FAST Application Software

Technology module

Electrical Shaft Position ______________________

Reference Manual EN

13531722

Lenze

Contents

1 About this documentation

This documentation ...

- contains detailed information on the functionalities of the "Electrical Shaft Position" technology module;
- is part of the "Controller-based Automation" manual collection. It consists of the following sets of documentation:

Documentation type	Subject
Product catalogue	Controller-based Automation (system overview, sample topologies) Lenze Controller (product information, technical data)
System manuals	Visualisation (system overview/sample topologies)
Communication manuals **Online helps**	Bus systems • Controller-based Automation EtherCAT® • Controller-based Automation CANopen® • Controller-based Automation PROFIBUS® • Controller-based Automation PROFINET®
Reference manuals **Online helps**	Lenze Controllers: • Controller 3200 C • Controller c300 • Controller p300 • Controller p500
Software manuals **Online helps**	Lenze Engineering Tools: • »PLC Designer« (programming) • »Engineer« (parameter setting, configuration, diagnostics) • »VisiWinNET® Smart« (visualisation) • »Backup & Restore« (data backup, recovery, update)

More technical documentation for Lenze components

Further information on Lenze products which can be used in conjunction with Controller-based Automation can be found in the following sets of documentation:

Planning / configuration / technical data	
☐	**Product catalogues** • Controller-based Automation • Controllers • Inverter Drives/Servo Drives
Mounting and wiring	
🕮	**Mounting instructions** • Controllers • Communication cards (MC-xxx) • I/O system 1000 (EPM-Sxxx) • Inverter Drives/Servo Drives • Communication modules
☐	**Hardware manuals** • Inverter Drives/Servo Drives
Parameter setting / configuration / commissioning	
☐	**Online help/reference manuals** • Controllers • Inverter Drives/Servo Drives • I/O system 1000 (EPM-Sxxx)
☐	**Online help/communication manuals** • Bus systems • Communication modules
Sample applications and templates	
☐	**Online help / software and reference manuals** • i700 application sample • Application Samples 8400/9400 • FAST Application Template Lenze/PackML • FAST technology modules

Symbols:

- 🕮 Printed documentation
- ☐ PDF file / online help in the Lenze engineering tool

Tip!

Current documentation and software updates with regard to Lenze products can be found in the download area at:

www.lenze.com

Target group

This documentation is intended for all persons who plan, program and commission a Lenze automation system on the basis of the Lenze FAST Application Software.

1.1 Document history

Version			Description
3.3	05/2017	TD17	• Content structure has been changed. • General revisions New: ▸ Torque-controlled drive as master (📖 12) ▸ Use of setpoints or actual values (📖 12)
3.2	11/2016	TD29	• General revisions • Parameters supplemented: L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) • New: Extended clutch-in/declutch mechanism (📖 40)
3.1	04/2016	TD17	General revisions
3.0	11/2015	TD17	• Corrections and additions • New: Relative clutching-in/declutching (📖 34) • Content structure has been changed.
2.1	05/2015	TD17	General revisions
2.0	01/2015	TD17	• General editorial revision • Modularisation of the contents for the »PLC Designer« online help
1.0	04/2014	TD00	First edition

1.2 Conventions used

This documentation uses the following conventions to distinguish between different types of information:

Type of information	Highlighting	Examples/notes
Spelling of numbers		
Decimal separator	Point	The decimal point is always used. For example: 1234.56
Text		
Program name	» «	»PLC Designer« ...
Variable names	*italics*	By setting *bEnable* to TRUE...
Function blocks	**bold**	The **L_MC1P_AxisBasicControl** function block ...
Function libraries		The **L_TT1P_TechnologyModules** function library ...

Source code	Font
	"Courier new"
		`...`
		`dwNumerator := 1;`
		`dwDenominator := 1;`
		`...`

Icons		
Page reference	(📖 6)	Reference to further information: Page number in PDF file.

Variable names

The conventions used by Lenze for the variable names of Lenze system blocks, function blocks, and functions are based on the "Hungarian Notation". This notation makes it possible to identify the most important properties (e.g. the data type) of the corresponding variable by means of its name, e.g. xAxisEnabled.

1.3 Definition of the notes used

The following signal words and symbols are used in this documentation to indicate dangers and important information:

Safety instructions

Layout of the safety instructions:

Pictograph and signal word!

(characterise the type and severity of danger)

Note

(describes the danger and gives information about how to prevent dangerous situations)

Pictograph	Signal word	Meaning
	Danger!	**Danger of personal injury through dangerous electrical voltage** Reference to an imminent danger that may result in death or serious personal injury if the corresponding measures are not taken.
	Danger!	**Danger of personal injury through a general source of danger** Reference to an imminent danger that may result in death or serious personal injury if the corresponding measures are not taken.
	Stop!	**Danger of property damage** Reference to a possible danger that may result in property damage if the corresponding measures are not taken.

Application notes

Pictograph	Signal word	Meaning
	Note!	Important note to ensure trouble-free operation
	Tip!	Useful tip for easy handling
		Reference to another document

2 Safety instructions

Please observe the safety instructions in this documentation when you want to commission an automation system or a plant with a Lenze Controller.

The device documentation contains safety instructions which must be observed!

Read the documentation supplied with the components of the automation system carefully before you start commissioning the Controller and the connected devices.

Danger!

High electrical voltage

Injury to persons caused by dangerous electrical voltage

Possible consequences

Death or severe injuries

Protective measures

Switch off the voltage supply before working on the components of the automation system.

After switching off the voltage supply, do not touch live device parts and power terminals immediately because capacitors may be charged.

Observe the corresponding information plates on the device.

Danger!

Injury to persons

Risk of injury is caused by ...

- unpredictable motor movements (e.g. unintended direction of rotation, too high velocities or jerky movement);
- impermissible operating states during the parameterisation while there is an active online connection to the device.

Possible consequences

Death or severe injuries

Protective measures

- If required, provide systems with installed inverters with additional monitoring and protective devices according to the safety regulations valid in each case (e.g. law on technical equipment, regulations for the prevention of accidents).
- During commissioning, maintain an adequate safety distance to the motor or the machine parts driven by the motor.

STOP **Stop!**

Damage or destruction of machine parts

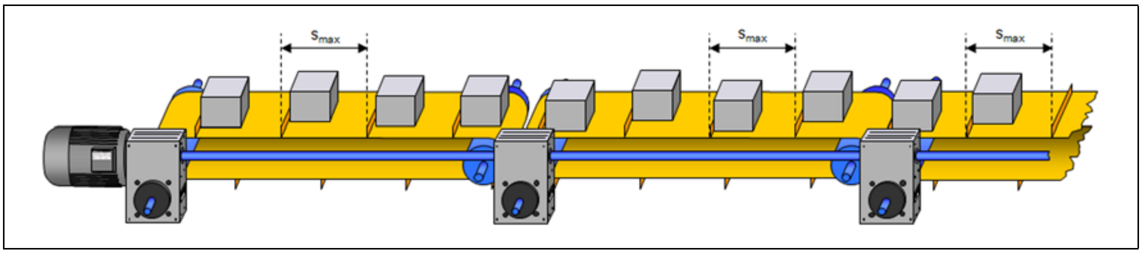
Damage or destruction of machine parts can be caused by ...

- Short circuit or static discharges (ESD);
- unpredictable motor movements (e.g. unintended direction of rotation, too high velocities or jerky movement);
- impermissible operating states during the parameterisation while there is an active online connection to the device.

Protective measures

- Always switch off the voltage supply before working on the components of the automation system.
- Do not touch electronic components and contacts unless ESD measures were taken beforehand.
- If required, provide systems with installed inverters with additional monitoring and protective devices according to the safety regulations valid in each case (e.g. law on technical equipment, regulations for the prevention of accidents).

3 Functional description of "Electrical Shaft Position"



[3-1] Typical mechanics of the technology module

- In the "Base" version, the synchronism and the setting of an offset are activated with a position jump.
- In the "State" version, clutching in without step changes is additionally possible. For this purpose, a position-dependent clutch is used. Furthermore, an offset between the master and slave axis can be set - in a manner similar to manual jog. The offset that takes effect in an absolute manner is accepted immediately with a position jump.
- In addition to the State version, the "High" version provides jerk-free connection of the position offset using a profile generator and the function of a clutch-in and declutch mechanism.

▶ Overview of the functions (🕮 11)

3.1 Overview of the functions

In addition to the basic functions for operating the **L_MC1P_AxisBasicControl** function block, the **Stop function,** and the **Holding function**, the technology module offers the following functionalities that are assigned to the "Base", "State", and "High" versions:

Functionality	Versions		
	Base	State	High
Manual jog (jogging) (📖 27)	●	●	●
Homing (📖 28)	●	●	●
Synchronism (SyncPos) (📖 29)	●	●	●
Position offset during synchronism (📖 31)	●	●	●
Synchronism with clutch-in/declutch mechanism (📖 32)		●	●
▸ Direct clutching-in/declutching (📖 33)		●	●
▸ Relative clutching-in/declutching (📖 34)			●
Position trimming (📖 36)		●	●
Position offset with profile generator (📖 37)			●
Extended clutch-in/declutch mechanism (📖 40)			●

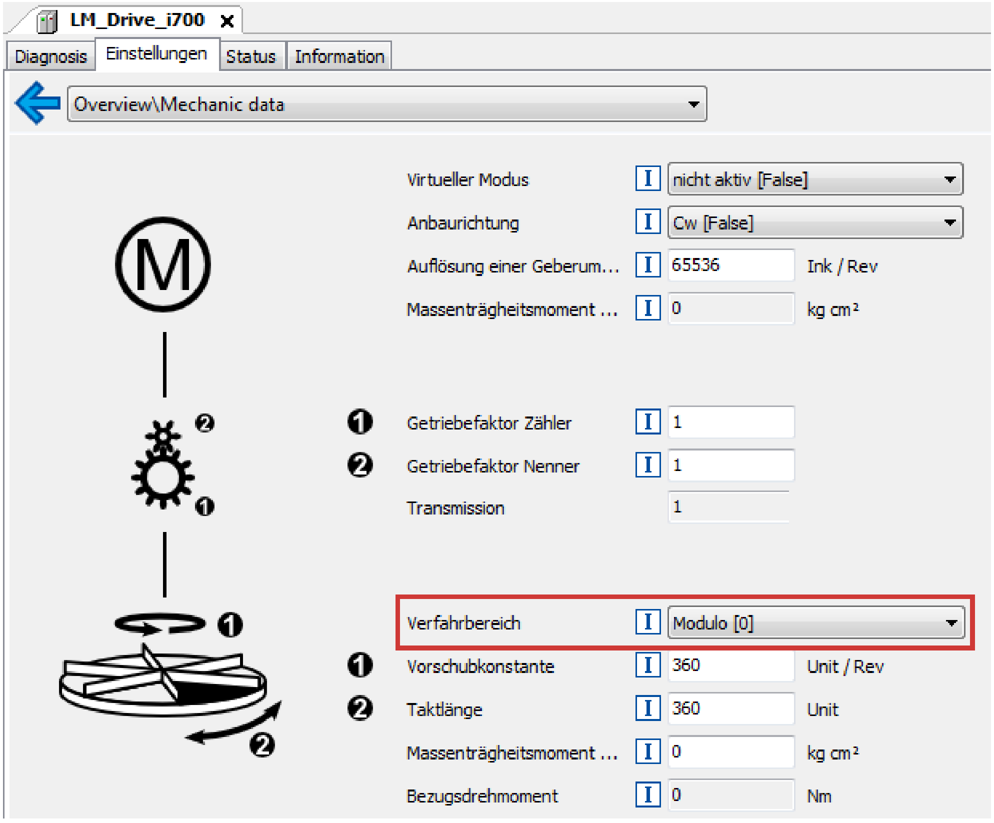
»PLC Designer« Online help

Here you will find detailed information on the **L_MC1P_AxisBasicControl** function block, the **stop function** and the **holding function**.

3.2 Important notes on how to operate the technology module

The "ElectricalShaft Position" technology module only supports axes with the same travel range setting: Either the master axis and the slave axis must be set as "Modulo" rotary axes or both must be set as "Limited" linear axes.

Go to the »PLC Designer« and set the "Modulo" or "Limited" machine measuring system for each axis under the **Settings** tab:



Setting of the operating mode

The operating mode for the slave axis has to be set to "cyclically synchronous position" (csp) because the axis is led via the master position value.

Torque-controlled drive as master

In its function as a master, the technology module can also have an axis which runs in the cyclic sync torque mode (cst).

The actual values are written to the setpoints.

Use of setpoints or actual values

The technology module uses the setpoint of the master axis.

The **L_MC1P_AverageFilterSetValue** filter function can be used to influence the setpoints, making it possible for the technology module to switch over to the actual values.

Controlled start of the axes

Motion commands that are set in the inhibited axis state (*xAxisEnabled* = FALSE) after enable (*xRegulatorOn* = TRUE) must be activated again by a FALSE↗TRUE edge.

In this way it is prevented that the drive starts in an uncontrolled manner after controller enable.

Example Manual jog (jogging) (📖 27)**:**

1. In the inhibited axis state (*xAxisEnabled* = FALSE), *xJogPos* is set to TRUE.
   - *xRegulatorOn* = FALSE (axis is inhibited.)
     ==> "READY" state (*xAxisEnabled* = FALSE)
   - *xJogPos* = TRUE (manual jog is to be executed.)
2. Enable axis.
   - *xRegulatorOn* = TRUE
     ==> "READY" state (*xAxisEnabled* = TRUE)
3. Execute manual jog.
   - *xJogPos* = FALSE↗TRUE
     ==> "JOGPOS" state

3.3 Function block L_TT1P_ElectricalShaftPos[Base/State/High]

The figure shows the relation of the inputs and outputs to the "Base", "State" and "High" versions. The additional inputs and outputs of the "State" and "High" versions are shaded.

L_TT1P_ElectricalShaftPos[Base/State/High]

Base				
	BOOL	xEnableInternalControl	xInternalControlActive	BOOL
	BOOL	xEnable	eTMState	L_TT1P_States
	scCtrl_ABC	scCtrlABC	scStatusABC	scStatus_ABC
	BOOL	xResetError	xError	BOOL
	BOOL	xRegulatorOn	xWarning	BOOL
	BOOL	xStop	eErrorID	L_IE1P_Error
	BOOL	xHalt	scErrorInfo	L_TT1P_scErrorInfo
	L_TT1P_scPar_ElectricalShaftPos[Base/State/High]	scPar	xAxisEnabled	BOOL
	AXIS_REF	MasterAxis	scSignalFlow	L_TT1P_scSF_ElectricalShaftPos[Base/State/High]
	AXIS_REF	SlaveAxis	xDone	BOOL
	L_TT1P_scAP_ElectricalShaftPos[Base/State/High]	scAccessPoints	xBusy	BOOL
	BOOL	xJogPos	xIsHomed	BOOL
	BOOL	xJogNeg	lrActVel	LREAL
	BOOL	xHomeExecute	lrActPos	LREAL
	BOOL	xHomeAbsSwitsch	lrOffset	LREAL
	BOOL	xSyncPos		
	LREAL	lrSetOffsetSlave		
State				
	BOOL	xTrimPos	lrOffsetTrim	LREAL
	BOOL	xTrimNeg	lrOffsetTotal	LREAL
			xSynchronised	BOOL
			xAccDecSync	BOOL
High				
	BOOL	xSyncInstant	lrOffsetSyncPos	LREAL
	BOOL	xSyncOutInstant		
	BOOL	xSyncPosRestore		

3.3.1 Inputs and outputs

Designator / Data type	Description	Available in version: Base	State	High
MasterAxis / AXIS_REF	Reference to the master axis (master axis)	●	●	●
SlaveAxis / AXIS_REF	Reference to the slave axis	●	●	●

3.3.2 Inputs

Designator / Data type	Description		Available in version: Base	State	High
xEnableInternalControl BOOL	TRUE	In the visualisation, the internal control of the axis can be selected via the "Internal Control" axis.	●	●	●
xEnable BOOL	Execution of the function block		●	●	●
	TRUE	The function block is executed.			
	FALSE	The function block is not executed.			
scCtrlABC scCtrl_ABC	Input structure for the **L_MC1P_AxisBasicControl** function block • scCtrlABC can be used in "Ready" state. • If there is a request, the state changes to "Service". • The state change from "Service" back to "Ready" takes place if there are no more requests.		●	●	●
xResetError BOOL	TRUE	Reset axis error or software error.	●	●	●
xRegulatorOn BOOL	TRUE	Activate controller enable of the axis (via the **MC_Power** function block).	●	●	●
xStop BOOL	TRUE	Cancel the active movement and brake the axis to a standstill with the deceleration defined via the lrStopDec parameter. • The state changes to "Stop". • The technology module remains in the "Stop" state as long as xStop is set to TRUE (or xHalt = TRUE). • The input is also active with "Internal Control".	●	●	●
xHalt BOOL	TRUE	Cancel the active movement and brake the axis to a standstill with the deceleration defined via the lrHaltDec parameter. • The state changes to "Stop". • The technology module remains in the "Stop" state as long as xStop is set to TRUE (or xHalt = TRUE).	●	●	●
scPar L_TT1P_scPar_ElectricalShaftPos[Base/State/High]	The parameter structure contains the parameters of the technology module. The data type depends on the version used (Base/State/High).		●	●	●
scAccessPoints L_TT1P_scAP_ElectricalShaftPos[Base/State/High]	Structure of the access points The data type depends on the version used (Base/State/High).		●	●	●
xJogPos BOOL	TRUE	Traverse axis in positive direction (manual jog). If xJogNeg is also TRUE, the traversing direction selected first remains set.	●	●	●
xJogNeg BOOL	TRUE	Traverse axis in negative direction (manual jog). If xJogPos is also TRUE, the traversing direction selected first remains set.	●	●	●
xHomeExecute BOOL	The input is edge-controlled and evaluates the rising edge.		●	●	●
	FALSE↗TRUE	Start homing. The function is aborted via the xStop input.			
xHomeAbsSwitch BOOL	TRUE	Connection for reference switch: For homing modes with a reference switch, connect this input to the digital signal which maps the state of the reference switch.	●	●	●
xSyncPos BOOL	Synchronisation of the slave axis to the master axis		●	●	●
	TRUE	Base: Synchronisation without clutch function			
		State/High: Synchronisation with position clutch			

Designator / Data type	Description		Available in version: Base	State	High
lrSetOffsetSlave LREAL	Position offset to master axis The position is approached in the "POS_IS_SYNCHRONISED" state when the value changes • Unit: units		●	●	●
	Base/ State	The offset is directly applied.			
	High	The offset is assigned via the profile generator.			
xTrimPos BOOL	TRUE	Trim position in positive direction. If xTrimNeg is also TRUE, the traversing direction selected first remains set.		●	●
xTrimNeg BOOL	TRUE	Trim position in negative direction. If xTrimPos is also TRUE, the traversing direction selected first remains set.		●	●
xSyncInstant BOOL	TRUE	Synchronisation with relative position coupling (in connection with xSyncPos) • Master axis at standstill: The slave axis directly (abruptly) clutches in to its current position. • Master axis in motion: The slave axis immediately clutches in via the clutching distance in the lrSlaveSyncInDist parameter (by analogy with a velocity coupling).			●
xSyncOutInstant BOOL	TRUE	Declutching with relative position coupling • Master axis at standstill: The slave axis directly (abruptly) clutches in to its current position. • Master axis in motion: The slave axis immediately declutches via the clutching distance in the lrSlaveSyncOutDist parameter (by analogy with a velocity coupling or MC_Halt).			●
xSyncPosRestore BOOL	FALSE↗TRUE	A FALSE↗TRUE edge serves to compensate the position offset generated by a relative clutch-in by means of these parameters: • eOffsetSlaveDirection • eOffsetSlaveProfileType • lrOffsetSlaveVelPos • lrOffsetSlaveVelNeg • lrOffsetSlaveAccDec			●
	TRUE↘FALSE	A TRUE↘FALSE edge aborts the synchronisation process. A possibly remaining position offset is displayed at the lrOffsetSyncPos output.			

3.3.3 Outputs

Designator Data type	Description		Available in version: Base	State	High
xInternalControlActive BOOL	TRUE	The internal control of the axis is activated via the visualisation. (xEnableInternalControl input = TRUE)	●	●	●
eTMState L_TT1P_States	Current state of the technology module ▸ State machine (📖 23)		●	●	●
scStatusABC scStatus_ABC	Structure of the status data of the **L_MC1P_AxisBasicControl** function block		●	●	●
xError BOOL	TRUE	There is an error in the technology module.	●	●	●
xWarning BOOL	TRUE	There is a warning in the technology module.	●	●	●
eErrorID L_IE1P_Error	ID of the error or warning message if xError = TRUE or xWarning = TRUE. **"FAST technology modules" reference manual:** Here you can find information on error or warning messages.		●	●	●
scErrorInfo L_TT1P_scErrorInfo	Error information structure for a more detailed analysis of the error cause		●	●	●
scSignalFlow L_TT1P_scSF_ElectricalShaftPos[Base/State/High]	Structure of the signal flow The data type depends on the version used (Base/State/High). ▸ Signal flow diagram (📖 24)		●	●	●
xAxisEnabled BOOL	TRUE	The axis is enabled.	●	●	●
xDone BOOL	TRUE	The request/action has been completed successfully.	●	●	●
xBusy BOOL	TRUE	The request/action is currently being executed.	●	●	●
xIsHomed BOOL	TRUE	The axis has been referenced (reference known).	●	●	●
lrActVel LREAL	Current velocity • Unit: units/s		●	●	●
lrActPos LREAL	Current position • Unit: units		●	●	●
lrOffset LREAL	Set position offset from the lrSetOffsetSlave input between the master axis and the slave axis • Unit: units		●	●	●
lrOffsetTrim LREAL	Position offset from the trimming function between the master axis and the slave axis • Unit: units			●	●
lrOffsetTotal LREAL	The total position offset between the master axis and the slave axis contains the information of the master offset, slave offset and offset from the trimming function and the offset caused by relative clutch-in. • Unit: units			●	●
xSynchronised BOOL	TRUE	The axis is coupled with reference to the master axis.		●	●

Designator Data type	Description		Available in version		
			Base	State	High
xAccDecSync BOOL	TRUE	The synchronisation function is active. The axis is synchronised or desynchronised (clutch opens or closes).		●	●
lrOffsetSyncPos LREAL	Position offset caused by relative clutch-in. • Unit: units				●

3.3.4 Parameters

L_TT1P_scPar_ElectricalShaftPos[Base/State/High]

The **L_TT1P_scPar_ElectricalShaftPos[Base/State/High]** structure contains the parameters of the technology module.

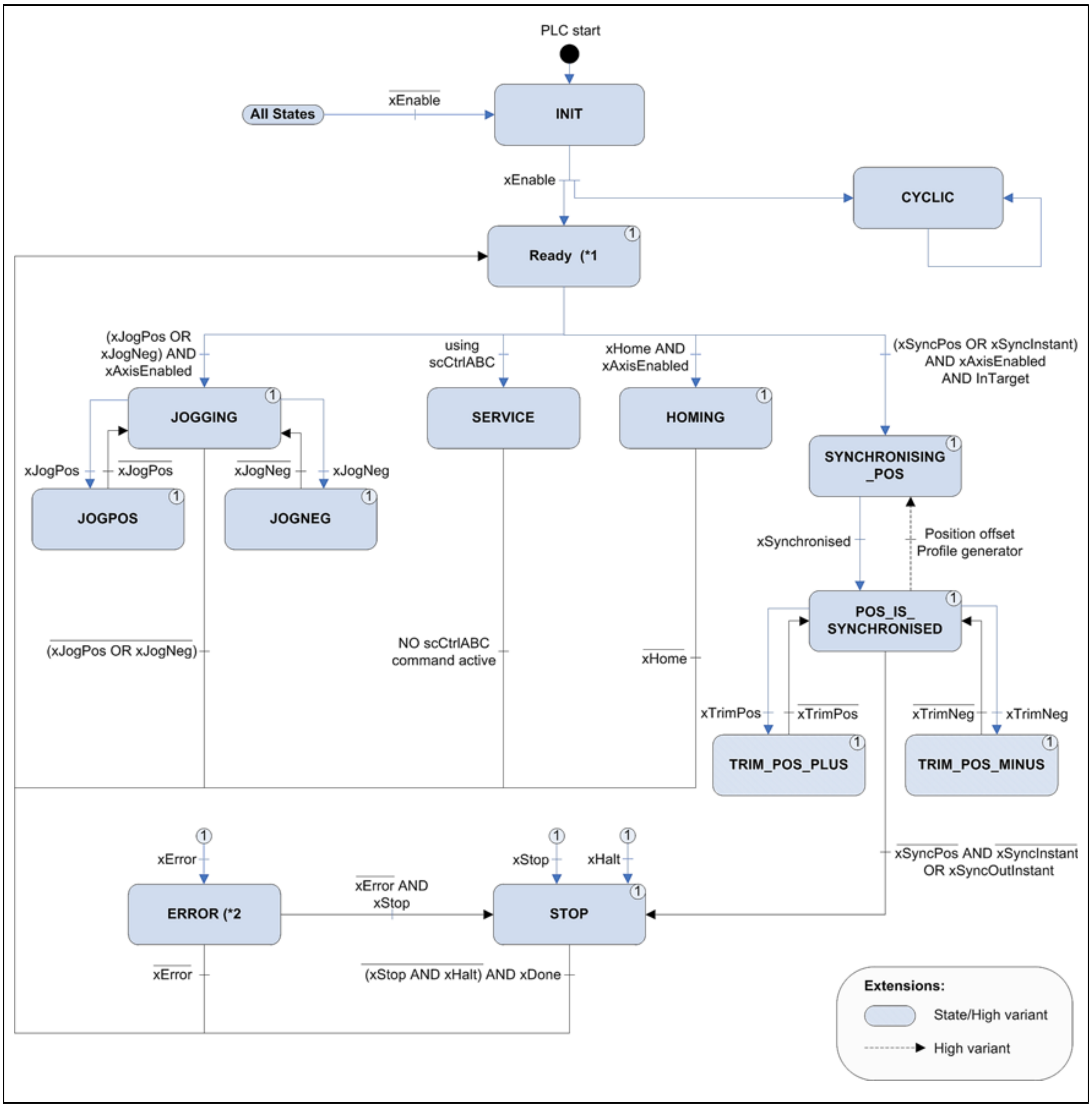
Designator / Data type	Description	Available in version		
		Base	State	High
lrStopDec LREAL	Deceleration for the stop function and when hardware/ software limit switches and the following error monitoring function are triggered • Unit: units/s² • Initial value: 10000	●	●	●
lrStopJerk LREAL	Jerk for the stop function and for the triggering of the hardware limit switches, software limit positions, and the following error monitoring function • Unit: units/s³ • Initial value: 100000	●	●	●
lrHaltDec LREAL	Deceleration for the holding function Specification of the maximum speed variation which is to be used for deceleration to standstill. • Unit: units/s² • Initial value: 3600 • Only positive values are permissible.	●	●	●
lrJerk LREAL	Jerk for compensating an offset value, trimming, clutch, or holding function • Unit: units/s³ • Initial value: 100000	●	●	●
lrJogJerk LREAL	Jerk for manual jog • Unit: units/s³ • Initial value: 10000	●	●	●
lrJogVel LREAL	Maximum speed to be used for manual jog. • Unit: units/s • Initial value: 10	●	●	●
lrJogAcc LREAL	Acceleration for manual jog Specification of the maximum speed variation which is to be used for acceleration. • Unit: units/s² • Initial value: 100	●	●	●
lrJogDec LREAL	Deceleration for manual jog Specification of the maximum speed variation which is to be used for deceleration to standstill. • Unit: units/s² • Initial value: 100	●	●	●
lrHomePosition LREAL	Home position for a reference run (homing) • Unit: units • Initial value: 0	●	●	●
xUseHomeExtParameter BOOL	Selection of the homing parameters to be used • Initial value: FALSE FALSE: The homing parameters defined in the axis data are used. TRUE: The **scHomeExtParameter** homing parameters from the application are used.	●	●	●
scHomeExtParameter L_MC1P_HomeParameter	Homing parameters from the application • Only relevant if xUseHomeExtParameter = TRUE.	●	●	●

Designator Data type	Description	Available in version: Base	State	High
scHomeExtTP MC_TRIGGER_REF	Transfer of an external touch probe event • Only relevant for "External source" touch probe configuration. • For describing the MC_TRIGGER_REF structure, see the **MC_TouchProbe** function block.	●	●	●
dwNumerator DWORD	This value is included in the resulting synchronous factor as numerator term. • Initial value: 1	●	●	●
dwDenominator DWORD	This value is included in the resulting synchronous factor as denominator term. • Initial value: 1	●	●	●
xLoadSyncPos BOOL	Automatic calculation and selection of the gearbox output position for direct clutch-in • Initial value: FALSE ▸ Direct clutching-in/declutching (📖 33) TRUE: The output position of the gearbox is calculated considering the current slave position. After this process, a direct, jerk-free clutch-in is possible.	●	●	●
lrTrimAcc LREAL	Acceleration for trimming Selection of the velocity change relative to the master to be used for accelerating. The acceleration acting on the drive is the sum of master and slave acceleration. • Unit: units/s^2 • Initial value: 100		●	●
lrTrimDec LREAL	Deceleration for trimming Selection of the velocity change relative to the master to be used for decelerating. The deceleration acting on the drive is the sum of master and slave deceleration. • Unit: units/s^2 • Initial value: 100		●	●
lrTrimVel LREAL	Velocity for trimming Selection of the velocity used for trimming. • Unit: units/s • Initial value: 50		●	●
lrSlaveSyncInDist LREAL	Distance of the clutch-in movement from the slave axis (path-based coupling mode). • Unit: units • Initial value: 90		●	●
lrSlaveSyncOutDist LREAL	Distance of the declutch movement from the slave axis (path-based coupling mode). • Unit: units • Initial value: 90		●	●
lrSlaveSyncOutPos LREAL	Declutch setpoint position of the slave axis At this position, the slave axis is stopped as soon as the declutch process has been carried out (path-based clutch mode). • Unit: units • Initial value: 0		●	●
eOffsetSlaveDirection L_TT1P_Direction	Direction selection for the profile generator • Initial value: 1 (Direction Master) 0: Both: The axis may travel in positive and negative direction 1: Master direction: The slave axis may only travel in the same direction as the master axis.			●

Designator Data type	Description	Available in version		
		Base	State	High
eOffsetSlaveProfileType L_TT1P_ProfileType	Profile type of the profile generator • Initial value: 2 0: poly_4th_order (4th order polynomial) 1: poly_2nd_order (2nd order polynomial) 2: poly_5th_order (5th order polynomial)			●
lrOffsetSlaveVelPos LREAL	Maximum positive velocity to be used for the profile. The sum of this velocity and the velocity of the master is the velocity acting on the slave axis. • Unit: units/s • Initial value: 100			●
lrOffsetSlaveVelNeg LREAL	Maximum negative velocity to be used for the profile. The sum of this velocity and the velocity of the master is the velocity acting on the slave axis. • Unit: units/s • Initial value: 100			●
lrOffsetSlaveAccDec LREAL	Maximum acceleration to be used for the profile. The sum of this acceleration and the one of the master is the acceleration acting on the slave axis. **Note:** With the "poly_4th" and "poly_5th" profile type selection, the parameter profile value of the acceleration and deceleration is exceeded. • Unit: units/s^2 • Initial value: 1000			●
xLoadOffsetSlave BOOL	Loading the position offset to the master axis (via lrSetOffsetSlave input) • Initial value: FALSE TRUE: The position offset is loaded cyclically. FALSE: The position offset is run via the profile generator.			●
eSyncDirection L_TT1P_SyncDirection ElectricalShaftPos	Permitted clutch-in direction with regard to the master motion -1: mcNegativeDirection (starting condition in negative direction of the master axis) 1: mcPositiveDirection (starting condition in positive direction of the master axis) 2: mcShortestWay (by the shortest way possible in both directions) Initial value := 0: mcCurrentDirection (in both directions)			●
eSyncMode L_TT1P_ SyncMode ElectricalShaftPos	Clutch-in/declutch mode: 3: Ramp_Time (time-based clutching within a time slot) 4: Ramp_VelAcc (clutching via a profile generator) 5: Ramp_Dist (path-based clutching via the distance of the slave axis) Initial value := 5 Ramp_Dist			●
lrSyncInTime LREAL	Relevant for coupling mode: eSyncMode = 3 Ramp_TIme Period of time of the clutch-in process in seconds (time-based coupling mode). Initial value:= 5			●
lrSyncOutTime LREAL	Relevant for coupling mode: eSyncMode = 3 Ramp_TIme Period of time of the declutch process in seconds (time-based coupling mode). Initial value:= 5			●

Designator Data type	Description	Available in version		
		Base	State	High
lrSyncVel LREAL	Maximum speed at which the clutch-in/declutch process in mode eSyncMode = 4 (ramp_VelAc) is to be carried out. • Unit: units/s • Initial value: 100			●
lrSyncAcc LREAL	Acceleration for the clutch-in/declutch process in mode eSyncMode = 4 (ramp_VelAc) Specification of the maximum speed variation which is to be used for acceleration. • Unit: units/s2 • Initial value: 1000			●
lrSyncDec LREAL	Deceleration for the clutch-in/declutch process in mode eSyncMode = 4 (ramp_VelAc) Specification of the maximum speed variation which is to be used for deceleration to standstill. • Unit: units/s2 • Initial value: 1000			●
lrSyncJerk LREAL	Jerk for the clutch-in/declutch process in mode eSyncMode = 4 (ramp_VelAc) • Unit: units/s3 • Initial value: 1000000			●

3.4 State machine

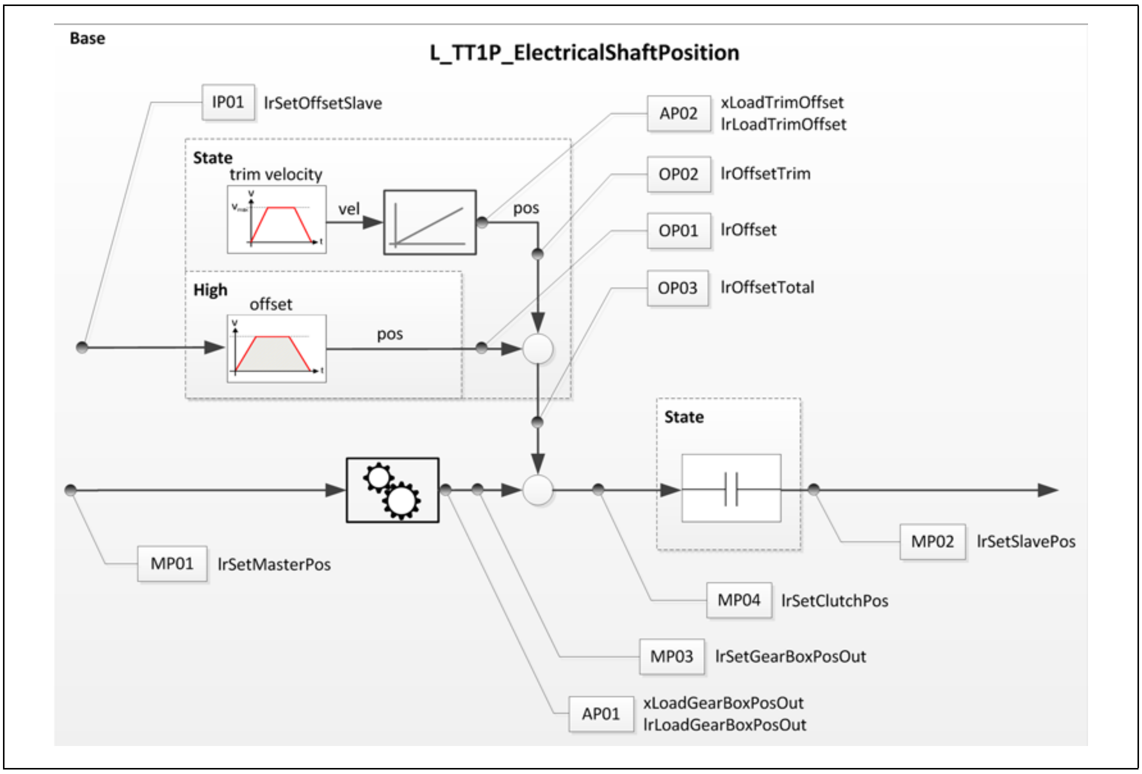


[3-2] State machine of the technology module

(*1 In the "Ready" state, xRegulatorOn has to be set to TRUE.

(*2 In the "ERROR" state, xResetError has to be set to TRUE in order to acknowledge and reset the errors.

3.5 Signal flow diagram



[3-3] Signal flow diagram

The illustration [3-3] shows the main signal flow of the implemented functions.

The signal flow of the additional functions such as "manual jog" is not displayed here.

3.5.1 Structure of the signal flow

L_TT1P_scSF_ElectricalShaftPos[Base/State/High]

The contents of the **L_TT1P_scSF_ElectricalShaftPos[Base/State/High]** structure are read-only and offer a practical diagnostics option within the signal flow (Signal flow diagram (📖 24)).

Designator Data type	Description	Available in version		
		Base	State	High
IP01_lrSetOffsetSlave LREAL	Position offset to master axis The position is approached in the "POS_IS_SYNCHRONISED" state when the value changes • Unit: units Base/State: The offset is directly applied. High: The offset is assigned via the profile generator.	●	●	●
MP01_lrSetMasterPos LREAL	Set position of the master axis • Unit: units	●	●	●
MP02_lrSetSlavePos LREAL	Set position of the slave axis • Unit: units	●	●	●
MP03_lrSetGearBoxPosOut LREAL	Resulting position from the gearbox • Unit: units	●	●	●
MP04_lrSetClutchPos LREAL	Master position for Direct clutching-in/declutching (📖 33) • Unit: units	●	●	●
OP01_lrOffset LREAL	Set position offset from the lrSetOffsetSlave input between the master axis and the slave axis • Unit: units	●	●	●
OP02_lrOffsetTrim LREAL	Position offset from the trimming function between the master axis and the slave axis • Unit: units		●	●
OP03_lrOffsetTotal LREAL	Total position offset between the master axis and the slave axis • Unit: units		●	●

3.5.2 Structure of the access points

L_TT1P_scAP_ElectricalShaftPos[Base/State/High]

The access points (AP) can be used to influence signals. In the initial state, the access points do not have any effect.

Each access point acts as an alternative branch and is activated via an OR operation or a switch.

Designator / Data type	Description		Available in version: Base	State	High
AP01_xLoadGearBoxPosOut BOOL	Enable of the AP01_lrLoadGearBoxPosOut access point		●	●	●
	TRUE	The access point overwrites the values at the access point in the signal flow.			
AP01_lrLoadGearBoxPosOut LREAL	Loading of the resulting position from the gearbox • Unit: units				
AP02_xLoadTrimOffset BOOL	Enable of the AP02_lrLoadTrimOffset access point			●	●
	TRUE	The access point overwrites the values at the access point in the signal flow.			
AP02_lrLoadTrimOffset LREAL	Loading of the resulting distance from the trimming function • Unit: units				
AP05_xLoadOffsetSync BOOL	Enable of the AP05_lrLoadOffsetSync access point				●
	TRUE	The access point overwrites the values of the synchronisation offset.			
AP05_lrLoadOffsetSync LREAL	Loading the synchronisation offset				

3.6 Manual jog (jogging)

Precondition

- The technology module is in the "Ready" state.
- The slave axis is enabled (*xRegulatorOn* = TRUE).

Execution

For manual jog of the axis, the manual jog speed *lrJogVel* is used.

If the *xJogPos* input is TRUE, the axis is traversed in positive direction and if the *xJogNeg* input is TRUE, the axis is traversed in negative direction. The axis is executed for as long as the input remains set to TRUE.

The current travel command cannot be replaced by another jog command. Only if both inputs have been reset, the State machine (📖 23) changes to the "Ready" state again.

Parameters to be set

The parameters for the manual jog are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
lrJogVel : LREAL := 10;       // Velocity [units/s]
lrJogAcc : LREAL := 100;      // Acceleration [units/s^2]
lrJogDec : LREAL := 100;      // Deceleration [units/s^2]
lrJogJerk : LREAL := 10000;   // Jerk [units/s^3]
```

The parameter values can be changed during operation. They are accepted when the *xJogPos* or *xJogNeg* input is set to TRUE again.

3.7 Homing

Precondition

- The technology module is in the "Ready" state.
- The slave axis is enabled (*xRegulatorOn* = TRUE).

Execution

Homing is started with a rising edge (FALSE↗TRUE) at the *xHomeExecute* input. The axis will be travelling until the home position is reached. After successful homing, the State machine (📖 23) changes back again to the "Ready" state.

The homing process is not interrupted if the *xHomeExecute* input is set to FALSE too early. The function is aborted via the *xStop* input.

Parameters to be set

The parameters for homing are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
xUseHomeExtParameter : BOOL := FALSE;
lrHomePosition : LREAL := 0.0;
scHomeExtParameter : L_MC1P_HomeParameter;
scHomeExtTP : MC_TRIGGER_REF;
```

3.8 Synchronism (SyncPos)

Note!

Synchronism is activated with a position jump.

Execution

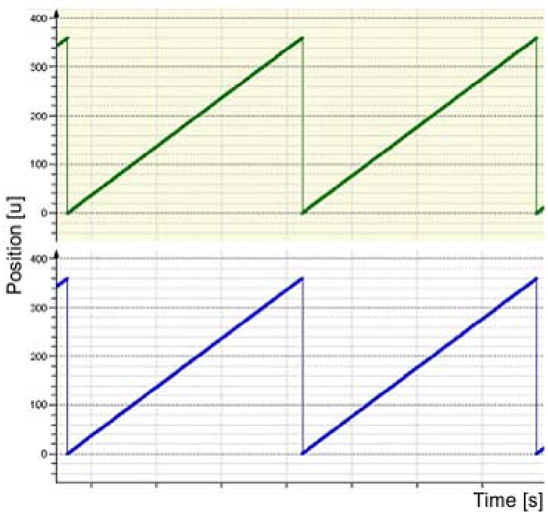
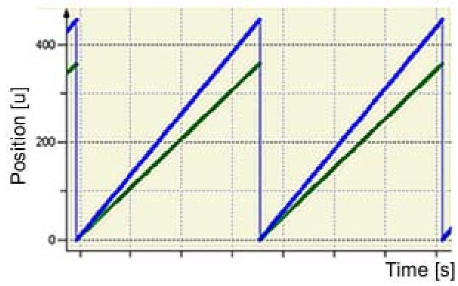
In order to synchronise the slave axis and master axis, synchronism factors are used to calculate a setpoint position based on the master axis. Synchronism is started by setting the *xSyncPos* input to TRUE. As a result, the calculated setpoint position is abruptly connected to the axis. A jerk-free connection is only possible at standstill after prior positioning. The gearbox factor is preset to 1:1.

Parameters to be set

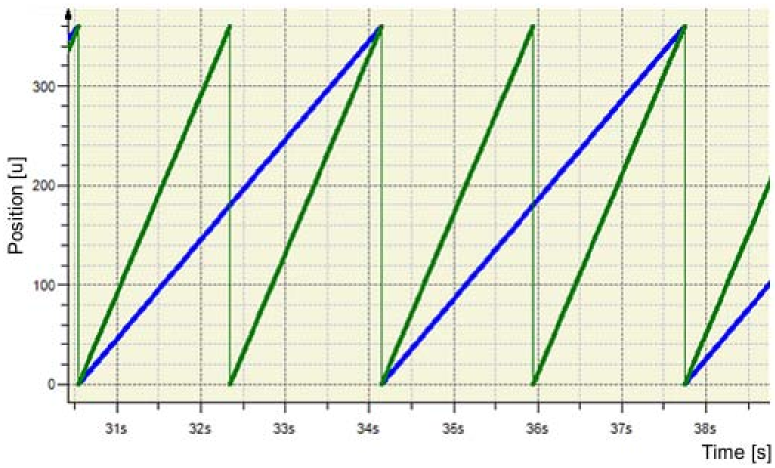
The parameters for the gearbox factor are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
dwNumerator : DWORD := 1;
dwDenominator : DWORD := 1;
```

Examples

Synchronism with identical cycle (360/360)	Synchronism with different cycle (360/450)
	

If, for instance, the gearbox factor is set to 2:1 (*dwNumerator* = 2, *dwDenominator* = 1), the following synchronism response can be observed:



[3-4] Synchronism behaviour at gearbox factor 2:1

3.9 Position offset during synchronism

Note!

A position offset is set with a position jump.

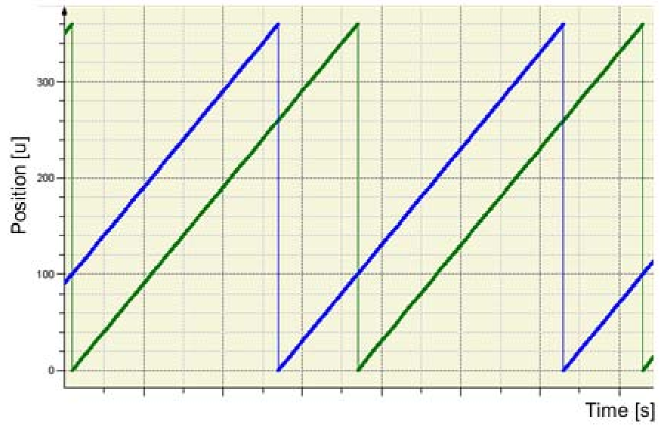
Precondition

Setting a position offset is only possible in the "POS_IS_SYCHRONISED" state.

Execution

A variable position offset between master and slave is defined with the *lrSetOffsetSlave* input. In the "POS_IS_SYNCHRONISED" state and with a changed value, the offset is abruptly connected to the setpoint position of the axis.

Example



[3-5] Position offset lrSetOffsetSlave = 100

3.10 Synchronism with clutch-in/declutch mechanism

Execution

Synchronism of the slave axis and master axis is extended by a clutch function. The clutch function synchronises the position of the slave axis with the master position of the master axis, positioning taking place without step changes.

Clutch-in starts at any position when *xSyncPos* = TRUE.

When declutching with *xSyncPos* = FALSE, the drive is braked to a standstill at the *lrSlaveSyncOutPos* position and changed to the "Ready" state.

The *lrSlaveSyncInDist* parameters (for clutch-in) and *lrSlaveSyncOutDist* (for declutch) describe the path via which the clutch process shall take place. For the initial values of the parameters, the clutch process has to be completed after 90 units.

In order that the clutching process is started, the position of the master axis has to be located upstream by at least double the clutch-in distance of the position of the slave axis. Otherwise, the master axis would travel another complete cycle until the clutch-in process is started.

Note!

In case of "Limited" axis setting:

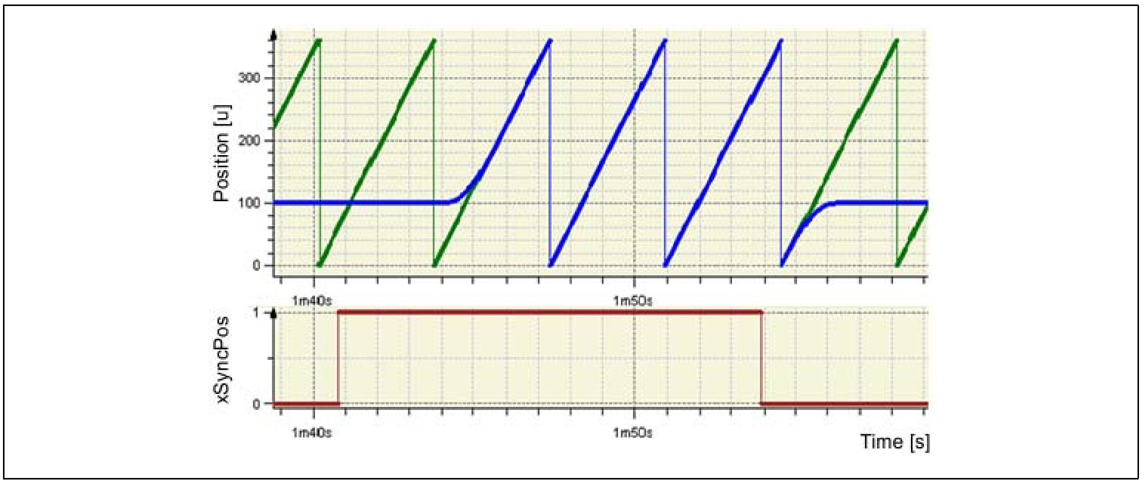
- The slave axis is clutched in when the master axis has reached the *lrSlaveSyncInDist* distance before the slave axis.
- In order that the slave axis is declutched at the *lrSlaveSyncOutPos* declutch position, the *lrSlaveSyncOutDist* distance must be defined in advance.

Parameters to be set

The parameters for the clutch function are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
lrSlaveSyncOutPos : LREAL := 0.0;
lrSlaveSyncInDist : LREAL := 90.0;
lrSlaveSyncOutDist : LREAL := 90.0;
```

Example



[3-6] Clutching-in/declutching with lrSlaveSyncOutPos = 100

The [3-6] figure shows the clutch-in process on position 100.0 which is completed within 90 units. After declutching, it ends again on position 100.0 after 90 units.

3.10.1 Direct clutching-in/declutching

The clutch function also provides for a direct clutching-in/declutching. For this purpose, set the parameters *lrSlaveSyncInDist* and *lrSlaveSyncOutDist* to the value '0.0'. Clutching-in is then executed directly and abruptly.

In order to prevent a jump of the position at the clutch output and thus at the slave axis, the following options are available:

- Positioning of the slave axis to the input position of the clutch (*MP04:lrSetClutchPos*) before clutching-in hard.
  This version offers a position synchronism without position offset between the master axis and the slave axis.
  More information on *MP04:lrSetClutchPos* can be found here:
  L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19)
- Automatic calculation and definition of the gearbox position for direct clutch-in with *xLoadSyncPos parameter = TRUE*.
  This version offers a position synchronism with position offset between the master axis and the slave axis. The resulting position offset can be eliminated afterwards by applying an offset.

3.10.2 Relative clutching-in/declutching

This function can only be used in the High version of the technology module!

These functions are selected via inputs and not via selecting a coupling mode. The selection of the general coupling mode is not affected by this function.

When the *xSyncInstant* input = TRUE, the synchronisation is carried out with relative position coupling.

- If the master axis is at standstill, the slave axis directly (abruptly) clutches in to its current position.
- When the master axis is in motion, the slave axis immediately clutches in via the clutching distance in the *lrSlaveSyncInDist* parameter (by analogy with a velocity coupling).
- For declutching, the *xSyncInstant* input has no function.

When the *xSyncOutInstant* input = TRUE, it is declutched with relative position coupling.

- If the master axis is at standstill, the slave axis directly (abruptly) declutches from its current position.
- When the master axis is in motion, the slave axis immediately declutches via the clutching distance in the *lrSlaveSyncOutDist* parameter (by analogy with a velocity coupling or MC_Halt).
- For declutching, the *xSyncOutInstant* input has no function.

A position offset caused by relative clutching-in is displayed at the *lrOffsetSyncPos* output (in units).

Coupling behaviour if the inputs are stimulated at different times

Clutching-in via the *xSyncInstant* input:

Combinations of the inputs		Coupling behaviour
xSyncPos	xSyncInstant	
FALSE↗TRUE	FALSE	Coupling behaviour as before
FALSE	FALSE↗TRUE	No response
TRUE	FALSE↗TRUE	No response
FALSE↗TRUE	FALSE↗TRUE	Relative clutching-in
FALSE↗TRUE	TRUE	Relative clutching-in

Declutching via the *xSyncOutInstant* input:

Combinations of the inputs		Coupling behaviour
xSyncPos	xSyncOutInstant	
TRUE↘FALSE	FALSE	Coupling behaviour as before
TRUE↘FALSE	FALSE↗TRUE	Relative declutching
TRUE	FALSE↗TRUE	Relative declutching

Parameters to be set

The parameters for the clutch function are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
lrSlaveSyncInDist : LREAL := 90.0;
lrSlaveSyncOutDist : LREAL := 90.0;
eOffsetSlaveDirection : L_TT1P_Direction := 1;
eOffsetSlaveProfileType : L_TT1P_ProfileType := 2;
lrOffsetSlaveVelPos : LREAL := 100;
lrOffsetSlaveVelNeg : LREAL := 100;
lrOffsetSlaveAccDec : LREAL := 1000;
```

3.11 Position trimming

Precondition

The position trimming is only possible in the "POS_IS_SYCHRONISED" state.

Execution

Position trimming makes it possible to adjust the position of the slave axis with regard to the master axis by "inching" – as in the case of Manual jog (jogging) (📖 27).

Position trimming is started by setting the input *xTrimPos* or *xTrimNeg* to TRUE. The "POS_IS_SYCHRONISED" state then changes to "TRIM_POS_PLUS" or "TRIM_POS_MINUS", depending on the direction, and only leaves it when the respective input *xTrimPos* or *xTrimNeg* is reset to FALSE.

Offsets adjusted by trimming can be detected via the *lrOffsetTrim* output. The value of *lrOffsetTrim* can only be reset to zero by switching of the technology module.

Parameters to be set

The parameters for position trimming are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
lrJerk : LREAL := 100000;
lrTrimAcc : LREAL := 100;
lrTrimDec : LREAL := 100;
lrTrimVel : LREAL := 50;
```

The acceleration and velocity of the trimming superimpose the ones of the master axis. Hence, the results for the axis to be trimmed are as follows:

- Resulting velocity of: $\mathbf{v_{AxisRes} = v_{MasterAxis} + lrTrimVel}$
- Resulting acceleration of: $\mathbf{a_{AxisRes} = a_{MasterAxis} + lrTrimAcc}$

3.12 Position offset with profile generator

Precondition

Setting a position offset is only possible in the "POS_IS_SYCHRONISED" state.

Execution

The position offset is transferred to the axis via a profile generator without position jumps. The offset is selected using the *lrSetOffsetSlave* input.

The position offset can be travelled with 3 different rounding profiles using the profile generator. The profile generator is activated by setting the *xLoadOffsetSlave* parameter = FALSE. A profile can be specified via the *eOffsetSlaveProfileType* parameter.

The *eOffsetSlaveDirection* parameter serves to define whether the drive may rotate in the opposite direction of the master direction of rotation (*0: Both*) or not (*1: Direction Master*).

The basic conditions for calculating the profile are defined via the parameters *lrOffsetSlaveVelPos*, *lrOffsetSlaveVelNeg* and *lrOffsetSlaveAccDec*.

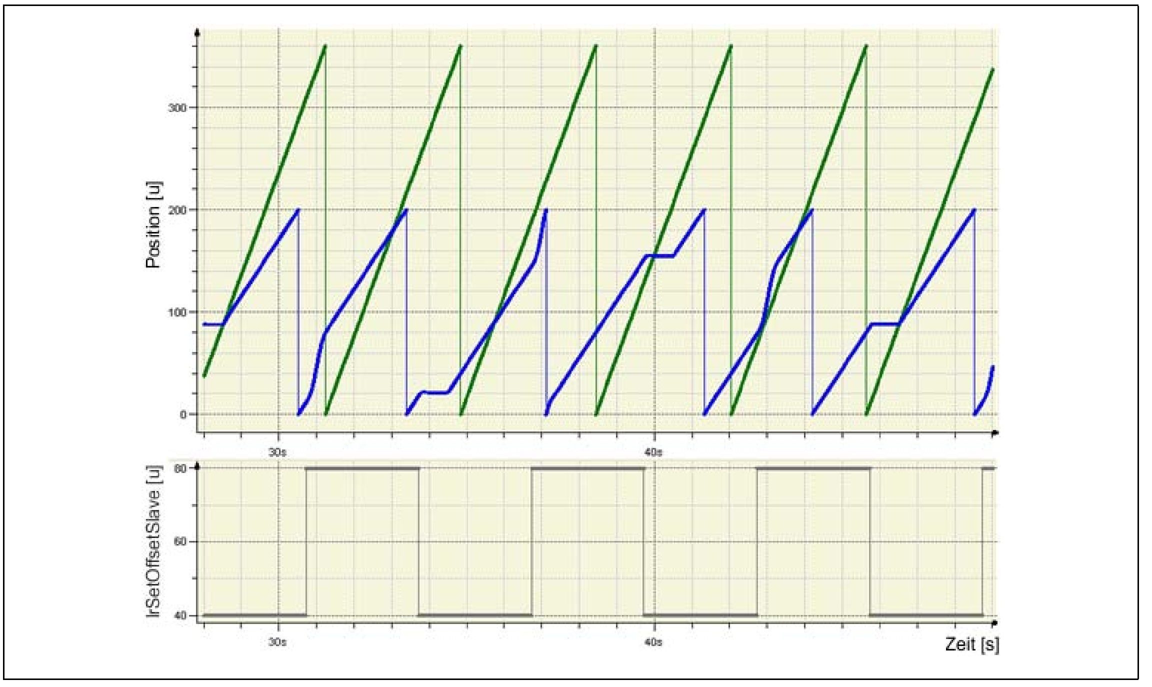
Parameters to be set

The parameters for the position offset with profile generator are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
xLoadOffsetSlave : BOOL := FALSE;
eOffsetSlaveProfileType : L_TT1P_ProfileType := 0;
eOffsetSlaveDirection : L_TT1P_Direction := 0;
lrJerk : LREAL := 100000;
lrOffsetSlaveVelPos : LREAL := 100;
lrOffsetSlaveVelNeg : LREAL := 100;
lrOffsetSlaveAccDec : LREAL := 1000;
```

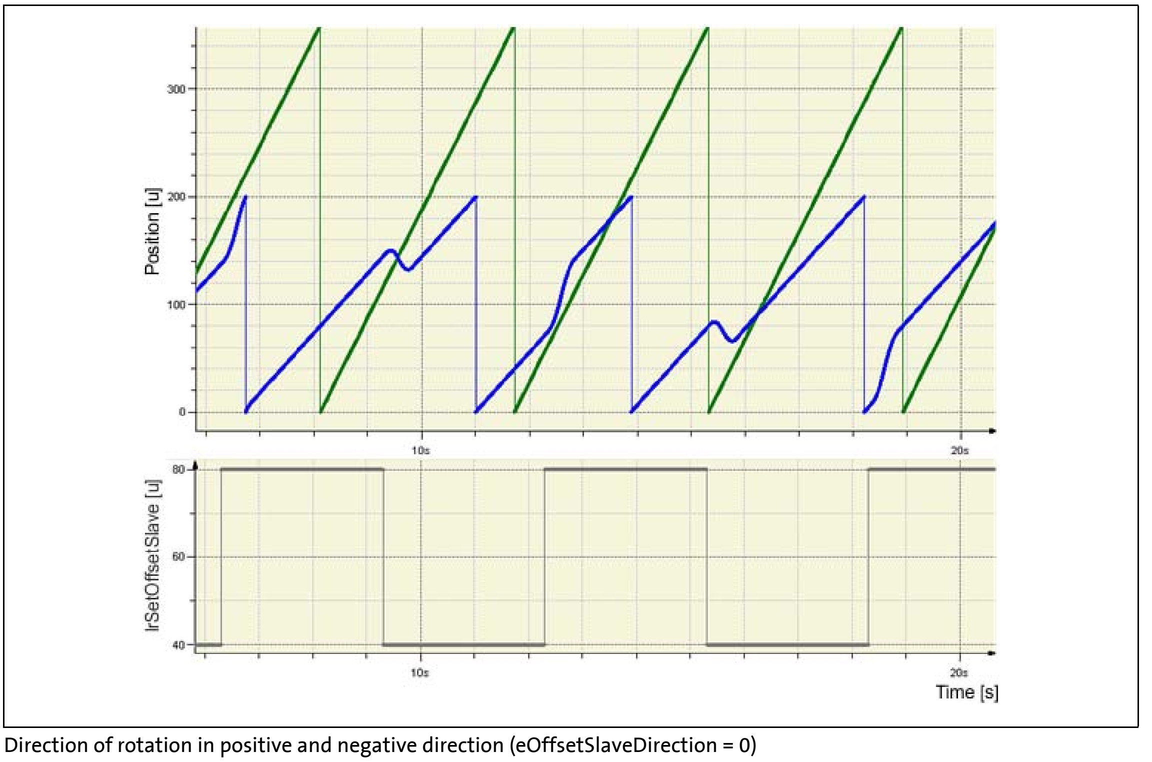
Examples

If, for instance, the master axis is operated in positive direction, *eOffsetSlaveDirection = 1* (*DirectionMaster*) serves to prevent the slave axis from rotating in the negative direction. The [3-7] figure shows how the slave axis (blue) is waiting for the master axis in order to correct its position offset *lrSetOffsetSlave*.



[3-7] Direction of rotation only in master direction of rotation (eOffsetSlaveDirection = 1)

The [3-8] figure shows the behaviour when the slave axis is allowed to rotate in the positive and negative direction (*eOffsetSlaveDirection = 0* (*Both*)).



[3-8] Direction of rotation in positive and negative direction (eOffsetSlaveDirection = 0)

In the figures [3-7] and [3-8], the rounding profile has been calculated with a 4th grade polynomial. This is the standard setting specified via the *eOffsetSlaveProfileType* parameter. There are 3 possible profiles for this parameter:

```
eOffsetSlaveProfileType : L_TT1P_ProfileType := 0;
// 0: poly_4th_order (4th order polynomial)
// 1: poly_2nd_order (2nd order polynomial)
// 2: poly_5th_order (5th order polynomial)
```

The *lrSetOffsetSlave* position offset changes every 3 seconds between 40 and 80 units.

3.13 Extended clutch-in/declutch mechanism

This function can only be used in the High version of the technology module!

The clutch-in and declutch mechanism of the State version has been extended by the *scPar.eSyncMode* mode.

3.13.1 eSyncMode = Ramp_Dist

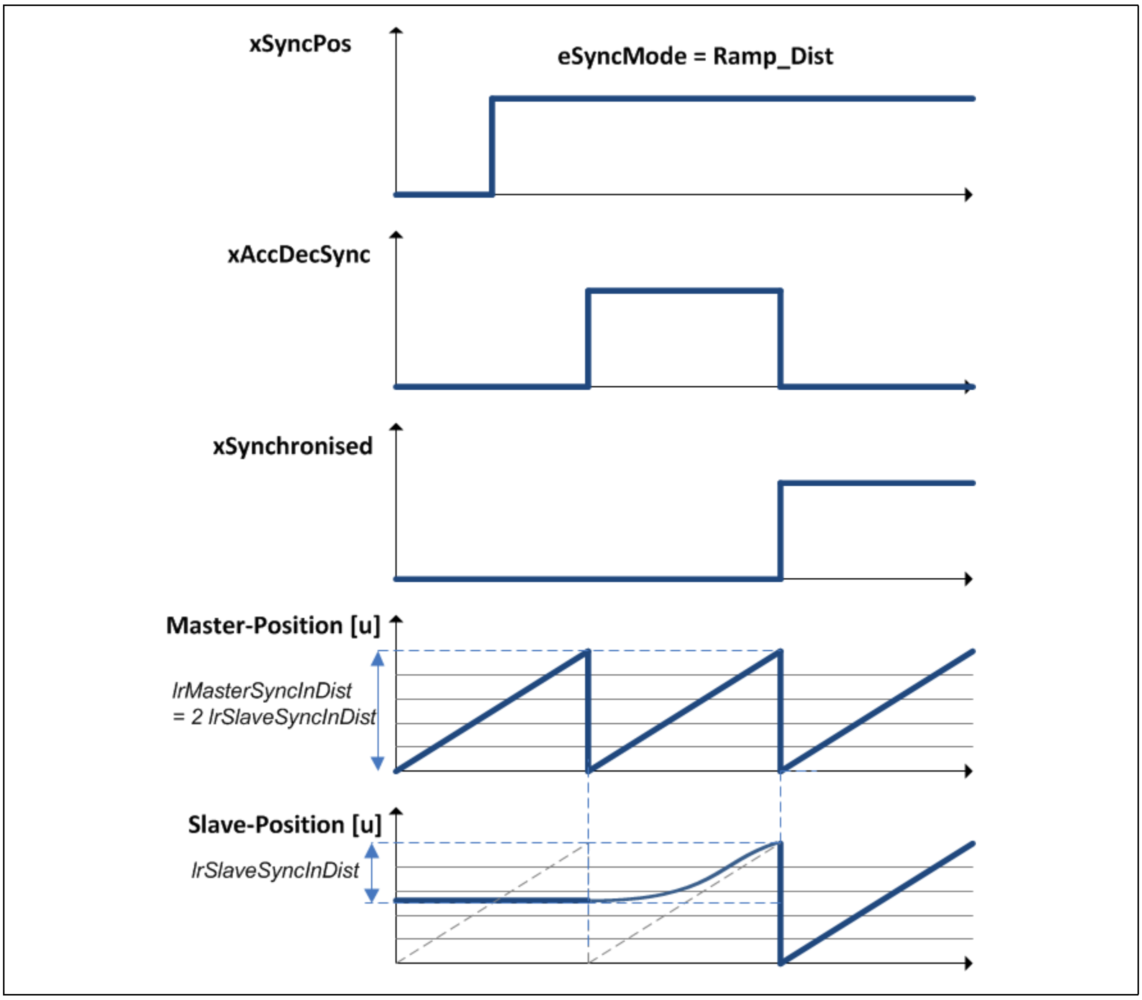
The "Ramp_Dist" coupling mode is the clutch-in and declutch mechanism from the State version.

In this mode, the slave axis can clutch in or declutch over several cycles of the master axis.

The slave axis only clutches in or declutches to/from the master position if the master axis is moving.

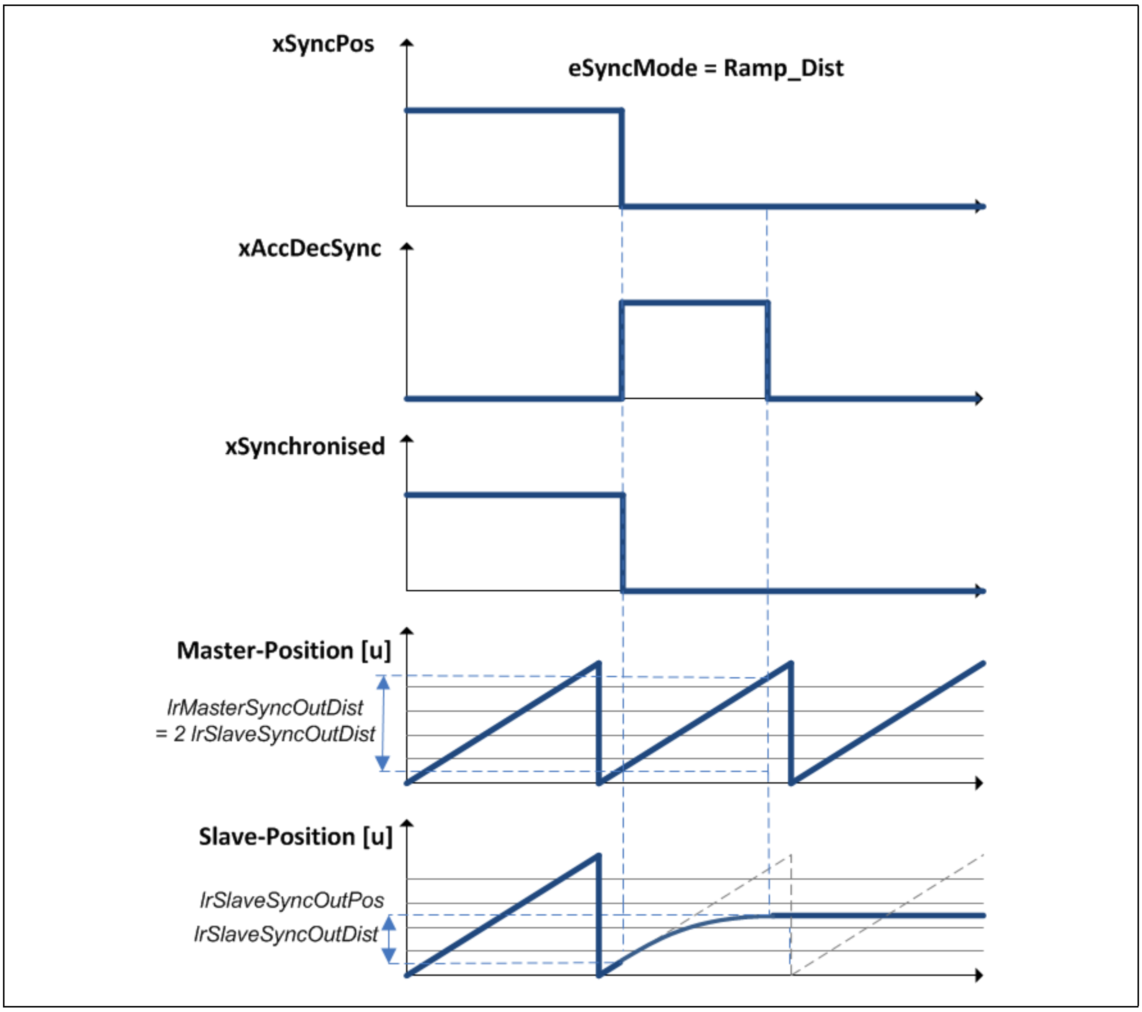
The slave axis is positioned from its current position to the resulting target position in a path-based fashion via a polynomial of the fifth degree.

Clutching in



[3-9] Clutching in with eSyncMode = 5 Ramp_Dist

Declutching



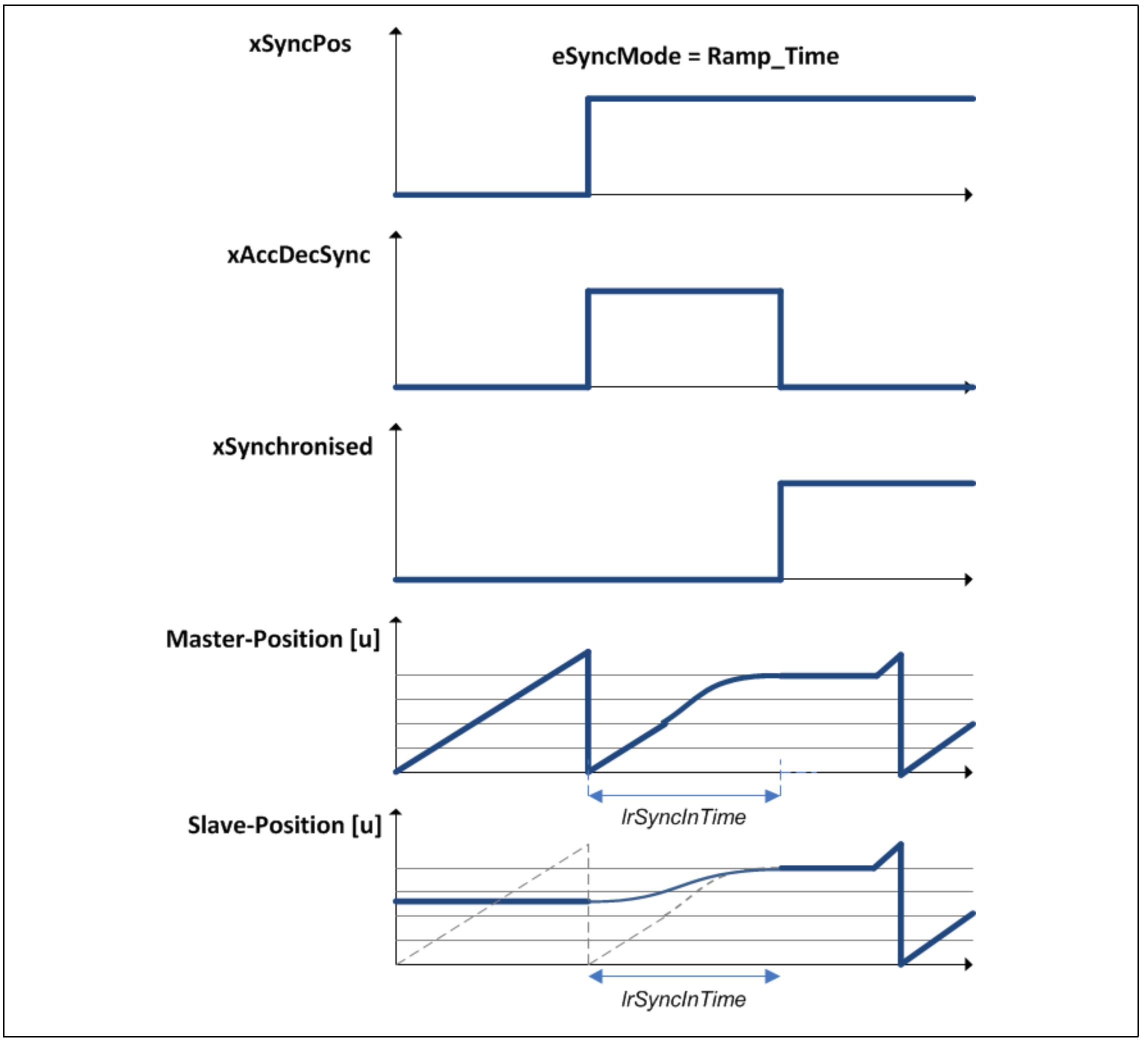
[3-10] Declutching with eSyncMode = 5 Ramp_Dist

3.13.2 eSyncMode = Ramp_Time

The "Ramp_Time" coupling mode does not depend on the motion of the master axis. The slave axis is also synchronised with a standing master axis.

Clutching in

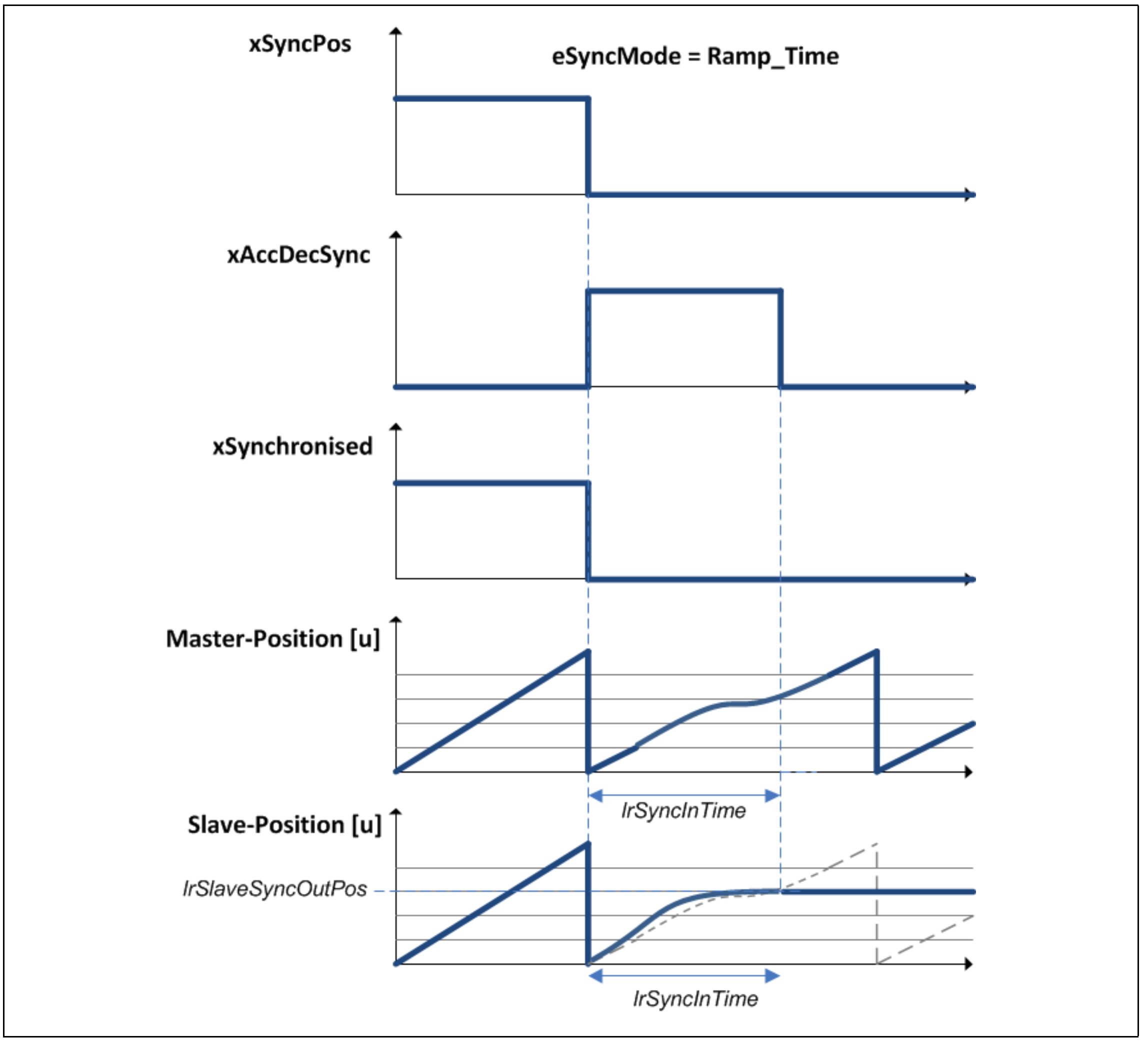
The slave axis clutches in to the master position from its current position via a polynomial of the fifth degree in a time-based fashion (parameter *lrSyncInTime*). The movement is executed within the slave cycle of the modulo axes.



[3-11] Clutching in with eSyncMode = 3 Ramp_Time

Declutching

Declutching is triggered with the *xSyncPos* input = FALSE. The time-controlled declutching is executed by the slave axis from the current position within a defined time (parameter *lrSyncOutTime*). The *lrSlaveSyncOutPos* parameter is used to define the stopping position of the slave axis.



[3-12] Declutching with eSyncMode = 3 Ramp_Time

Parameters to be set

The parameters to be set are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
eSyncMode : L_TT1P_SyncMode :=  L_TT1P_SyncMode.Ramp_time;
lrSlaveSyncOutPos
lrSyncInTime : LREAL := 5;
lrSyncOutTime : LREAL := 5;
lrSlaveSyncOutPos : LREAL := 0;
```

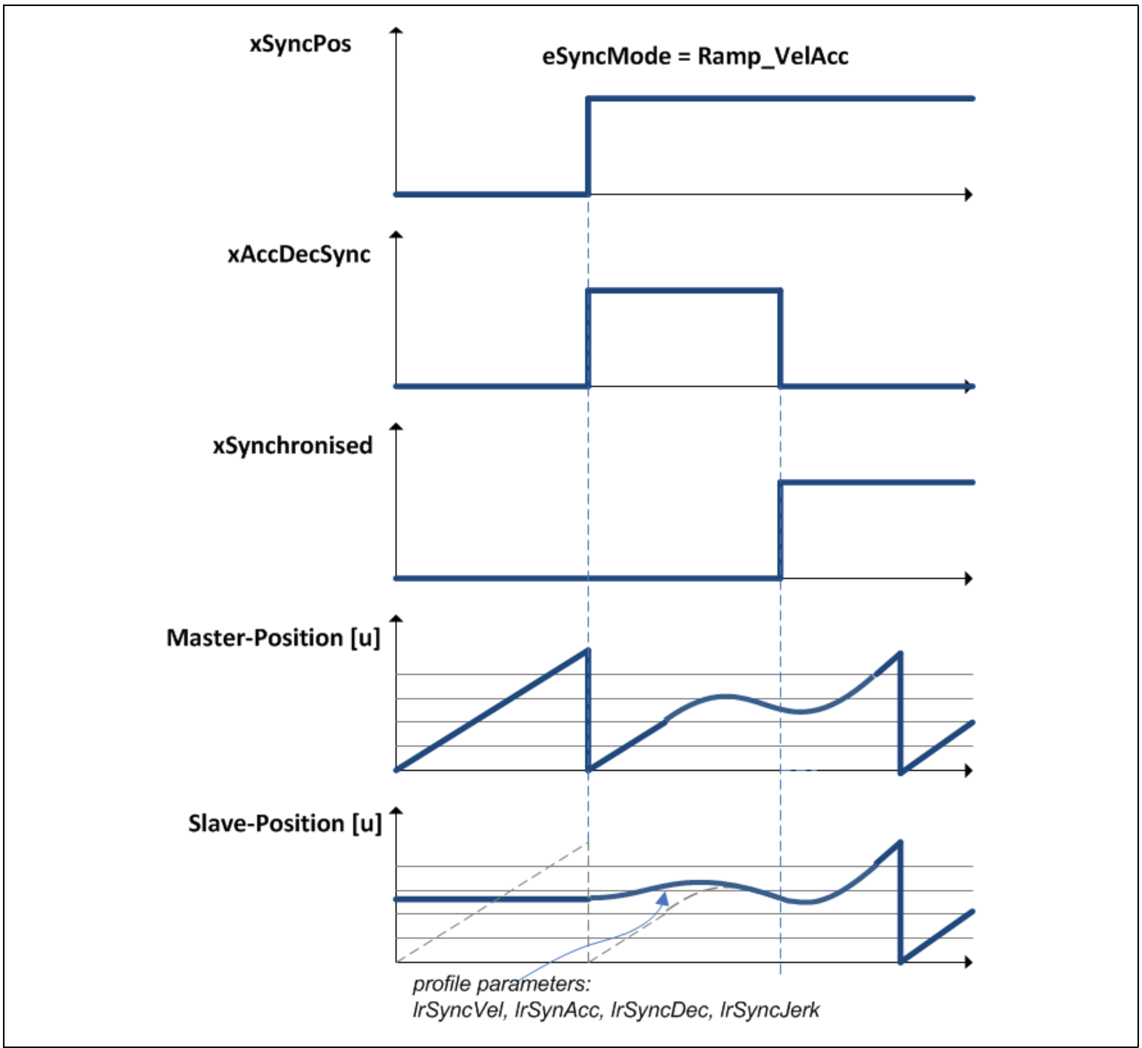
3.13.3 eSyncMode = Ramp_VelAcc

Note!

This clutch-in or declutch version does not depend on the master motion, which means it also synchronises the slave axis with a standing master axis.

Clutching in

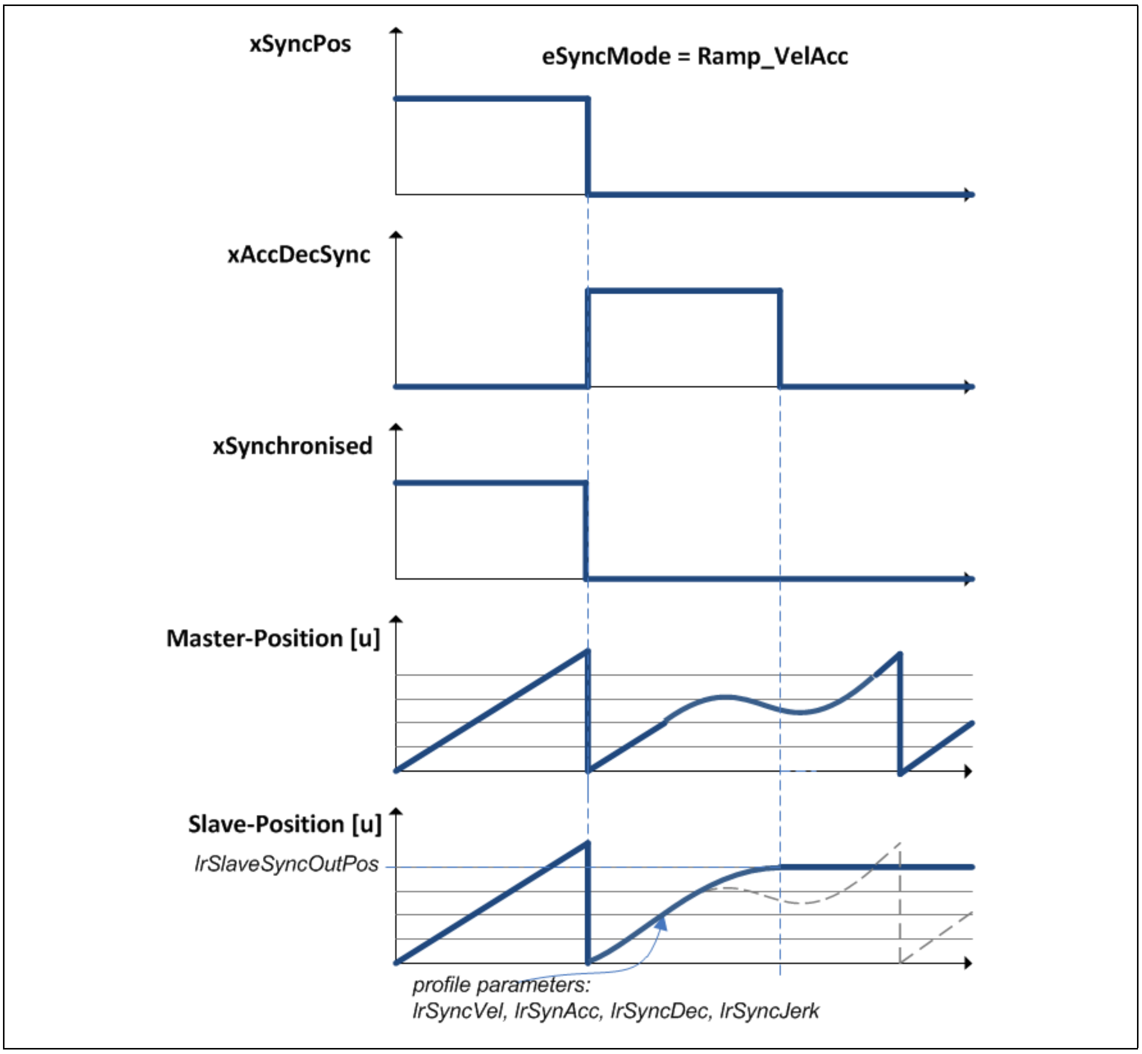
The slave axis clutches in from its current position to the master position via the profile generator with the parameters *lrSyncVel*, *lrSyncAcc*, *lrSyncDec* and *lrSyncJerk*. The motion is executed within the slave cycle of the modulo axes. The resulting velocity of the slave axis in the clutch-in phase results from the sum of speed of the master axis and the *lrSyncVel* velocity. The acceleration of the slave axes in the clutch-in phase also results from the sum of acceleration of the master axis and the acceleration and deceleration of the coupling (*lrSyncAcc*, *lrSyncDec*).



[3-13] Clutching in with eSyncMode = 4 Ramp_Time

Declutching

Declutching is triggered via the *xSyncPos* input = FALSE. The profile-controlled declutching brakes the slave axis to a standstill from the current position with the parameters *lrSyncVel*, *lrSyncAcc*, *lrSyncDec* and *lrSyncJerk*. The *lrSlaveSyncOutPos* parameter is used to define the stopping position of the slave axis.



[3-14] Declutching with eSyncMode = 4 Ramp_Time

Parameters to be set

The parameters to be set are located in the L_TT1P_scPar_ElectricalShaftPos[Base/State/High] (📖 19) parameter structure.

```
eSyncMode : L_TT1P_SyncMode :=  L_TT1P_SyncMode.Ramp_VelAcc;
lrSyncVel : LREAL := 100;
lrSyncAcc : LREAL := 1000;
lrSyncDec : LREAL := 1000;
lrSyncJerk : LREAL := 100000;
```

3.14 CPU utilisation (example Controller 3231 C)

The following table shows the CPU utilisation in microseconds using the example of the 3231 C controller (ATOM™ processor, 1.6 GHz).

Versions	Interconnection of the technology module	CPU utilisation	
		Average	Maximum peak

Base	xEnable := TRUE;
	xRegulatorOn := TRUE;
	xSyncPos := TRUE;
		40 µs	83 µs

State	xEnable := TRUE;
	xRegulatorOn := TRUE;
	xSyncPos := TRUE;
		55 µs	83 µs

High	xEnable := TRUE;
	xRegulatorOn := TRUE;
	xSyncPos := TRUE;
		70 µs	92 µs

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FEEDBACK

Your opinion is important to us

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Perhaps we have not succeeded in achieving this objective in every respect. If you have suggestions for improvement, please e-mail us to:

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Thank you very much for your support.

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