in which they are installed complies with the national regulations, safety specifications and standards of the application.
- Operation is only permitted 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 documentation (Project Planning Manuals of components and system).
The machine or installation manufacturer is responsible for compliance with the limiting values as prescribed in the national regulations.
- Technical data, connection and installation conditions are specified in the product documentation and must be followed at all times.

National regulations which the user must take into account

- European countries: according to 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)

2.1.3 Explanation of Warning Symbols and Degrees of Hazard Seriousness

The safety instructions describe the following degrees of hazard seriousness. The degree of hazard seriousness informs about the consequences resulting from non-compliance with the safety instructions:

Safety Instructions for Electric Drives and Controls




Warning symbol	Signal word	Degree of hazard seriousness acc. to ANSI Z 535.4-2002
	Danger	Death or severe bodily harm will occur.
	Warning	Death or severe bodily harm may occur.
	Caution	Minor or moderate bodily harm or material damage may occur.

Fig.2-1: Hazard classification (according to ANSI Z 535)

2.1.4 Hazards by Improper Use

**DANGER****High electric voltage and high working current! Risk of death or severe bodily injury by electric shock!**

Observe the safety instructions!

**DANGER****Dangerous movements! Danger to life, severe bodily harm or material damage by unintentional motor movements!**

Observe the safety instructions!

**WARNING****High electric voltage because of incorrect connection! Risk of death or bodily injury by electric shock!**

Observe the safety instructions!

**WARNING****Health hazard for persons with heart pacemakers, metal implants and hearing aids in proximity to electrical equipment!**

Observe the safety instructions!

**CAUTION****Hot surfaces on device housing! Danger of injury! Danger of burns!**

Observe the safety instructions!

**CAUTION****Risk of injury by improper handling! Risk of bodily injury by bruising, shearing, cutting, hitting or improper handling of pressurized lines!**

Observe the safety instructions!



CAUTION

Risk of injury by improper handling of batteries!

Observe the safety instructions!

2.2 Instructions with Regard to Specific Dangers

2.2.1 Protection Against Contact with Electrical Parts and Housings



This section concerns devices and drive components with voltages of **more than 50 Volt**.

Contact with parts conducting voltages above 50 Volts can cause personal danger and electric shock. When operating electrical equipment, it is unavoidable that some parts of the devices conduct dangerous voltage.



DANGER

High electrical voltage! Danger to life, electric shock and severe bodily injury!

- Only those trained and qualified to work with or on electrical equipment are permitted to operate, maintain and repair this equipment.
- Follow general construction and safety regulations when working on power installations.
- Before switching on the device, the equipment grounding conductor must have been non-detachably connected to all electrical equipment in accordance with the connection diagram.
- Do not operate electrical equipment at any time, even for brief measurements or tests, if the equipment grounding conductor is not permanently connected to the mounting points of the components provided for this purpose.
- Before working with electrical parts with voltage potentials higher than 50 V, the device must be disconnected from the mains voltage or power supply unit. Provide a safeguard to prevent reconnection.
- With electrical drive and filter components, observe the following:
Wait **30 minutes** after switching off power to allow capacitors to discharge before beginning to work. Measure the electric voltage on the capacitors before beginning to work to make sure that the equipment is safe to touch.
- Never touch the electrical connection points of a component while power is turned on. Do not remove or plug in connectors when the component has been powered.
- Install the covers and guards provided with the equipment properly before switching the device on. Before switching the equipment on, cover and safeguard live parts safely to prevent contact with those parts.
- A residual-current-operated circuit-breaker or r.c.d. cannot be used for electric drives! Indirect contact must be prevented by other means, for example, by an overcurrent protective device according to the relevant standards.
- Secure built-in devices from direct touching of electrical parts by providing an external housing, for example a control cabinet.

Safety Instructions for Electric Drives and Controls



For electrical drive and filter components with voltages of **more than 50 volts**, observe the following additional safety instructions.



High housing voltage and high leakage current! Risk of death or bodily injury by electric shock!

- Before switching on, the housings of all electrical equipment and motors must be connected or grounded with the equipment grounding conductor to the grounding points. This is also applicable before short tests.
- The equipment grounding conductor of the electrical equipment and the devices must be non-detachably and permanently connected to the power supply unit at all times. The leakage current is greater than 3.5 mA.
- Over the total length, use copper wire of a cross section of a minimum of 10 mm² for this equipment grounding connection!
- Before commissioning, also in trial runs, always attach the equipment grounding conductor or connect to the ground wire. Otherwise, high voltages may occur at the housing causing electric shock.

2.2.2 Protection Against Electric Shock by Protective Extra-Low Voltage

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

All connections and terminals with voltages between 5 and 50 volts at Rexroth products are PELV systems. ¹⁾ It is therefore allowed to connect devices equipped with basic insulation (such as programming devices, PCs, notebooks, display units) to these connections and terminals.



High electric voltage by incorrect connection! Risk of death or bodily injury by electric shock!

If extra-low voltage circuits of devices containing voltages and circuits of more than 50 volts (e.g. the mains connection) are connected to Rexroth products, the connected extra-low voltage circuits must comply with the requirements for PELV. ²⁾

2.2.3 Protection Against Dangerous Movements

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

- improper or wrong wiring of cable connections
- incorrect operation of the equipment components
- wrong input of parameters before operation
- malfunction of sensors, encoders and monitoring devices
- defective components
- software or firmware errors

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

1) "Protective Extra-Low Voltage"

2) "Protective Extra-Low Voltage"

Safety Instructions for Electric Drives and Controls

The monitoring in the drive components will normally be sufficient to avoid faulty operation in the connected drives. Regarding personal safety, especially the danger of bodily harm and material 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.

**DANGER****Dangerous movements! Danger to life, risk of injury, severe bodily harm or material damage!**

- Ensure personal safety by means of qualified and tested higher-level monitoring devices or measures integrated in the installation.

These measures have to be provided for by the user according to the specific conditions within the installation and a hazard and fault analysis. The safety regulations applicable for the installation have to be taken into consideration. Unintended machine motion or other malfunction is possible if safety devices are disabled, bypassed or not activated.

To avoid accidents, bodily harm and/or material damage:

- Keep free and clear of the machine's range of motion and moving parts. Possible measures to prevent people from accidentally entering the machine's range of motion:
 - use safety fences
 - use safety guards
 - use protective coverings
 - install light curtains or light barriers
- Fences and coverings must be strong enough to resist maximum possible momentum.
- Mount the emergency stop switch in the immediate reach of the operator. Verify that the emergency stop works before startup. Don't operate the device if the emergency stop is not working.
- Isolate the drive power connection by means of an emergency stop circuit or use a safety related starting lockout to prevent unintentional start.
- Make sure that the drives are brought to a 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 equilibration of the vertical axes.
- The standard equipment motor brake or an external brake controlled directly by the drive controller are **not sufficient to guarantee personal safety!**
- Disconnect electrical power to the equipment using a master switch and secure the switch against reconnection 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 electronics circuits and supply leads. If the use of such devices cannot be avoided, verify the system and the installation for possible malfunctions in all possible positions of normal use before initial startup. If necessary, perform a special electromagnetic compatibility (EMC) test on the installation.

2.2.4 Protection Against Magnetic and Electromagnetic Fields During Operation and Mounting

Magnetic and electromagnetic fields generated by current-carrying conductors and permanent magnets in motors represent a serious personal danger to those with heart pacemakers, metal implants and hearing aids.



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

- Persons with heart pacemakers and metal implants are not permitted to enter following areas:
 - Areas in which electrical equipment and parts are mounted, being operated or commissioned.
 - Areas in which parts of motors with permanent magnets are being stored, repaired or mounted.
- If it is necessary for somebody with a pacemaker to enter such an area, a doctor must be consulted prior to doing so. The noise immunity of present or future implanted heart pacemakers differs greatly so 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. Otherwise health hazards may occur.

2.2.5 Protection Against Contact with Hot Parts



Hot surfaces at motor housings, on drive controllers or chokes! Danger of injury! Danger of burns!

- Do not touch surfaces of device housings and chokes in the proximity of heat sources! Danger of burns!
- Do not touch housing surfaces of motors! Danger of burns!
- According to the operating conditions, temperatures can be **higher than 60 °C, 140°F** during or after operation.
- Before accessing motors after having switched them off, let them cool down for a sufficiently long time. Cooling down can require **up to 140 minutes!** Roughly estimated, the time required for cooling down is five times the thermal time constant specified in the Technical Data.
- After switching drive controllers or chokes 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, the manufacturer of the end product, machine or installation, according to the respective safety regulations, has to take measures to avoid injuries caused by burns in the end application. These measures can be, for example: warnings, guards (shielding or barrier), technical documentation.

2.2.6 Protection During Handling and Mounting

In unfavorable conditions, handling and mounting certain parts and components in an improper way can cause injuries.

**CAUTION****Risk of injury by improper handling! Bodily injury by bruising, shearing, cutting, hitting!**

- Observe the general construction and safety regulations on handling and mounting.
- Use suitable devices for mounting and transport.
- Avoid jamming and bruising by appropriate measures.
- Always use suitable tools. Use special tools if specified.
- Use lifting equipment and tools in the correct manner.
- If necessary, use suitable protective equipment (for example safety goggles, safety shoes, safety gloves).
- Do not stand under hanging loads.
- Immediately clean up any spilled liquids because of the danger of skidding.

2.2.7 Battery Safety

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

**CAUTION****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 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 electrical parts installed in the devices.
- Only use the battery types specified by the manufacturer.



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 separate from other waste. Observe the local regulations in the country of assembly.

2.2.8 Protection Against Pressurized Systems

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

Safety Instructions for Electric Drives and Controls



CAUTION

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 (for example safety goggles, safety shoes, safety gloves).
 - Immediately clean up any spilled liquids from the floor.
-



Environmental protection and disposal! The agents used to operate the product might not be economically friendly. Dispose of ecologically harmful agents separately from other waste. Observe the local regulations in the country of assembly.

3 Functions and Function Modules for the Crank Kinematics

3.1 Introduction and Overview

The functions and function modules described in this section serve for converting translational into rotational movements (crank angle) and vice versa, and are designed for crank kinematics applications.

Crank kinematics often are used to drive transverse sealing shoes in tubular bag machines or forming and punching tools in thermoforming machines. The translational slide in this kinematics is moved by the rotational movement of a crank. In doing so, the pivot point of the crank can be offset in relation to the translational movement (de-axiation).

In case of the crank kinematics below, the set points and actual values are to be specified respectively displayed in translational units, although the measurement system works in rotational units.

That is why the set points and actual values have to be converted from translational to rotational units and vice versa.

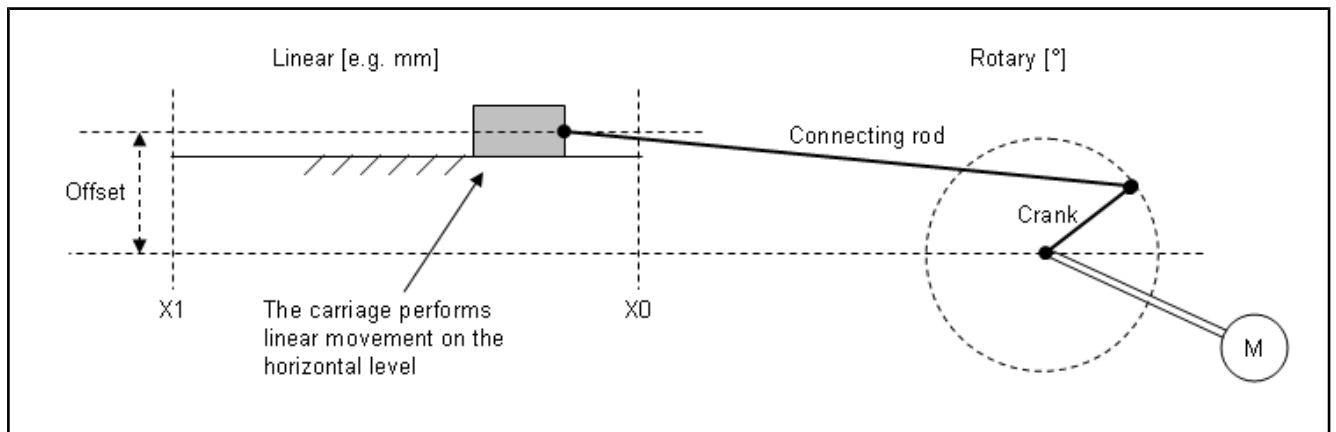


Fig.3-1: Single axis crank kinematics with offset crank axis

The following functions and function modules are supported:

Function	Description
MB_MasterToPhi	Displays crank angles calculated on the basis of the guide axis position and the superimposed cam disk.

Fig.3-2: Crank kinematics function

Function module	Description
MB_CamTableCrank	Calculates the cam disk for transforming a translational virtual guide axis position into rotational values (crank angle).
MB_CamTableCrankSuperimposed	Superimposes a user cam disk with the transformation can disk for a superimposed cam disk.

Functions and Function Modules for the Crank Kinematics

Function module	Description
MB_PhiToXvirt	Converts crank angle (Phi) into virtual translational position values (Xvirt) to be used by the PLC program.
MB_XvirtToXmech	Converts virtual translational position values (Xvirt) into mechanic translational position values (Xmech).

Fig.3-3: Crank kinematics function modules

Typical application examples are as follows:

Application Case 1: Operating Mode Single Axis

The term single axis mode relates to the positioning- or velocity-controlled operation of the translational axis. In the present application a virtual guide axis (with translational weighting) is moved by positioning or velocity control function modules (e.g. MC_MoveAbsolute, MC_MoveRelative or MC_MoveVelocity).

The virtual guide axis position is converted from translational position values into crank angle values by the transformation cam disk. The transformation cam disk is calculated by the function module MB_CamTableCrank and activated with the function module MC_CamIn. Then, the crank axis follows the virtual guide axis (issuing translational units), at which the transformation cam disk converts the translational position values into crank angle values. Detailed information can be found in [chapter 3.3 "MB_CamTableCrank" on page 17](#).

Application Case 2: Synchronous Operation with Cam Disk

In this application case, a translational axis having a user-defined cam disk profile follows a guide axis. The user-defined cam disk exclusively relates to the translational axis. Thus, the transfer behavior of the crank does not have to be taken into account in the user-defined cam disk.

The user defined cam disk is superimposed with a transformation cam disk by the function module MB_CamTableSuperimposed, and the resulting cam disk is transferred to the drive by the PLC program. Detailed information can be found in [chapter 3.4 "MB_CamTableCrankSuperimposed" on page 20](#).

Reversed Transformation

In both of the application cases described above, translational units are converted into rotational units (set point path). Using the reversed transformation via the function module MB_PhiToXvirt, the translational position from the crank angle further can be determined in the PLC program. Detailed information can be found in [chapter 3.5 "MB_PhiToXvirt" on page 23](#).

Functions and Function Modules for the Crank Kinematics

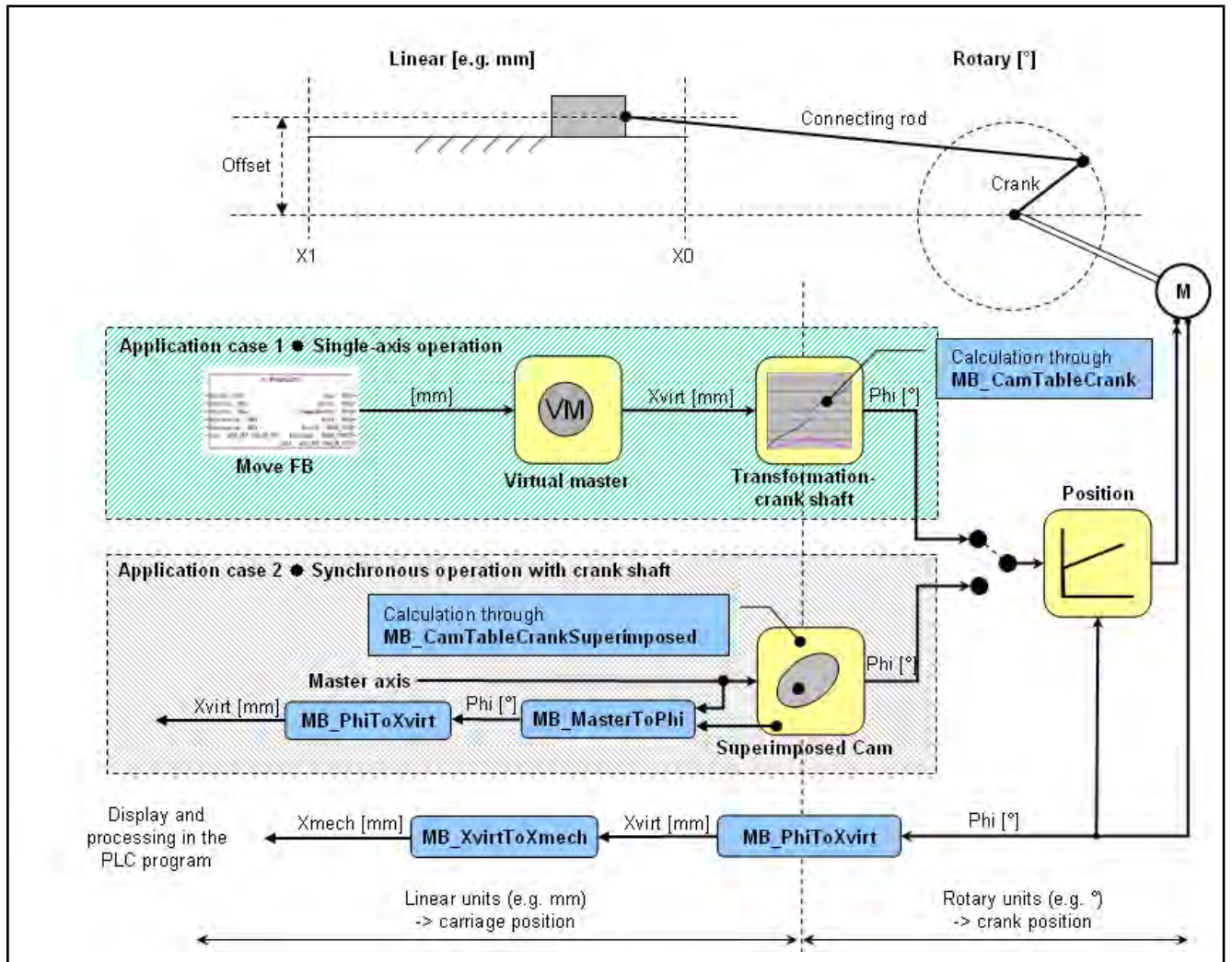


Fig.3-4: Schematic representation of the crank kinematics technology function modules

3.2 General Definitions

The following illustrations depict the relations between crank and translational coordinates, as well as the importance of different mechanical parameters.

Functions and Function Modules for the Crank Kinematics

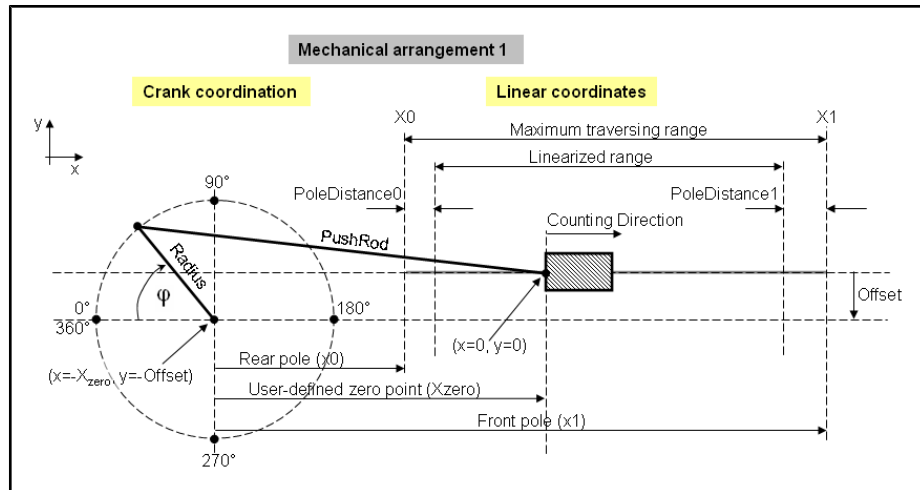


Fig.3-5: Mechanical arrangement 1: Relation of crank and translational coordinates in case of the crank kinematics

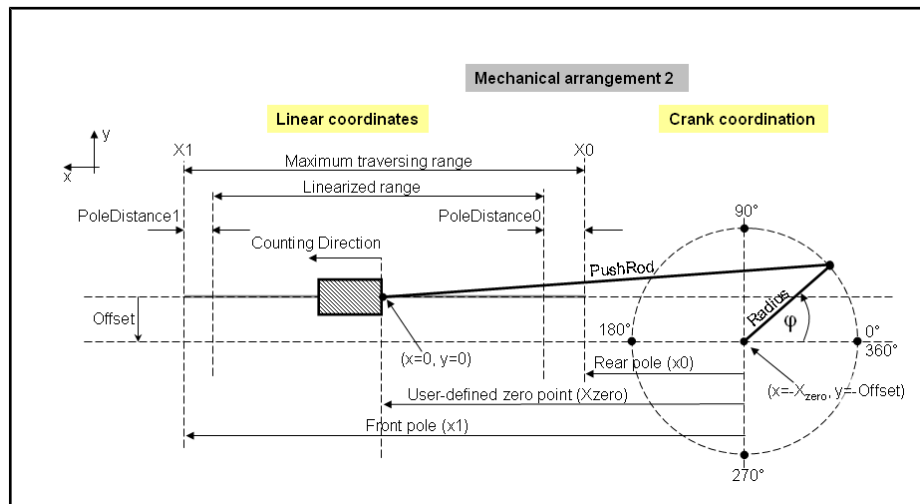


Fig.3-6: Mechanical arrangement 2: Relation of crank and translational coordinates in case of the crank kinematics

Variable / term	Definition
XNull	Distance between crank pivot point and slide zero point on the X-axis.
PoleDistance0 PoleDistance1	At the poles X0 / X1, the direction of the translational axis is reversed. X0 is described as rear and X1 as front pole.
Maximum traversing range	Traversing range of the translational coordinate system = $ X1-X0 $.
Linearized range	In the linearized range, no backup polynomial is effective.
Transformation cam disk	Converts translational (mm) coordinates into crank angles (degrees).

Fig.3-7: Variable and terms

Counting Direction

To the mechanical arrangements shown in fig. 3-5 "Mechanical arrangement 1: Relation of crank and translational coordinates in case of the crank kinematics" on page 16 and fig. 3-6 "Mechanical arrangement 2: Relation of crank and translational coordinates in case of the crank kinematics" on page 16 the following counting directions are applicable in general:

- Counting direction of the crank angle:
 - Mechanical arrangement 1:
 - Clockwise, starting on the left with 0° and terminating with 360°

Functions and Function Modules for the Crank Kinematics

- Mechanical arrangement 2:
Counterclockwise, starting on the right with 0° and terminating with 360°
- Counting direction of the translational slide:
 - Mechanical arrangement 1:
Increasing numerical values to the right
 - Mechanical arrangement 2:
Increasing numerical values to the left

Mechanical (Xmech) and Virtual (Xvirt) Translational Position

Mechanically, the slide (translational axis) can move between the rear (X0) and the front (X1) pole. Between these two limits, the "maximum traversing range" is situated. Every mechanical translational position (Xmech) corresponds to two different crank angles. Thus, the virtual translational position (Xvirt) serves for assigning a unique translational position to every crank angle. The virtual translational position thus moves to positive direction, even though the mechanical position (Xmech) reverses the direction by exceeding the pole. The modulo overflow of Xvirt is defined by the user with the help of the zero point (Xnull). Furthermore, the modulo value of Xvirt corresponds to the double traversing range of the crank kinematics. The traversing range is determined as follows:

$$\text{Travelrange} = (\text{FrontPolePoint} - \text{RearPolePoint})$$

$$\text{Travelrange} = \sqrt{(\text{Radius} + \text{PushRod})^2 - \text{Offset}^2} - \sqrt{(\text{Radius} - \text{PushRod})^2 - \text{Offset}^2}$$

Fig.3-8: Traversing range equation for the crank kinematic

The following illustration depicts Xvirt and Xmech in an example:

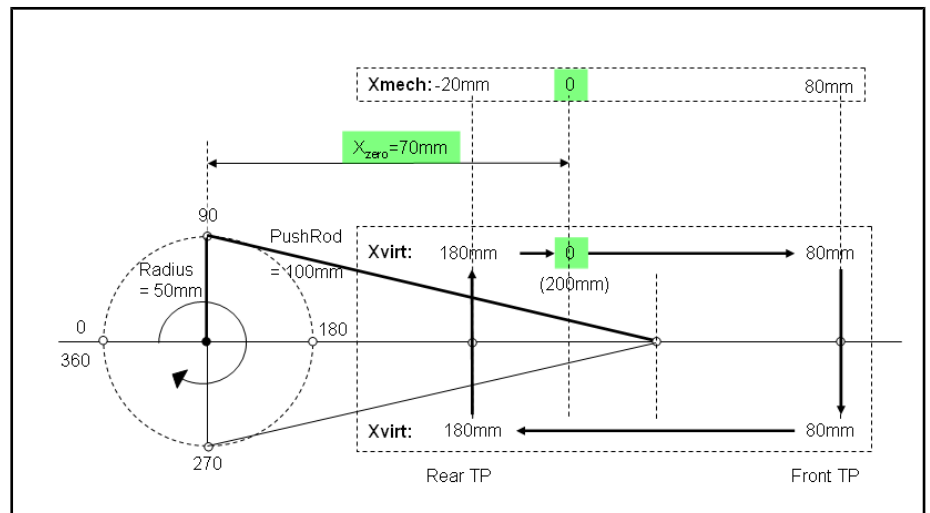


Fig.3-9: Counting direction of the slide position (Xvirt and Xmech)

3.3 MB_CamTableCrank

Short Description

The function module MB_CamTableCrank calculates a transformation cam disk on the basis of the crank-specific input values (with 1024 data points). This transformation cam disk converts translational position values into rotational position values (crank angle) to be used in a crank kinematics. It allows for coupling a translational virtual guide axis with a rotational crank drive. Detailed

Functions and Function Modules for the Crank Kinematics

information can be found in [chapter 3.1 "Introduction and Overview"](#) on page 13.

The linear range is set using the inputs "PoleDistance0" and "PoleDistance1". Outside of the linear range the crank drive is approximated using a polynomial to limit the dynamics in the area of the poles. During transition in and from the linearized range, position, velocity and acceleration are constant.

The function module provides the calculated transformation cam disk using VAR_IN_OUT "CamTable". The calculated cam disk is provided using VAR_IN_OUT "CamTable" and first has to be transferred to the drive or the control system to be used. Furthermore, the corresponding synchronous operating mode has to be activated.

Interface Description

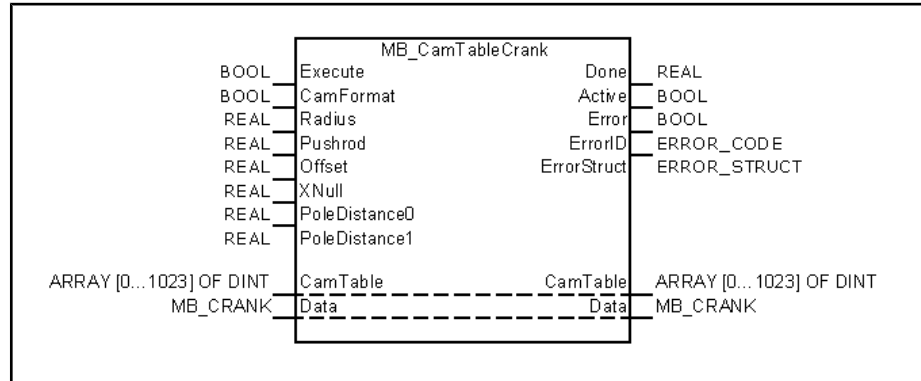


Fig.3-10: MB_CamTableCrank function module

I/O type	Name	Data type	Description
VAR_IN_OUT	CamTable	ARRAY[0..1023] OF DINT	Array with the data of the calculated transformation cam disk.
	Data	MB_CRANK	Structure with internally calculated data of the crank kinematics. The data are calculated in this function module and transferred to other function modules.
VAR_INPUT	Execute	BOOL	Calculation of the transformation cam disk is triggered by a positive pitch.
	CamFormat	BOOL	TRUE = new format (last point = first point = 360°) FALSE = old format (last point = 360° - d)
	Radius	REAL	Crank length in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Offset	REAL	Offset of the slide level regarding the crank center [mm]
	XNull	REAL	Distance between crank center and slide zero point [mm]
	PoleDistance0	REAL	Distance between the rear pole X0 [mm] and the linearized range, in which the movement is influenced by the limited drive dynamics.
	PoleDistance1	REAL	Distance between the front pole X1 [mm] and the linearized range, in which the movement is influenced by the limited drive dynamics.

Functions and Function Modules for the Crank Kinematics

I/O type	Name	Data type	Description
VAR_OUTPUT	Done	BOOL	Calculation finished, cam disk table data and output data are valid.
	Active	BOOL	Function module is being executed.
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorStruct	ERROR_STRUCT	Detailed error description

Fig. 3-11: I/O interface MB_CamTableCrank

Data Structure MB_Crank

The data structure MB_Crank is responsible for internal data exchange between function modules and functions. The content of the data structure MB_CRANK is calculated by the function modules MB_CamTableCrank and MB_CamTableCrankSuperimposed and is applicable to all remaining relevant function modules and functions.

Basic Condition

The following basic conditions have to be met to prevent PLC error messages:

Basic Condition	Reason
$Pushrod \geq Radius + Off-set $	If this basic condition is not met, the translational slide cannot traverse mechanically on a constant y-coordinate.
$(XNull \geq rear\ TP) \ \& \ (XNull \leq rear\ TP + 2 \times traversing\ range)$	The zero point has to be within the traversing range.

Fig. 3-12: Basic conditions

In order to be able to traverse the translational slide in single axis mode, the following configuration has to be conducted in IndraWorks:

- Translational weighting of the virtual axis with a modulo value of (2 x traversing range).
- Rotational weighting of the crank drive (real axis) with a modulo value of 360°.



In order to configure the scaling factors, IndraWorks has to be in online mode and the drive has to be in parameterizing mode.

Application Examples for MB_Cam-TableCrank

The following flowchart applies in an exemplary manner to positioning the translational axis:

1. The function module MB_CamTableCrank calculates the transformation cam disk.
2. The calculated transformation cam disk is written to the crank drive by the function module MB_WriteListParameter.
3. Using the function module MC-Power, the crank drive is activated.
4. Reference drive of the crank drive using MC_Home. This step is necessary, if there is no absolute sensor at the crank drive engine.
5. The crank angle is converted into a translational variable using the function module MB_PhiToXvirt.
6. The translational virtual guide axis is set to the actual position calculated on the basis of the crank angle. For this, function module MB_PhiToXvirt is used to determine the corresponding translational position from the crank angle. Afterwards, the virtual translational axis is set to this position (e.g. using MC_MoveAbsolute). After completion of the positioning movement, the transformation cam disk can be activated without synch-up movement.

Functions and Function Modules for the Crank Kinematics

7. Switching the crank drive to the cam disk operating mode using MC_CamIn. Setting the CamShaftDistance = 360, gear ratio to 1:1, selecting the transformation cam disk and the virtual guide axis as master. The crank drive does not move for synchronization with the virtual guide axis, as the virtual guide axis has been set to the crank position in step 6. If step 6 has not been conducted, the crank drive conducts a dynamic synch-up movement.
8. Now, the virtual axis can be moved in single axis mode using the function modules MC_MoveAbsolute and MC_MoveVelocity (the crank axis now follows the guide axis and in doing so uses the transformation cam disk).

3.4 MB_CamTableCrankSuperimposed

Short Description The function module MB_CamTableSuperimposed superimposes the user-defined cam disk (CamInput) with the transformation cam disk and issues the resulting cam disk via the output CamOutput. The transformation cam disk is calculated within the function module, comparable to the function module MB_CamTableCrank. The principle of superimposition is shown in [fig. 3-13 "Principle of a cam disk superimposition" on page 21](#). The user defined cam disk has to contain 1024 data points and has to define the movement of the translational axis in relation to the guide axis (irrespective of the crank kinematics). The 100 percent value of the table corresponds to the movement (2 x traversing range = modulo value of the virtual translational axis).

The calculated cam disk has to be transferred - before being used - to the drive or the control system, e.g. using MB_WriteListParameter or MB_ChangeCamData. Furthermore, the cam disk has to be activated by the corresponding motion function modules, such as MC_CamIn or MB_MotionProfile,

Notes for users

Depending on the corresponding end point of the user-defined cam disk, the following cases are distinguished:

- If the end point of the user-defined cam disk is near 100%, the crank does not reverse the direction (but rotations continually in the same direction). Energetically, this is the most economic procedure, as the natural movement of the crank is used.
- If the end point of the user-defined cam disk is 0%, a see-saw movement of the translational axis takes place, during which the crank changes direction continually (see figure below).

Functions and Function Modules for the Crank Kinematics

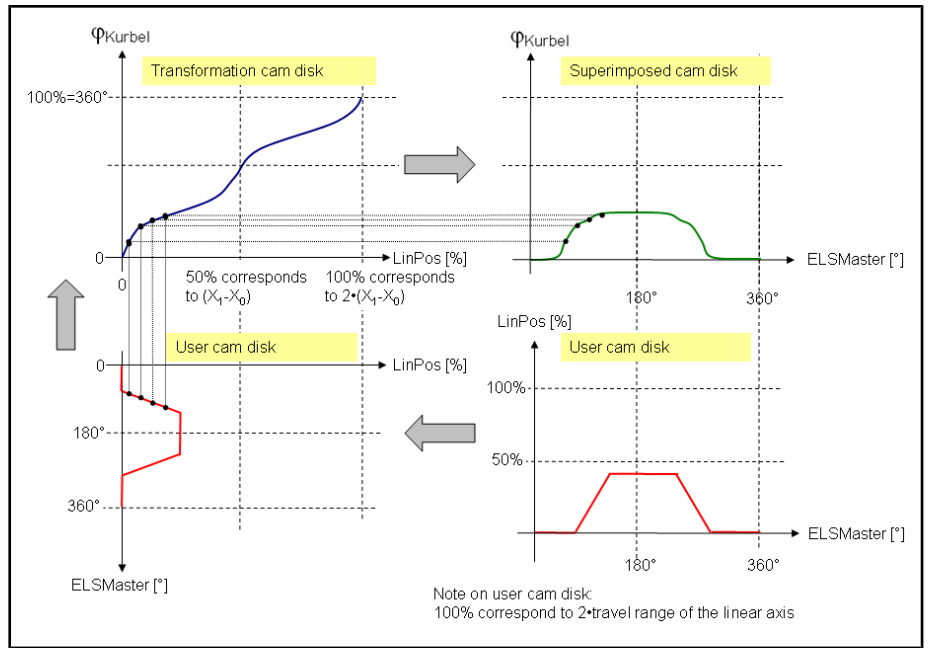


Fig.3-13: Principle of a cam disk superimposition

Interface Description

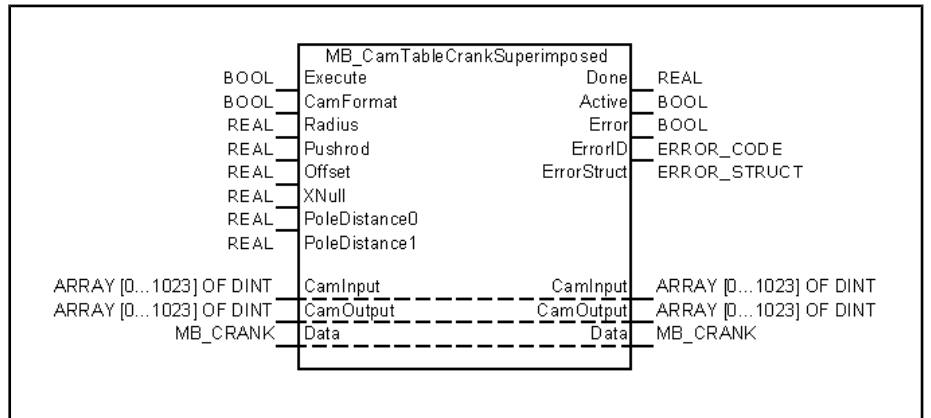


Fig.3-14: Function module MB_CamTable_Superimposed

I/O type	Name	Data type	Description
VAR_IN_OUT	CamInput	ARRAY[0..1023] OF DINT	Arrays with the points of the user cam disk relating exclusively to the translational movement.
	CamOutput	ARRAY[0..1023] OF DINT	Array with the points of the superimposed user cam disk.
	Data	MB_CRANK	Structure with internally calculated data of the crank kinematics. The data are calculated in this function module and then used by other function modules.

Functions and Function Modules for the Crank Kinematics

I/O type	Name	Data type	Description
VAR_INPUT	Execute	BOOL	Calculation of the superimposed cam disk is triggered by a positive pitch.
	CamFormat	BOOL	TRUE = new format (last point = first point = 360°) FALSE = old format (last point = 360° - d)
	Radius	REAL	Crank length in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Offset	REAL	Offset of the slide level regarding the crank center [mm].
	XNull	REAL	Distance between crank center and slide zero point [mm].
	PoleDistance0	REAL	Distance between the rear pole X0 [mm] and the linearized range, in which the movement is influenced by the limited drive dynamics.
PoleDistance1	REAL	Distance between the front pole X1 [mm] and the linearized range, in which the movement is influenced by the limited drive dynamics.	
VAR_OUTPUT	Done	BOOL	Calculation finished, cam disk table data and output data are valid.
	Active	BOOL	Function module is being executed.
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorStruct	ERROR_STRUCT	Detailed error description

Fig.3-15: I/O interface MB_CamTableSuperimposed

Basic Condition

Detailed information can be found in [chapter 3.3 "MB_CamTableCrank" on page 17](#).

In order to be able to traverse the translational slide in synchronous mode with a specified, user-defined cam disk, the following configuration has to be conducted in IndraWorks:

Rotational weighting of the crank drive (real axis) with a modulo value of 360°.



In order to configure the scaling factors, IndraWorks has to be in online mode and the drive has to be in parameterizing mode.

Application Example Superimposed Cam Disk

The following flowchart exemplarily applies to the synchronous mode of the translational axis:

1. Entry of a user cam disk using the input CamInput of the function module (e.g. by reading a drive cam disk or reading out from a file, etc.)
2. Calculation of the superimposed user cam disk with the function module MB_CamTableCrankSuperimposed. See diagram in [fig. 3-13 "Principle of a cam disk superimposition" on page 21](#).
3. The calculated superimposed cam disk is written to the crank drive by the function module MB_WriteListParameter for example.
4. Using the function module MC_Power, activate the crank drive.
5. Reference drive of the crank drive using FB_Home. This step is required, if no absolute sensor is used.
6. The position set point resulting from the superimposed user cam disk and the guide axis position may deviate from the actual position value of the

Functions and Function Modules for the Crank Kinematics

crank. Activating the user cam disk thus can be done using one of the following options:

- Activation of the cam disk operating mode without prior position alignment of the crank axis.
The crank axis synchronizes with a dynamic synch-up movement.
- The crank angle resulting from the guide axis position is calculated by the function module MB_MasterToPhi first. Afterwards, the crank axis is moved to this position using a positioning movement. Upon completion of the positioning movement, the superimposed user cam disk can be activated without dynamic synch-up movement.



The superimposed user cam disk should be activated using CamShaftDistance = 360°.

3.5 MB_PhiToXvirt

Short Description The function module MB_PhiToXvirt converts crank angle values (Phi) into virtual translational position values (Xvirt).

Interface Description

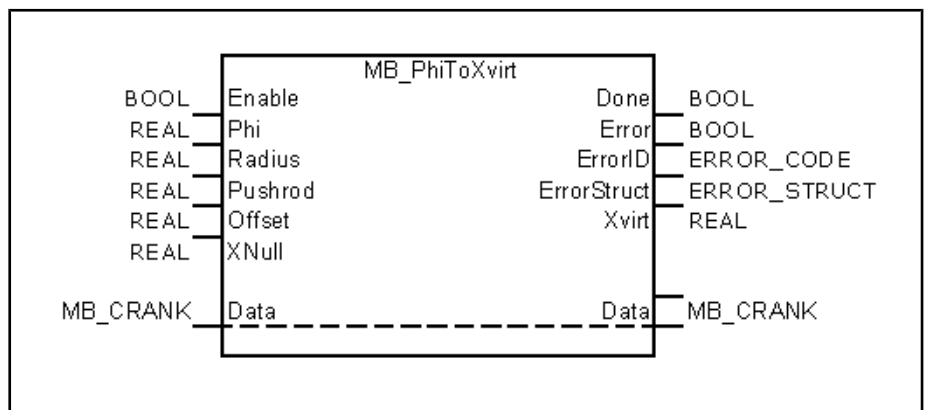


Fig.3-16: Function module MB_PhiToXvirt

I/O type	Name	Data type	Description
VAR_IN_OUT	Data	MB_CRANK	Structure with internal data of the crank kinematics (content of the data structure has to be calculated beforehand by MB_CamTableCrank respectively MB_CamTableCrankSuperimposed).
VAR_INPUT	Enable	BOOL	Calculation of Xvirt in every cycle, while Enable=TRUE
	Phi	REAL	Crank position in [°]
	Radius	REAL	Crank length in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Offset	REAL	Offset of the slide level regarding the crank center [mm]
	XNull	REAL	Distance between crank center and slide zero point [mm]
VAR_OUTPUT	Done	BOOL	Calculation complete, Xvirt valid
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorStruct	ERROR_STRUCT	Detailed error description
	Xvirt	REAL	Virtual translational position (Xvirt)

Fig.3-17: I/O interface of MB_PhiToXvirt

Functions and Function Modules for the Crank Kinematics

3.6 MB_MasterToPhi

Short Description The function MB_MasterToPhi provides the crank angle (Phi) calculated on the basis of the guide axis position (guide value) and the (superimposition) cam disk. The superimposed cam disk has to be calculated before retrieving this function (by MB_CamTableCrankSuperimposed). Using the position value provided by function MB_MasterToPhi, the crank drive can be set to the resulting synchronous position to prevent the dynamic synch-up movement when activating the synchronous operating mode

Interface Description

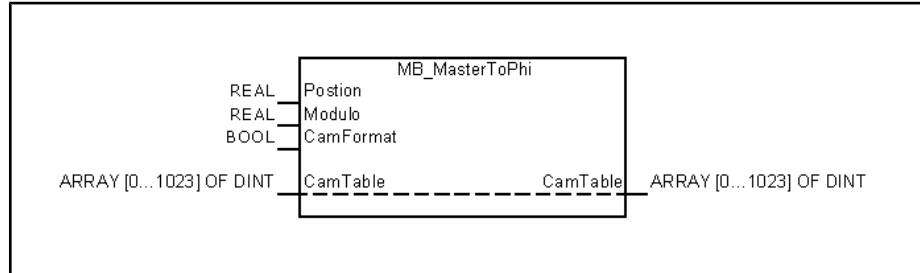


Fig.3-18: Function MB_MasterToPhi

I/O type	Name	Data type	Description
VAR_IN_OUT	CamTable	AR- RAY[0..1023] OF DINT	Array with the data of the superimposed cam disk.
VAR_INPUT	Position	REAL	Guide axis position
	Modulo	REAL	Modulo value of the guide axis
	CamFormat	BOOL	TRUE = new format (last point = first point = 360°) FALSE = old format (last point = 360° - d)

Fig.3-19: I/O interface of MB_MasterToPhi

3.7 MB_XvirtToXmech

Short Description The MB_XvirtToXmech function block converts the virtual translatory position (Xvirt) into the mechanical translatory position (Xmech) of the slide. Xmech values can be used for display purposes (e.g., HMI interface).

Interface Description

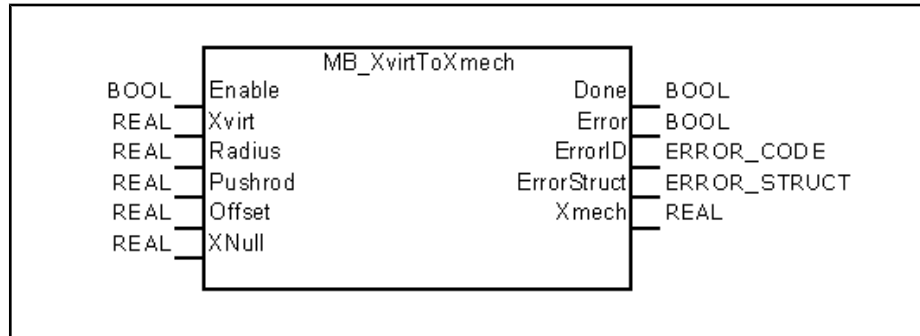


Fig.3-20: MB_XvirtToXmech Function Block

I/O Type	Name	Data Type	Comment
VAR_INPUT	Enable	BOOL	FB executes calculation while Enable=TRUE
	Xvirt	REAL	Virtual translatory position in [mm]
	Radius	REAL	Length of the crank in [mm]

Functions and Function Modules for the Crank Kinematics

I/O Type	Name	Data Type	Comment
	Pushrod	REAL	Length of the pushrod in [mm]
	Offset	REAL	Offset of the slide level to the crank center [mm]
	XNull	REAL	Distance from the crank center to the zero point of the slide [mm]
VAR_OUTPUT	Done	BOOL	Output value (Phi) is valid
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorStruct	ERROR_STRUCT	Detailed error description
	Xmech	REAL	Mechanical translatory position (Xmech) of the slide

Fig.3-21: MB_XvirtToXmech I/O Interface

4 Functions and Function Modules for Bell-Crank Lever Kinematics

4.1 Introduction and Overview

Bell-crank lever kinematics are used to drive forming tools for thermoforming machines or pressing machines for example. The following figure shows the mechanical structure of the bell-crank lever kinematics used below.

In case of this kinematics, turning crank 1 results in a translational movement in y direction. The crank is driven by the actuator. The measurement system is attached to the actuator and thus works in rotational units.

For the bell-crank lever kinematics shown, set points and actual values (such as position, velocity) are specified respectively displayed in translational units, although the measurement system works in a rotational manner. The Tech function modules described below conduct the corresponding transformations.

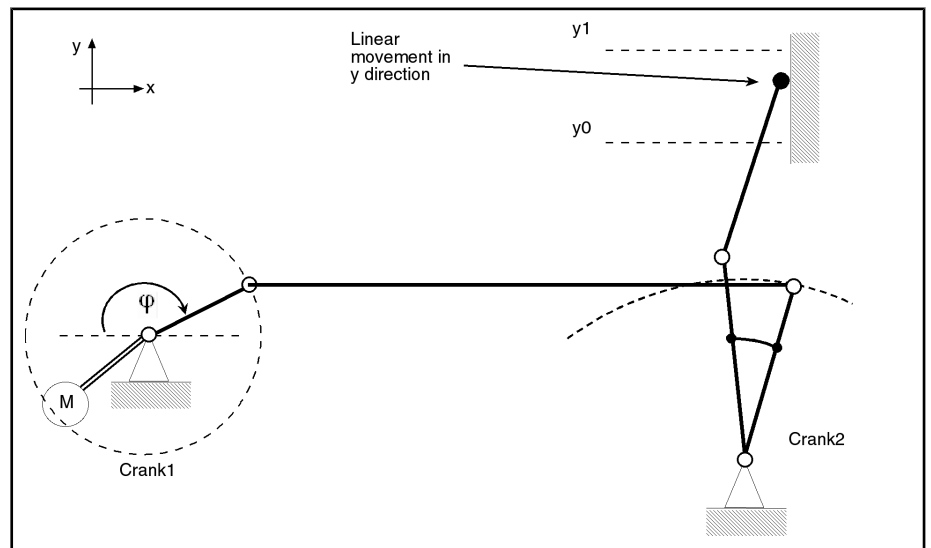


Fig.4-1: Bell-crank lever kinematics

4.2 General Definitions

Basic Variables The following illustration shows the relation between crank and translational coordinates, as well as the importance of the individual mechanical parameters.

Functions and Function Modules for Bell-Crank Lever Kinematics

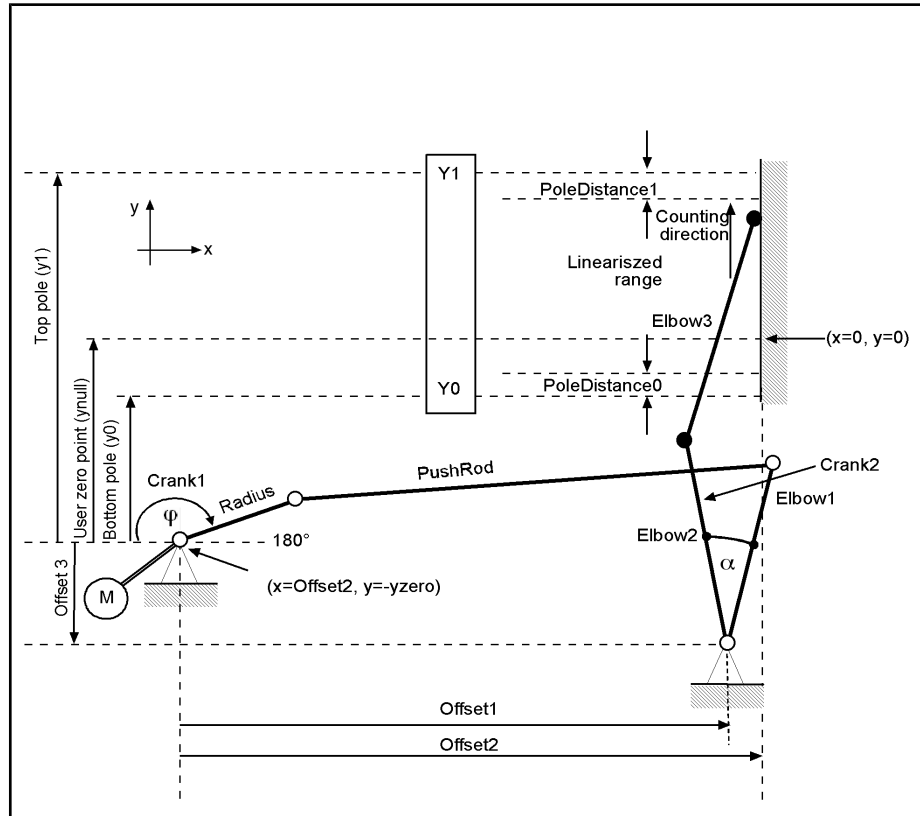


Fig.4-2: Relation crank and translational coordinates at the bell-crank lever kinematics

Counting Direction Basically, the following counting directions are applicable to the arrangement shown in figure 2:

- Counting direction of the crank angle:
Clockwise, starting on the left with 0° and terminating with 360°
- Counting mode of the translational y position:
Increasing numerical values in upwards direction

Mechanical (Ymech) and Virtual (Yvirt) Translational Position

A mechanical translational position (Ymech) typically can be achieved via two different angular positions of crank 1. Thus, the mechanical translational position (Ymech) cannot be assigned clearly to one crank angle. In order to solve this ambiguity, the virtual translational position (Yvirt) is introduced, which continues counting in positive direction even if the direction of the translational axis is reversed.

Using the zero point (Ynull) the user can specify where the mechanical zero point and thus the modulo overflow as well is located in the traversing range. In doing so, the modulo value of Yvirt has to correspond to the double traversing range of the translational axis. For this, the traversing range (Sv) shall be defined as distance between top (Y1) and bottom (Y0) pole.

Functions and Function Modules for Bell-Crank Lever Kinematics

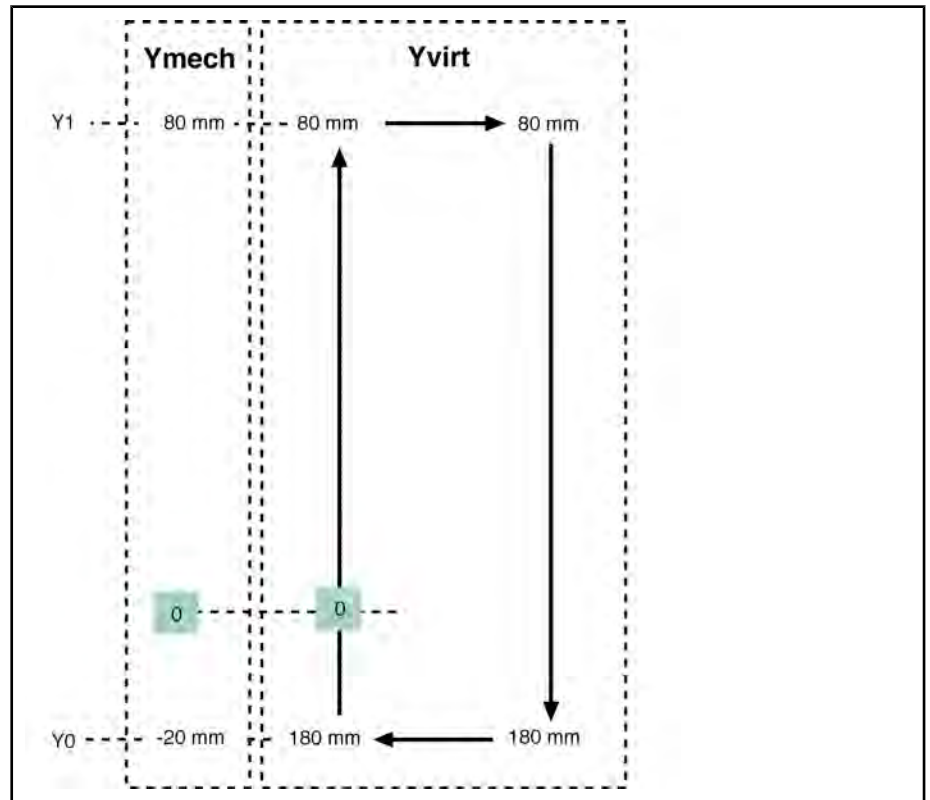


Fig.4-3: Relation between Y_{virt} and Y_{mech}

Basic Principle of the Cam Disk Transformation

The cam disks calculated by the function modules of the bell-crank lever kinematics transform a guide axis position into a crank angle of the bell-crank lever drive. Basically, the following two application cases are distinguished:

- In the first case the real crank axis is coupled to a translationally weighted virtual axis using a transformation cam disk.

In doing so, the virtual axis can be operated in all available operating modes in user-friendly translational units (e.g. mm, mm/s) and the crank follows according to the transformation cam disk. In doing so, the necessary transformation cam disk is calculated by the function module "MB_CamTableBellCrank". In case of the target system MLD, the virtual axis does not support any synchronous operating modes. That is why this application case only makes sense to a limited extent.

Functions and Function Modules for Bell-Crank Lever Kinematics

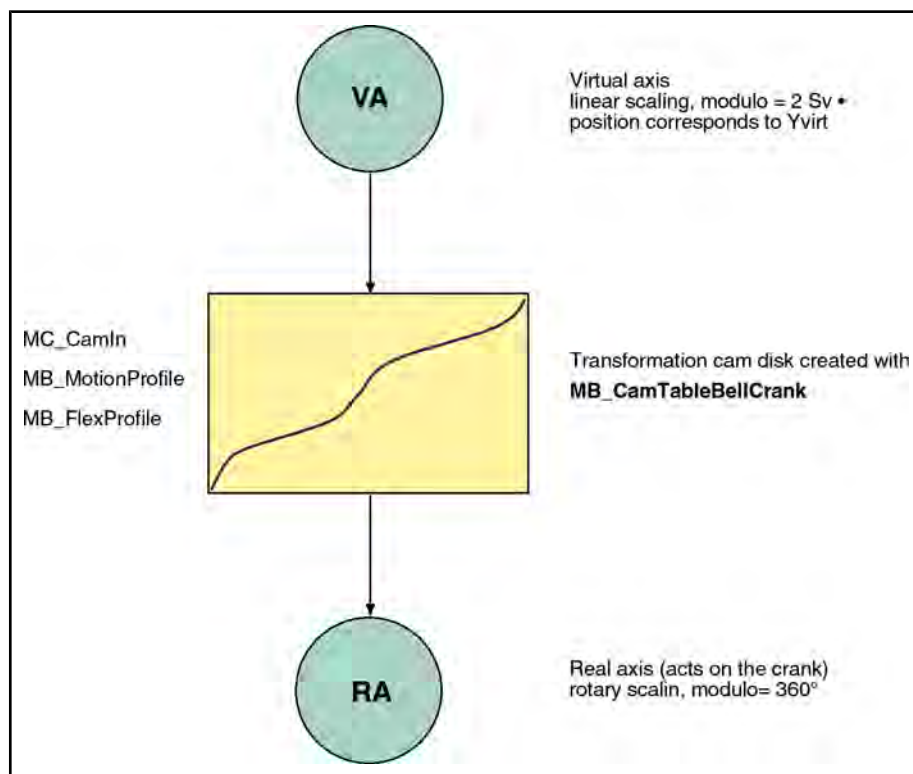


Fig.4-4: Mode of operation of the transformation cam disk with a translational virtual axis

- In the second case, the real crank axis is coupled to any guide axis with freely selectable module weighting using a superimposed user cam disk. The user cam disk describes the movement of the translational axis in relation to the guide axis, without taking the non-linear transmission behavior of the kinematics. For this, the function module "MB_CamTableBellCrankSuperimposed" superimposes the user cam disk with the transformation equations of the kinematics and calculates the superimposed cam disk. With this, the bell-crank lever drive with a user cam disk can be coupled to any guide axis with freely selectable modulo value. This application case particularly makes sense for the target system MLD, as the bell-crank lever drive can be coupled to a guide axis. For the target system MLC this application example has a lower significance, however, an additional virtual axis is not required.

Functions and Function Modules for Bell-Crank Lever Kinematics

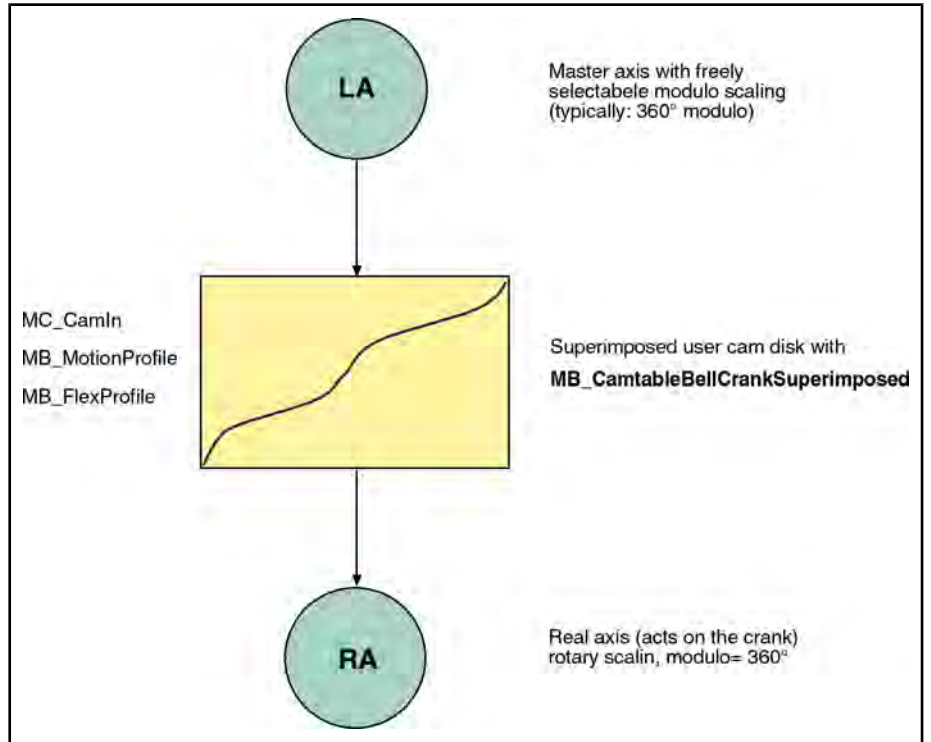


Fig.4-5: Mode of operation of the superimposed cam disk to any guide axis

Simplifications and Basic Conditions

The following simplifications are specified and have to be met. The mechanical kinematics data (such as radius, pushrod) have to be selected accordingly.

- Both cranks reach their dead center simultaneously at the top pole (Y1). Thus, radius and pushrod, as well as elbow2 and elbow3 form a straight line at the top pole.
- The second crank moves only in working range 1. In working range 1, the mechanical position of the Y-axis moves in positive direction if the second crank turns in a clockwise manner. However, the first crank may move in both working ranges and turn endlessly in one direction.

4.3 MB_BellCrankData

Functional Description The function module "MB_BellCrankData" calculates the y positions (Y0, Y1) and the crank angles Phi (Phi0, Phi1) at the bottom and top poles, as well as the maximum traversing range (Sv) of the Y-axis.

Interface Description

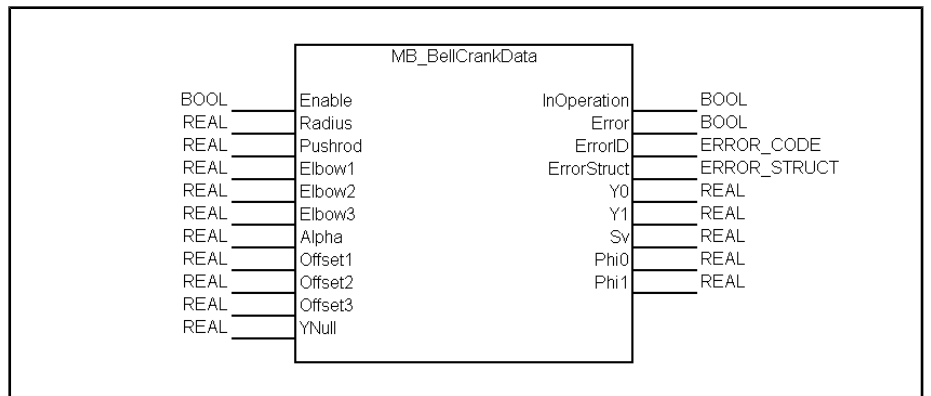


Fig.4-6: Function module MB_BellCrankData

Functions and Function Modules for Bell-Crank Lever Kinematics

	Name	Type	Comment
VAR_INPUT	Enable	BOOL	Calculation of the data in every cycle as long as Enable=TRUE.
	Radius	REAL	Length of crank 1 in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Elbow1	REAL	Length of the bell-crank lever 1 [mm]
	Elbow2	REAL	Length of the bell-crank lever 2 [mm]
	Elbow3	REAL	Length of the bell-crank lever 3 [mm]
	Alpha	REAL	Angle between bell-crank levers 1 and 2 [°]
	Offset1	REAL	X-axis offset between crank and bell-crank lever pivot point [mm].
	Offset2	REAL	X-axis offset between crank pivot point and translational movement [mm].
	Offset3	REAL	Y-axis offset between crank and bell-crank lever pivot point [mm].
	YNull	REAL	Distance crank pivot point to zero position of the translational movement [mm].
VAR_OUTPUT	InOperation	BOOL	Error-free processing, output data valid.
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorStruct	ERROR_STRUCT	Detailed error description
	Y0	REAL	Mechanical y position of the bottom pole [mm]
	Y1	REAL	Mechanical y position of the top pole [mm]
	Sv	REAL	Maximum traversing range of the Y-axis = ABS(Y1-Y0) [mm]
	Phi0	REAL	Angle Phi of crank 1 at the bottom pole [°]
	Phi1	REAL	Angle Phi of crank 1 at the top pole [°]

Fig. 4-7: Interface description FB MB_BellCrankData

Troubleshooting The function module generates the following error messages in Additional1/ Additional2 of table „F_RELATED_TABLE“, 16#0170:

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0004	Radius <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0005	Pushrod <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0009	Elbow1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000A	Elbow2 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000B	Elbow3 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000C	Alpha > 360° OR Alpha < -360°
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000D	Ynull < (Y0+Ynull)

Functions and Function Modules for Bell-Crank Lever Kinematics

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000E	Ynull > ((Y0+Ynull)+2*traversing range)
CALCULATION_ERROR (16#0007)	16x1002	16#xxyy	Internal calculation error, see Additional 2: xx = 16#01: Error caused by MB_BellCrankData xx = 16#02: Error caused by MB_PhiToYvirt xx = 16#03: Error caused by MB_YvirtToPhi xx = 16#04: Error caused by MB_YvirtToPhiPoly5

Fig.4-8: Troubleshooting

4.4 MB_CamTableBellCrank

Functional Description

The function module "MB_CamTableBellCrank" calculates the necessary transformation cam disk (with 1024 data points) for a bell-crank lever drive. The transformation cam disk serves for converting translational units into the crank angle Phi. Thus, the rotational crank drive can be coupled to a translationally weighted virtual axis using the transformation cam disk.

The virtual axis can be moved in translational units and the crank drive correspondingly follows the transformation cam disk.

In order to pass through the poles as well, the distance to the poles (PoleDistance0 und PoleDistance1) may be defined. Within the PoleDistance a compensation function (backup polynomial of 5th grade) approximating the bell-crank lever drive and limiting the resulting drive dynamics. During transition in and from the linearized range, position, velocity and acceleration are constant.

The function module provides the PLC program with the calculated cam disk using the input/output "CamTable".

Interface Description

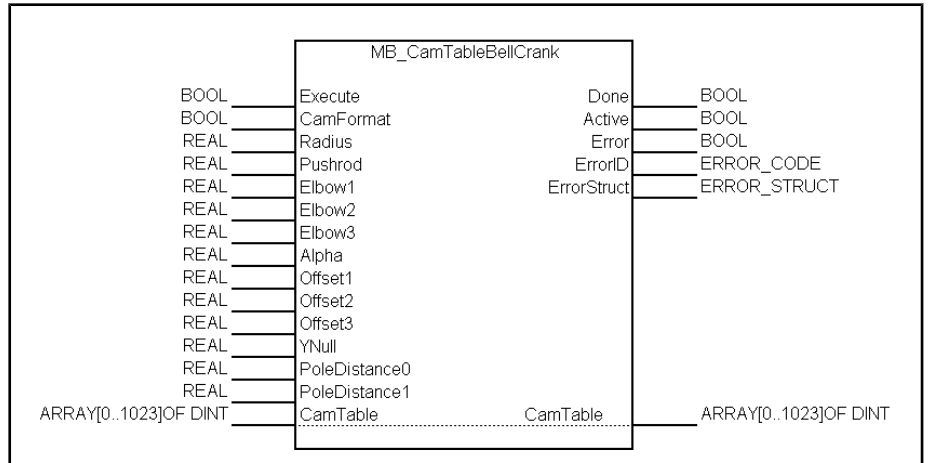


Fig.4-9: Function module MB_CamTableBellCrank

Functions and Function Modules for Bell-Crank Lever Kinematics

	Name	Type	Comment
VAR_IN_OUT	CamTable	AR- RAY[0..1023] OF DINT	Array with the data of the calculated transformation cam disks.
VAR_INPUT	Execute	BOOL	Positive pitch starts calculation of the transformation cam disk.
	CamFormat	BOOL	TRUE: New cam disk format -> last table point corresponds to first table point.
	Radius	REAL	Length of crank 1 in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Elbow1	REAL	Length of the bell-crank lever 1 [mm]
	Elbow2	REAL	Length of the bell-crank lever 2 [mm]
	Elbow3	REAL	Length of the bell-crank lever 3 [mm]
	Alpha	REAL	Angle between bell-crank levers 1 and 2 [°]
	Offset1	REAL	X-axis offset between crank and bell-crank lever pivot point [mm]
	Offset2	REAL	X-axis offset between crank pivot point and translational movement [mm]
	Offset3	REAL	Y-axis offset between crank and bell-crank lever pivot point [mm]
	YNull	REAL	Distance crank pivot point to zero position of the translational movement [mm]
	PoleDistance0	REAL	Distance from the bottom pole Y0 (in [mm]), in order to pass the pole with limited drive dynamics. Within this area, a polynomial of the 5th grade is used approximating the bell-crank lever kinematics and limiting the necessary drive dynamics.
PoleDistance1	REAL	Distance from the top pole Y1 (in [mm]), in order to pass the pole with limited drive dynamics. Within this area, a polynomial of the 5th grade is used approximating the bell-crank lever kinematics and limiting the necessary drive dynamics.	
VAR_OUTPUT	Done	BOOL	Calculation complete -> cam disk table valid
	Active	BOOL	Function module is being processed
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_ CODE	Error description
	ErrorStruct	ERROR_ STRUCT	Detailed error description

Fig.4-10: Interface description function module MB_CamTableBellCrank

Necessary Basic Conditions and Requirements

- Both cranks reach their dead center simultaneously at the top pole (Y1). Thus, radius and pushrod, as well as elbow2 and elbow3 form a straight line at the top pole.
- The second crank moves only in working range 1. In working range 1, the mechanical position of the Y-axis moves in positive direction if the second crank turns in a clockwise manner. However, the first crank may move in both working ranges and turn endlessly in one direction.
- The axis used for the cam disk (as master) has to be module weighted translationally.

The modulo value shall be set as follows: Modulo value = $2 \cdot$ traversing range (Sv). For this, the traversing range (Sv) shall be defined as distance between top (Y1) and bottom (Y0) pole.

Functions and Function Modules for Bell-Crank Lever Kinematics

The traversing range (Sv) can be determined with the help of function module MB_BellCrankData.

- The crank drive has to be weighted rotationally and modulo 360°.

Application Example of MB_Cam-TableBellCrank

Using the following sequence, the translational axis can be traversed in single axis mode:

- Calculation of the transformation cam disk with the help of module MB_CamTableBellCrank.
- Load calculated transformation cam disk to the crank drive (e.g. with MB_WriteListParameter, if this has not been loaded already).
- Activation of Power (MC_Power)
- Establishing the absolute dimensional reference, if no absolute sensor is used. For this, the drive command "Drive-controlled referencing" C0600 is used.
- Position the virtual axis on the translational position resulting from the crank angle. The resulting translational position "Yvirt" can be determined from the crank angle (Phi) with the function module MB_PhiToYvirt. Afterwards, the virtual axis is set to the determined position.
- Activating the cam disk operating mode at the crank drive (e.g. using cMC_CamIn, with CamShaftDistance=360, 1:1 gearbox with selection of the transformation cam disk calculated and loaded beforehand). The crank drive will not conduct a synch-up movement, as the virtual axis already is in "Synchronous position".
- Now, the virtual axis can be traversed in single axis mode using the modules C_MoveAbsolute and MC_MoveVelocity or AxisInterface (the crank axis then follows the transformation cam disk). From MLC03VRS the virtual axis can be operated in a synchronous operating mode as well.



The crank drive conducts a dynamic synch-up movement when the cam disk operating mode is activated, unless the virtual axis has been set to the crank position beforehand.

Troubleshooting

The function module generates the following error messages in Additional1/ Additional2 of the table "F_RELATED_TABLE", 16#0170:

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0004	Radius <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0005	Pushrod <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0006	PoleDistance0 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0007	PoleDistance1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0008	PoleDistance0+PoleDistance1 > traversing range
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0009	Elbow1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000A	Elbow2 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000B	Elbow3 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000C	Alpha > 360° OR Alpha < -360°
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000D	Ynull < (Y0+Ynull)

Functions and Function Modules for Bell-Crank Lever Kinematics

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000E	$Y_{null} > ((Y_0 + Y_{null}) + 2 \cdot \text{traversing range})$
CALCULATION_ERROR (16#0007)	16x1002	16#xxyy	Internal calculation error, see Additional 2: xx = 16#01: Error caused by MB_BellCrankData xx = 16#02: Error caused by MB_PhiToYvirt xx = 16#03: Error caused by MB_YvirtToPhi xx = 16#04: Error caused by MB_YvirtToPhiPoly5

Fig.4-11: Troubleshooting

4.5 MB_CamTableBellCrankSuperimposed

Functional Description

This module superimposes the specified user cam disk (CamInput) with the transformation cam disk and provides the result via the input/output "CamOutput". The transformation curve disk is calculated within the function module according to the same rules as in the function module "MB_CamTableBellCrank". The principle of superimposition is shown in [fig. 4-12 "Principle of a cam disk superimposition" on page 37](#). The user cam disk has to contain 1024 data points and, in doing so, defines the movement of the translational axis in relation to the guide axis (without taking the bell-crank lever kinematics into account). In doing so, the table value 100% corresponds to movement $2 \cdot \text{traversing range} = \text{modulo value of the virtual translational axis}$.

The calculated superimposed cam disk has to be loaded to the drive and used via the cam disk operating mode to be used by the PLC program.



Depending on the specified end point of the user cam disk, the following cases are distinguished:

- If the end point of the user cam disk is near 100%, crank 1 does not reverse the direction (crank 1 "rotates") -> energy-saving procedure, as natural movement of the crank is used
- If the end point of the user cam disk is 0%, the translational axis moves forwards and backwards with reversal of direction of crank 1 (as shown in [fig. 4-12 "Principle of a cam disk superimposition" on page 37](#)).

Advanced Note

From MLC03VRS the virtual axis used supports synchronous operating modes. Thus, superimposing the user cam disk with the transformation cam disk typically is only possible for MLC03 applications, if an additional virtual axis is not to be used.

Functions and Function Modules for Bell-Crank Lever Kinematics

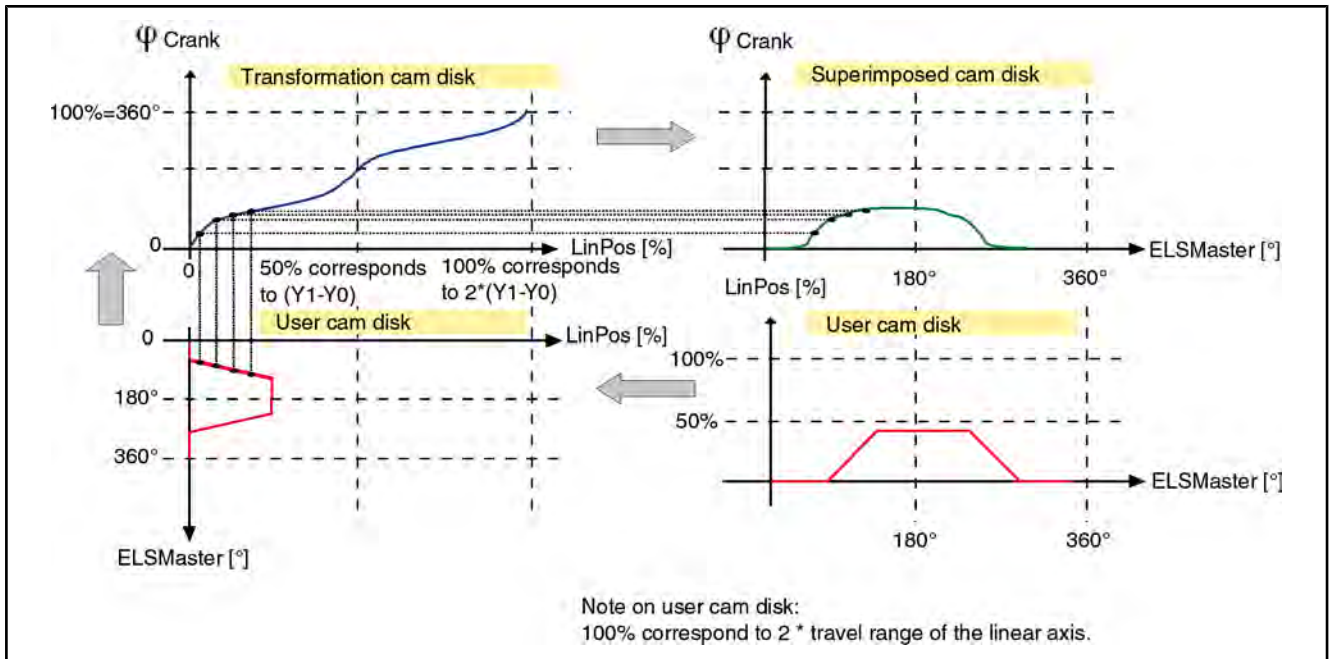


Fig.4-12: Principle of a cam disk superimposition

Interface Description

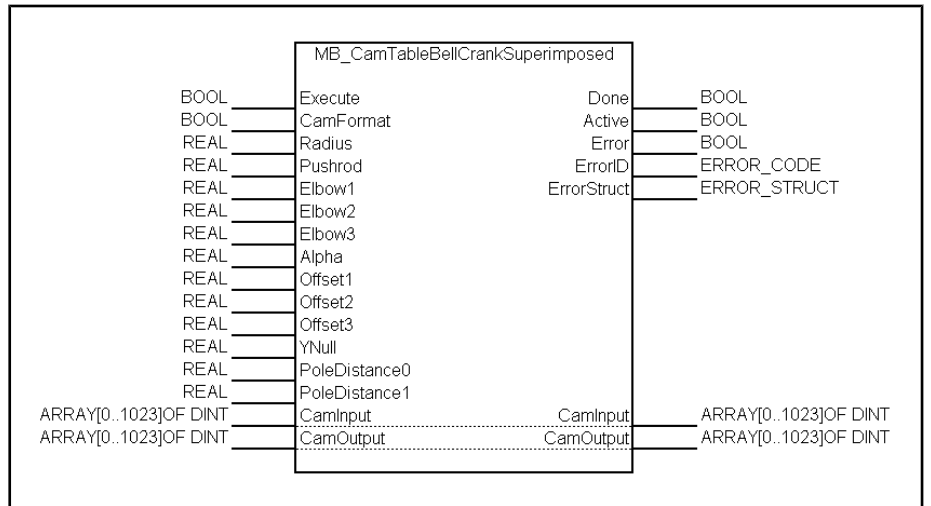


Fig.4-13: Function module MB_CamTableBellCrankSuperimposed

	Name	Type	Comment
VAR_IN_OUT	CamInput	ARRAY[0..1023] OF DINT	Array with the data of the user cam disk to specify the translational movement.
	CamOutput	ARRAY[0..1023] OF DINT	Array with data of the calculated superimposed cam disk to actuate the crank axis.

Functions and Function Modules for Bell-Crank Lever Kinematics

	Name	Type	Comment
VAR_INPUT	Execute	BOOL	Positive pitch starts calculation of the superimposed cam disk.
	CamFormat	BOOL	TRUE: new cam disk format -> last table point corresponds to first table point.
	Radius	REAL	Length of crank 1 in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Elbow1	REAL	Length of the bell-crank lever 1 [mm]
	Elbow2	REAL	Length of the bell-crank lever 2 [mm]
	Elbow3	REAL	Length of the bell-crank lever 3 [mm]
	Alpha	REAL	Angle between bell-crank levers 1 and 2 [°]
	Offset1	REAL	X-axis offset between crank and bell-crank lever pivot point [mm].
	Offset2	REAL	X-axis offset between crank pivot point and translational movement [mm].
	Offset3	REAL	Y-axis offset between crank and bell-crank lever pivot point [mm].
	YNull	REAL	Distance crank pivot point to zero position of the translational movement [mm].
	PoleDistance0	REAL	Distance from the bottom pole Y0 (in [mm]), in order to pass the pole with limited drive dynamics. Within this area, a polynomial of the 5th grade is used approximating the bell-crank lever kinematics and limiting the necessary drive dynamics.
PoleDistance1	REAL	Distance from the top pole Y1 (in [mm]), in order to pass the pole with limited drive dynamics. Within this area, a polynomial of the 5th grade is used approximating the bell-crank lever kinematics and limiting the necessary drive dynamics.	
VAR_OUTPUT	Done	BOOL	Calculation complete -> output cam disk table valid.
	Active	BOOL	Function module is being processed
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorStruct	ERROR_STRUCT	Detailed error description

Fig.4-14: Interface description function module MB_CamTableBellCrankSuperimposed

Functions and Function Modules for Bell-Crank Lever Kinematics

**to use the superimposed cam disk**

If the translational axis is to be synchronized to the superimposed cam disk, the procedure is as follows:

- The function module is provided with the user cam disk via input/output "CamInput" (e.g. by reading out a drive cam disk, or a file...).
- The superimposed cam disk is calculated by the module MB_CamTableBellCrankSuperimposed.
- Upon superimposition of the cam disk, the user program loads the superimposed cam disk "CamOutput" to the drive or the control system (MB_WriteListParameter).
- Activation of Power (MC_Power) at the crank drive.
- Establishing the absolute dimensional reference of the crank axis, if no absolute sensor is used. For this, the drive command C0600 "Drive-controlled referencing" has to be used.
- The current crank position and the position set point from the superimposed cam disk may be the same. Thus, the cam disk operating mode (e.g. üvia MC_CamIn, with CamShaftDistance=360 , 1:1 gearbox and selection of the superimposed cam disk) may be activated using the following 2 options:
 - Activation of the cam disk operating mode at the crank drive without prior position comparison -> The crank drive will synch-up dynamically.
 - Crank axis is set to "Synchronous position" before activating the cam disk operating mode. For this, the crank angle from the superimposed cam disk can be determined using the function "MB_MasterToPhi". Before activating the synchronous operating mode, the crank drive can be set to this position. Afterwards, the superimposed cam disk can be activated without synch-up movement.

**for weighting the axes**

- The guide axis used has to be modulo weighted (translational or rotational).
- The axis for driving the crank has to be weighted rotationally and modulo 360°.

Necessary Basic Conditions See "[Necessary Basic Conditions and Requirements](#)" on page 34 of MB_CamTableBellCrank.

Troubleshooting The function module generates the following error messages in Additional1/ Additional2 of the table "F_RELATED_TABLE", 16#0170:

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0004	Radius <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0005	Pushrod <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0006	PoleDistance0 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0007	PoleDistance1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0008	PoleDistance0+PoleDistance1 > traversing range
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0009	Elbow1 <= 0

Functions and Function Modules for Bell-Crank Lever Kinematics

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000A	Elbow2 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000B	Elbow3 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000C	Alpha > 360° OR Alpha < -360°
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000D	Ynull < (Y0+Ynull)
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000E	Ynull > ((Y0+Ynull)+2*traversing range)
CALCULATION_ERROR (16#0007)	16x1002	16#xyyy	Internal calculation error, see Additional 2: xx = 16#01: Error caused by MB_BellCrankData xx = 16#02: Error caused by MB_PhiToYvirt xx = 16#03: Error caused by MB_YvirtToPhi xx = 16#04: Error caused by MB_YvirtToPhiPoly5

Fig.4-15: Troubleshooting

4.6 MB_PhiToYvirt

Functional Description The function module "MB_PhiToYvirt" converts the crank angle (Phi) into the mechanical and virtual translational position (Ymech, Yvirt).

Interface Description

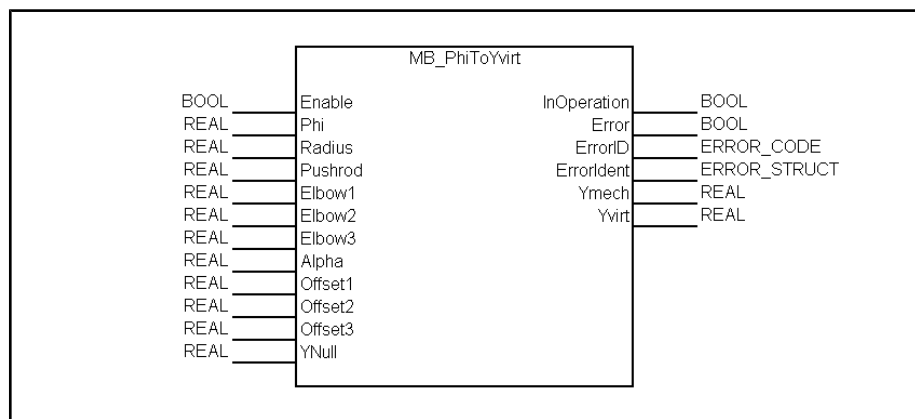


Fig.4-16: Function module MB_PhiToYvirt

Functions and Function Modules for Bell-Crank Lever Kinematics

	Name	Type	Comment
VAR_INPUT	Enable	BOOL	Calculation of Yvirt in every cycle as long as Enable=TRUE
	Phi	REAL	Crank position in [°]
	Radius	REAL	Length of crank in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Elbow1	REAL	Length of the bell-crank lever 1 [mm]
	Elbow2	REAL	Length of the bell-crank lever 2 [mm]
	Elbow3	REAL	Length of the bell-crank lever 3 [mm]
	Alpha	REAL	Angle between bell-crank levers 1 and 2 [°]
	Offset1	REAL	X-axis offset between crank and bell-crank lever pivot point [mm].
	Offset2	REAL	X-axis offset between crank pivot point and translational movement [mm]
	Offset3	REAL	Y-axis offset between crank and bell-crank lever pivot point [mm].
YNull	REAL	Distance crank pivot point to zero position of the translational movement [mm].	
VAR_OUTPUT	InOperation	BOOL	Calculation complete -> Yvirt valid
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorIdent	ERROR_STRUCT	Detailed error description
	Ymech	REAL	Mechanical translational position [mm]
	Yvirt	REAL	Virtual translational position [mm]

Fig.4-17: Interface description function module MB_PhiToYvirt

Troubleshooting The function module generates the following error messages in Additional1/ Additional2 of the table "F_RELATED_TABLE", 16#0170:

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0004	Radius <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0005	Pushrod <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0009	Elbow1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000A	Elbow2 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000B	Elbow3 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000C	Alpha > 360° OR Alpha < -360°
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000D	Ynull < (Y0+Ynull)

Functions and Function Modules for Bell-Crank Lever Kinematics

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000E	$Y_{null} > ((Y_0 + Y_{null}) + 2 \cdot \text{traversing range})$
CALCULATION_ERROR (16#0007)	16x1002	16#xyyy	Internal calculation error, see Additional 2: xx = 16#01: Error caused by MB_BellCrankData xx = 16#02: Error caused by MB_PhiToYvirt xx = 16#03: Error caused by MB_YvirtToPhi xx = 16#04: Error caused by MB_YvirtToPhiPoly5

Fig.4-18: Troubleshooting

4.7 MB_YvirtToPhi

Functional Description The function module "MB_YvirtToPhi" converts the virtual translational position (Yvirt) in the crank angle (Phi).

Interface Description

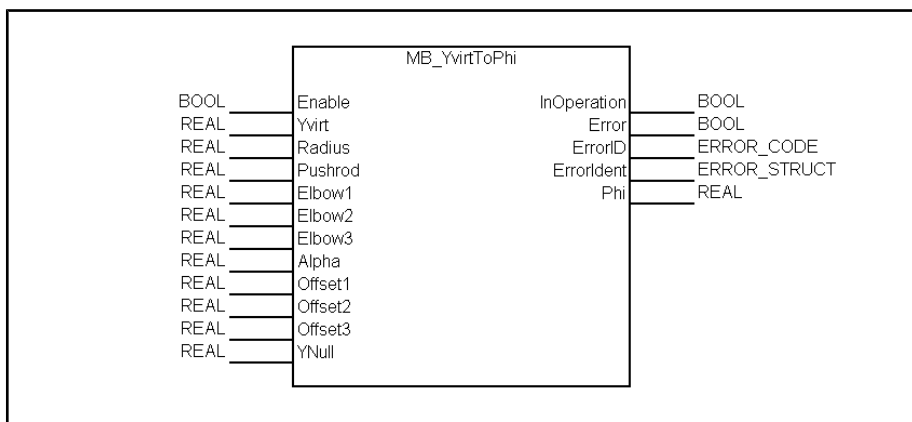


Fig.4-19: Funtional module MB_YvirtToPhi

	Name	Type	Comment
VAR_INPUT	Enable	BOOL	Calculation of Phi in every cycle as long as Enable=TRUE
	Yvirt	REAL	Virtual translational position [mm]
	Radius	REAL	Length of crank in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Elbow1	REAL	Length of the bell-crank lever 1 [mm]
	Elbow2	REAL	Length of the bell-crank lever 2 [mm]
	Elbow3	REAL	Length of the bell-crank lever 3 [mm]
	Alpha	REAL	Angle between bell-crank levers 1 and 2 [°]
	Offset1	REAL	X-axis offset between crank and bell-crank lever pivot point [mm].
	Offset2	REAL	X-axis offset between crank pivot point and translational movement [mm].
	Offset3	REAL	Y-axis offset between crank and bell-crank lever pivot point [mm].
	YNull	REAL	Distance crank pivot point to zero position of the translational movement [mm].

Functions and Function Modules for Bell-Crank Lever Kinematics

	Name	Type	Comment
VAR_OUTPUT	InOperation	BOOL	Calculation complete -> Phi valid
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorIdent	ERROR_STRUCT	Detailed error description
	Phi	REAL	Crank angle in [°]

Fig.4-20: Interface description function module MB_YvirtToPhi

Troubleshooting The function module generates the following error messages in Additional1/ Additional2 of the table "F_RELATED_TABLE", 16#0170:

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0004	Radius <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0005	Pushrod <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0009	Elbow1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000A	Elbow2 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000B	Elbow3 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000C	Alpha > 360° OR Alpha < -360°
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000D	Ynull < (Y0+Ynull)
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000E	Ynull > ((Y0+Ynull)+2*traversing range)
CALCULATION_ERROR (16#0007)	16x1002	16#xxyy	Internal calculation error, see Additional 2: xx = 16#01: Error caused by MB_BellCrankData xx = 16#02: Error caused by MB_PhiToYvirt xx = 16#03: Error caused by MB_YvirtToPhi xx = 16#04: Error caused by MB_YvirtToPhiPoly5

Fig.4-21: Troubleshooting

4.8 MB_YvirtToPhiPoly5

Functional Description The function module "MB_YvirtToPhiPoly5" converts the virtual translational position (Yvirt) in the crank angle (Phi). Within the PoleDistance a compensation function (backup polynomial of 5th grade) approximating the bell-crank lever drive and limiting the resulting drive dynamics. During transition in and from the linearized range, position, velocity and acceleration at crank 1 are constant.

Functions and Function Modules for Bell-Crank Lever Kinematics

Interface Description

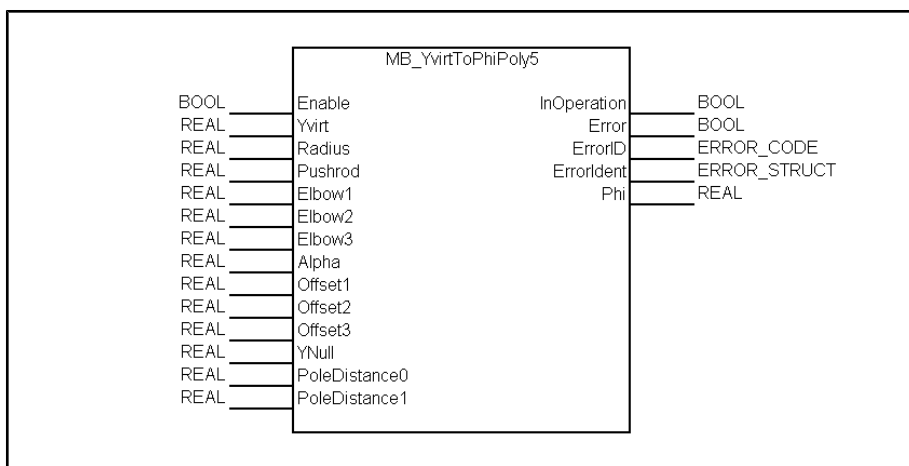


Fig.4-22: Functional module MB_YvirtToPhiPoly5

	Name	Type	Comment
VAR_INPUT	Enable	BOOL	Calculation of Phi in every cycle as long as Enable=TRUE
	Yvirt	REAL	Virtual translational position [mm]
	Radius	REAL	Length of crank in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Elbow1	REAL	Length of the bell-crank lever 1 [mm]
	Elbow2	REAL	Length of the bell-crank lever 2 [mm]
	Elbow3	REAL	Length of the bell-crank lever 3 [mm]
	Alpha	REAL	Angle between bell-crank levers 1 and 2 [°]
	Offset1	REAL	X-axis offset between crank and bell-crank lever pivot point [mm].
	Offset2	REAL	X-axis offset between crank pivot point and translational movement [mm].
	Offset3	REAL	Y-axis offset between crank and bell-crank lever pivot point [mm].
	YNull	REAL	Distance crank pivot point to zero position of the translational movement [mm].
	PoleDistance0	REAL	Distance from the bottom pole Y0 (in [mm]), in order to pass the pole with limited drive dynamics. Within this area, a polynomial of the 5th grade is used approximating the bell-crank lever kinematics and limiting the necessary drive dynamics.
	PoleDistance1	REAL	Distance from the top pole Y1 (in [mm]), in order to pass the pole with limited drive dynamics. Within this area, a polynomial of the 5th grade is used approximating the bell-crank lever kinematics and limiting the necessary drive dynamics.

Functions and Function Modules for Bell-Crank Lever Kinematics

	Name	Type	Comment
VAR_OUTPUT	InOperation	BOOL	Calculation complete -> Phi valid
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorIdent	ERROR_STRUCT	Detailed error description
	Phi	REAL	Crank angle in [°]

Fig.4-23: Interface description function module MB_YvirtToPhiPoly5

Troubleshooting The function module generates the following error messages in Additional1/ Additional2 of the table "F_RELATED_TABLE", 16#0170:

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0004	Radius <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0005	Pushrod <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0006	PoleDistance0 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0007	PoleDistance1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0008	PoleDistance0+PoleDistance1 > traversing range
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0009	Elbow1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000A	Elbow2 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000B	Elbow3 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000C	Alpha > 360° OR Alpha < -360°
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000D	Ynull < (Y0+Ynull)
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000E	Ynull > ((Y0+Ynull)+2*traversing range)
CALCULATION_ERROR (16#0007)	16x1002	16#xxyy	Internal calculation error, see Additional 2: xx = 16#01: Error caused by MB_BellCrankData xx = 16#02: Error caused by MB_PhiToYvirt xx = 16#03: Error caused by MB_YvirtToPhi xx = 16#04: Error caused by MB_YvirtToPhiPoly5

Fig.4-24: Troubleshooting

4.9 MB_YvirtToYmech

Functional Description The function module "MB_YvirtToYmech" converts the virtual translational position (Yvirt) in the mechanical translational position (Ymech). Ymech can be used for display purposes for example.

Functions and Function Modules for Bell-Crank Lever Kinematics

Interface Description

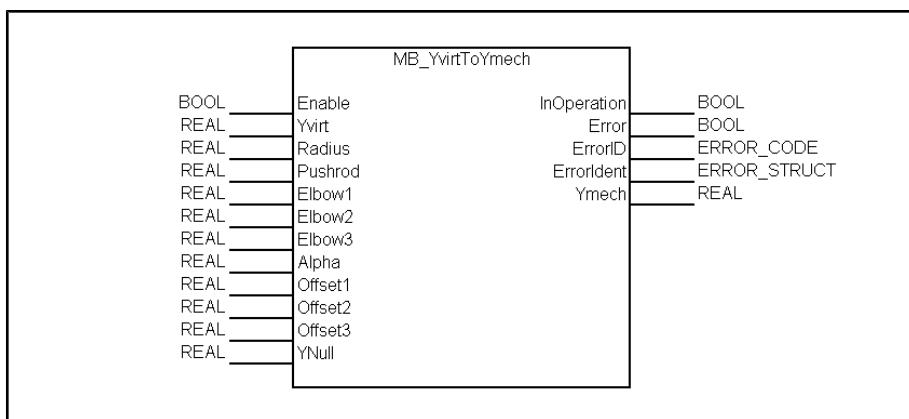


Fig.4-25: Functional module MB_YvirtToYmech

	Name	Type	Comment
VAR_INPUT	Enable	BOOL	Function module calculates as long as Enable=TRUE
	Yvirt	REAL	Virtual translational position in [mm]
	Radius	REAL	Length of crank in [mm]
	Pushrod	REAL	Length of the pushrod in [mm]
	Elbow1	REAL	Length of the bell-crank lever 1 [mm]
	Elbow2	REAL	Length of the bell-crank lever 2 [mm]
	Elbow3	REAL	Length of the bell-crank lever 3 [mm]
	Alpha	REAL	Angle between bell-crank levers 1 and 2 [°]
	Offset1	REAL	X-axis offset between crank and bell-crank lever pivot point [mm].
	Offset2	REAL	X-axis offset between crank pivot point and translational movement [mm].
	Offset3	REAL	Y-axis offset between crank and bell-crank lever pivot point [mm]
VAR_OUTPUT	YNull	REAL	Distance crank pivot point to zero position of the translational movement [mm].
	InOperation	BOOL	Output value (Ymech) valid.
	Error	BOOL	Error (see ErrorID and ErrorStruct)
	ErrorID	ERROR_CODE	Error description
	ErrorIdent	ERROR_STRUCT	Detailed error description
	Ymech	REAL	Mechanical translational position (Ymech) [mm]

Fig.4-26: Interface description function module MB_YvirtToYmech

Troubleshooting The function module generates the following error messages in Additional1/ Additional2 of the table "F_RELATED_TABLE", 16#0170:

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0004	Radius <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0005	Pushrod <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#0009	Elbow1 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000A	Elbow2 <= 0

Functions and Function Modules for Bell-Crank Lever Kinematics

ErrorID	Additional1	Additional2	Description
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000B	Elbow3 <= 0
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000C	Alpha > 360° OR Alpha < -360°
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000D	Ynull < (Y0+Ynull)
INPUT_RANGE_ERROR (16#0006)	16#1000	16#000E	Ynull > ((Y0+Ynull)+2*traversing range)
CALCULATION_ERROR (16#0007)	16x1002	16#xxyy	Internal calculation error, see Additional 2: xx = 16#01: Error caused by MB_BellCrankData xx = 16#02: Error caused by MB_PhiToYvirt xx = 16#03: Error caused by MB_YvirtToPhi xx = 16#04: Error caused by MB_YvirtToPhiPoly5

Fig.4-27: Troubleshooting

4.10 MB_YVirtToWorkRange

Functional Description The function "MB_YVirtToWorkRange" provides the working range (1 or 2) of crank 1 as return value resulting from the virtual translational position. In working range 1 the mechanical position of the Y-axis moves in positive direction, if crank 1 rotates clockwise. In working range 2 the mechanical position of the Y-axis moves in negative direction, if crank 1 rotates clockwise. Internally this function is used by other function modules.

Interface Description

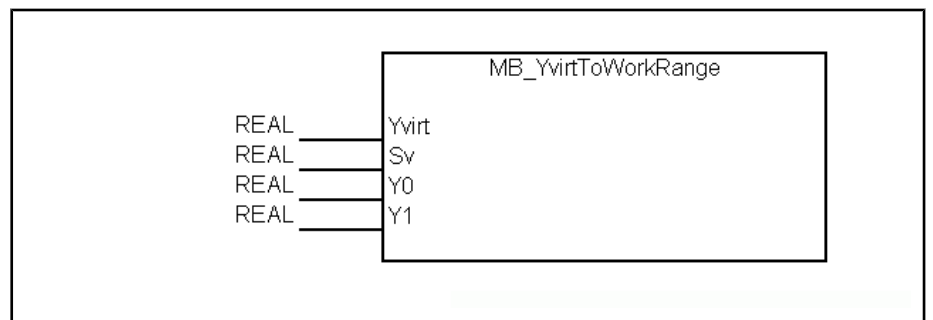


Fig.4-28: Funtional module MB_YVirtToWorkRange

	Name	Type	Comment
VAR_INPUT	Yvirt	REAL	Virtual translational position [mm]
	Sv	REAL	Maximum traversing range of the Y-axis = ABS(Y1-Y0) [mm]
	Y0	REAL	Mechanical y position of the bottom pole [mm]
	Y1	REAL	Mechanical y position of the top pole [mm]

Fig.4-29: Interface description function module MB_YVirtToWorkRange

Troubleshooting The function does not generate any errors.

5 Service and Support

Our service helpdesk at our headquarters in Lohr, Germany, will assist you with all kinds of enquiries. Out of helpdesk hours please contact our German service department directly.

	Helpdesk	Service Hotline Germany	Service Hotline Worldwide
Time ¹⁾	Mo-Fr 7:00 am - 6:00 pm CET	Mo-Fr 6:00 pm - 7:00 am CET Sa-Su 0:00 am - 12:00 pm CET	Outwith Germany please contact our sales/service office in your area first. For hotline numbers refer to the sales office addresses on the Internet.
Phone	+49 (0) 9352 40 50 60	+49 (0) 171 333 88 26 or +49 (0) 172 660 04 06	
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.		

1) Central European Time (CET)

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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