

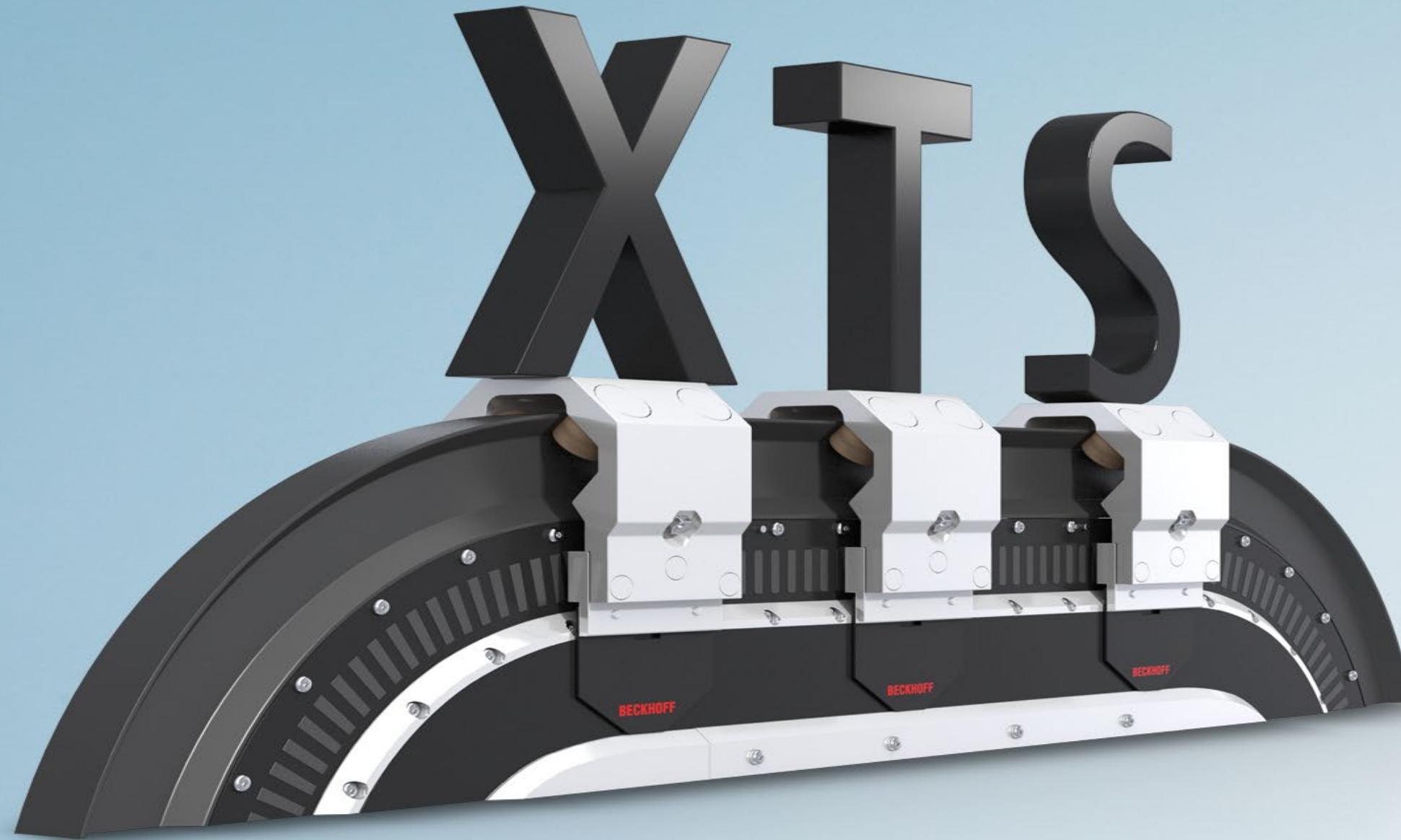
New Automation Technology

Beckhoff Automation

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF





BECKHOFF

XTS – TcSoftDrive



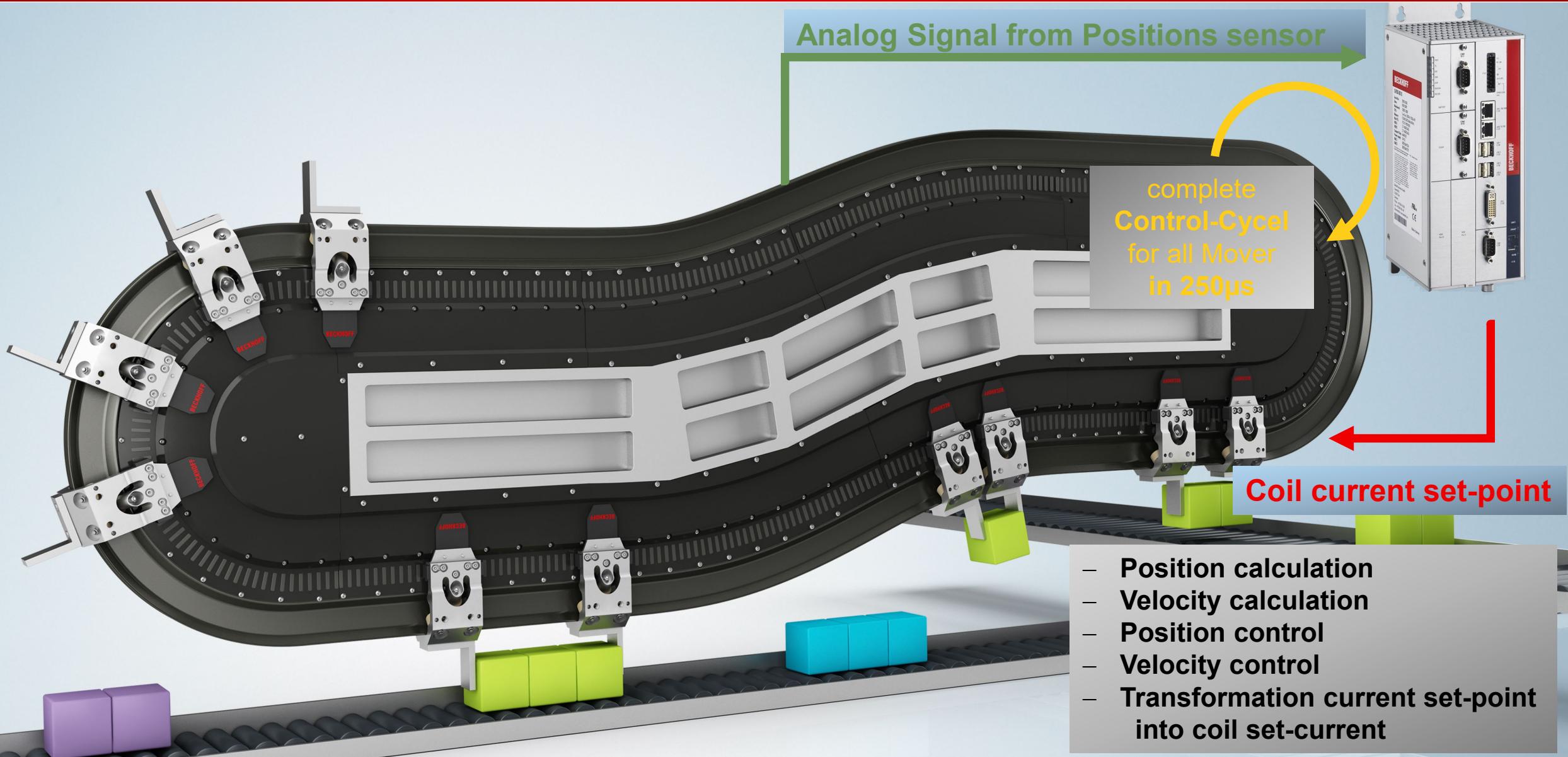
1. Short XTS basics
2. XTS IPC & capabilities
3. Scope for
Mover monitoring
4. TcSoftdrive
structure & parameter
5. Tuning



XTS – Overview and timing

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



XTS – EtherCAT timing and data size

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

each Motor module has

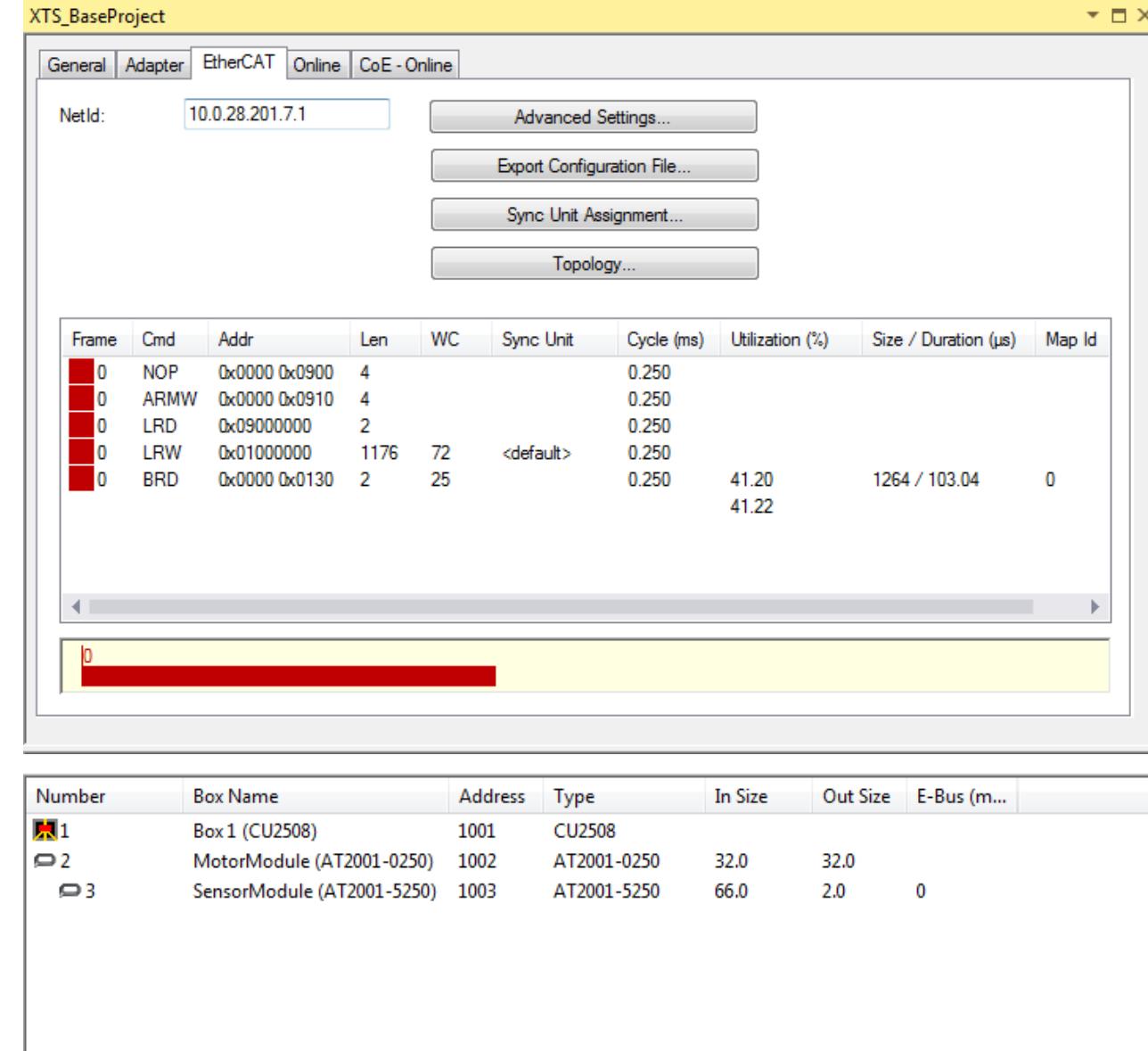
- 15 Coils → 15 current set-values
→ 15 current act-values
- 2 Byte Status & 2 Byte Control
→ 32 Byte Process Image

each Sensor Module has

- 32 Position Sensors
- 2 Byte Status & 2 Byte Control
→ 66 Byte Process Image Input

EtherCAT data size

98 Byte



XTS – EtherCAT timing and datasize

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

per Frame max. data size of 1500 Byte

per Module (Motor & Sensor)

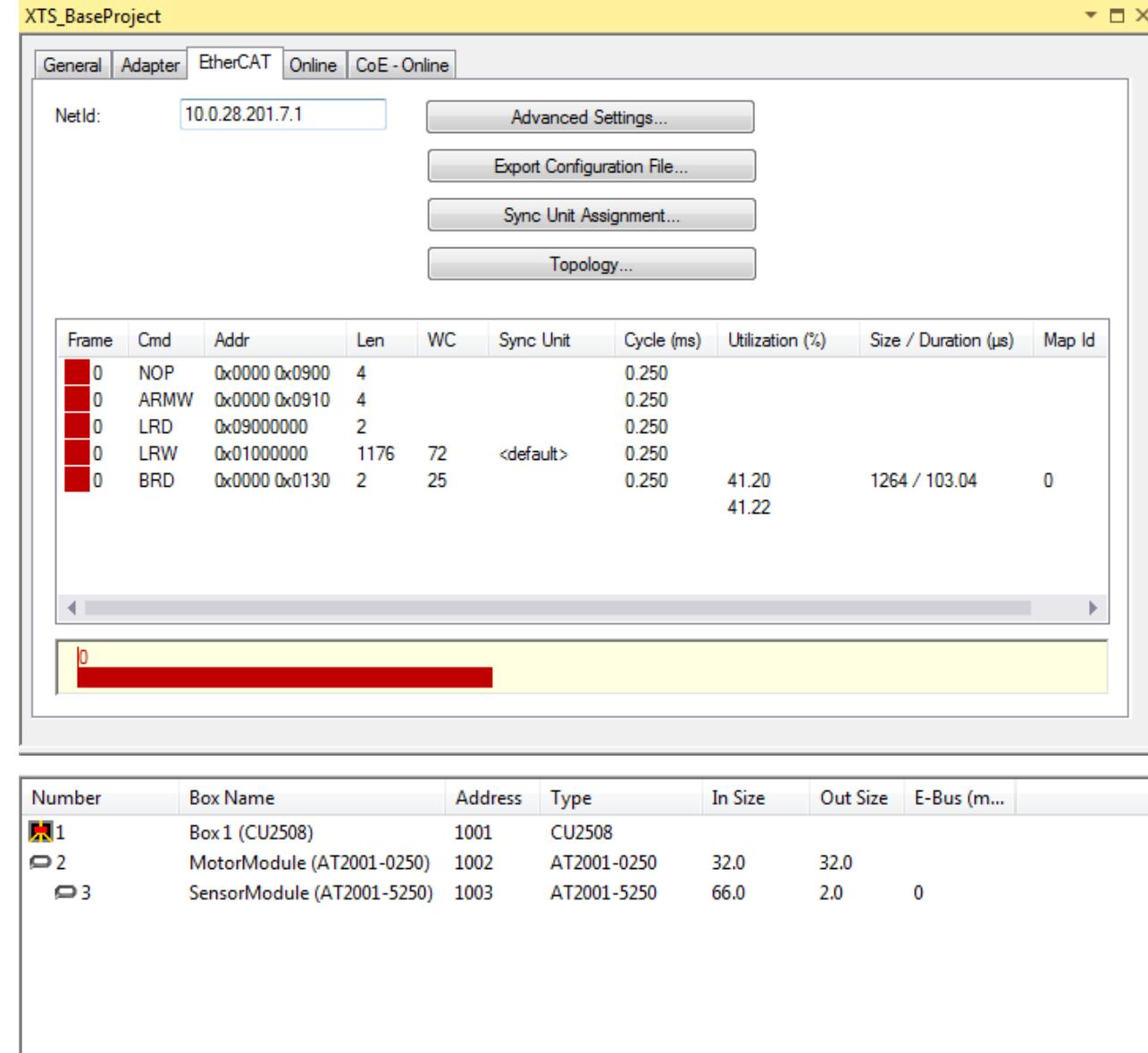
data size of 98 Byte

3m XTS-Track → 12 Modules

12 x 98 Byte = 1176 Byte Data

Full Frame size = 1264 Byte Data

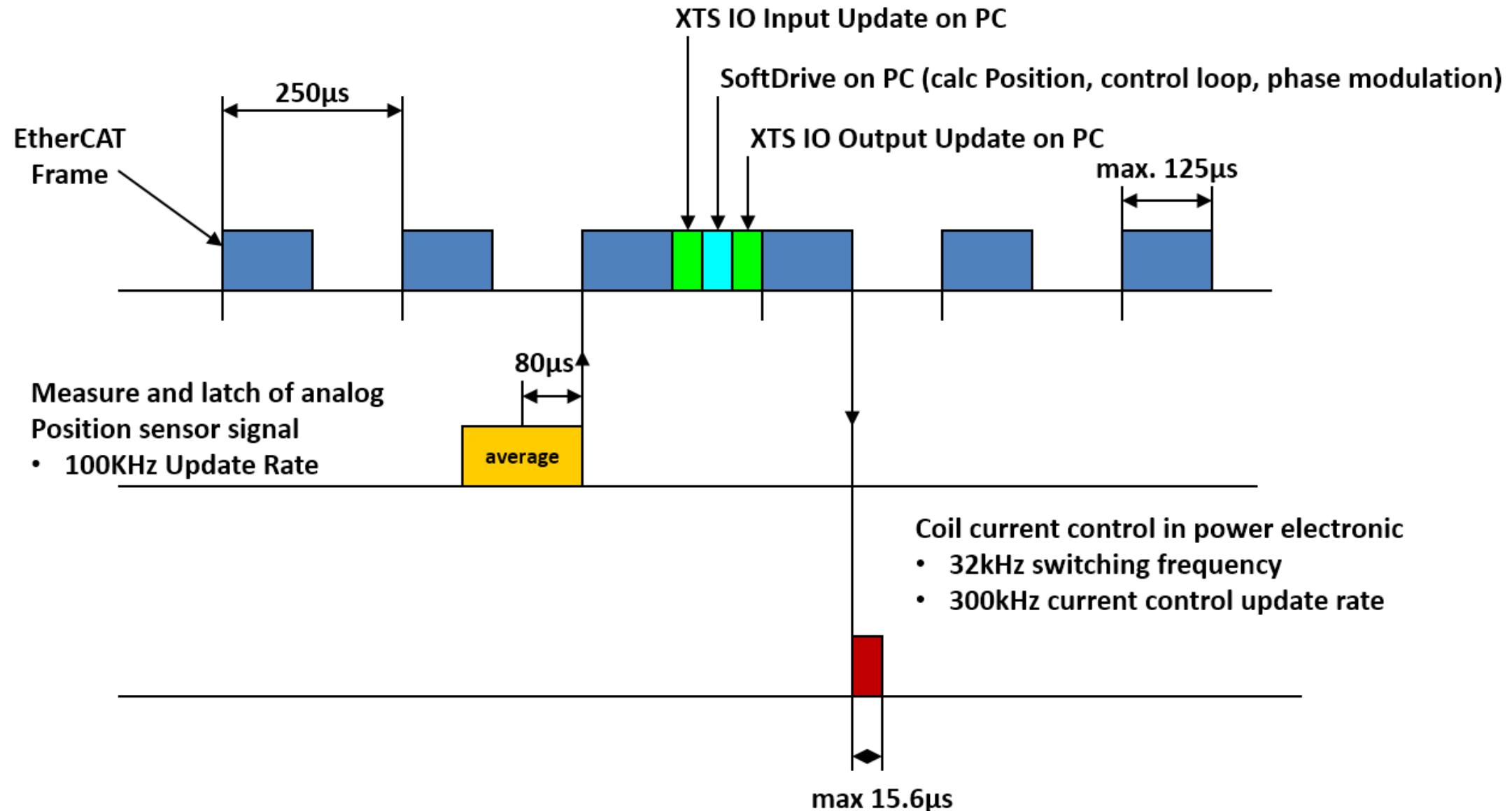
Frame runtime = 103 µs



XTS – Basic Timing

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

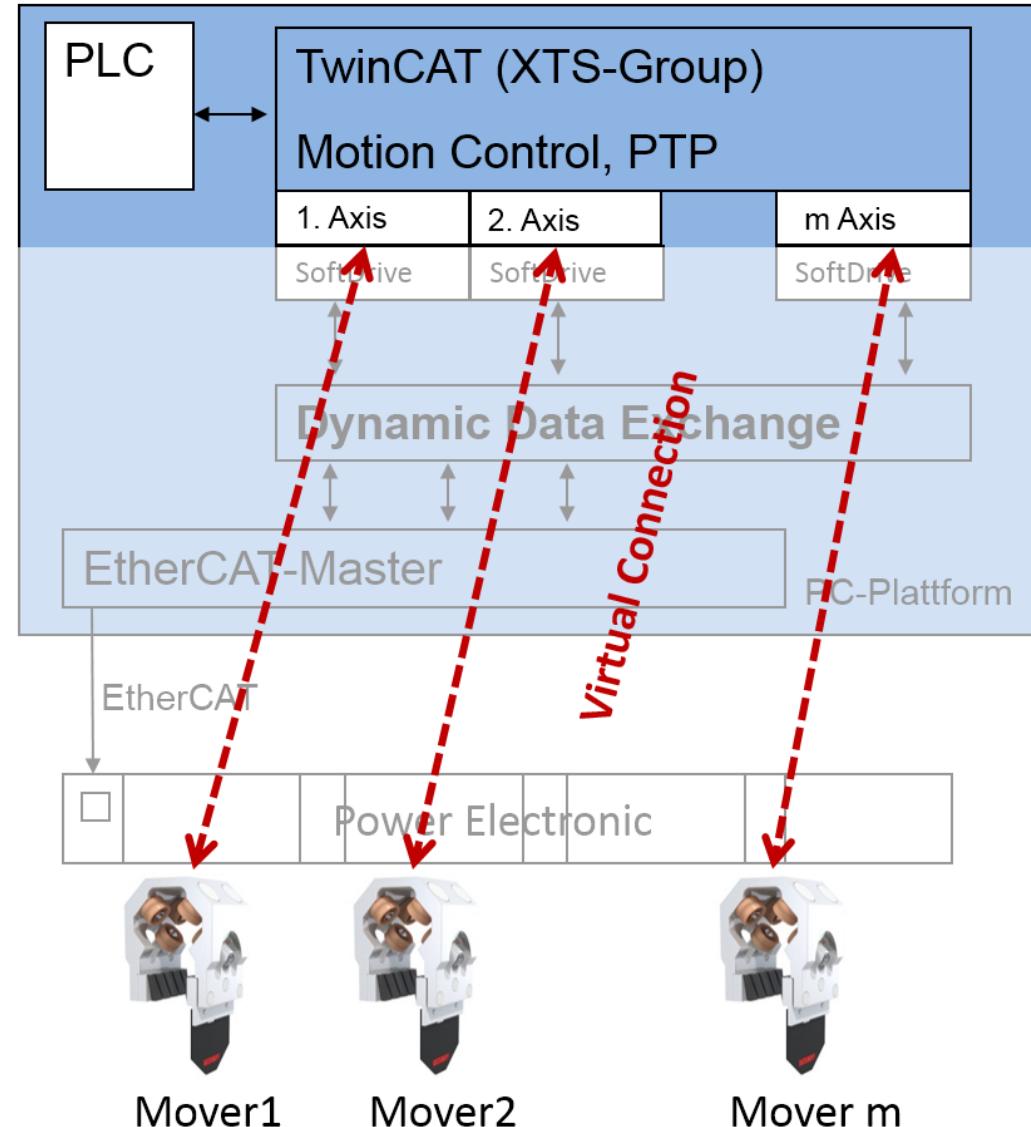


XTS – TwinCAT integration

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

- From the point of view of application programming, a mover looks like a „standard“ servo NC axis.
- New standard tasks are available:
 - Collision avoidance CA
 - Group building
 - Synchronous mechanisms
- Runs on powerful Beckhoff Standard IPCs with EtherCAT-Port
- Simulation mode is possible for TcSoftDrive

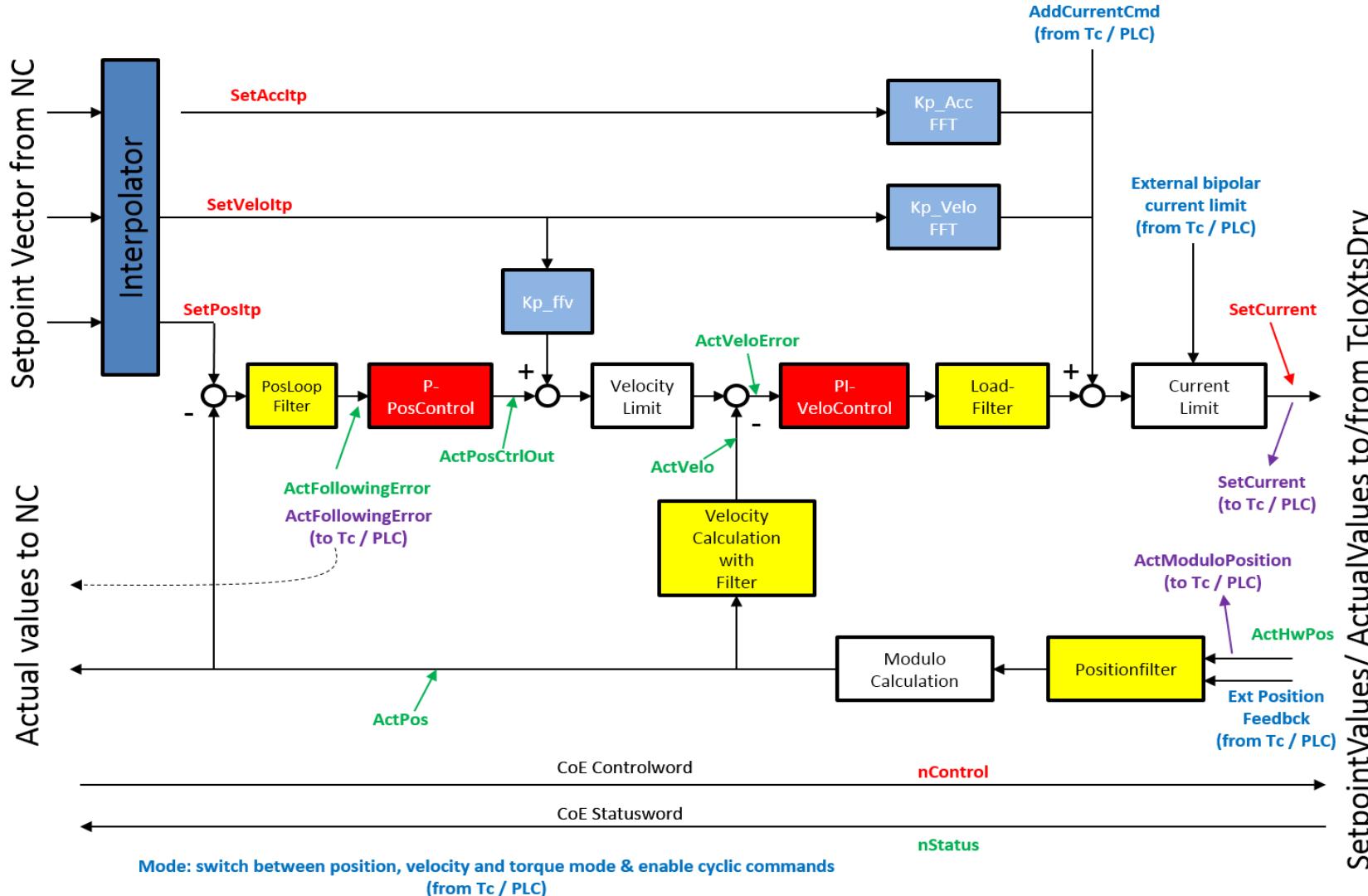


XTS – TcSoftDrive control loop structure

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

TcSoftDrive with Scope Symbol Variables and cyclic variables to & from TwinCAT and PLC



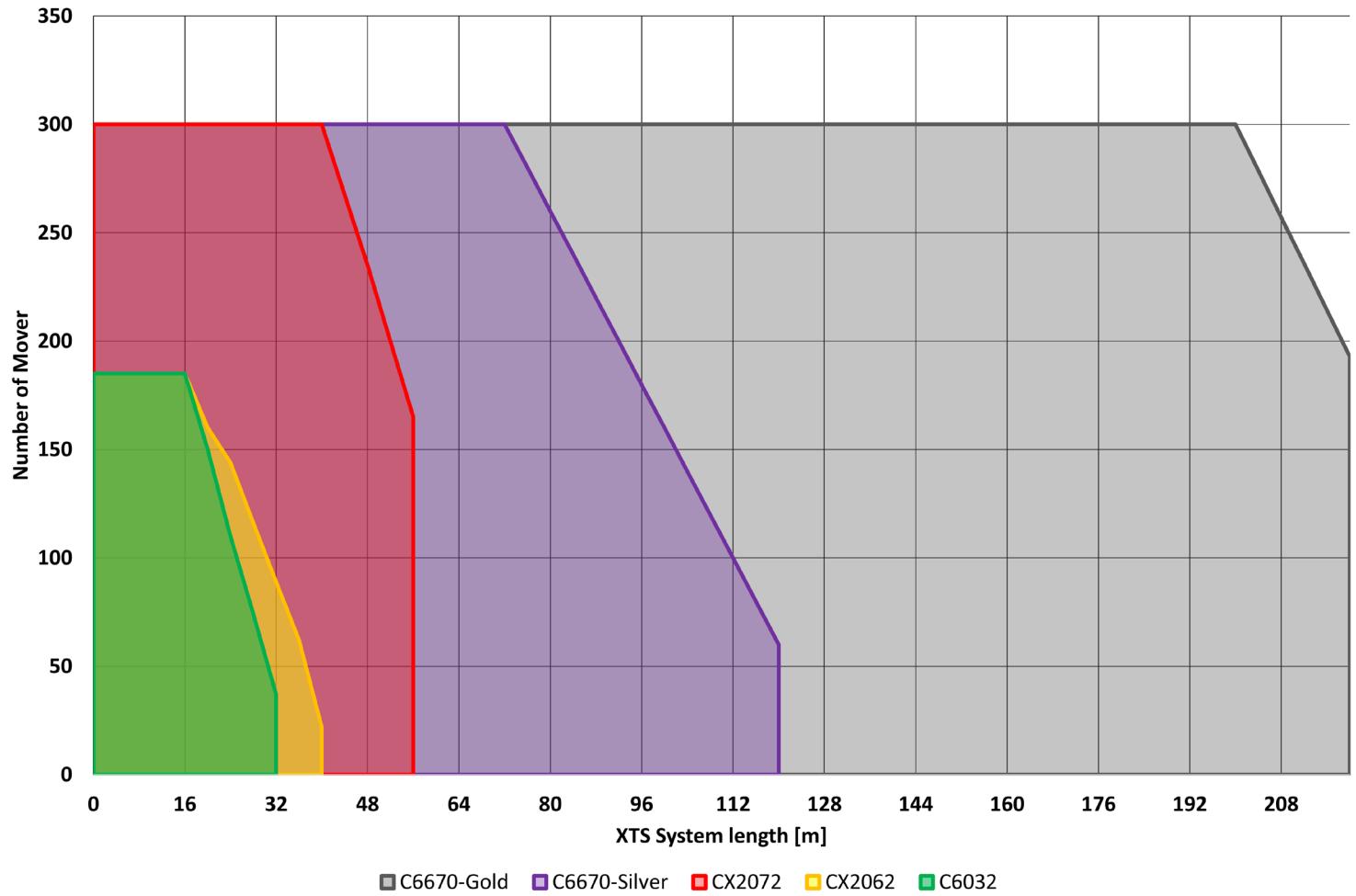
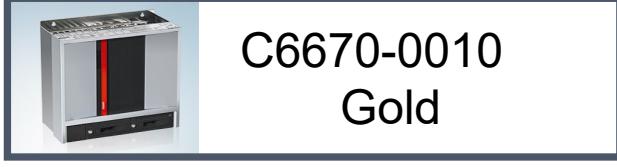
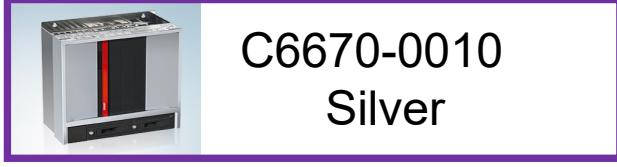
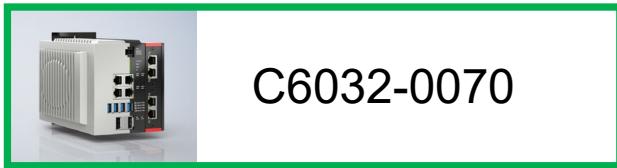
1. Short XTS basics
2. **XTS IPC & capabilities**
3. Scope for
Mover monitoring
4. TcSoftdrive
structure & parameter
5. Tuning



XTS IPC & capabilities

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



XTS IPC & capabilities

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



C6032-0070
Intel i7 – 8 Cores

Usable for XTS:

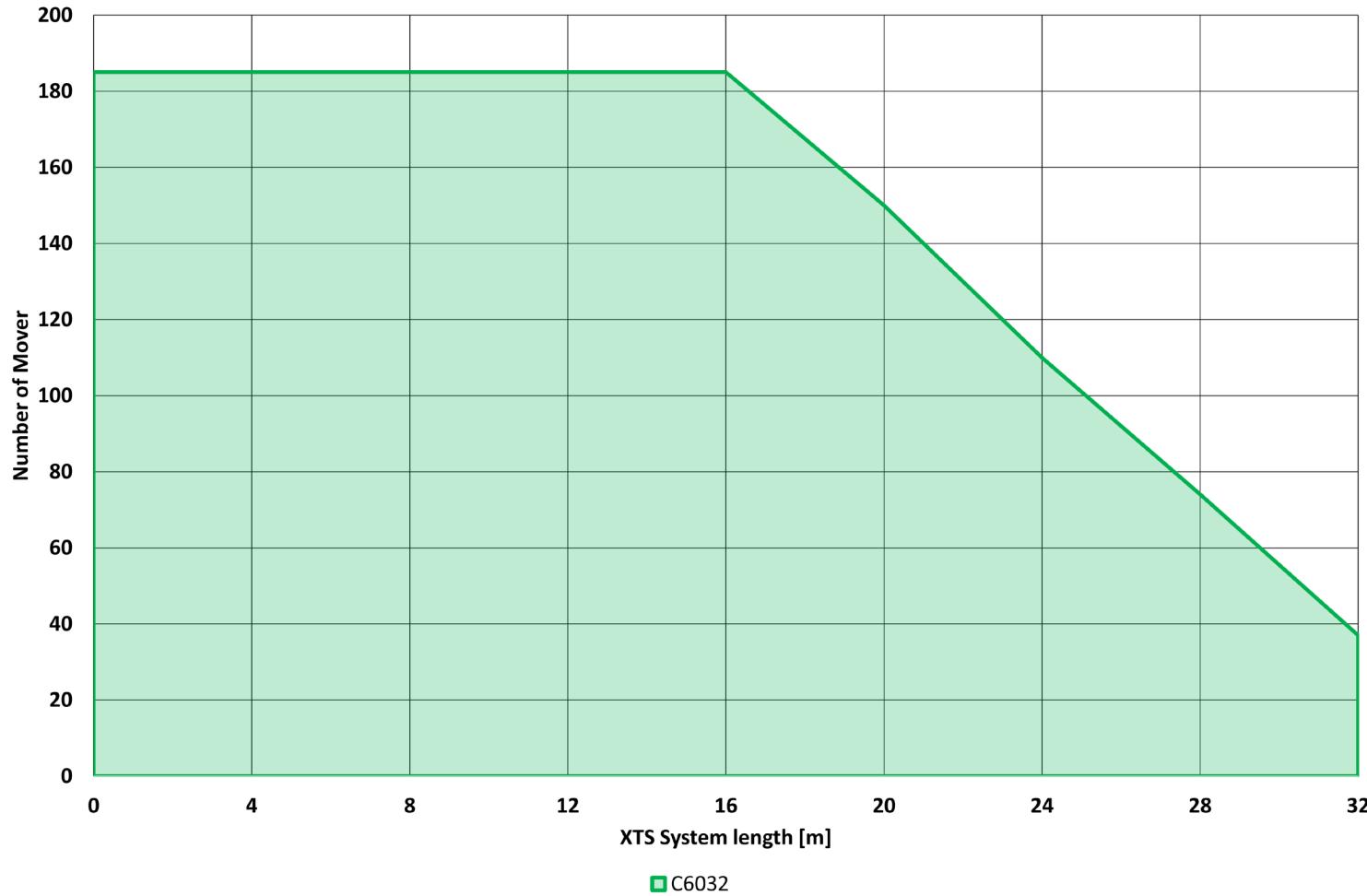
- Cores: 4
- EtherCAT ports: 4
- max. XTS infeeds: 16
(connected via 4x CU2508)

Configuration with licenses:

000153940

Configuration without licenses:

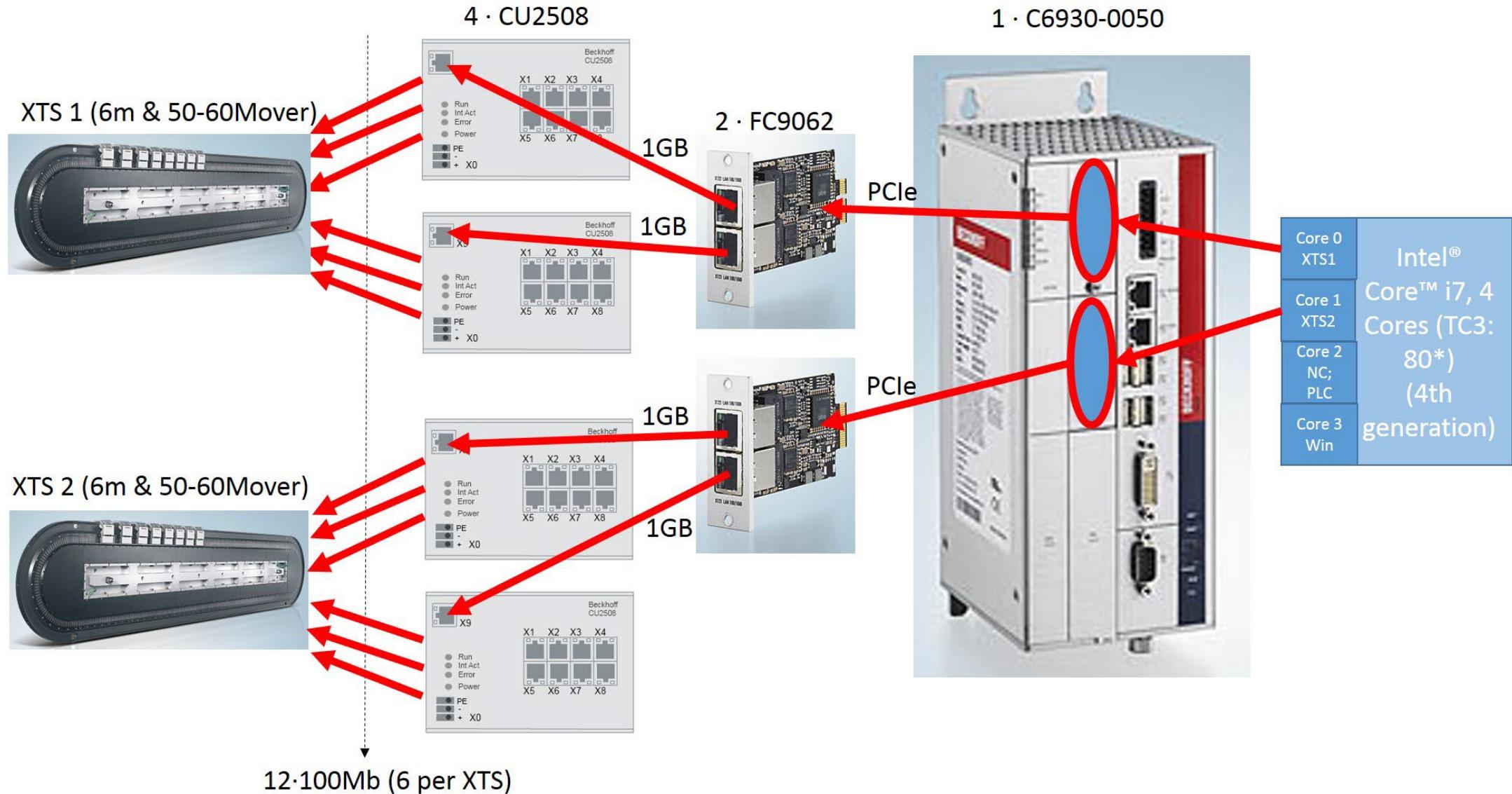
000157520



XTS – IPC C6930 Core™ i7 application examples

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



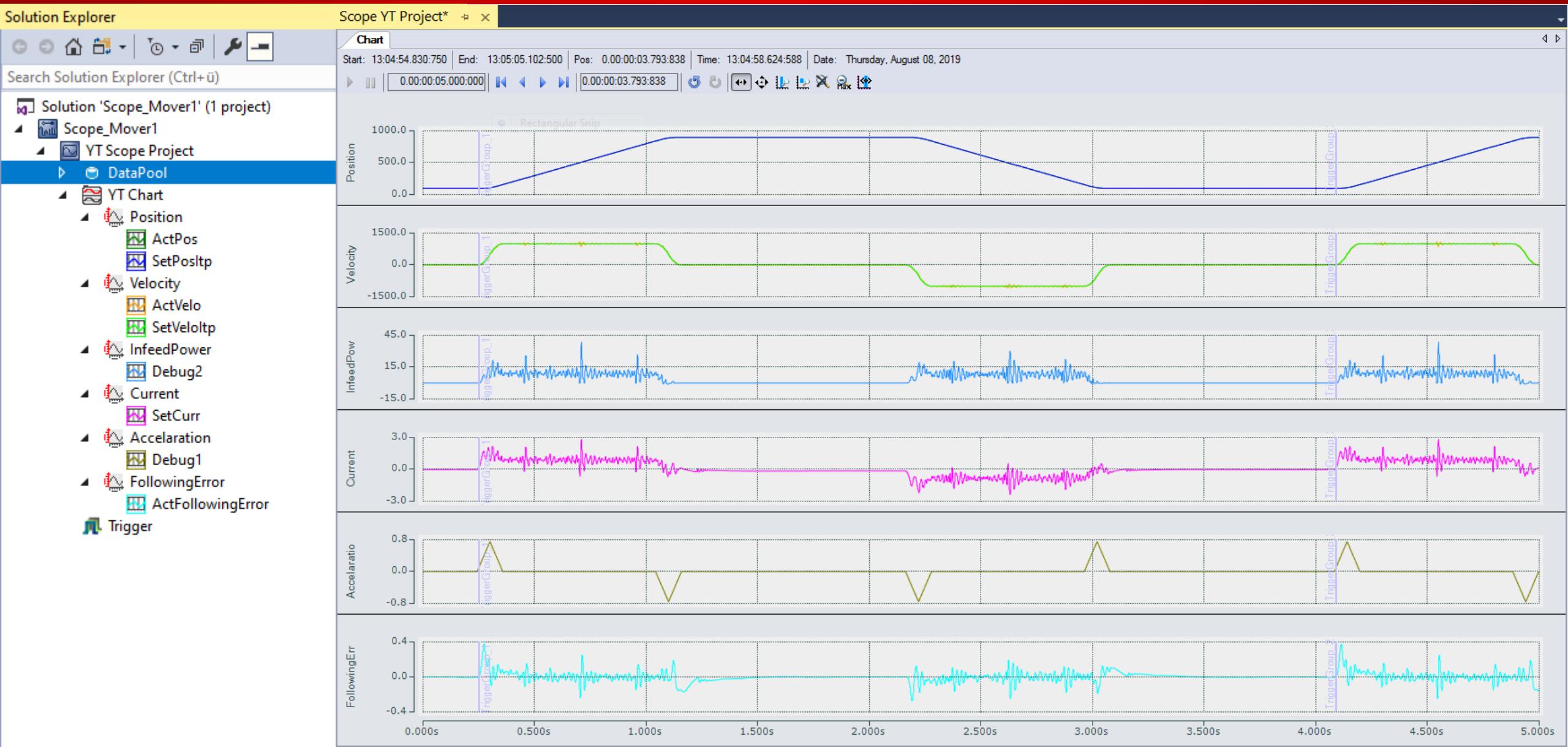
1. Short XTS basics
2. XTS IPC & capabilities
3. **Scope for Mover monitoring**
4. TcSoftdrive structure & parameter
5. Tuning



XTS TcSoftDrive – Scope for Mover monitoring

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



XTS TcSoftDrive – Signal selection for monitoring

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

Solution Explorer

Search Solution Explorer (Ctrl+ü)

Solution 'Scope_Mover1' (1 project)

Scope_Mover1

YT Scope Project

DataPool

YT Chart

Position

- ActPos
- SetPosItp

Velocity

- ActVelo
- SetVelolt

InfeedPower

- Debug2

Current

- SetCurr

Acceleration

- Debug1

FollowingError

- ActFollowingError

Trigger

Target Browser

ADS OpcUa

Enter Filter...

Mover 1 > SoftDrive 1 > SdScopeVariable > ActFollowingError >

Name	Type	Size	Category	Full-Nam	Comment	Subitem
Mover 1	Struct	0	Mover 1	Mover 1		1
SoftDrive 1	Struct	0	Mover 1	Mover 1		3
SdScopeVariable	Struct	0	Mover 1	Mover 1		23
ActComPos	LREAL	8	Primitive	Mover 1	actual...	0
ActCurr	LREAL	8	Primitive	Mover 1	actual...	0
ActFollowingError	LREAL	8	Primitive	Mover 1	actual...	0
ActHwPos	LREAL	8	Primitive	Mover 1	actual...	0
ActPos	LREAL	8	Primitive	Mover 1	actual...	0
ActPosCtrlOut	LREAL	8	Primitive	Mover 1	setpoint...	0
ActVelo	LREAL	8	Primitive	Mover 1	actual...	0
ActVeloError	LREAL	8	Primitive	Mover 1	actual...	0
Debug1	LREAL	8	Primitive	Mover 1	debug...	0
Debug2	LREAL	8	Primitive	Mover 1	debug...	0
Debug3	LREAL	8	Primitive	Mover 1	debug...	0
Debug4	LREAL	8	Primitive	Mover 1	debug...	0
Debug5	LREAL	8	Primitive	Mover 1	debug...	0
Debug6	LREAL	8	Primitive	Mover 1	debug...	0
nControl	DINT	4	Primitive	Mover 1	DS402...	0
nError	DINT	4	Primitive	Mover 1	actual soft...	0
nStatus	DINT	4	Primitive	Mover 1	DS402...	0
nWarning	DINT	4	Primitive	Mover 1	actual soft...	0
SetAccItp	LREAL	8	Primitive	Mover 1	setpoint...	0
SetCurr	LREAL	8	Primitive	Mover 1	setpoint...	0
SetJerkItp	LREAL	8	Primitive	Mover 1	setpoint...	0
SetPosItp	LREAL	8	Primitive	Mover 1	setpoint...	0
SetVelotItp	LREAL	8	Primitive	Mover 1	setpoint...	0
SoftDriveActualToTC	Struct	0	Mover 1	Mover 1		7
SoftDriveCmdFromTC	Struct	0	Mover 1	Mover 1		6
SO Mover 1	Struct	0	Mover 1	Mover 1		1

XTS TcSoftDrive – Setup Motor-Parameter for monitoring

BECKHOFF

Beckhoff-Training | TR3056 : Q2/2023

- ◀ Axes
- ▶ Mover 1
 - ▶ Enc
 - ▶ Drive
 - ▶ Ctrl
 - ▶ Inputs
 - ▶ Outputs
- ▶ SoftDrive 1
 - ▶ SoftDriveCmdFromTC
 - ▶ SoftDriveActualToTC
 - ▶ Data Pointer
 - ▶ Interpolator_Obj1 (CTcSdInterpolator)
 - ▶ SoftDriveEncoder_Obj2 (CTcSdEncoder)
 - ▶ PositionControl_Obj3 (CTcSdPositionControl)
 - ▶ VelocityControl_Obj4 (CTcSdVelocityControl)
 - ▶ Filter_Obj5 (CTcSdFilter)
 - ▶ FeedForward_Obj6 (CTcSdFeedForward)

Change Parameter Motor.Type 1 → 2
- Variable Debug2 will be filled
with InfeedPower

set “Show Hidden Parameter” first

Object	Context	Parameter (Init)	Parameter (Online)	Data Area	Interfaces	Interface Pointer	Data Pointer
AdsPort	0x015e	0x015e	0x015e				WORD
TraceLevelMax	tlAlways	tlAlways	tlAlways				TcTraceLevel
HardwareModulo	3000.0	3000.0	3000.0		mm		LREAL
OperationMode	8	8	8				UDINT
MaxCurrentOutput	12.0	12.0	12.0		A		LREAL
EmergencyRamp	10000.0	10000.0	10000.0		mm/s^2		LREAL
EmergencyTimeOut	0.5	0.5	0.5		s		LREAL
StandstillSwitchTime	0.1	0.1	0.1		s		LREAL
+ ControlAreas	[...]	[...]		1 (Array Elements)			
- SoftDriveMotorPara					
.Type	2	1					UDINT
.Poles	2	2					UDINT
.TorqueConstant	8.0	8.0		Nm/A			LREAL
.Inertia	0.35	0.35		kgcm^2			LREAL
.NominalCurrent	3.7	3.7		A			LREAL
.EIThermalTimeCon...	33.0	33.0		s			LREAL
.RatedSpeed	12000.0	12000.0		rpm			LREAL
.VoltageConstant	0.118	0.118		V/rpm			LREAL
.WindingResistance...	1.1	1.1		Ohm			LREAL

Show Online Values Show Hidden Parameter

XTS TcSoftDrive – Trigger settings for monitoring

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

The screenshot shows the XTS TcSoftDrive software interface with the following components:

- Solution Explorer:** Displays the project structure. A blue arrow points from the "Trigger" node under "YT Scope Project" to the "Properties" window.
- Properties Window (Triggergroup):** Shows settings for a "Triggergroup".

Name	Triggergroup
Trigger Action	Stop Display
Trigger Group	Clear Chart: False, Color: Transparent, Enabled: True, Silent: False, Trigger Category: None, Trigger Image Size: 0, Trigger Position: 7, Trigger Release Capacity: 50, Visible: True

A second blue arrow points from the "Visible" row to the "Properties" window for the "Channel Triggerset".
- Properties Window (Channel Triggerset):** Shows settings for a "Channel Triggerset".

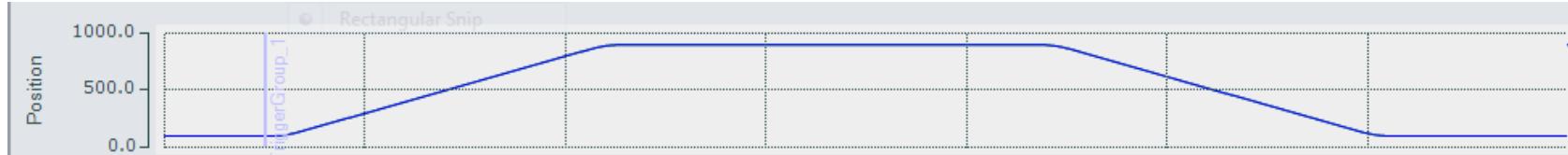
Combine	AND
Name	Channel Triggerset
Release	RisingEdge
Threshold	10
Used Data	Acquisition: SetVelotp
Modify	Offset: 0, Scalefactor: 1, Unit: (None)
- Context Menu:** A context menu is open over the "Visible" row in the "Triggergroup" properties window, with the "Show All" option highlighted.

XTS TcSoftDrive – Power monitoring example

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

Position [mm]



Velocity [mm/s]



Infeed Power [W]

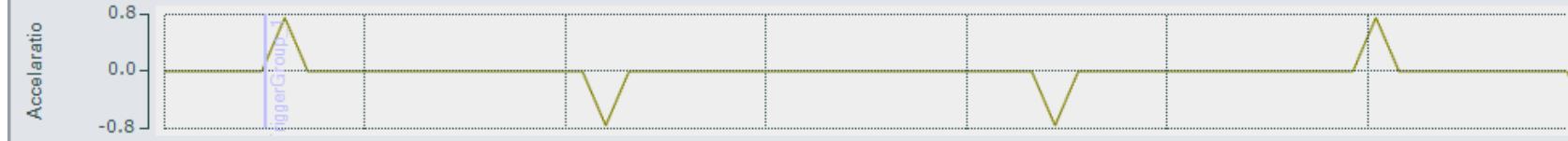


Mover Current [A]

(this is different to the infeed current on the 48V DC!!!)



Acceleration [mm/s²]



FollowingError [mm]



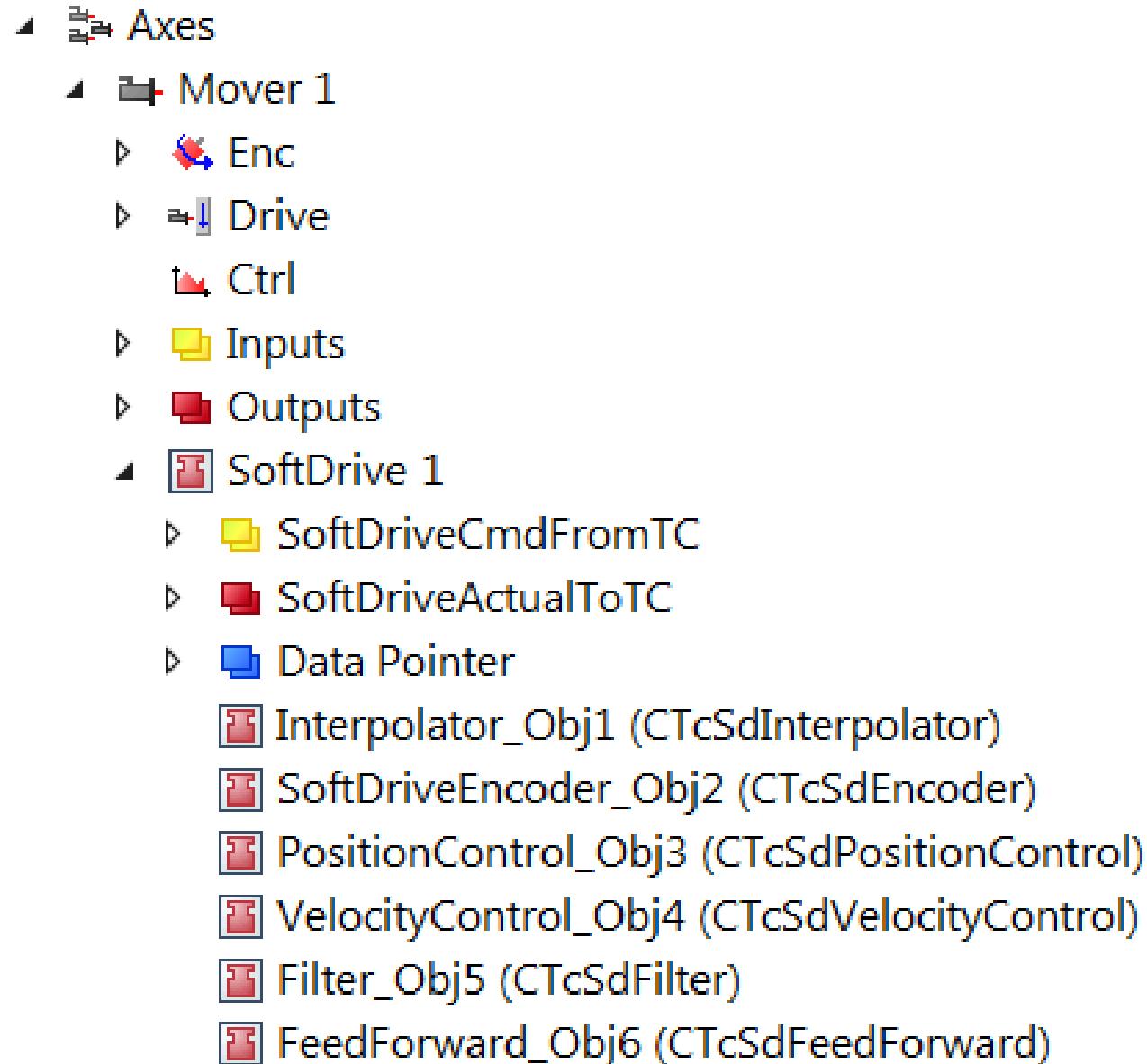
1. Short XTS basics
2. XTS IPC & capabilities
3. Scope for
Mover monitoring
4. **TcSoftdrive
structure & parameter**
5. Tuning



- ◀  Axes
 - ◀  Mover 1
 - ▷  Enc
 - ▷  Drive
 - ↳ Ctrl
 - ▷  Inputs
 - ▷  Outputs
 - ◀  SoftDrive 1
 - ▷  SoftDriveCmdFromTC
 - ▷  SoftDriveActualToTC
 - ▷  Data Pointer
 -  Interpolator_Obj1 (CTcSdInterpolator)
 -  SoftDriveEncoder_Obj2 (CTcSdEncoder)
 -  PositionControl_Obj3 (CTcSdPositionControl)
 -  VelocityControl_Obj4 (CTcSdVelocityControl)
 -  Filter_Obj5 (CTcSdFilter)
 -  FeedForward_Obj6 (CTcSdFeedForward)

- General SoftDrive Parameter

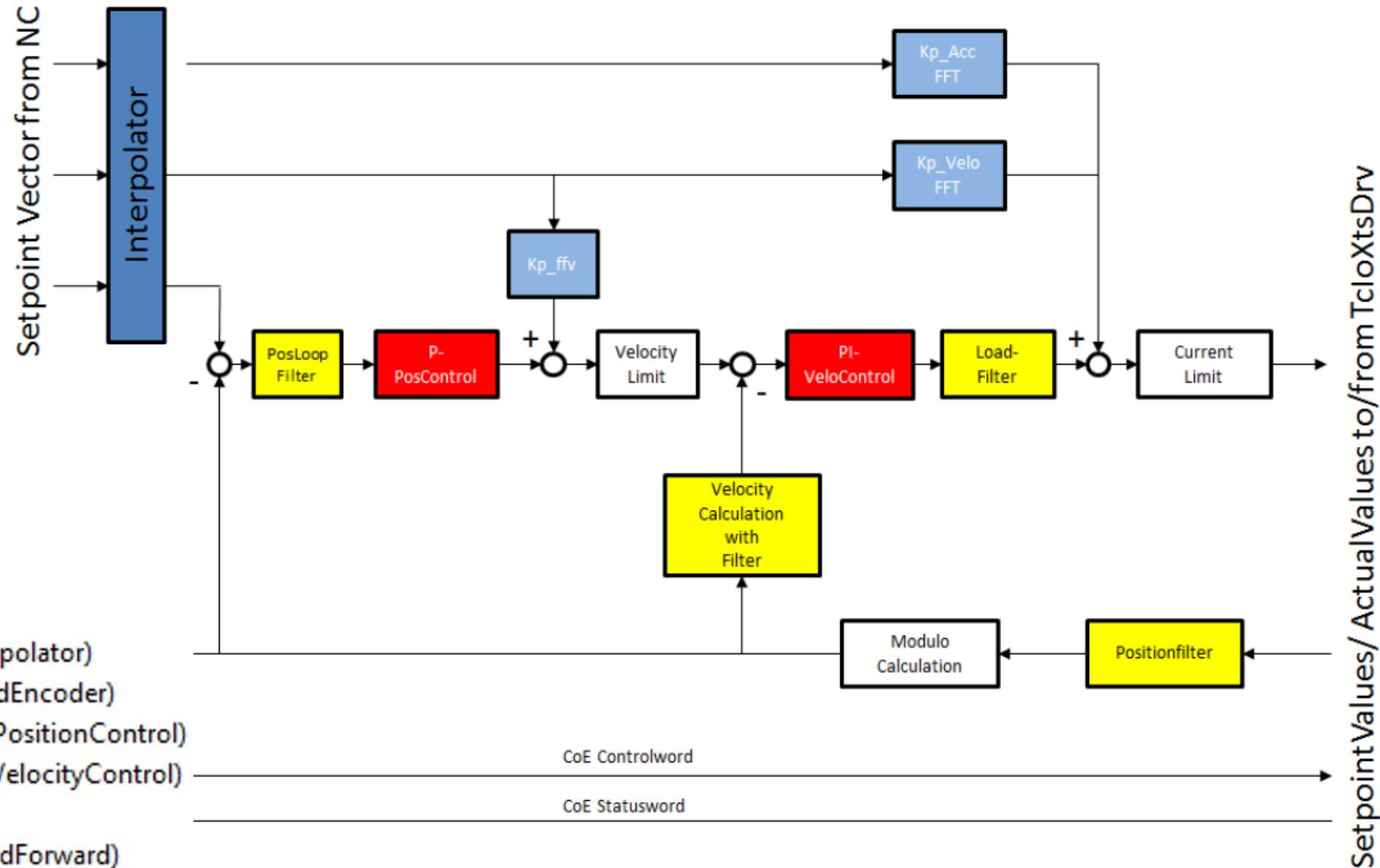
- Parameter for Interpolator
- Parameter for Position calculation
- Parameter for Position Control
- Parameter for Velocity Control
- Parameter for Filter settings
- Parameter for feedforward control



XTS TcSoftDrive - parameter structure

Beckhoff-Training | TR3056 : Q2/2023

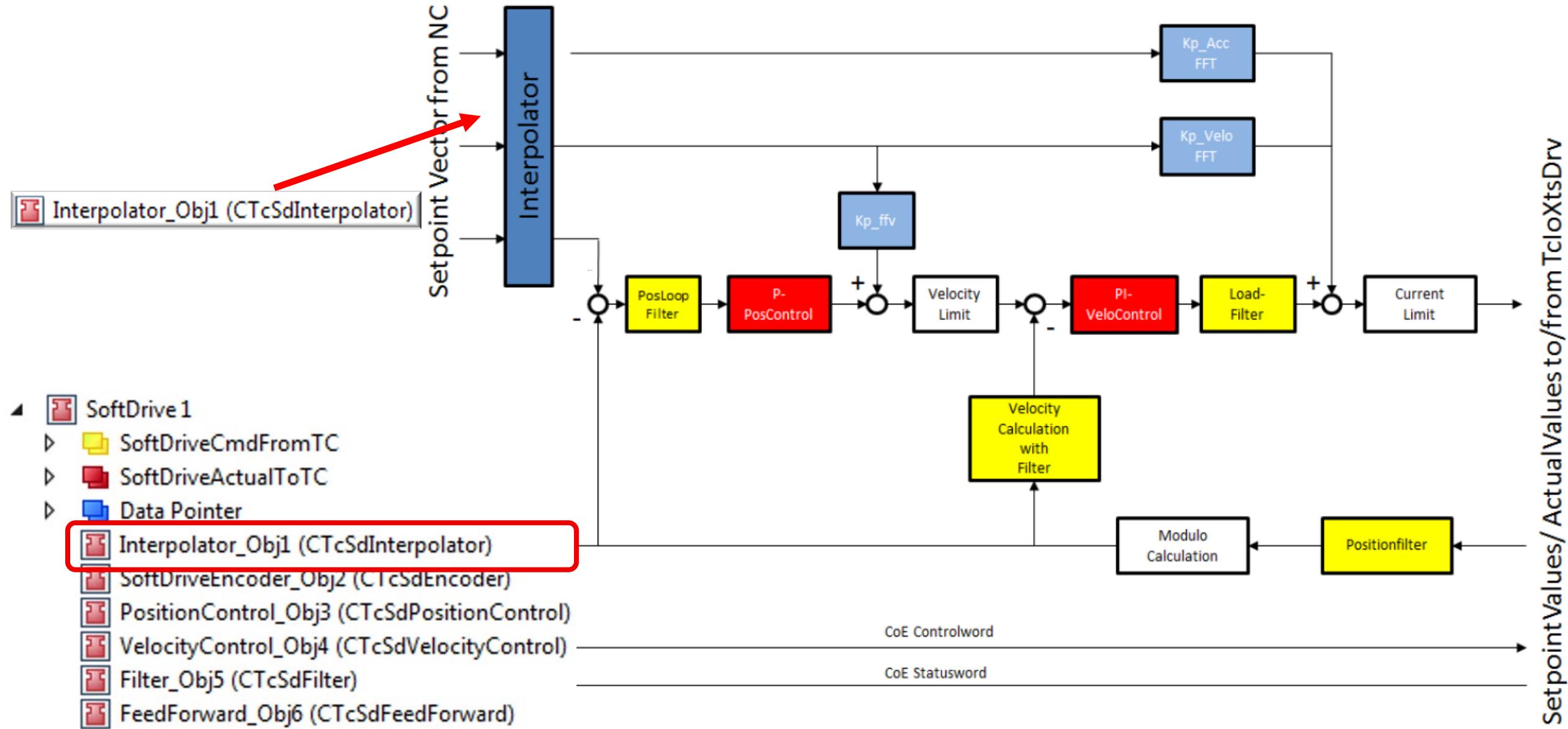
BECKHOFF



XTS TcSoftDrive - parameter structure

Beckhoff-Training | TR3056 : Q2/2023

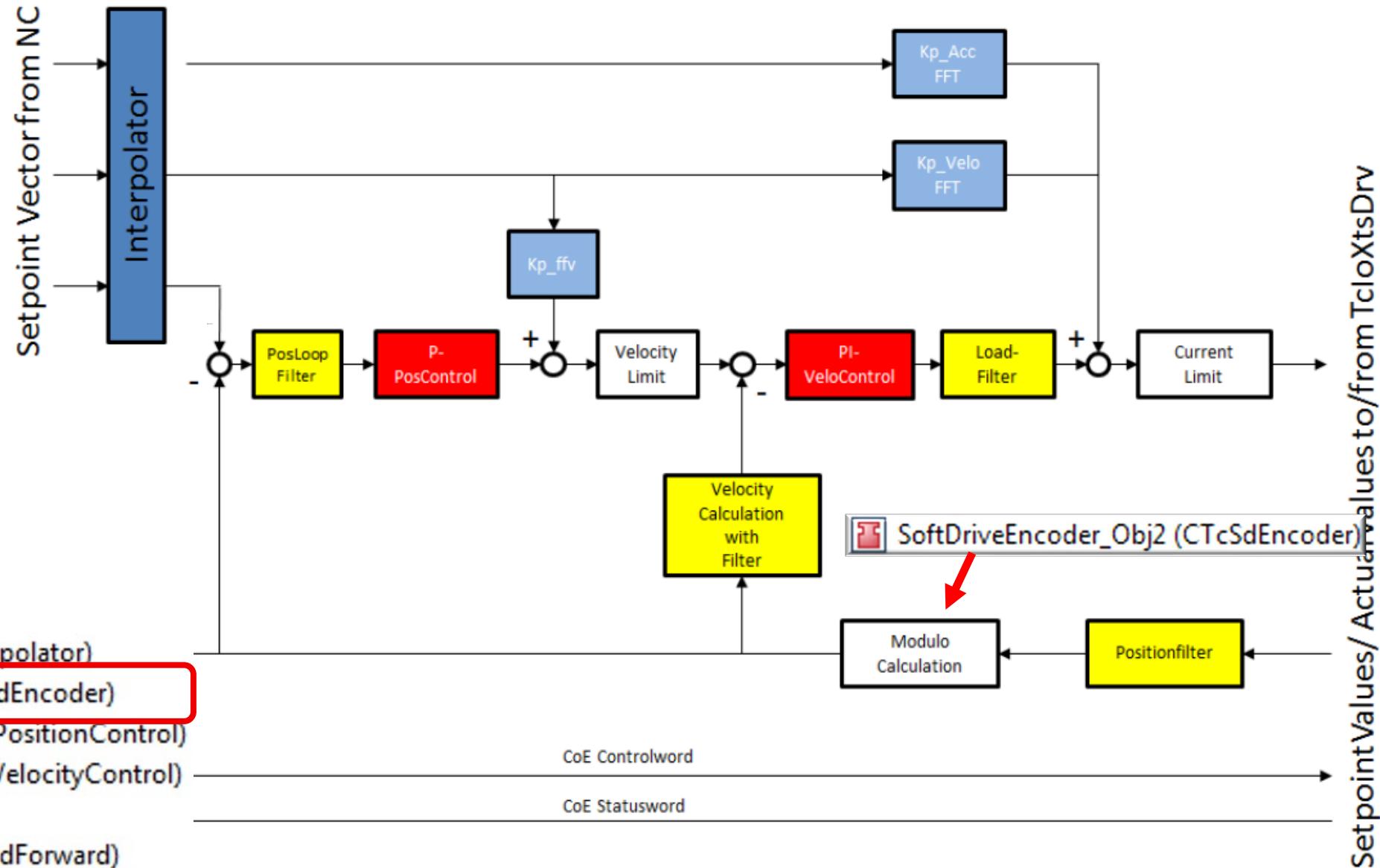
BECKHOFF



XTS TcSoftDrive - parameter structure

Beckhoff-Training | TR3056 : Q2/2023

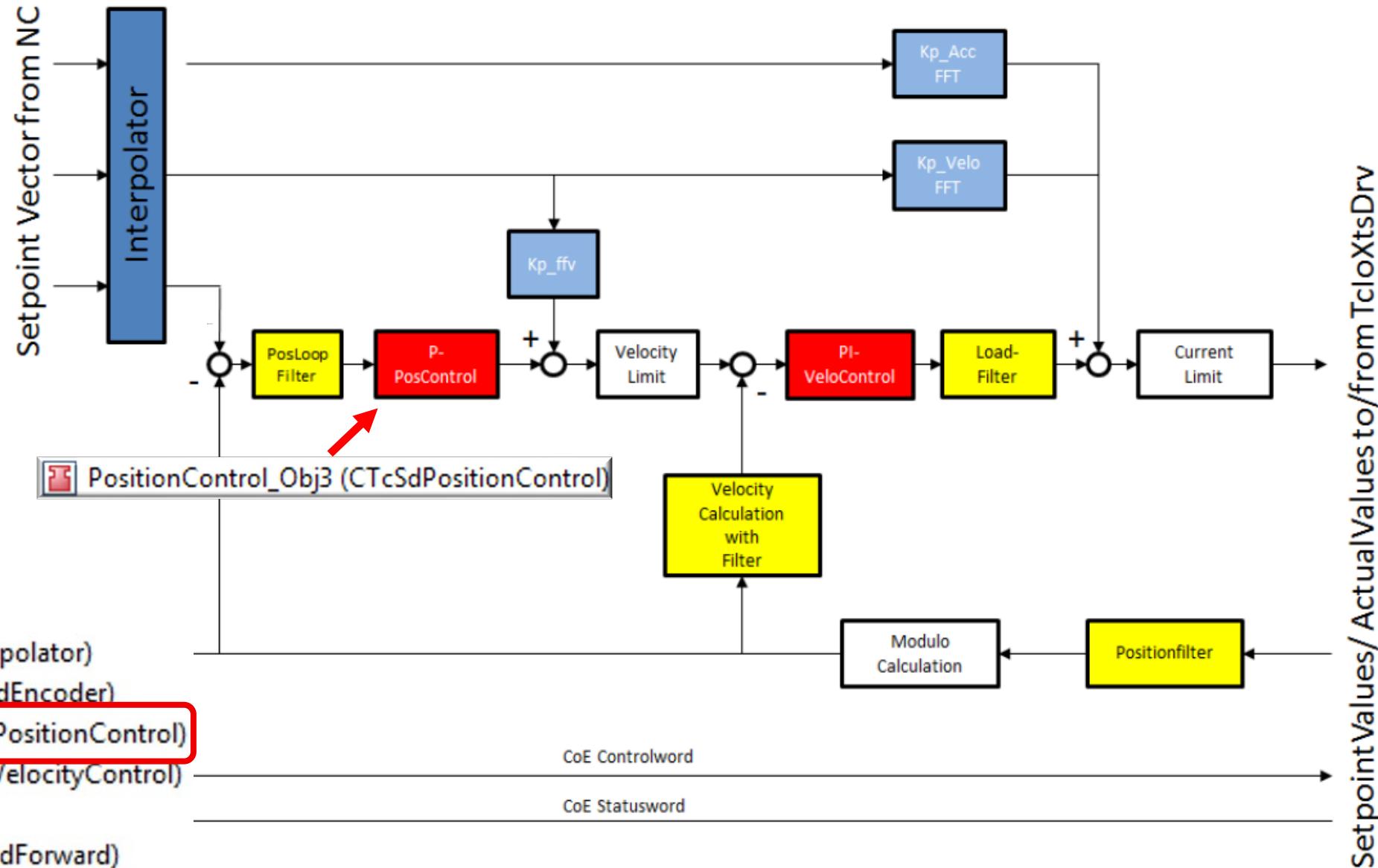
BECKHOFF



XTS TcSoftDrive - parameter structure

Beckhoff-Training | TR3056 : Q2/2023

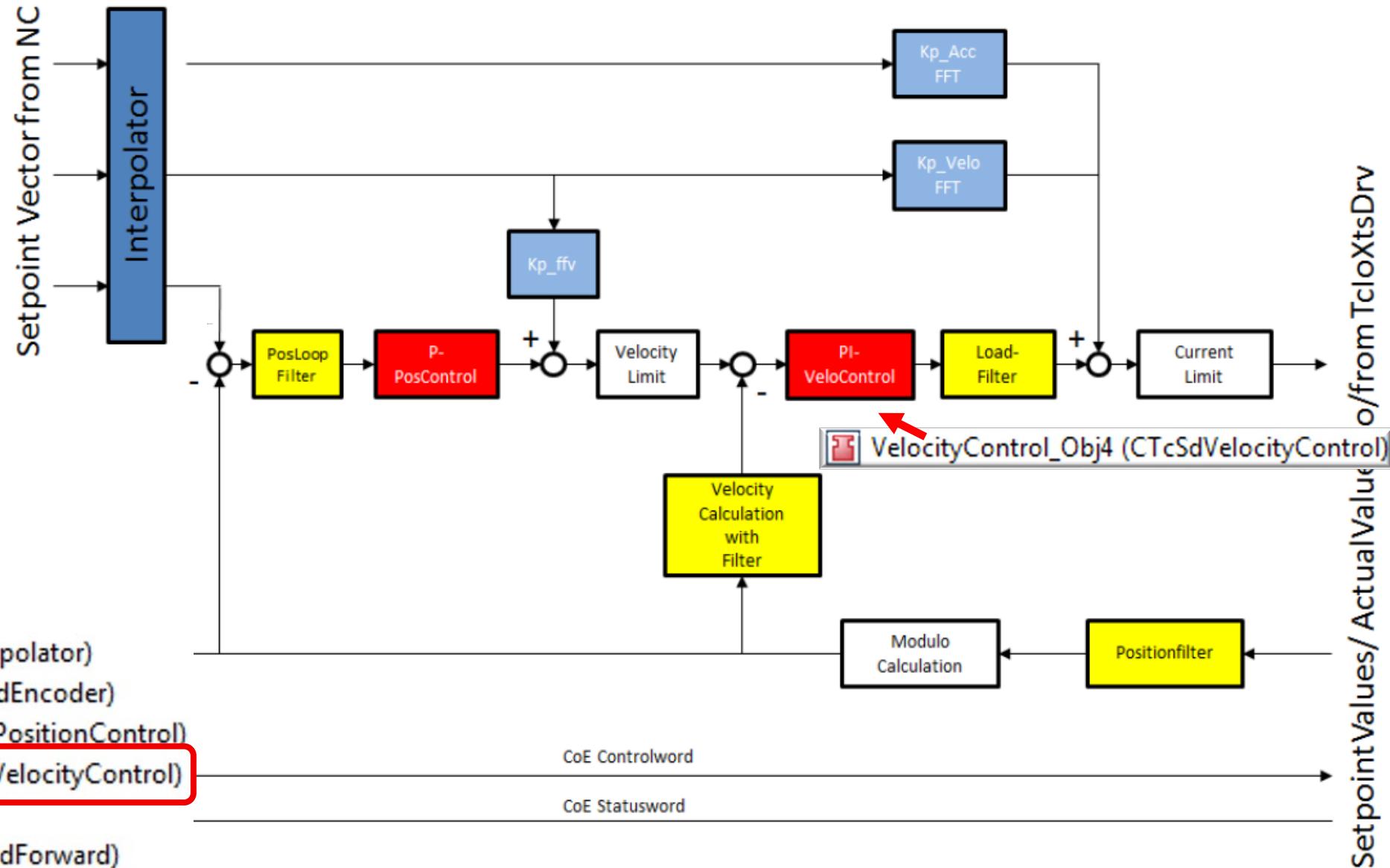
BECKHOFF



XTS TcSoftDrive - parameter structure

Beckhoff-Training | TR3056 : Q2/2023

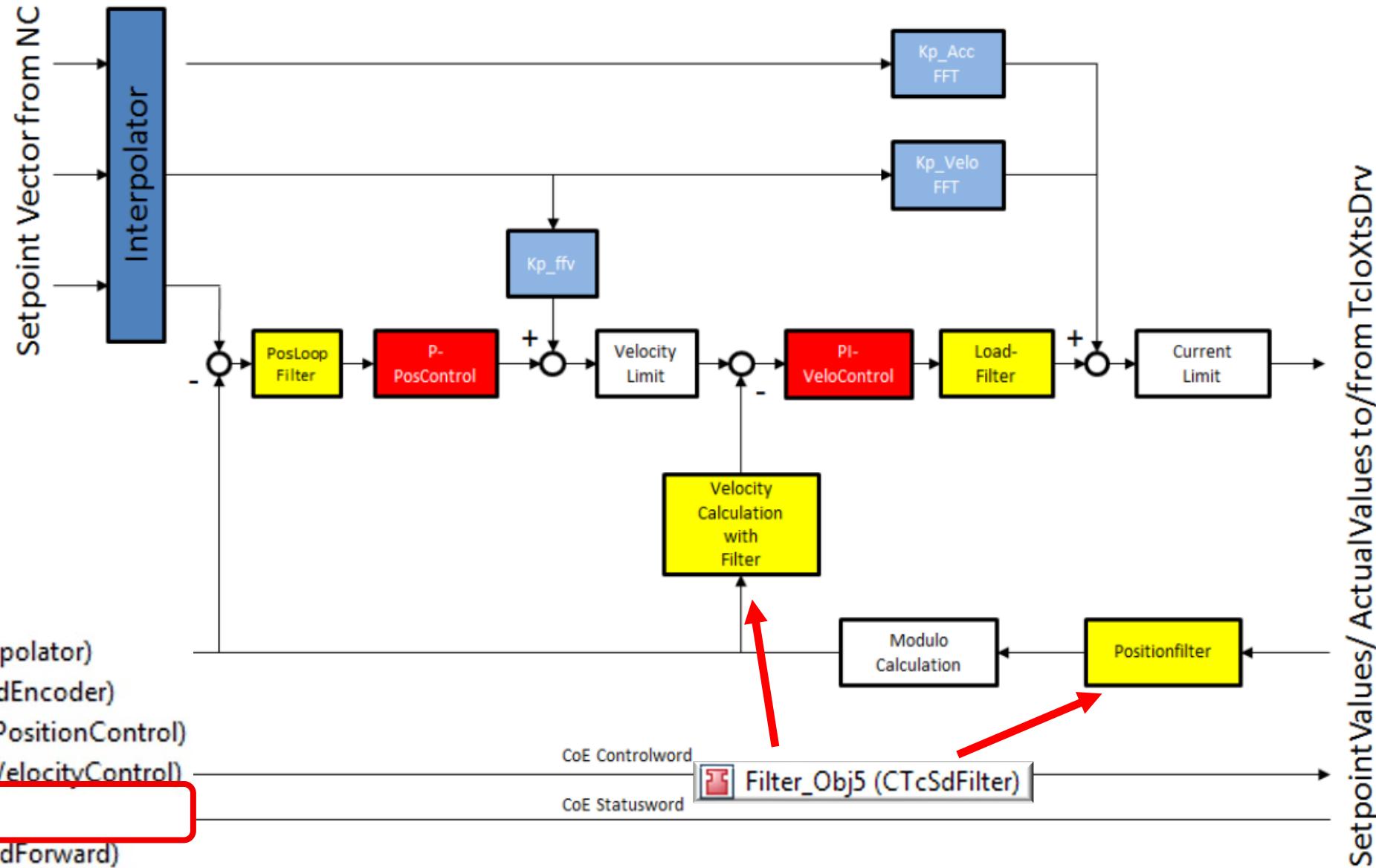
BECKHOFF



XTS TcSoftDrive - parameter structure

Beckhoff-Training | TR3056 : Q2/2023

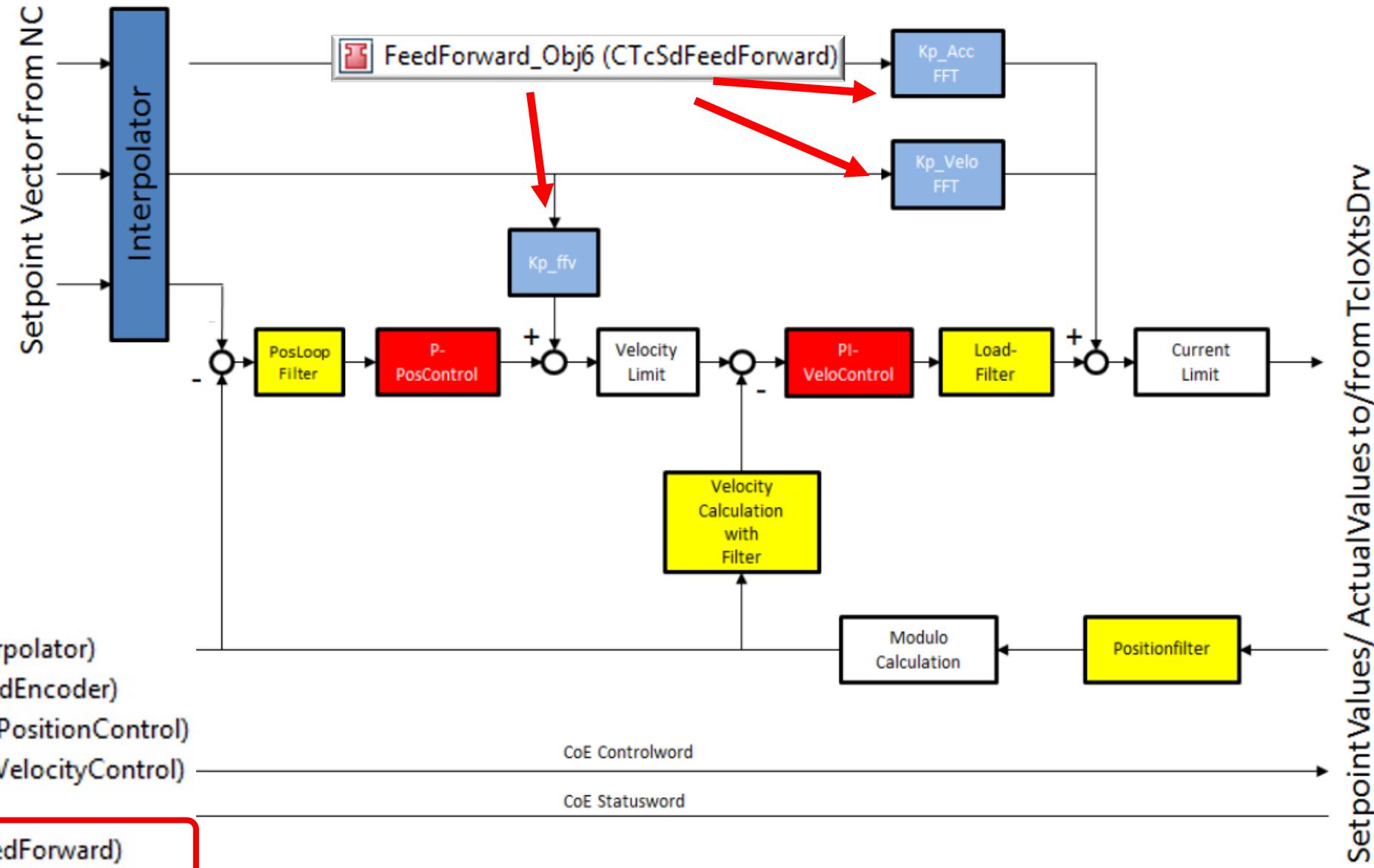
BECKHOFF



XTS TcSoftDrive - parameter structure

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



XTS TcSoftDrive - General SoftDrive Parameter

BECKHOFF

Beckhoff-Training | TR3056 : Q2/2023

Axes

- Mover 1
 - Enc
 - Drive
 - Ctrl
 - Inputs
 - Outputs
 - SoftDrive 1
 - SoftDriveCmdFromTC
 - SoftDriveActualToTC
 - Data Pointer
 - Interpolator_Obj1 (CTcSdInterpolator)
 - SoftDriveEncoder_Obj2 (CTcSdEncoder)
 - PositionControl_Obj3 (CTcSdPositionControl)
 - VelocityControl_Obj4 (CTcSdVelocityControl)
 - Filter_Obj5 (CTcSdFilter)
 - FeedForward_Obj6 (CTcSdFeedForward)

First_XTS_Project

	Name	Value	CS	Unit	Type	P.	Com...
-	General						
	AdsPort	0x015e			WORD	0..	
	HardwareModulo	3000.0			LREAL	0..	
	OperationMode	8			UDINT	0..	
	MaxCurrentOutput	12.0			LREAL	0..	
	EmergencyRamp	10000.0			LREAL	0..	
	EmergencyTimeOut	0.5			LREAL	0..	
	StandstillSwitchTime	0.1			LREAL	0..	
	StandstillSwitchMode	DIRECT_AT_SWIT...			Stand...	0..	
-	ControlAreas						
-	ControlAreas	[...]		1 (Array ...			
	[0].IsEnabled	FALSE					
	[0].reserved	0					
	[0].StartPosition	0.0					
	[0].EndPosition	0.0			LREAL		
	[0].TransitionLength	0.0			LREAL		
+	ExternalIO						
-	Advanced						
	TraceLevelMax	t1Always			TcTrac...	0..	
-	SoftDriveMotorPara	...				0..	
	.Type	1			UDINT		defin...
	.Poles	2			UDINT		set m...
	.TorqueConstant	8.0		N/A	LREAL		set th...
	.Inertia	0.25			LREAL		

XTS TcSoftDrive - 32 different control areas

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

- 1 up to 32 different control areas
- Different parameter for position and velocity control
- Different current limit could be set in Feedforward module
- To use a certain control area [X].IsEnabled must be set to TRUE and Activate Configuration

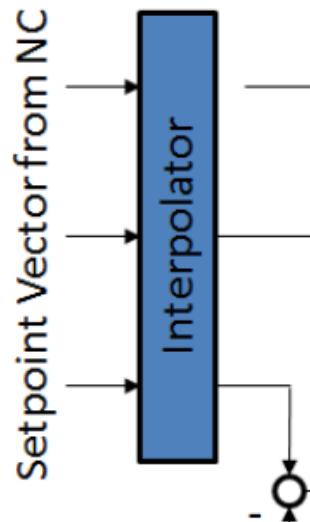
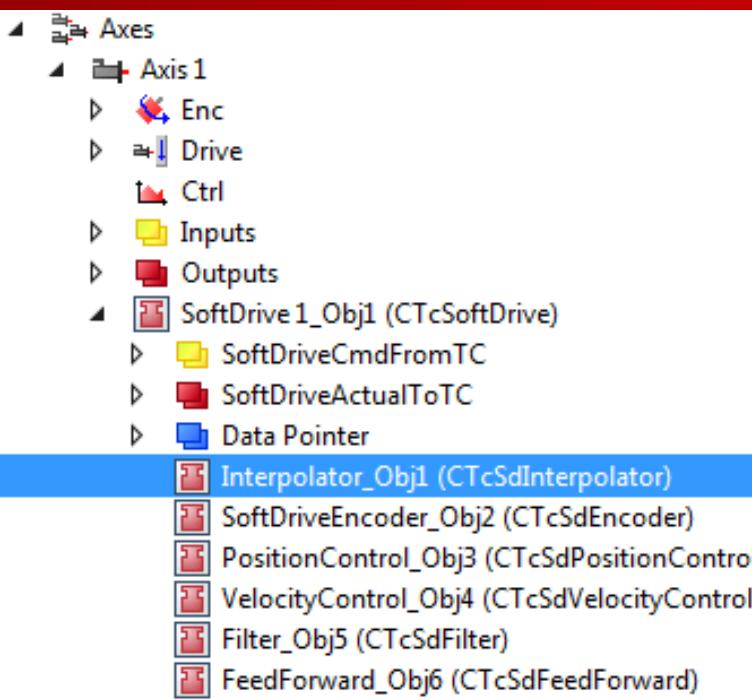


Name	Value	Online
HardwareModulo	3000.0	3000.0
OperationMode	8	8
MaxCurrentOutput	120.0	12.0
EmergencyRamp	40000.0	40000.0
EmergencyTimeOut	0.5	0.5
StandstillSwitchTime	0.1	0.1
ControlAreas	[...]	[...]
[0].IsEnabled	TRUE	TRUE
[0].reserved	0	0
[0].StartPosition	1000.0	1000.0
[0].EndPosition	1500.0	1500.0
[0].TransitionLength	40.0	40.0

XTS TcSoftDrive - Interpolator

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



First_XTS_Project

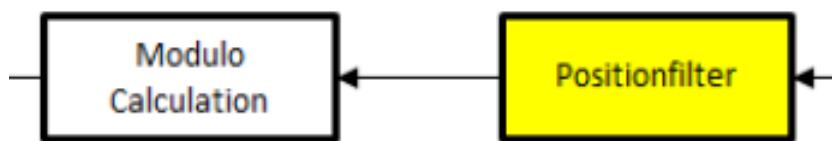
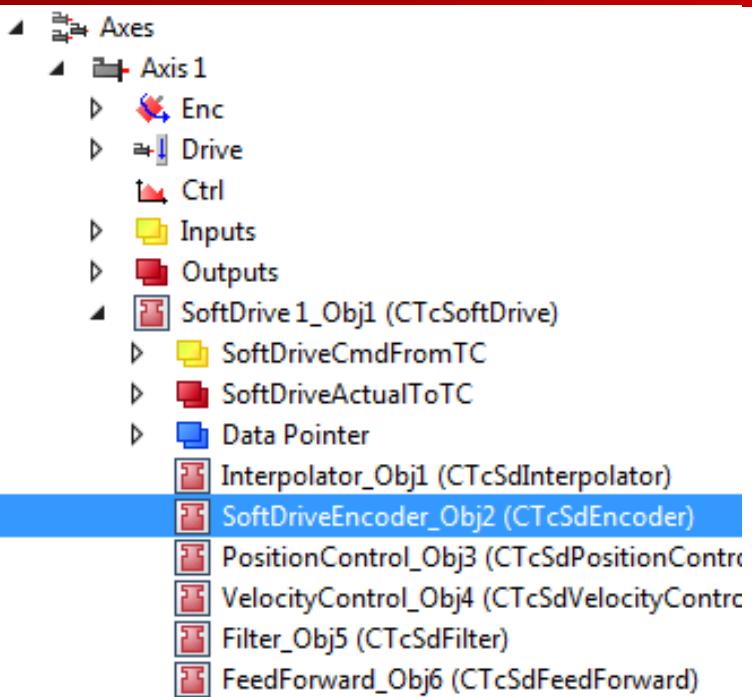
	Name	Value	CS	Type	P..
-	General				
-	InterpolatorType	INTERPOLATION_POLYN...		Inter...	0...
-	Advanced				
	TraceLevelMax	tlAlways		TcTra...	0...

Show Online Values Show Hidden Parameter

XTS TcSoftDrive - Encoder

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



First_XTS_Project

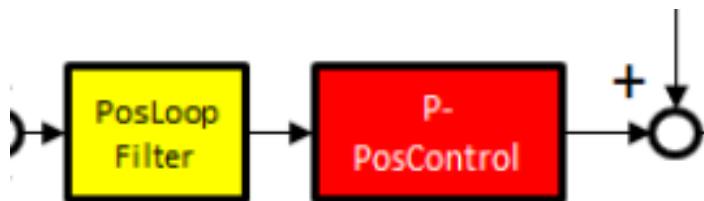
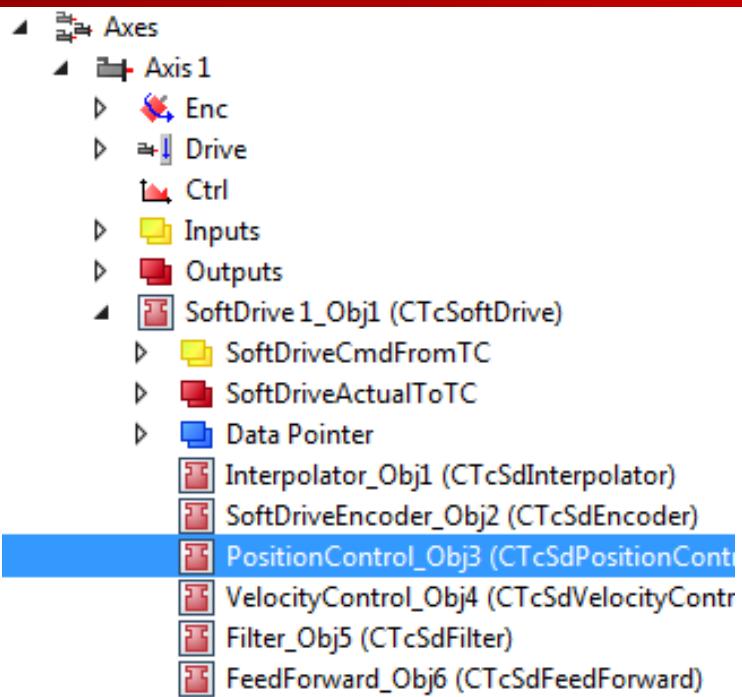
	Name	Value	CS	Unit	Type	P..
-	General					
	VelocityFeedbackMode	OBSERVER			Velo...	0...
	PositionFeedbackMode	MODULO_START			Posit...	0...
	PositionLowPassFilter	500.0		Hz	LREAL	0...
	VelocityFilterBandwidth	160.0		Hz	LREAL	0...
-	Advanced					
	StartUpPositionType	PART			Start...	0...
-	Advanced					
	TraceLevelMax	tlAlways			TcTra...	0...
	CorrectionFactor	0.5			LREAL	0...
	SimulationOffset	10.0		mm	LREAL	0...
	CommutationErrorVelocity	1000.0		mm/s	LREAL	0...

Show Online Values Show Hidden Parameter Expand All Collapse All

XTS TcSoftDrive - position control

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



First_XTS_Project

	Name	Value	CS	Unit	Type	P...
-	General					
	PositionLoopType	P_POSITION_STAND...			Positi...	0...
	Kp	0.03		1/s	LREAL	0...
	Kp_standstill	0.02		1/s	LREAL	0...
	Kp_area	0.02		1/s	LREAL	0...
	Kp_area_standstill	0.02		1/s	LREAL	0...
-	Advanced					
	TraceLevelMax	tlAlways			TcTrac...	0...
	Kp_ffv	1.0		100%	LREAL	0...
	PosLoopFilter	75.0		Hz	LREAL	0...
	PosLoopFilter_area	75.0		Hz	LREAL	0...
	InpositionTn	0.05		s	LREAL	0...

Show Online Values Show Hidden Parameter

XTS TcSoftDrive - parameter for position control

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

- Type: P_Position
only Kp is used
- Type: P_Position_Standstill
Kp &
Kp_standstill is used
- Type: P_Position_Standstill_Area
all parameter are used

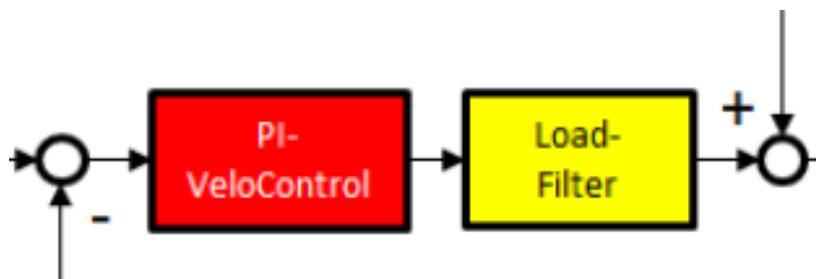
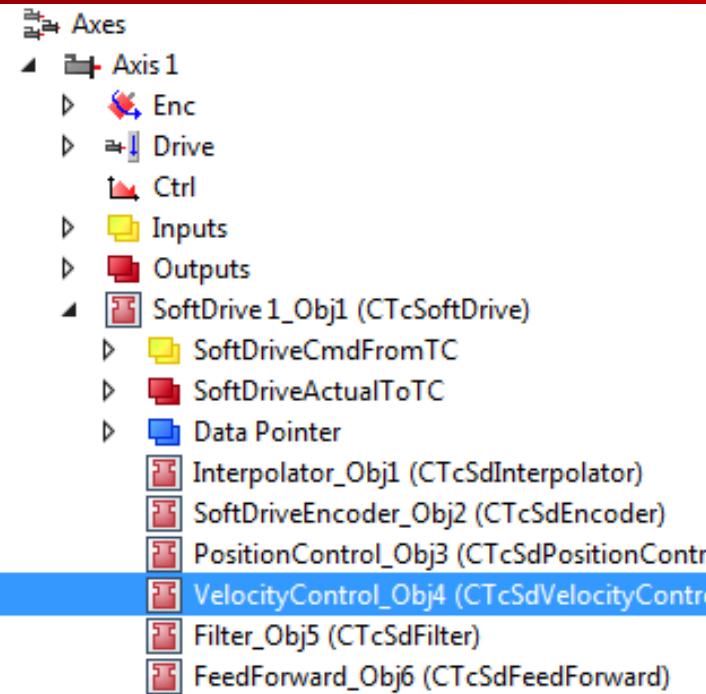
First_XTS_Project							
	Name	Value	CS	Unit	Type	P...	
-	General						
	PositionLoopType	P_POSITION_STAND...			Positi...	0...	
	Kp	0.03		1/s	LREAL	0...	
	Kp_standstill	0.02		1/s	LREAL	0...	
	Kp_area	0.02		1/s	LREAL	0...	
	Kp_area_standstill	0.02		1/s	LREAL	0...	
-	Advanced						
	TraceLevelMax	tlAlways			TcTrac...	0...	
	Kp_ffv	1.0		100%	LREAL	0...	
	PosLoopFilter	75.0		Hz	LREAL	0...	
	PosLoopFilter_area	75.0		Hz	LREAL	0...	
	InpositionTn	0.05		s	LREAL	0...	

Show Online Values Show Hidden Parameter

XTS TcSoftDrive - velocity control

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



First_XTS_Project

Object Context Parameter (Init) Interfaces Interface Pointer

	Name	Value	CS	Unit	Type	P.
-	General					
	VelocityLoopType	PI_VELOCITY_STAN...			Velo...	0..
	Kp	0.05		As/r...	LREAL	0..
	Kp_standstill	0.033		As/r...	LREAL	0..
	Kp_area	0.04		As/r...	LREAL	0..
	Kp_area_standstill	0.03		As/r...	LREAL	0..
	Tn	0.05		s	LREAL	0..
	Tn_standstill	0.05		s	LREAL	0..
	Tn_area	0.05		s	LREAL	0..
	Tn_area_standstill	0.05		s	LREAL	0..
	Kd	0.0		As^...	LREAL	0..
	Kd_standstill	0.0		As^...	LREAL	0..
	Kd_area	0.0		As^...	LREAL	0..
	Kd_area_standstill	0.0		As^...	LREAL	0..
-	Optimization					
	ResetPartAtMotionStart	OFF			Rese...	0..
-	Advanced					
	TraceLevelMax	tlAlways			TcTr...	0..

Show Online Values Show Hidden Parameter

XTS TcSoftDrive - parameter for velocity control

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

- Type: PI_Position
only Kp & Tn is used
- Type: PI_Velocity_Standstill
Kp/Kp_standstill &
Tn/Tn_standstill is used
- Type: PI_Velocity_Standstill_Area
all Kp and Tn are used
(standstill & area)

First_XTS_Project							
	Name	Value	CS	Unit	Type	P.	
-	General						
	VelocityLoopType	PI_VELOCITY_STAN...		Velo...	0..		
	Kp	0.05		As/r...	LREAL	0..	
	Kp_standstill	0.033		As/r...	LREAL	0..	
	Kp_area	0.04		As/r...	LREAL	0..	
	Kp_area_standstill	0.03		As/r...	LREAL	0..	
	Tn	0.05		s	LREAL	0..	
	Tn_standstill	0.05		s	LREAL	0..	
	Tn_area	0.05		s	LREAL	0..	
	Tn_area_standstill	0.05		s	LREAL	0..	
	Kd	0.0		As^...	LREAL	0..	
	Kd_standstill	0.0		As^...	LREAL	0..	
	Kd_area	0.0		As^...	LREAL	0..	
	Kd_area_standstill	0.0		As^...	LREAL	0..	
-	Optimization						
	ResetPartAtMotionStart	OFF		Rese...	0..		
-	Advanced						
	TraceLevelMax	tIAlways		TcTr...	0..		

Show Online Values Show Hidden Parameter

XTS TcSoftDrive - parameter for velocity control

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

- If one integral parameter is set to zero then the calculated value is also reset to zero.
- If an old tmc is used the functionality is backward compatible

First_XTS_Project

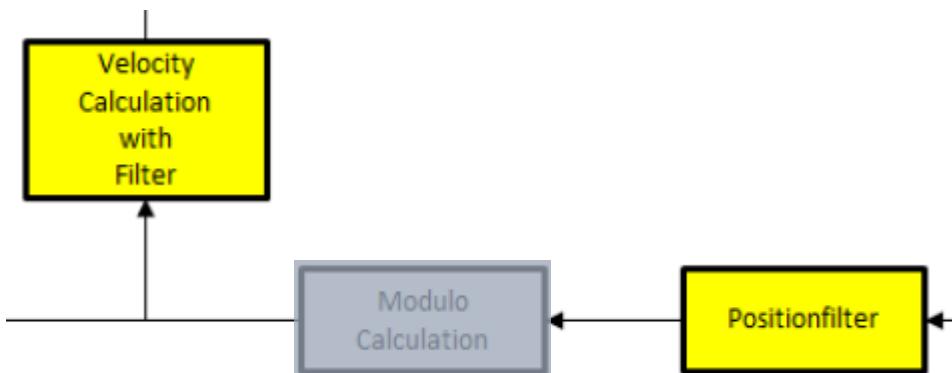
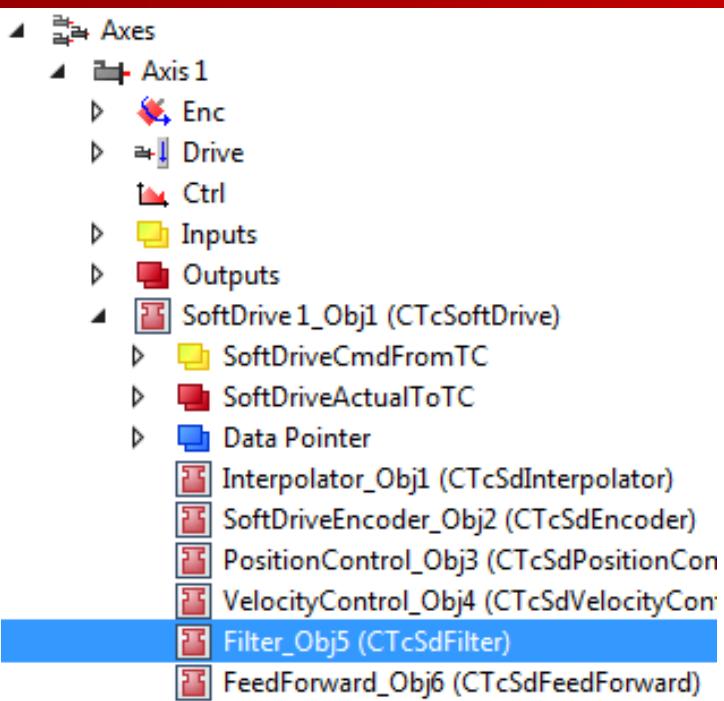
	Name	Value	CS	Unit	Type	P.
-	General					
	VelocityLoopType	PI_VELOCITY_STAN...			Velo...	0..
	Kp	0.05		As/r...	LREAL	0..
	Kp_standstill	0.033		As/r...	LREAL	0..
	Kp_area	0.04		As/r...	LREAL	0..
	Kp_area_standstill	0.03		As/r...	LREAL	0..
	Tn	0.05		s	LREAL	0..
	Tn_standstill	0.05		s	LREAL	0..
	Tn_area	0.05		s	LREAL	0..
	Tn_area_standstill	0.05		s	LREAL	0..
	Kd	0.0		As^...	LREAL	0..
	Kd_standstill	0.0		As^...	LREAL	0..
	Kd_area	0.0		As^...	LREAL	0..
	Kd_area_standstill	0.0		As^...	LREAL	0..
-	Optimization					
	ResetPartAtMotionStart	OFF			Rese...	0..
-	Advanced					
	TraceLevelMax	tIAlways			TcTr...	0..

Show Online Values Show Hidden Parameter

XTS TcSoftDrive - filter parameter

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



First_XTS_Project

Object Context Parameter (Init) Interfaces Interface Pointer

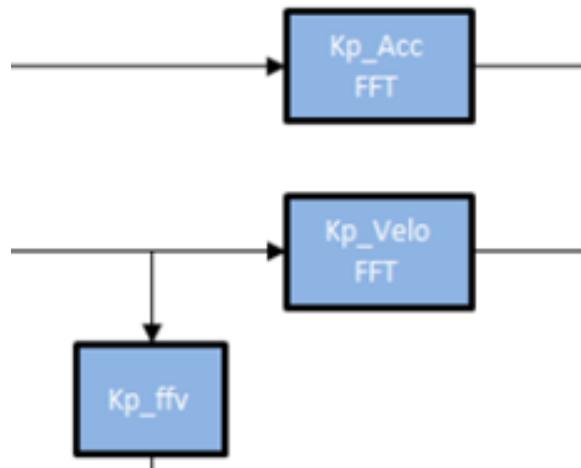
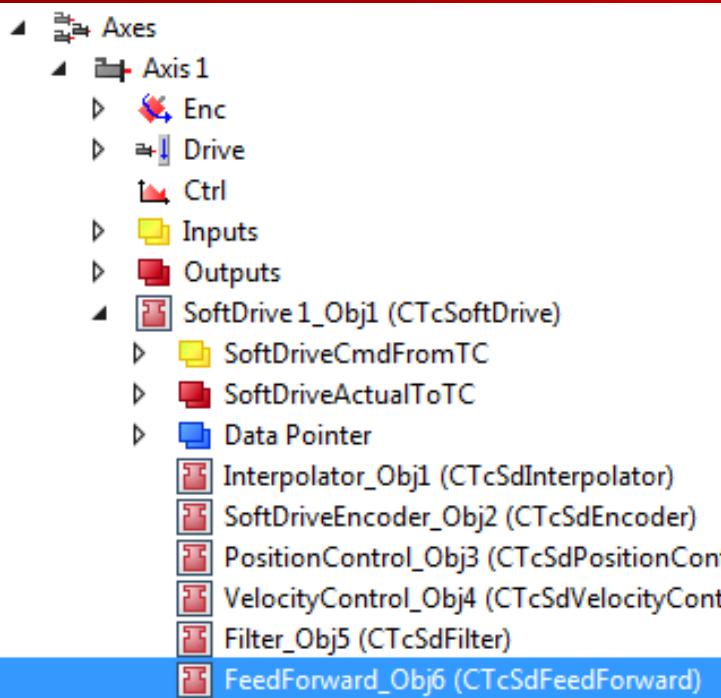
	Name	Value	CS	Unit	Type	P.	Co...
-	General						
-	ConfigurationFilter	...				0..	
.	.Type	LOWPASS2			DINT		
.	.Usage	ALWAYS			DINT		
.	.LowPassFrequency	250.0		Hz	LRE...	set t...	
.	.LowPassDamping	0.8			LRE...	set t...	
.	.HighPassFrequency	0.0		Hz	LRE...	set t...	
.	.HighPassDamping	0.0			LRE...	set t...	
-	Advanced						
	TraceLevelMax	tlAlways			TcTr...	0..	

Show Online Values Show Hidden Parameter Expand All Collapse All

XTS TcSoftDrive - Feed Forward

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



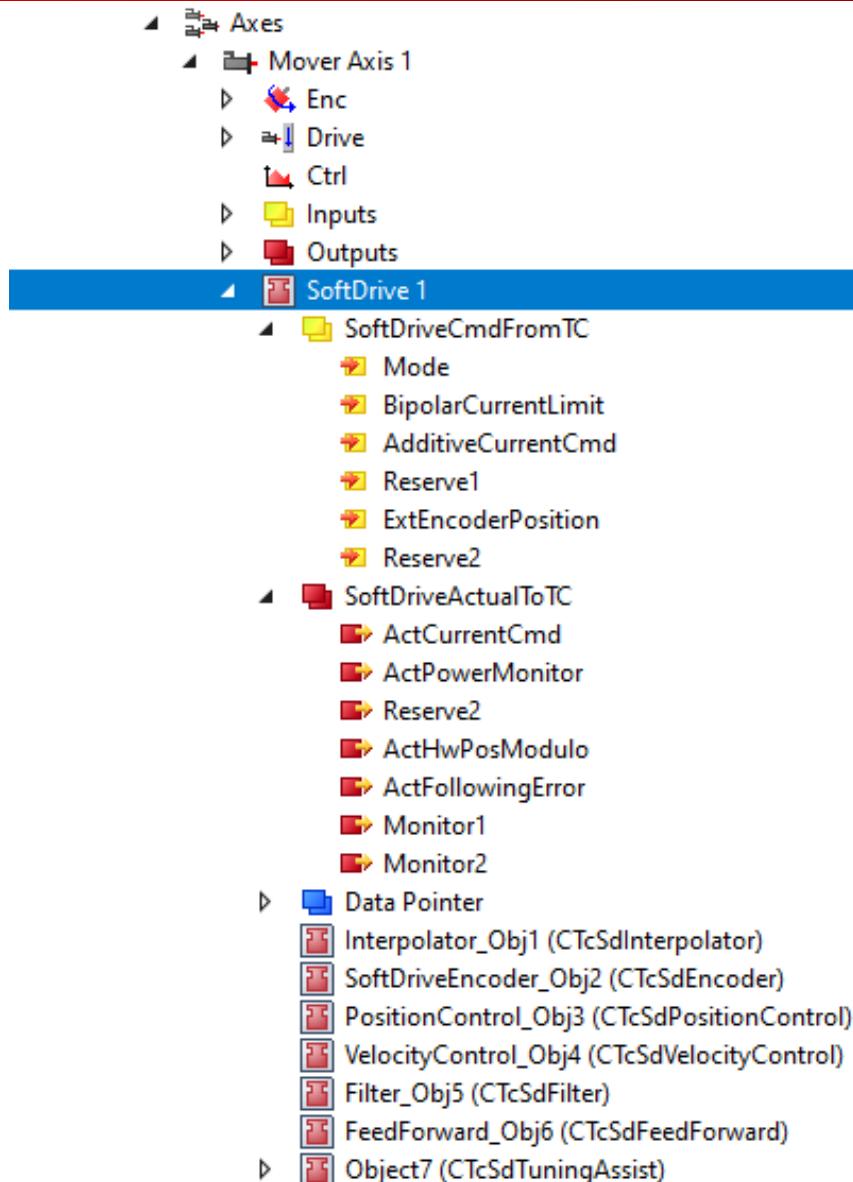
First_XTS_Project

	Name	Value	CS	Unit	Type	P.
-	General					
	FeedforwardType	FFT_ON			Fee... 0..	
	KpAccFFT	1.0		As^...	LREAL 0..	
	KpAccFFT_area	1.0		As^...	LREAL 0..	
	FrictionCompensation	0.0		A	LREAL 0..	
	FrictionCompensation_area	0.0		A	LREAL 0..	
	AreaCurrentLimit	0.0		A	LREAL 0..	
-	MoverIdDetection					
	DetectionMinMovement	0.1		mm	LREAL 0..	
	DetectionFilter	250.0		Hz	LREAL 0..	
	DetectionCurrentRamp	25.0		mA...	LREAL 0..	
	DetectionMaxCurrent	12.0		A	LREAL 0..	
	DetectionStandstillVelocity...	15.0		mm/s	LREAL 0..	
	DetectionStandstillSwitchTi...	0.015		s	LREAL 0..	
	DetectionTimeOut	2.0		s	LREAL 0..	
	DetectionInfoMessage	FALSE			BO... 0..	
-	Optimization					
	CyclicCurrentFeedforward...	OFF			Cycl... 0..	

Show Online Values Show Hidden Parameter

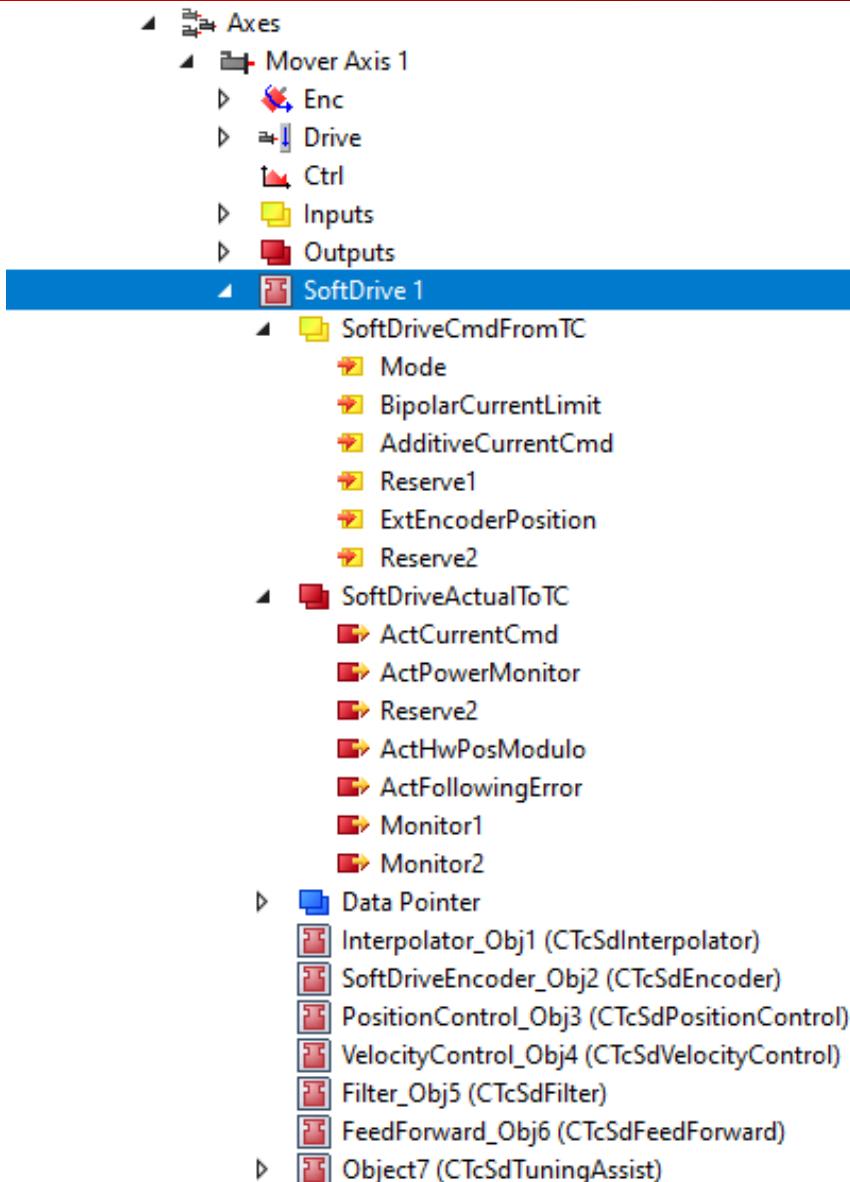
From NC / PLC → TcSoftDrive

- Mode: change TcSoftDrive operation mode & the use of the other cmd values
- BipolarCurrentLimit: add the cyclic current limit value
- AdditiveCurrentCmd: set an additional cyclic FFT current value. Functionality depends on the actual Operation mode used for real torque control
- AdditiveCurrentCmd: add an additional cyclic FFT current value
- ExtEncoderPosition: use position data from another source



From TcSoftDrive → NC / PLC

- ActCurrentCmd: actual current command
- ActHWPosModule: actual HW Position
- ActFollowingError: actual Following Error



XTS TcSoftDrive - setting for cyclic data

Beckhoff-Training | TR3056 : Q2/2023

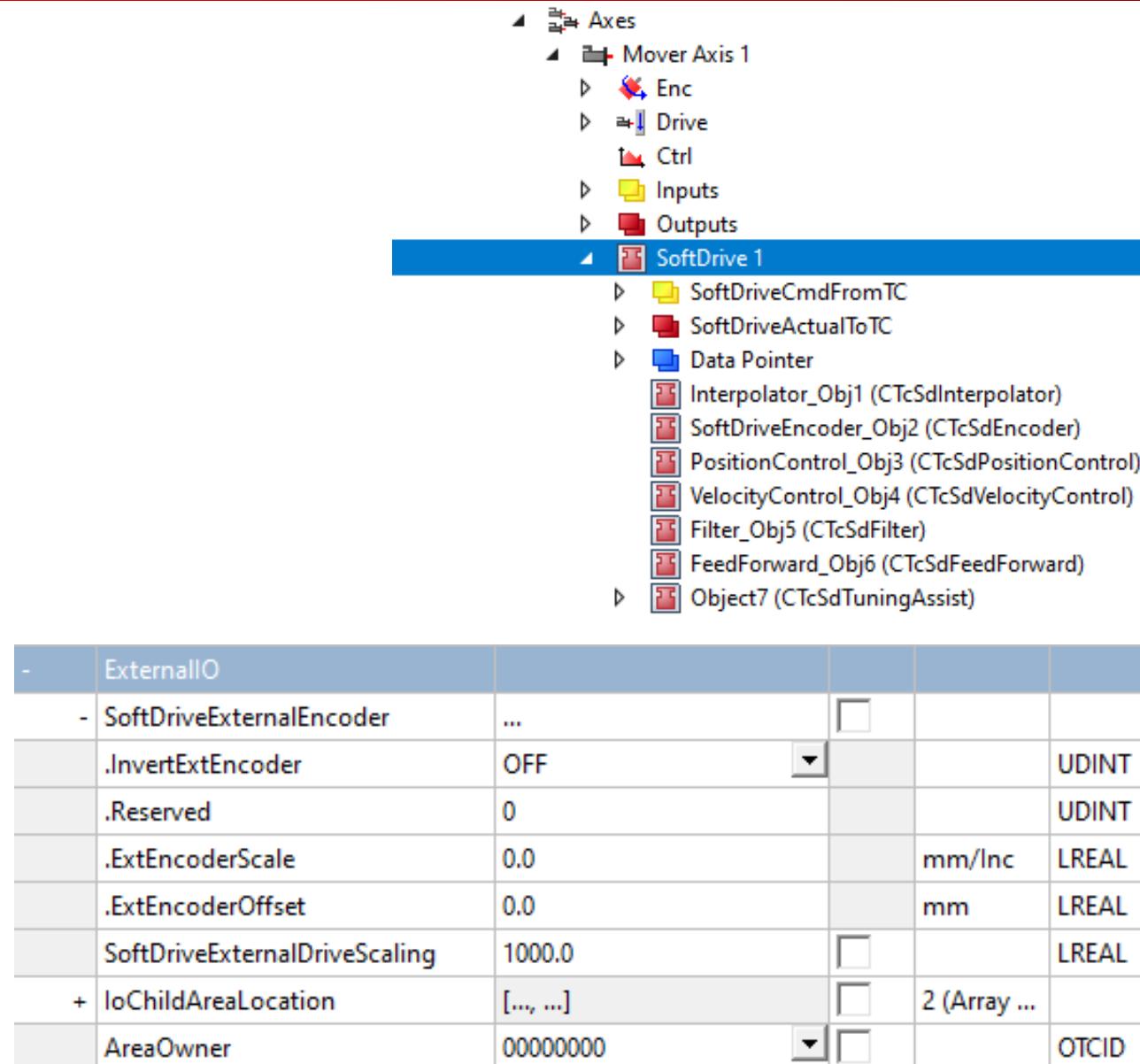
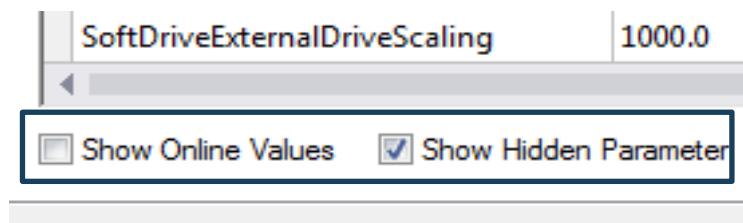
BECKHOFF

■ SoftDriveExternalEncoder

These parameters set the encoder counting direction, the scaling and offset for the external encoder feedback. This external encoder position could also be the position from another XTS mover.

■ SoftDriveExternalDriveScale

This parameter sets the scaling for the output of the actual SoftDrive current command e.g. for use with another drive HW



1. Short XTS basics
2. XTS IPC & capabilities
3. Scope for
Mover monitoring
4. TcSoftdrive
structure & parameter
5. Tuning

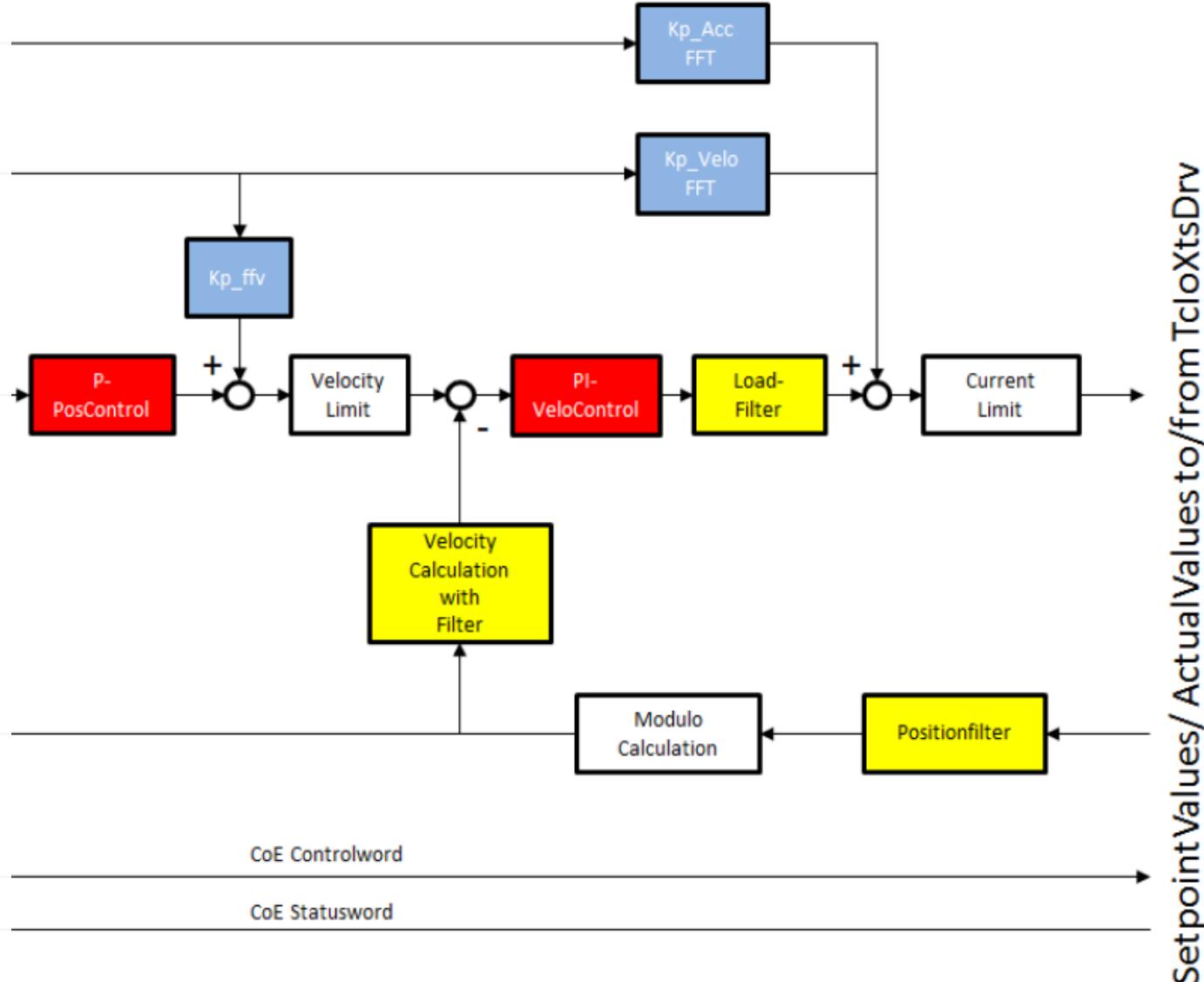


Servo systems typically use a combination (cascaded) of three types of control loops:

- current loop
(indirectly via the filter settings)
- velocity loop
- and position loop

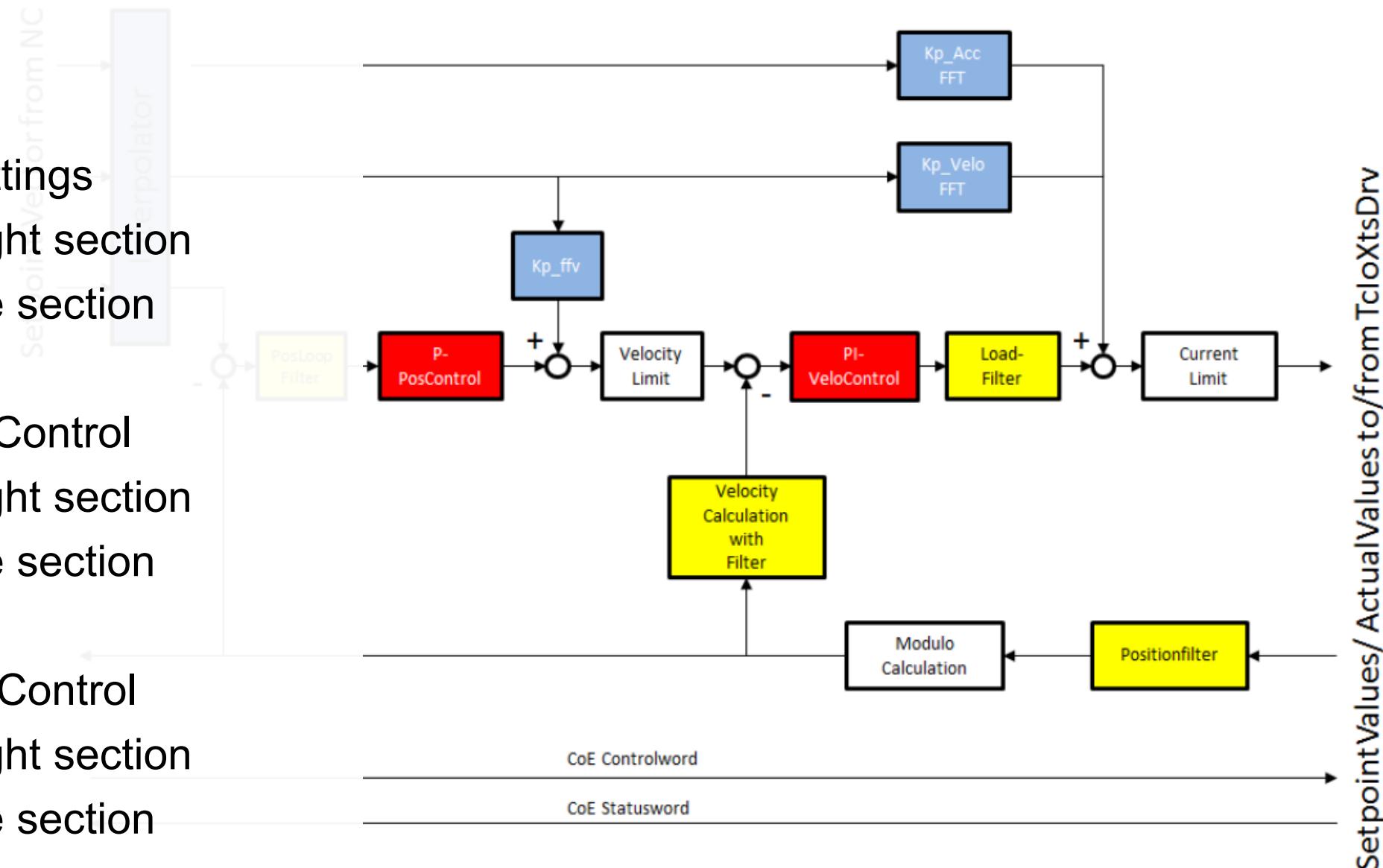
To tune the system, we have to tune each loop.

Starting at the first loop
(current indirectly via the filter settings)



Tuning Sequence

1. Setup Filter Settings
 - I. on the straight section
 - II. on the curve section
2. Setup Velocity-Control
 - I. on the straight section
 - II. on the curve section
3. Setup Position-Control
 - I. on the straight section
 - II. on the curve section

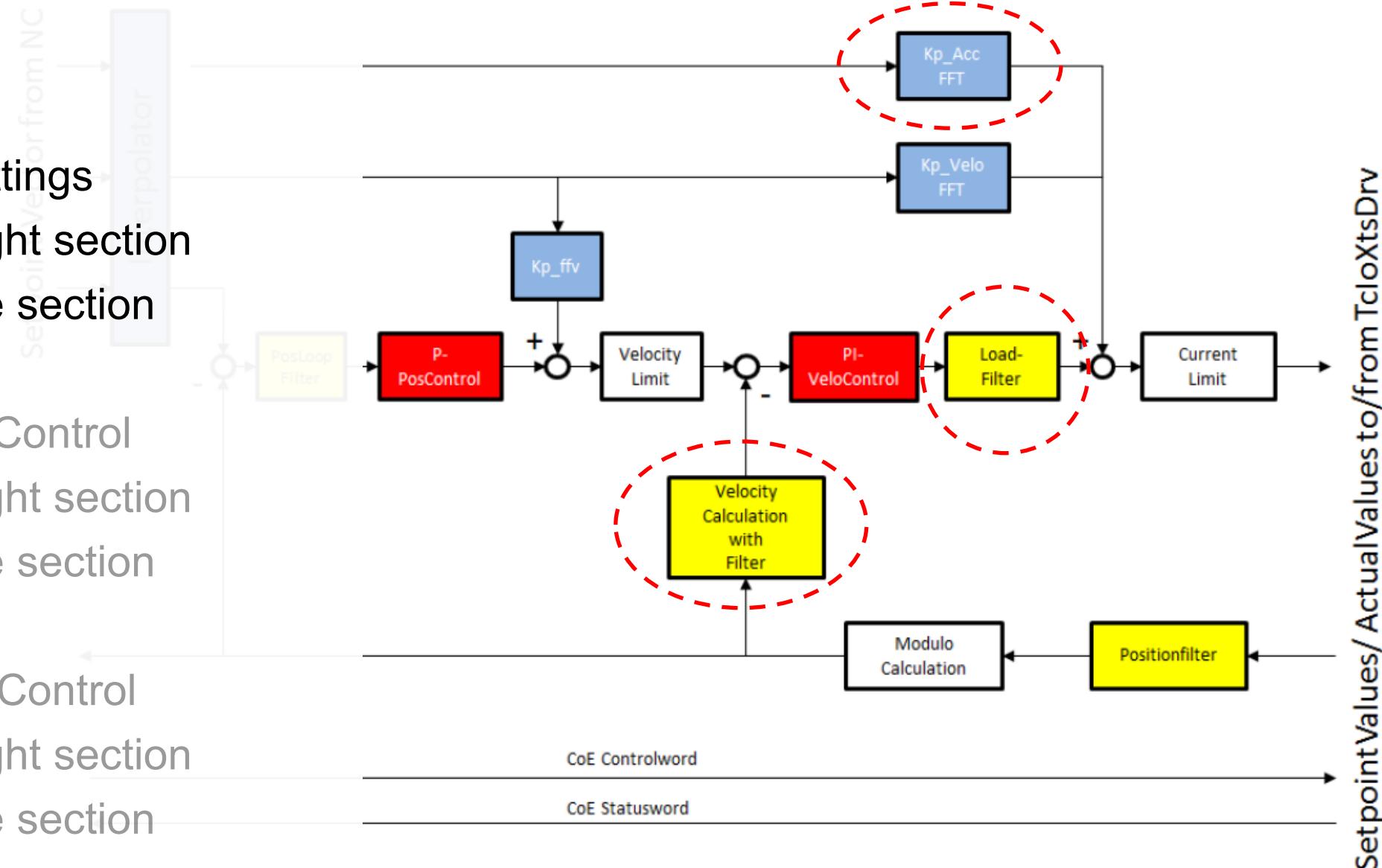


Tuning Sequence

1. Setup Filter Settings
 - I. on the straight section
 - II. on the curve section

2. Setup Velocity-Control
 - I. on the straight section
 - II. on the curve section

3. Setup Position-Control
 - I. on the straight section
 - II. on the curve section

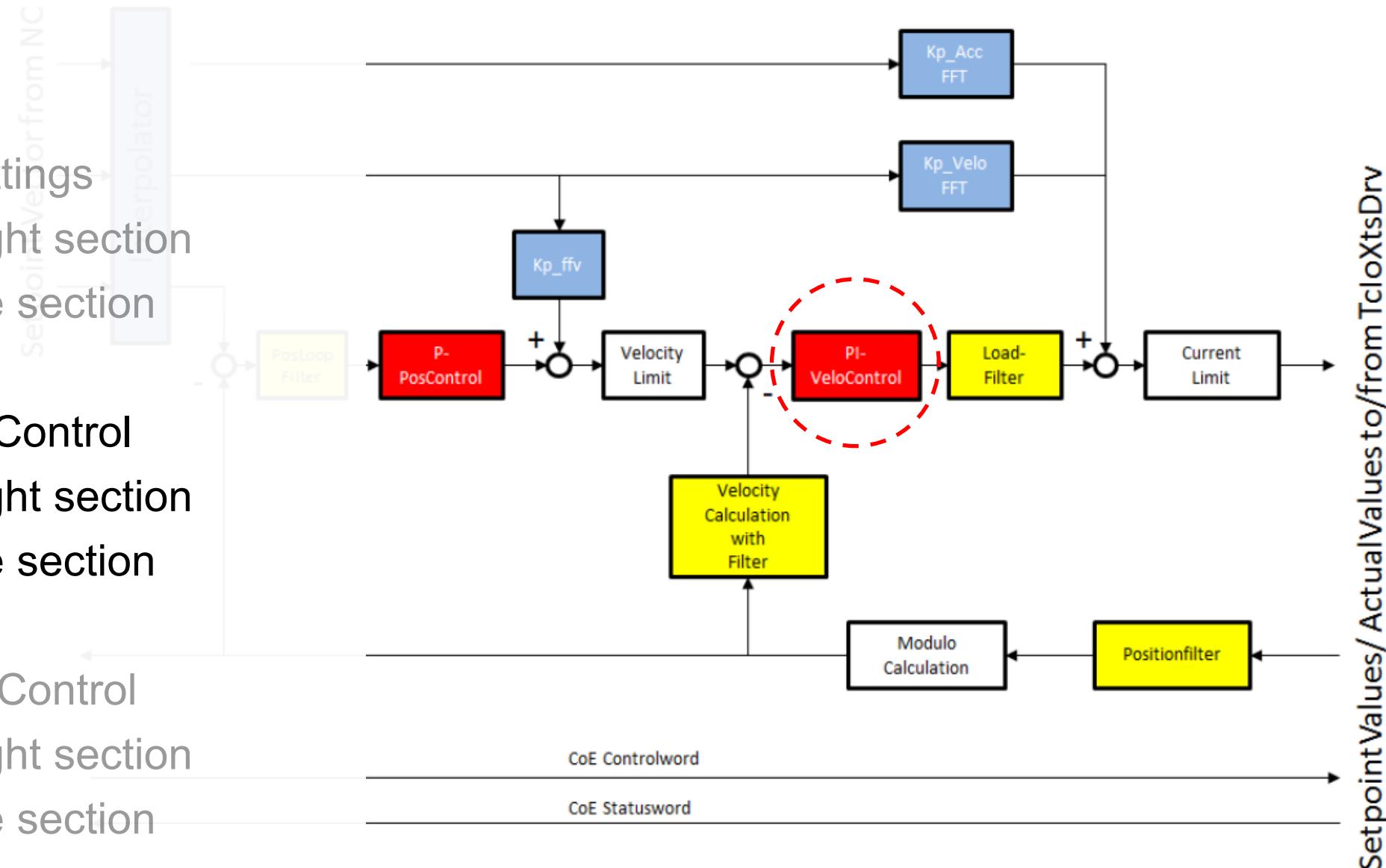


Tuning Sequence

1. Setup Filter Settings
 - I. on the straight section
 - II. on the curve section

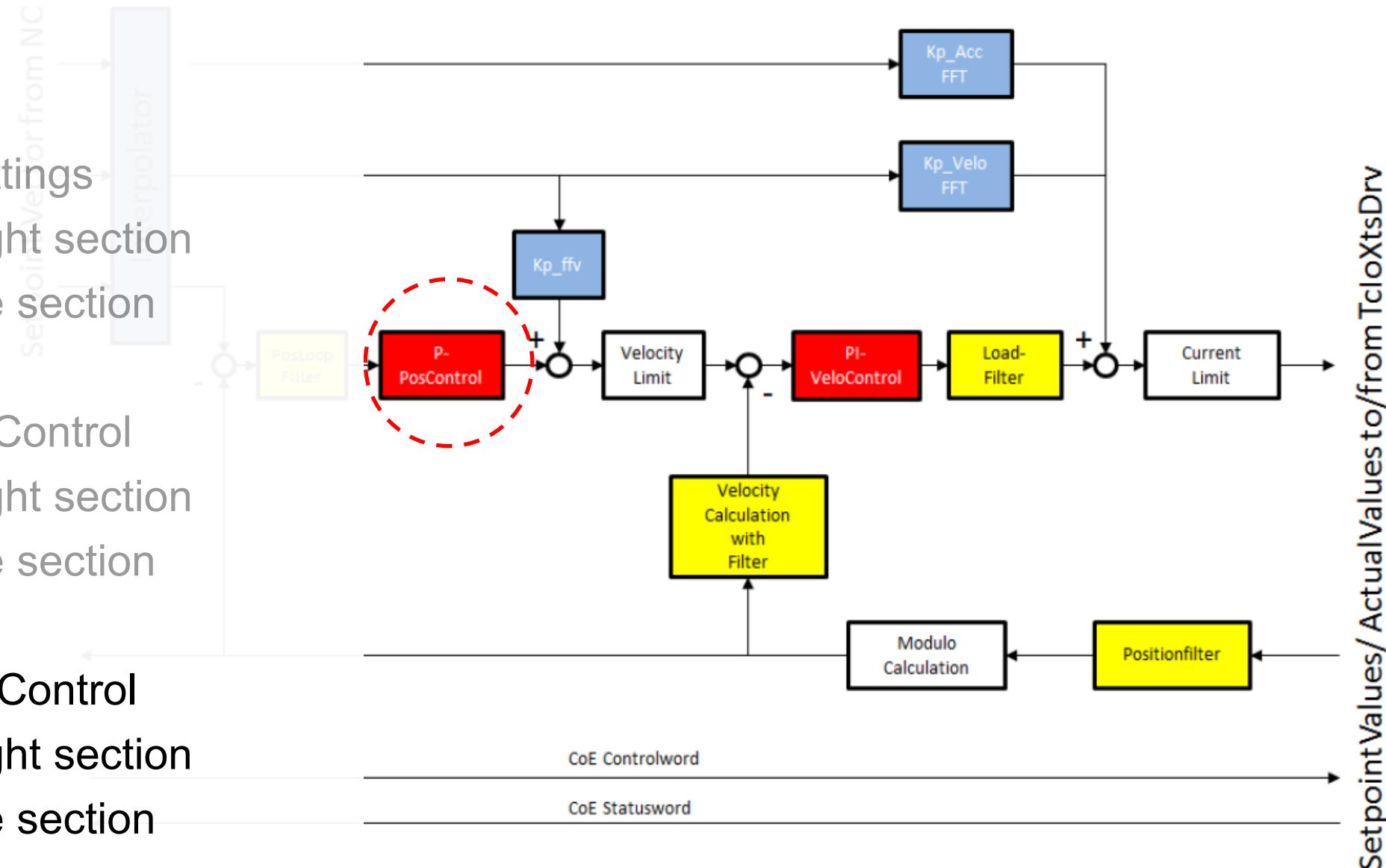
2. Setup Velocity-Control
 - I. on the straight section
 - II. on the curve section

3. Setup Position-Control
 - I. on the straight section
 - II. on the curve section



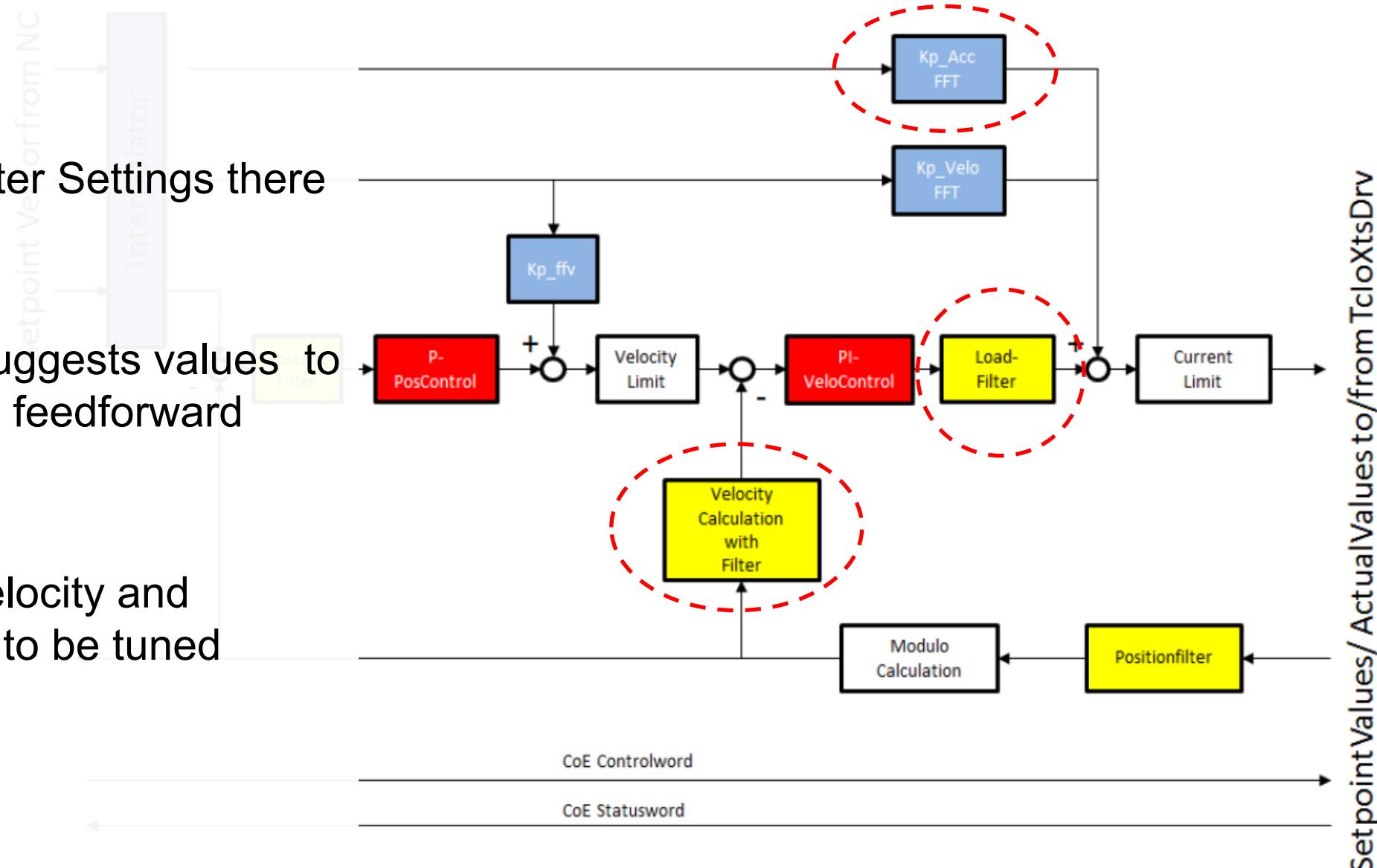
▪ Tuning Sequence

1. Setup Filter Settings
 - I. on the straight section
 - II. on the curve section
2. Setup Velocity-Control
 - I. on the straight section
 - II. on the curve section
3. Setup Position-Control
 - I. on the straight section
 - II. on the curve section



Setup Filter Settings

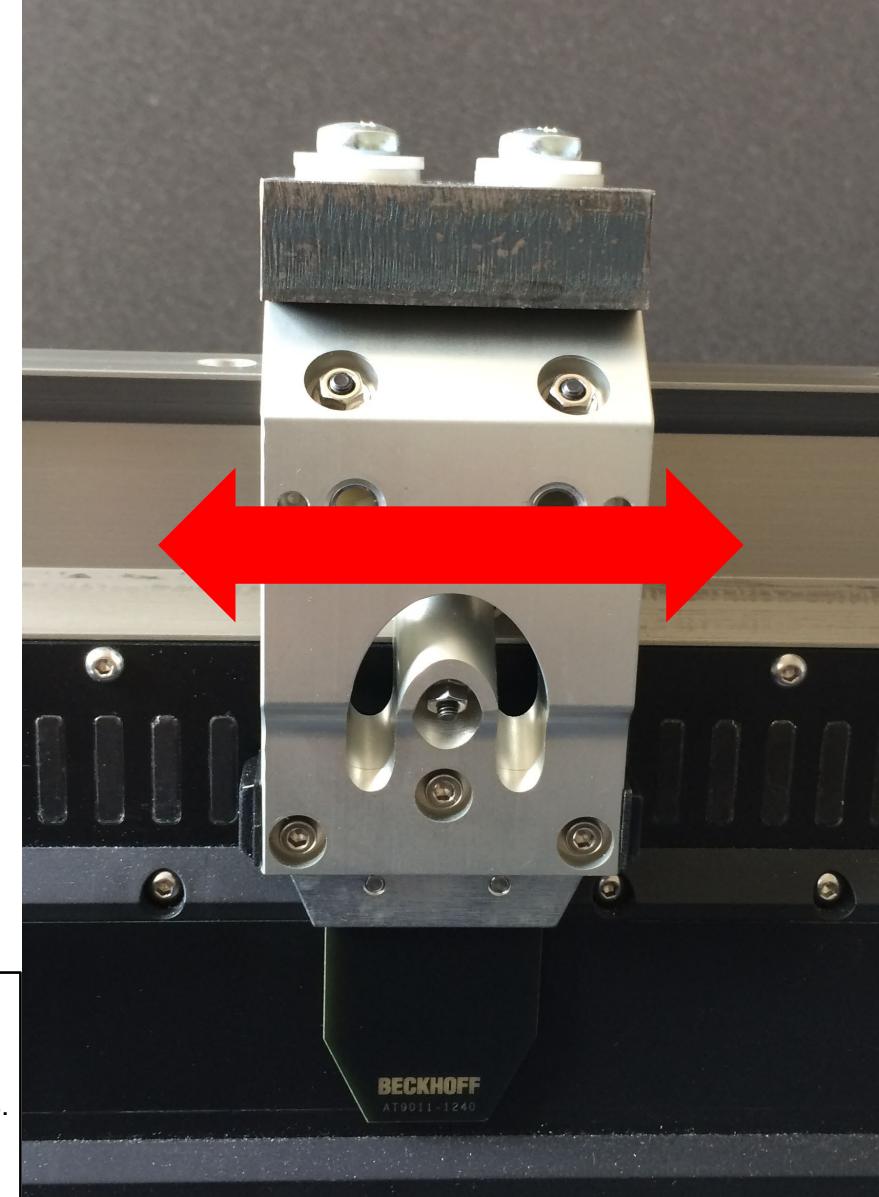
- To determine the Filter Settings there is a Tuning Assist
- The Tuning Assist suggests values to adjust the filters and feedforward parameters
- Typically only the Velocity and Position loops need to be tuned afterwards



Determining Filter Settings using Tuning Assist

- The Tuning Assist (TA) TcCom object is added to the existing TcSoftDrive module (Version \geq 3.10.43.0)
- The TA function operates in torque mode and generates a short current to the mover, followed by coasting to a stop. The Mover will be driven in both positive and negative directions and two measurements will be taken.

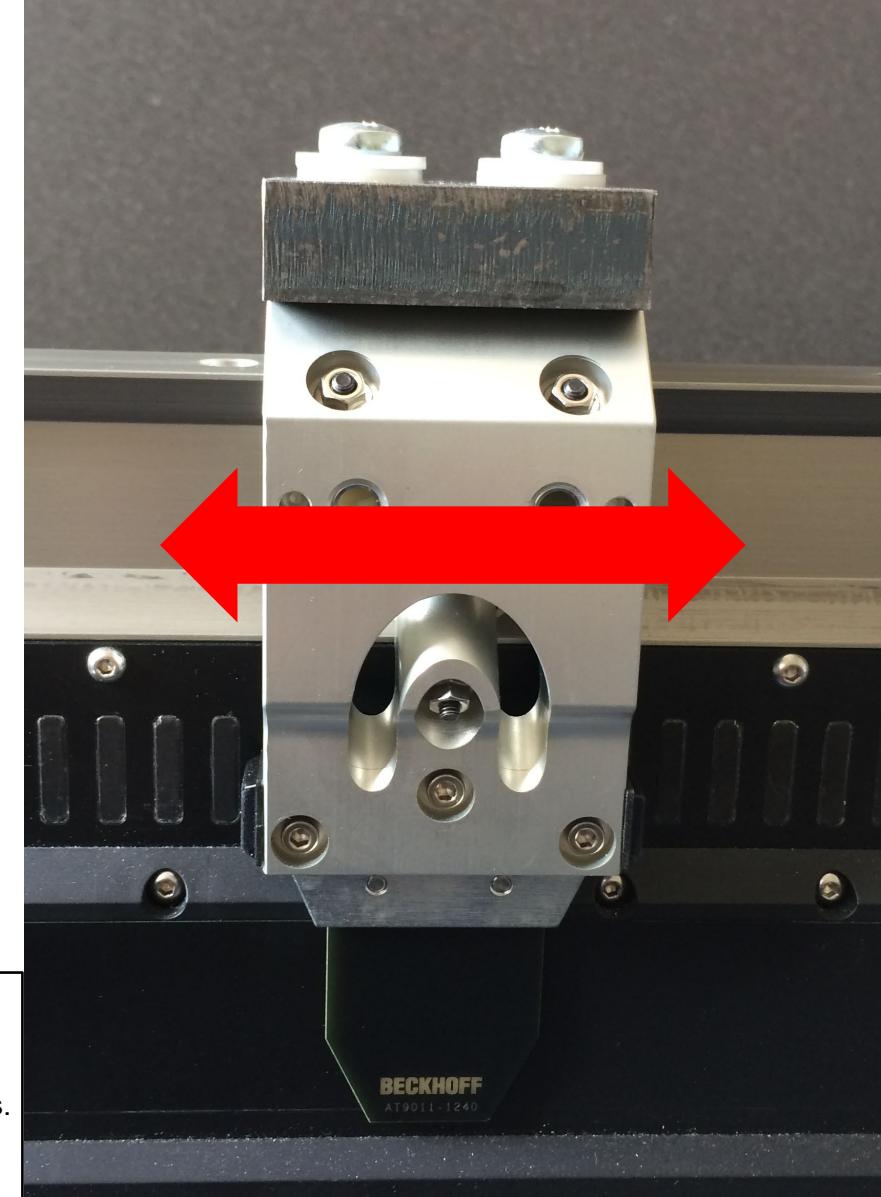
	Risk of injury from moving movers When the Tuning Assist function is started the mover starts to move open loop with a jump. There is a risk of injury to body parts. Keep an appropriate safety distance, and stay clear outside of the operating space.
WARNING	



Determining Filter Settings using Tuning Assist

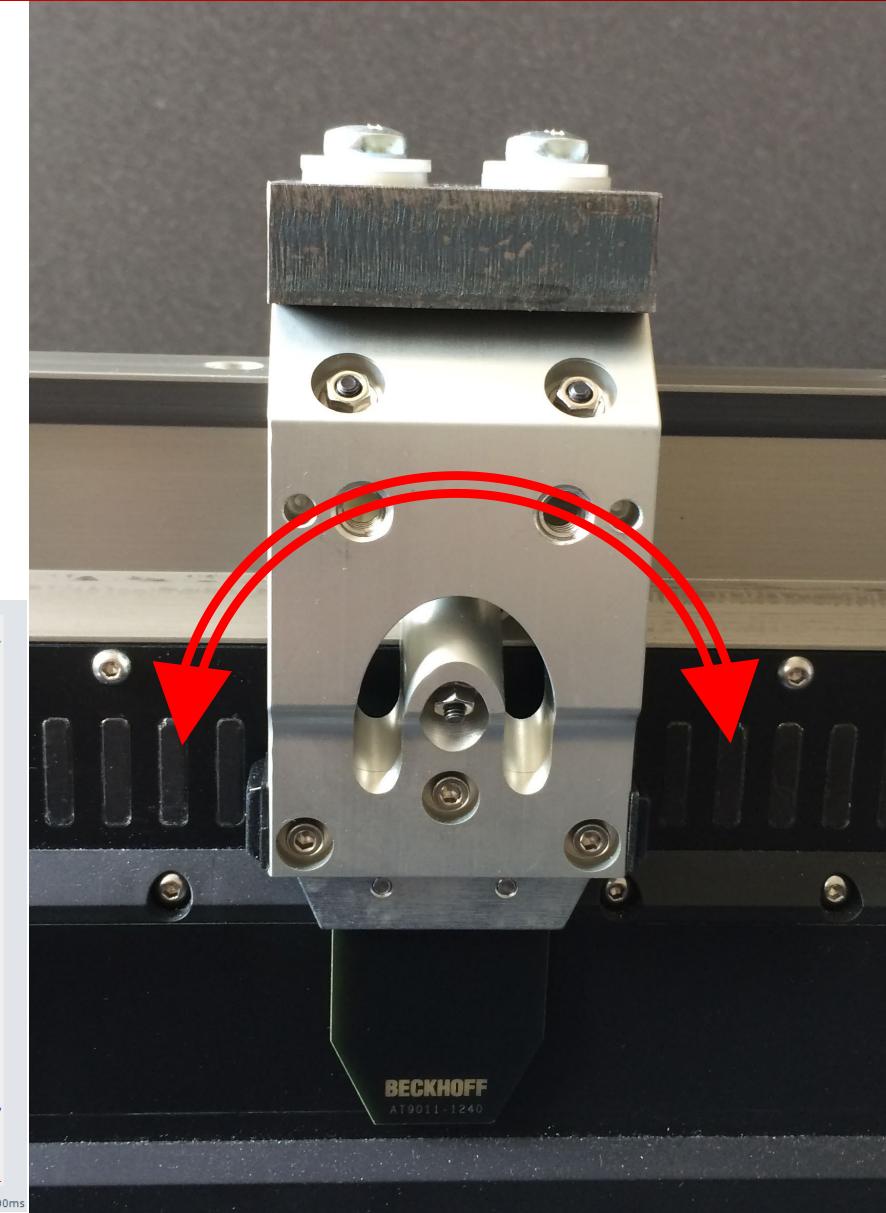
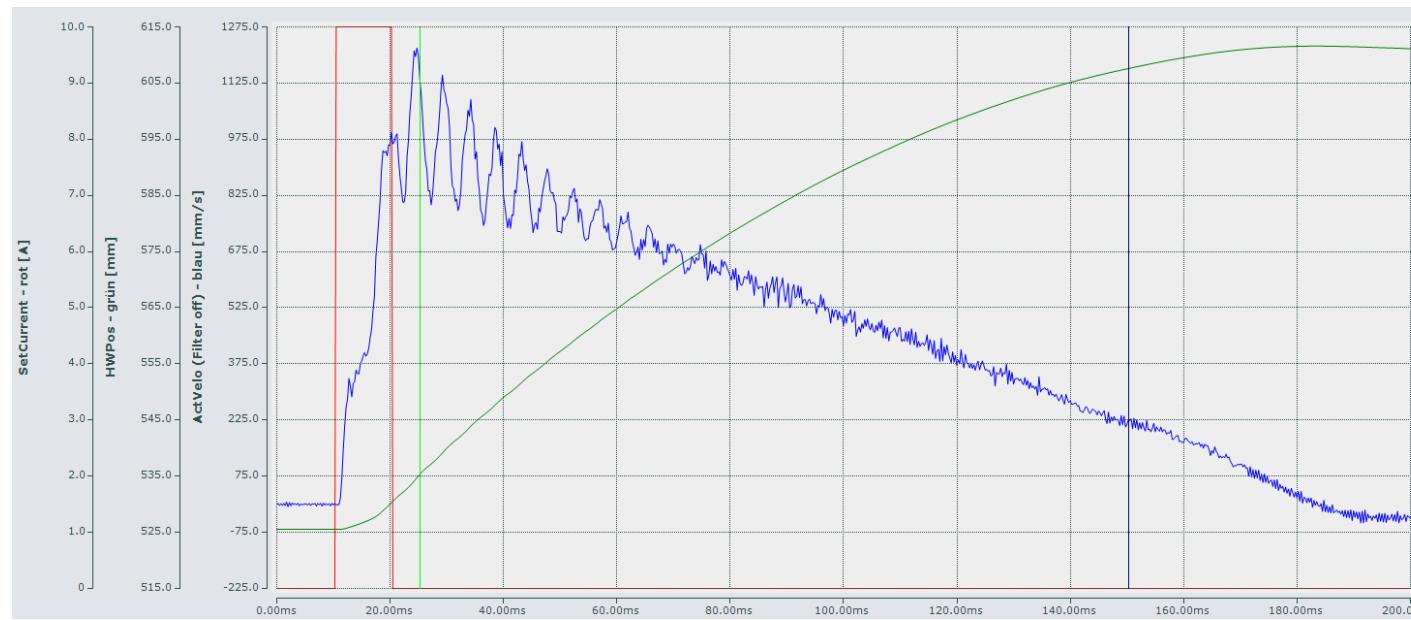
- The response of the system (Mover with tooling) will be measured and a Fast Fourier Transformation (FFT) is used to determine the frequency components
- The result could be visualized with the array bar chart functionality of TwinCAT 3 Scope Views (Version \geq 3.2.3136 starting with TwinCAT 3.1.4020.14)

	Risk of injury from moving movers When the Tuning Assist function is started the mover starts to move open loop with a jump. There is a risk of injury to body parts. Keep an appropriate safety distance, and stay clear outside of the operating space.
WARNING	



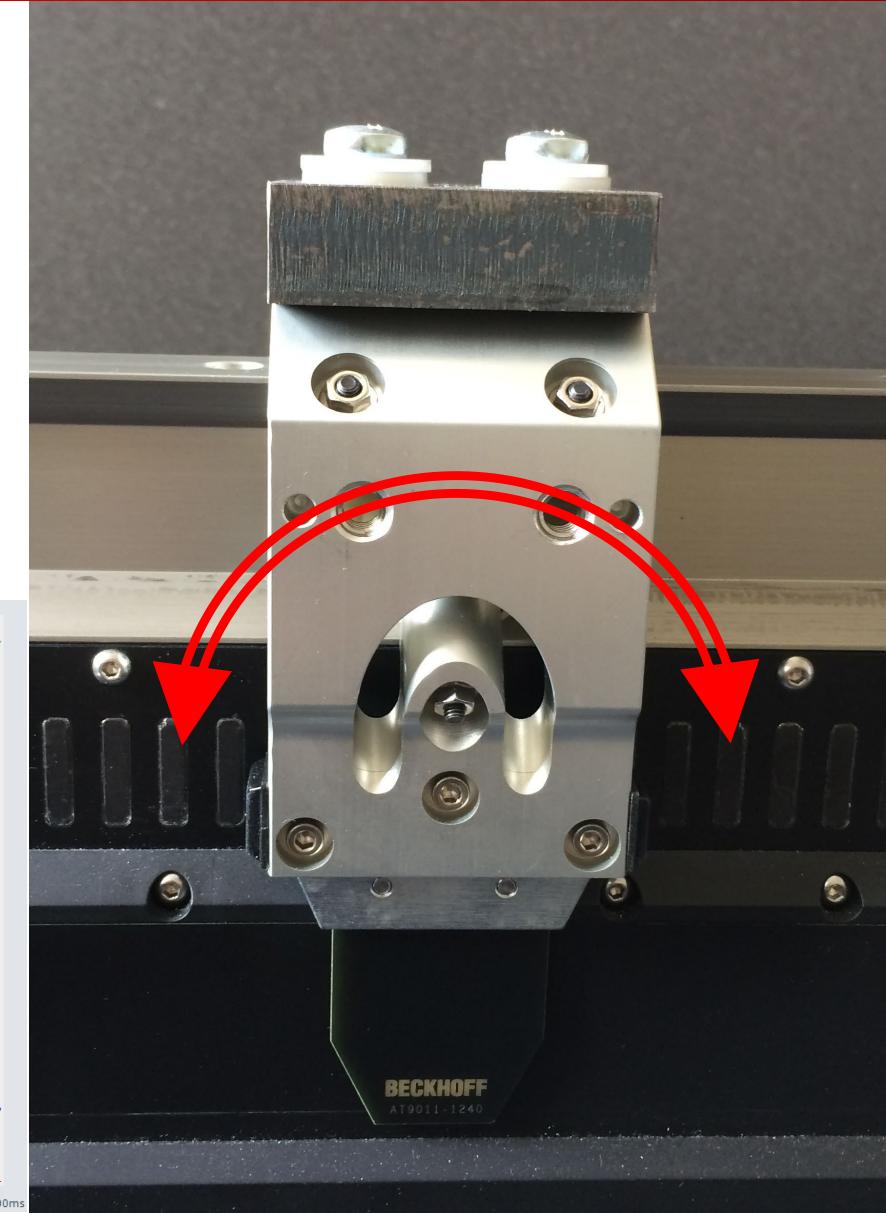
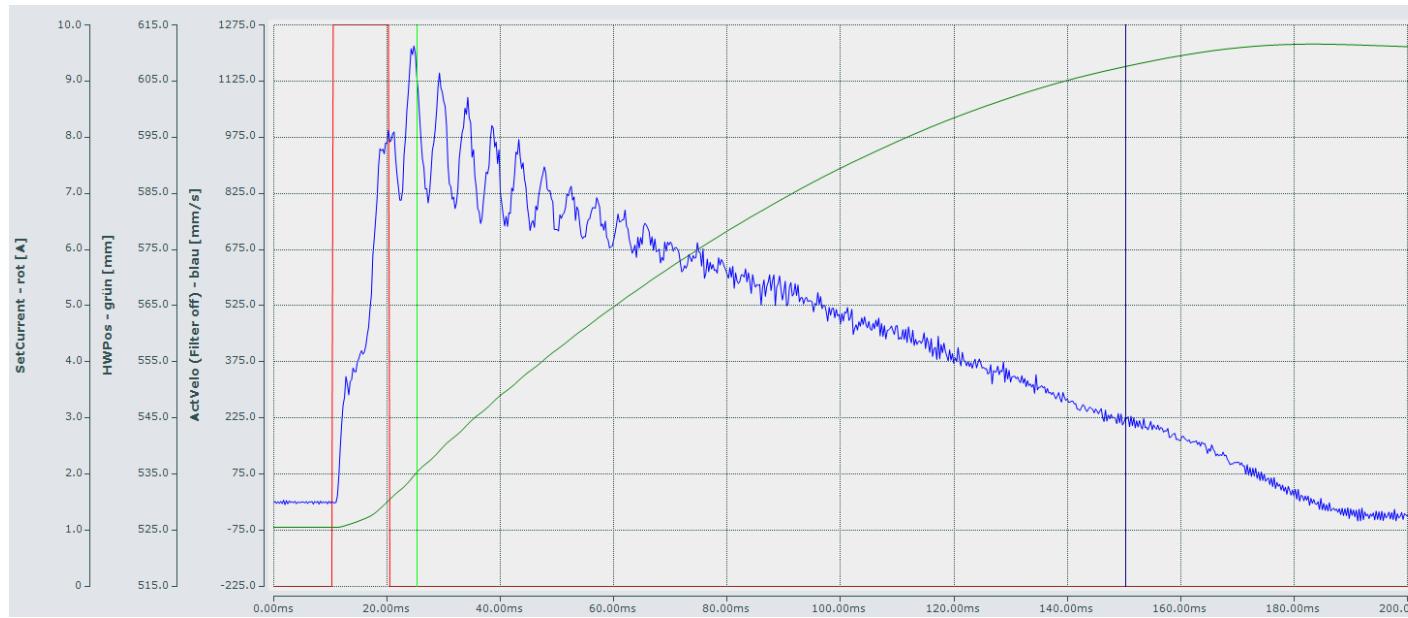
Determining Filter Settings using Tuning Assist

- The behaviour (torsional oscillation) of the mechanical system is analyzed. The normal direction of motion for the application should be used to ensure the best parameterization of the control loops for optimal motion performance.



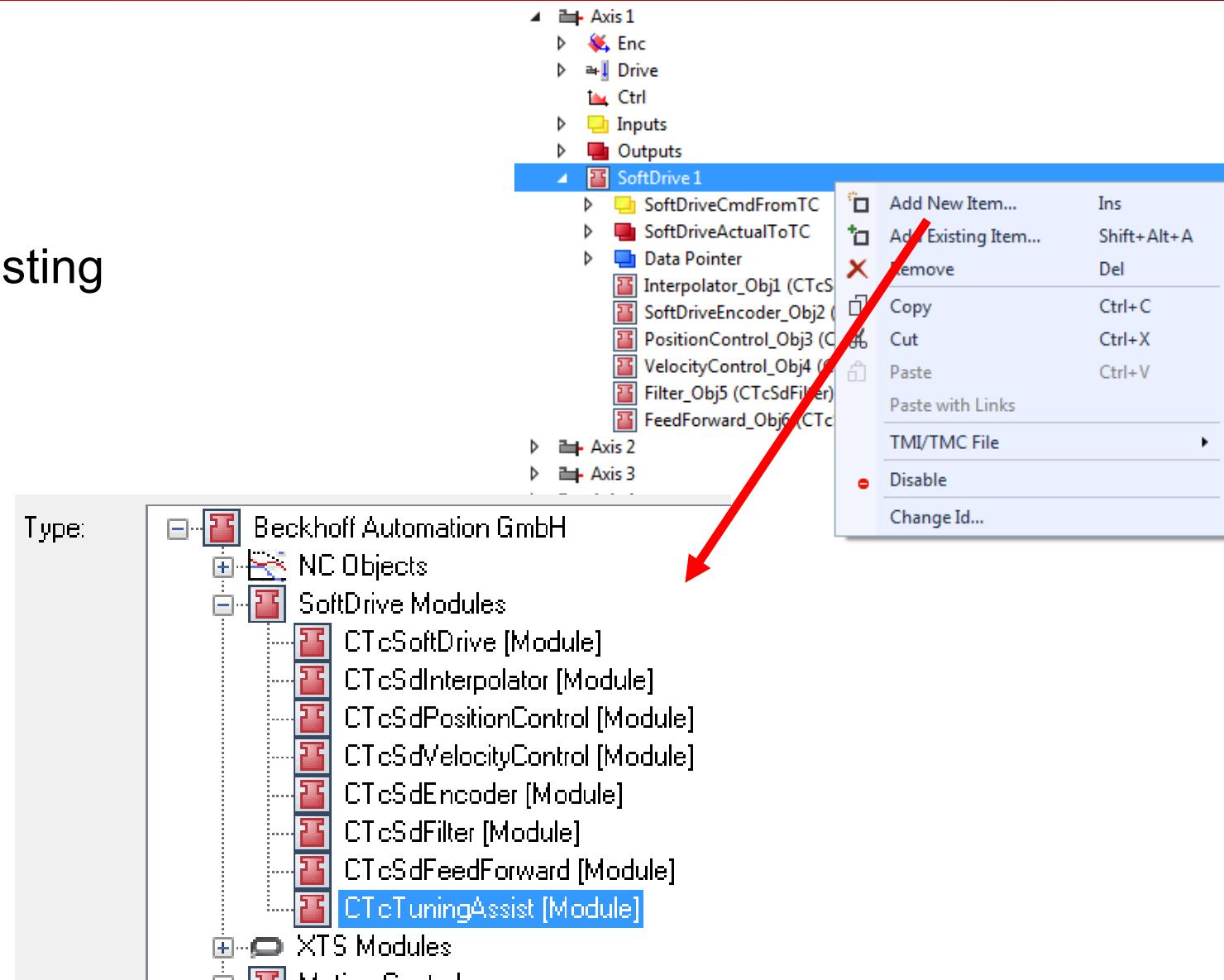
Determining Filter Settings using Tuning Assist

- The direction of torsional oscillations is shown in the picture on the right by the red double arrow
- The scope view example shows the oscillation response over time when a current is applied to the mover.



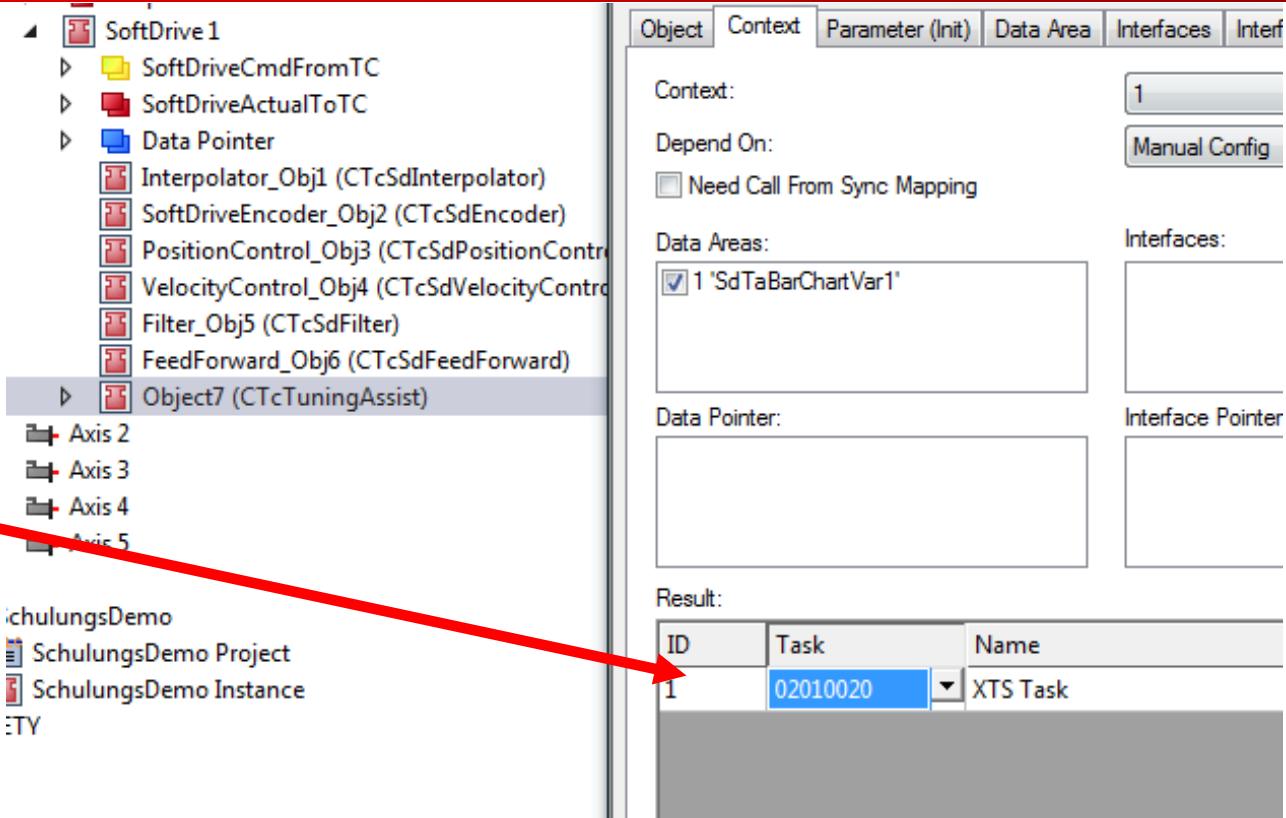
Determining Filter Settings using Tuning Assist

- Add a TuningAssist object to an existing TcSoftDrive



Determining Filter Settings using Tuning Assist

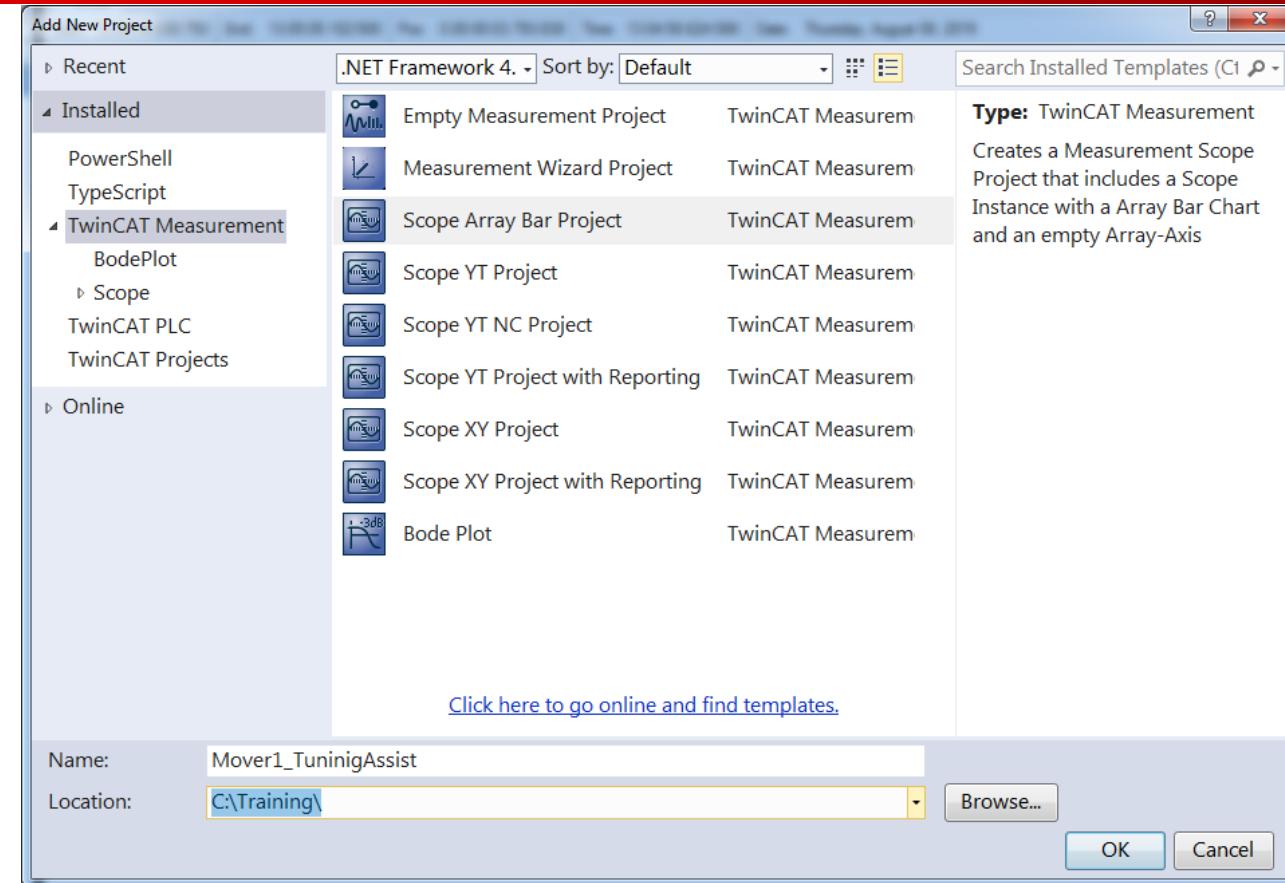
- Set the context task of the TuningAssist object to the same XTS task the TcSoftDrive is using
- Activate the configuration and restart TwinCAT



In the Tuning Assist Obj. set the TcSoftDrive automatic parameter to Mode 10 (force mode)

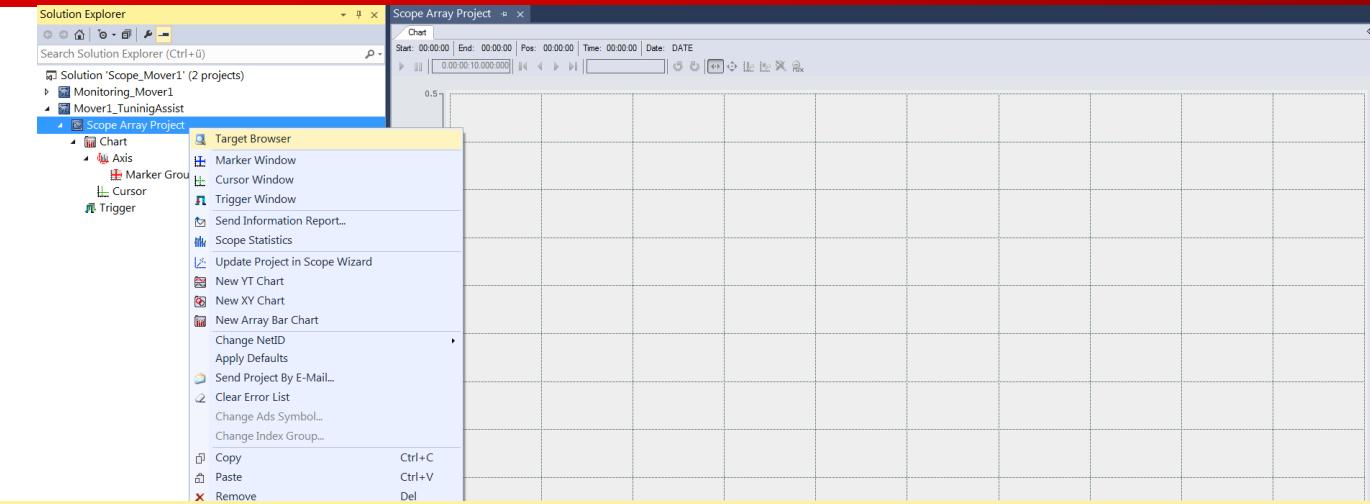
Determining Filter Settings using Tuning Assist

- Create a new measurement project and choose “Scope Array Bar Project” as the type



Determining Filter Settings using Tuning Assist

- Add the array variable “SdTaBarChartVar2” to the Scope Axis

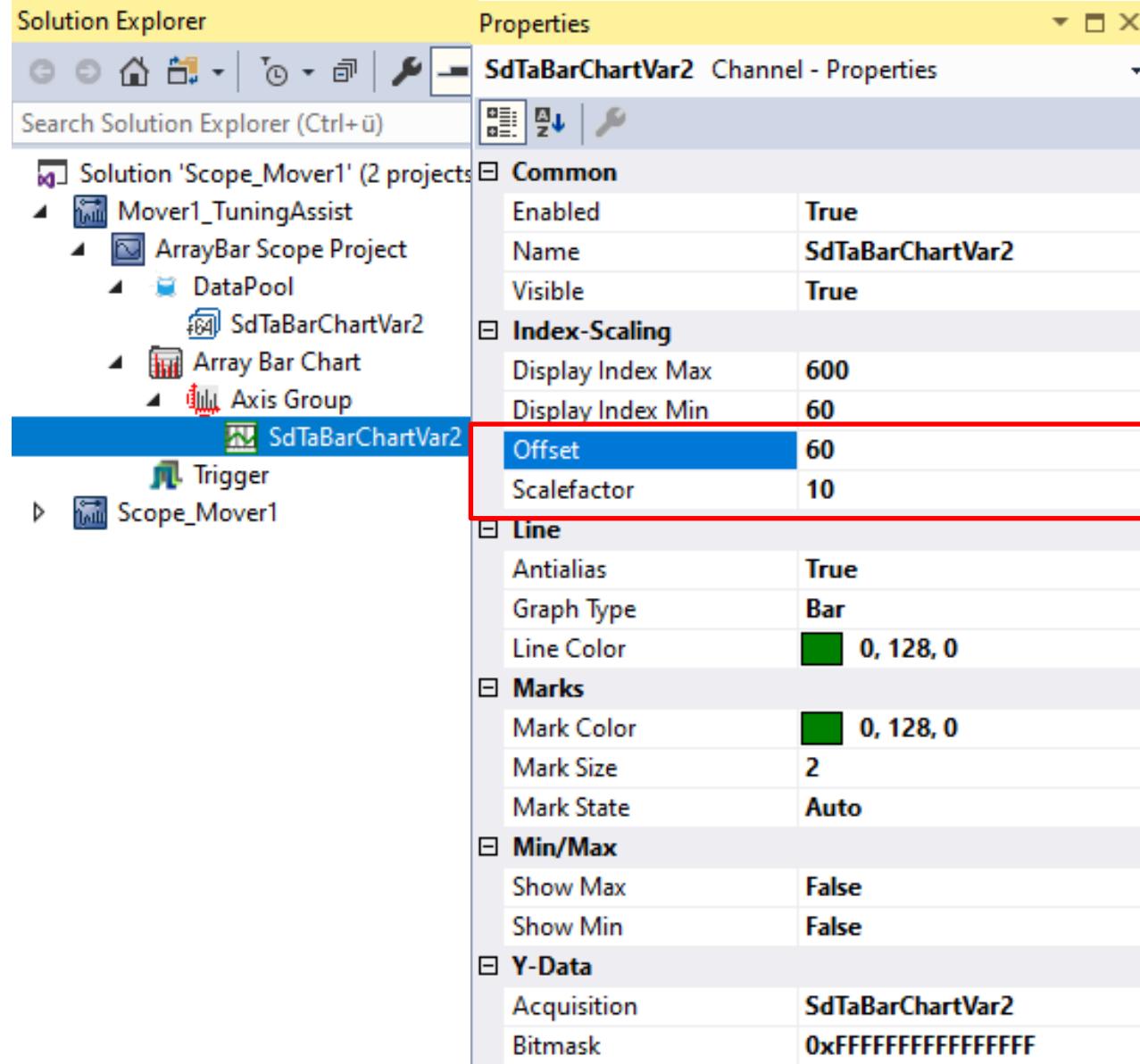


A screenshot of the Target Browser window. The left pane shows the ADS tree with nodes like BECK-NB-1294, CP-22F110, 350: XTS Task 1, 351: PlcTask, 352: VISUTASK, 501: TCNC.NcTaskSaf, and 851: Port851. The right pane shows a detailed table of objects under 'SoftDrive 1 > Object7 (CTcSdTuningAssist) > SdTaBarChartVar1 > SdTaBarChartVar2'. The table has columns for Name, Type, Size, Category, Full-Nam, Comment, and Subitem. The object 'SdTaBarChartVar2' is highlighted in yellow at the bottom of the list. A tooltip 'ARRAY... 440' appears above it, and a button labeled 'Add to Scope' is visible.

Determining Filter Settings using Tuning Assist

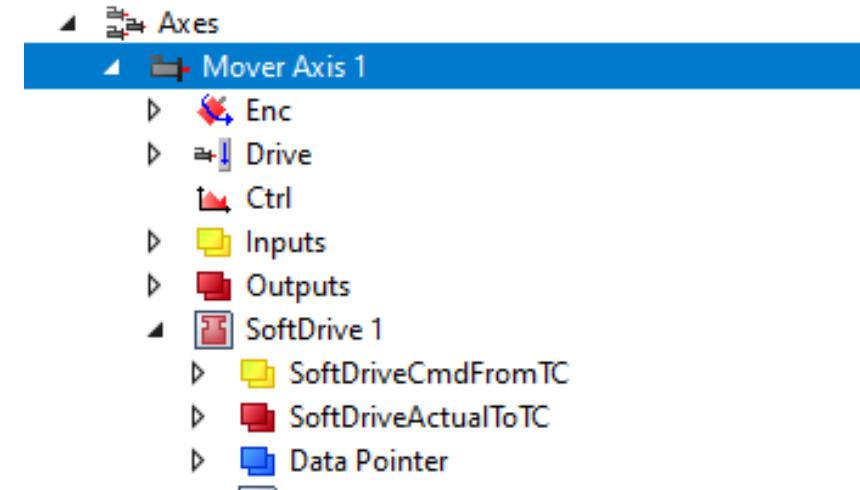
- Set the properties of the variable “SdTaBarChartVar2”:
 - X Offset is set to 60 and
 - X Scale Factor is set to 10

The calculated frequency spectrum by the FFT is always calculated from 60 Hz to 600 Hz in 10 Hz steps



Setup Position Leg Monitoring

- Set the following error monitoring to a high value e.g. 500mm (or disable it)



Parameter	Offline Value	Online Value
+ Maximum Dynamics:		
+ Default Dynamics:		
+ Manual Motion and Homing:		
+ Fast Axis Stop:		
+ Limit Switches:		
- Monitoring:		
Position Lag Monitoring	TRUE	TRUE
Maximum Position Lag Value	500.0	500.0
Maximum Position Lag Filter Time	0.02	0.02

Determining Filter Settings using Tuning Assist

- Process control is done by OnlineWrite and OnlineRead to the parameter “TuningProcess”
- The Online-Value shows the actual state of the “TuningProcess”

First_XTS_Project									
	Name	Value	PV	CS	Unit	Type	P...	C...	...
-	General								
	TuningType	METHODE1							Tunin... 0...
	TuningProcess	START_MEASURE							Tunin... 0...
	Suggested_KpAccFFT	0.0							As^2... LREAL 0...
	Suggested_VeloFilterBandwidth	0.0							Hz LREAL 0...
-	Suggested_LoadFilter	...							0...
	.Type	BIQUAD							DINT
	.Usage	ALWAYS							DINT
	.LowPassFrequency	0.0							
	.LowPassDamping	0.0							
	.HighPassFrequency	0.0							
	.HighPassDamping	0.0							
	Suggested_Friction_Compensati...	0.0							

TuningProcess Settings:

- TUNING_ASSIST_OFF
- START_MEASURE
- TUNING_ASSIST_ERROR
- BUSY_MEASURE
- DONE_MEASURE
- BUSY_SPEC_CALC1
- BUSY_SPEC_CALC2
- DONE_SPEC_CALC
- DONE_FILTER_CALC
- DONE_FRICTION_CALC
- ERROR_FRICTION_CALC

- The Tuning Assist object contain seven parameter

Parameter	Description
Tuning Type	Set the type of calculation – “Method1” measurement in move direction “Source2” measurement across move direction
Tuning Process	Status and control of the tuning assist procedure; set a new state with an “Online Write” access on this parameter and get the current state with an “Online Read” access on this parameter
Suggested_KpAccFFT	Suggestion for the acceleration feedforward gain “KpAccFFT” inside FeedForward_Obj6 after the complete tuning assist procedure was successful executed
Suggested_VeloFilterBandwidth	Suggestion for the “VelocityFilterBandwidth” inside the SoftDriveEncoder_Obj2 after the complete tuning assist procedure was successful executed
Suggested_LoadFilter	Suggestion for the load filter configuration inside the Filter_Obj5 after the complete tuning assist procedure was successful executed and this parameter was requested with an online read on this parameter
Suggested_Friction_Compensation	Suggestion for the parameter “FrictionCompensation” in Ampere, within the Feedforward object of the TcSoftDrive. To avoid following error, when changing the velocity, due to static friction
CurrentPulseTime	Set the time for the current pulse in ms. The default is 10ms but with higher load or more friction it is may necessary to increase it. The maximum possible time is 25 ms

XTS TcSoftDrive – Tuning Tuning Assist

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF

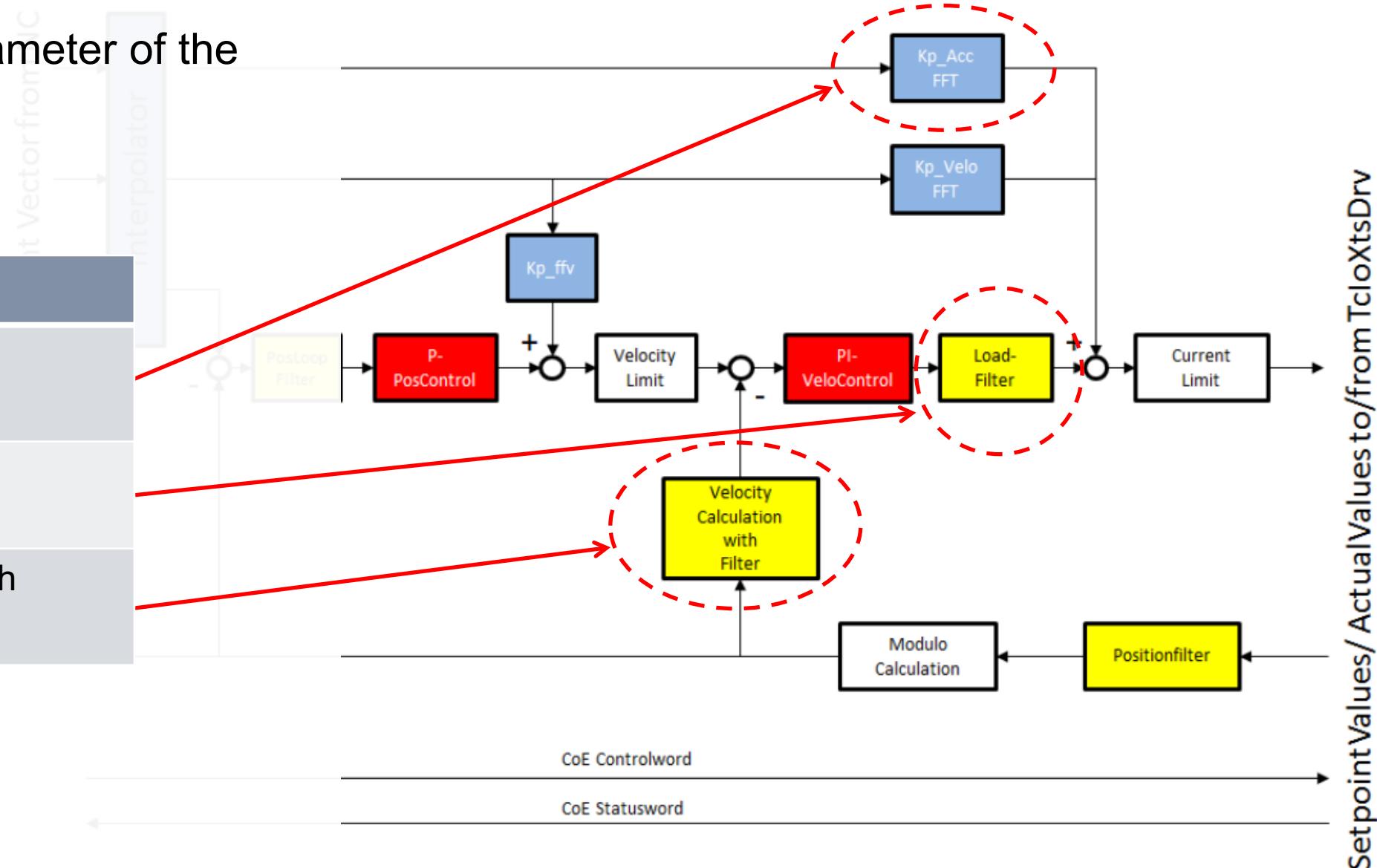
- The Suggested parameter of the Tuning Assist

Parameter

Suggested_KpAccFFT

Suggested_LoadFilter

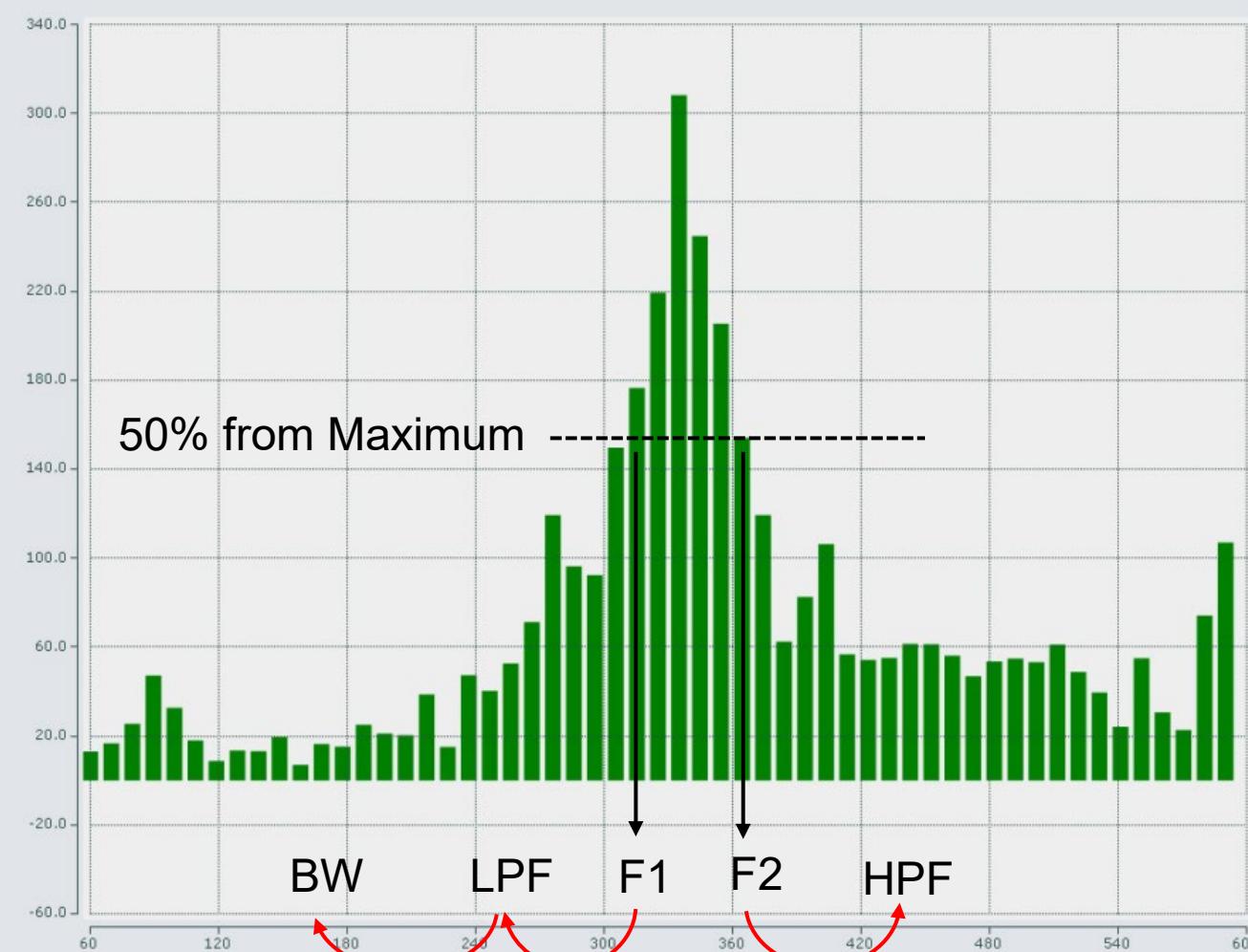
Suggested_VeloFilterBandwidth



XTS TcSoftDrive – Tuning Tuning Assist

Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



Name	Value
TraceLevelMax	tlAlways
TuningType	METHODE1
TuningProcess	DONE_FILTER_CALC
Suggested_KpAccFFT	1.6
Suggested_VeloFilterBandwidth	146.0
Suggested_LoadFilter	...
.Type	BIQUAD
.Usage	ALWAYS
.LowPassFrequency	256.0
.LowPassDamping	0.6
.HighPassFrequency	437.0
.HighPassDamping	0.3

Result of calculation

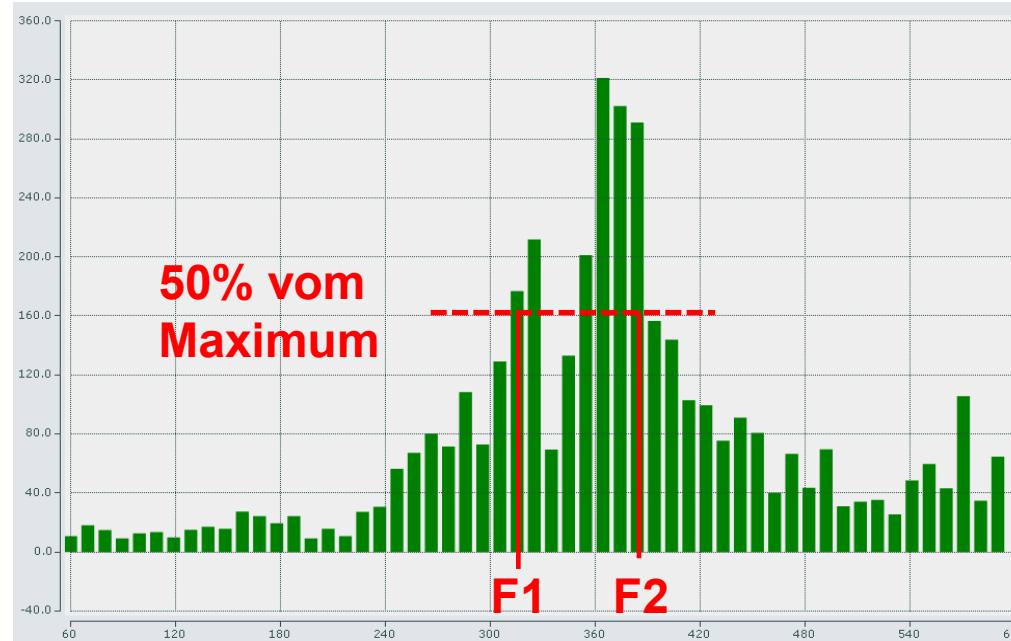
This graphic shows how the calculation for the filter suggestion is done with one FFT result

- LPF: LowPassFrequency
- HPF: HighPassFrequency
- BW: VelocityFilterBandwidth

XTS TcSoftDrive – Tuning Tuning Assist

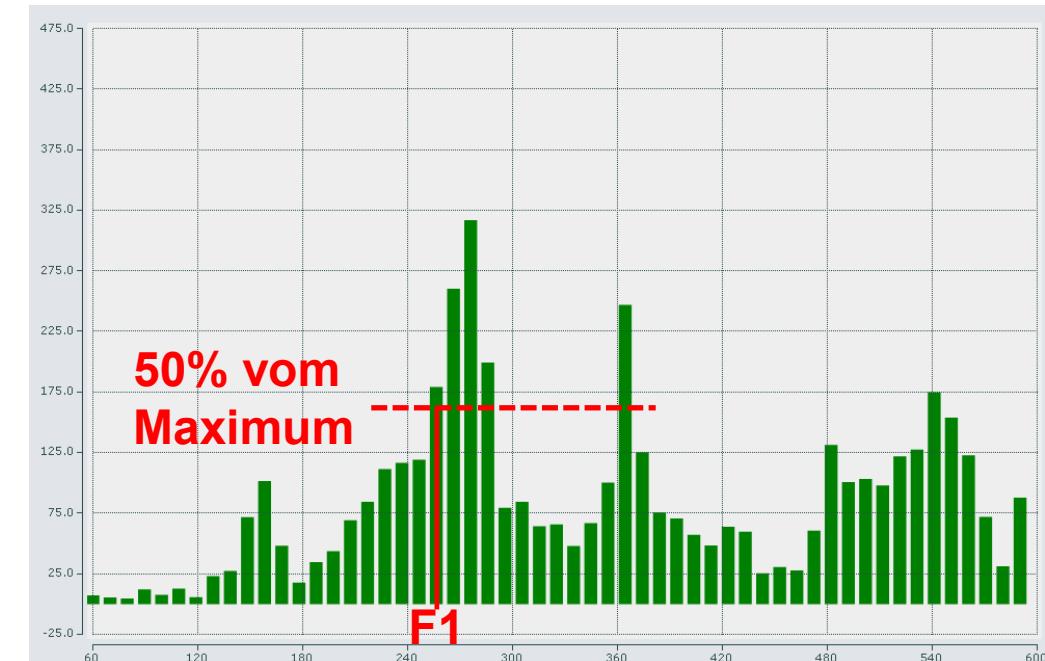
Beckhoff-Training | TR3056 : Q2/2023

BECKHOFF



Example 2:
If the maxima are too far apart, then a second order low pass filter is suggested

Example 1:
If the two maxima are close to each other then one Bi-Quad Filter may be used



▪ Steps / Tips for Tuning Assist

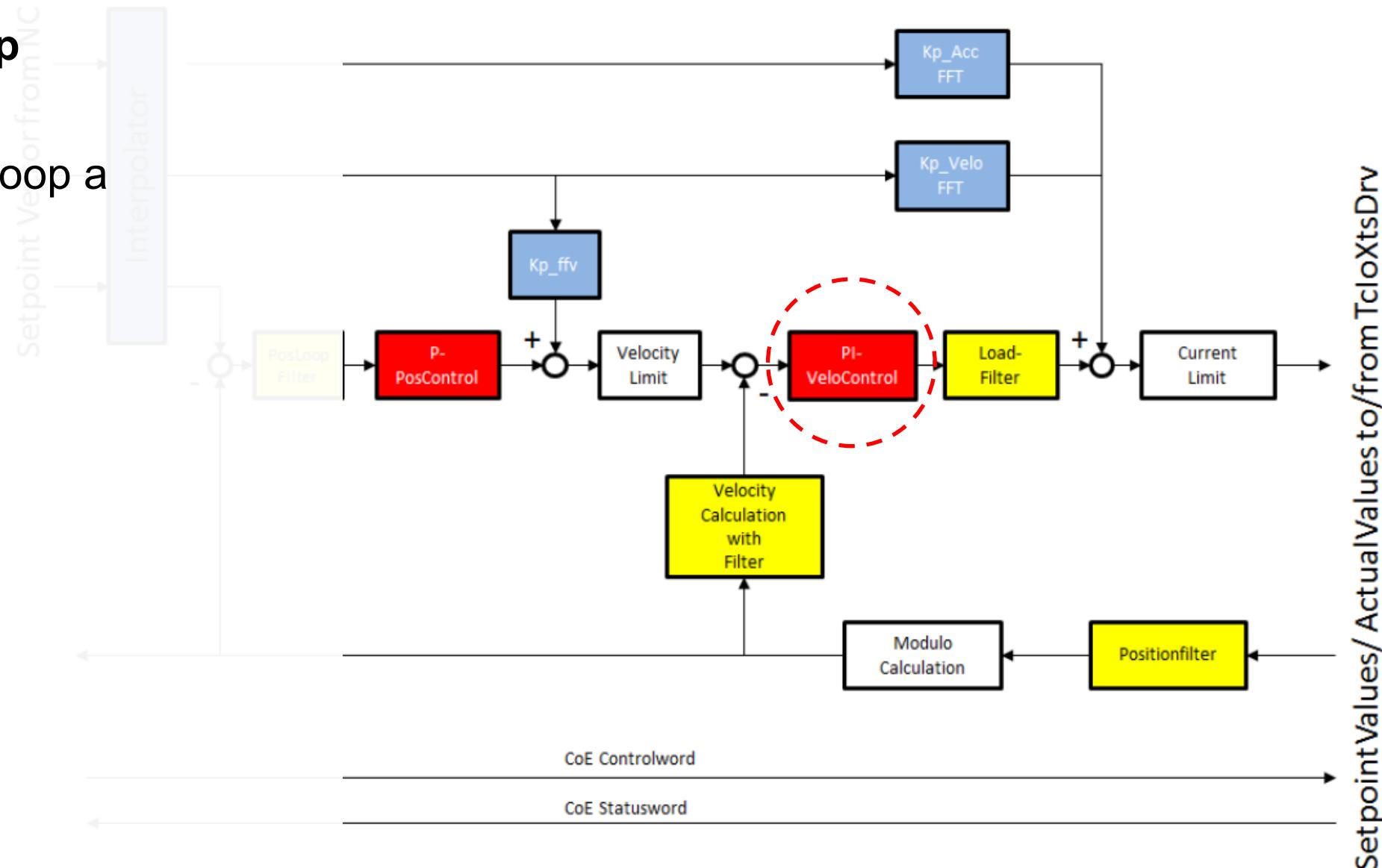
- Enable the NC axis first and set the following error monitoring in the corresponding NC axis to a high value e.g. 500mm (or disable it)
- Execute some more measurements e.g. three on the straight and three on the curve and maybe also with / without product on the mover
- Analyze the spectrum manually as well and try to categorize the FFT with the given examples by yourself

- Notice the parameter suggestions and try to combine the filter settings
 - Use lowest value for “Suggested_VeloFilterBandwidth”
 - Use lowest value for “Suggested_KpAccFFT” from a straight measurement
 - Use LowpassFilter2 if both filter types are suggested (Lowpass2 & Biquad)
 - Use lowest value for suggested “LowPassFrequency”
 - Use highest value for suggested “HighPassFrequency”

Velocity Control Loop

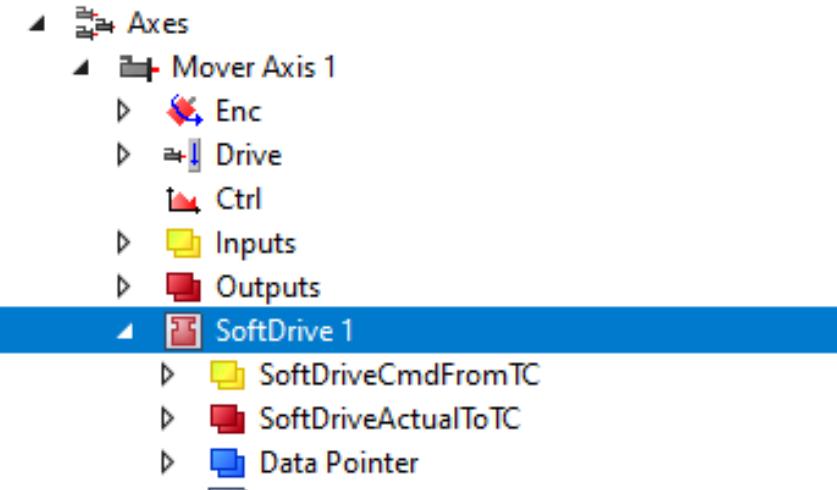
- For velocity control loop a “PI” – Loop is used.

- Setup Kp
- Setup Tn



Velocity Control Loop

- Disable or remove the Tuning assist object (if not already done)
- Set the SoftDrive “OperationMode” parameter in the main object to 9 (cyclic synchronous velocity mode)



The screenshot shows the Beckhoff XTS configuration software interface. On the left is a tree view of the project structure:

- Axes
 - Mover Axis 1
 - Enc
 - Drive
 - Ctrl
 - Inputs
 - Outputs
- SoftDrive 1
 - SoftDriveCmdFromTC
 - SoftDriveActualToTC
 - Data Pointer

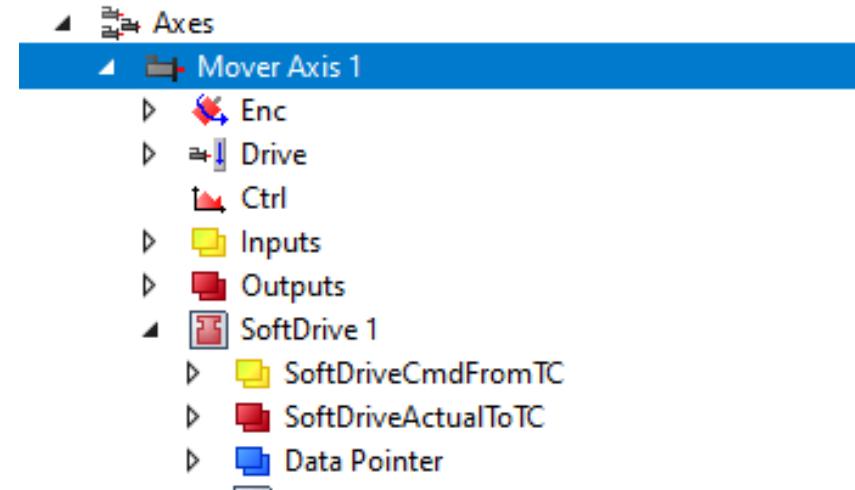
The "SoftDrive 1" node is selected, highlighted with a blue bar at the bottom of the tree.

Below the tree is a table titled "First_XTS_Project" containing project parameters:

Object	Context	Data Area		Interfaces		Interface Pointer		Data Pointer	
		Parameter (Init)	Parameter (Online)	Parameter (Init)	Parameter (Online)	Parameter (Init)	Parameter (Online)	Parameter (Init)	Parameter (Online)
-	General								
	AdsPort	0x015e						W...	0.
	HardwareModulo	3000.0						LR...	0.
	OperationMode	9						UD...	0.
	MaxCurrentOutput	12.0						LR...	0.
	EmergencyRamp	10000.0						LR...	0.
	EmergencyTimeOut	0.5						LR...	0.
	StandstillSwitchTime	0.1						LR...	0.
	EmergencyRampTime	10000.0						LR...	0.

Velocity Control Loop

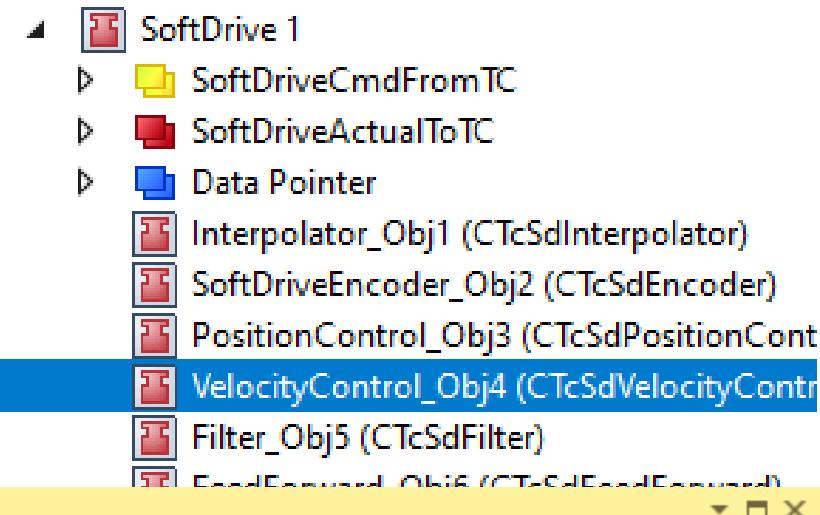
- Set the following error monitoring to a high value e.g. 500mm (or disable it)



Parameter	Offline Value	Online Value
+ Maximum Dynamics:		
+ Default Dynamics:		
+ Manual Motion and Homing:		
+ Fast Axis Stop:		
+ Limit Switches:		
- Monitoring:		
Position Lag Monitoring	TRUE	TRUE
Maximum Position Lag Value	500.0	500.0
Maximum Position Lag Filter Time	0.02	0.02

Velocity Control Loop

- Switch off the integral part of the velocity control
 - all Tn parameter set to zero

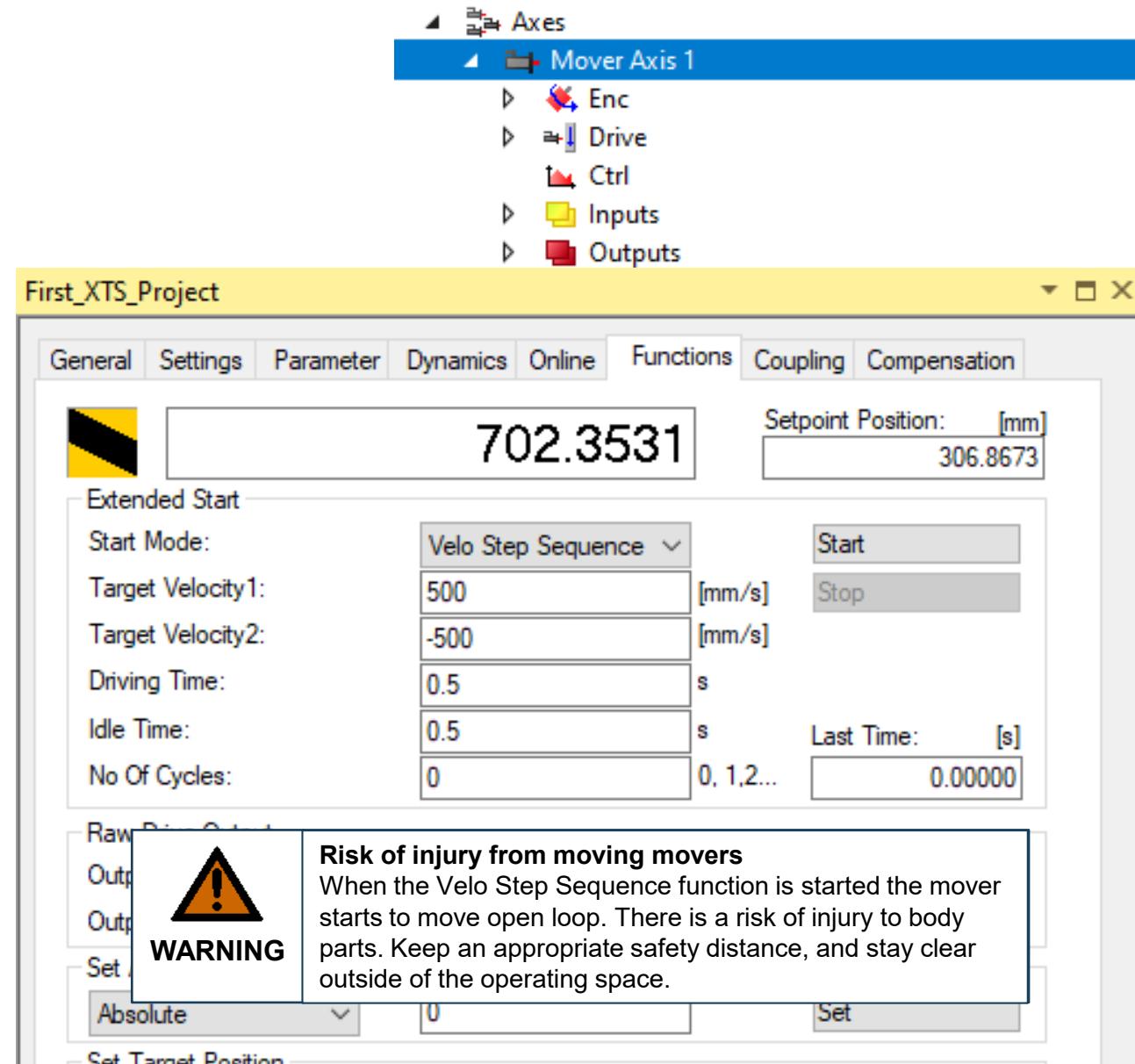


First_XTS_Project

Object	Context	Parameter (Init)	Interfaces	Interface Pointer								
-	General											
	VelocityLoopType	PI_VELOCITY_STAN...								Velo...	0..	
	Kp	0.05								As/r...	LREAL	0..
	Kp_standstill	0.033								As/r...	LREAL	0..
	Kp_area	0.04								As/r...	LREAL	0..
	Kp_area_standstill	0.03								As/r...	LREAL	0..
	Tn	0.05				s				LREAL	0..	
	Tn_standstill	0.05				s				LREAL	0..	
	Tn_area	0.05				s				LREAL	0..	
	Tn_area_standstill	0.05				s				LREAL	0..	
	Ki	0.0				A..				LREAL	0..	

Velocity Control Loop

- Enable the NC axis and start the service mode “Velo Step Sequence”
- Scope as minimum from the corresponding SoftDrive
 - Act Velocity
 - Set Velocity
 - Set Current
- May reduce the target velocity to avoid current saturation reaching the “MaxCurrentOutput” value (12A default)

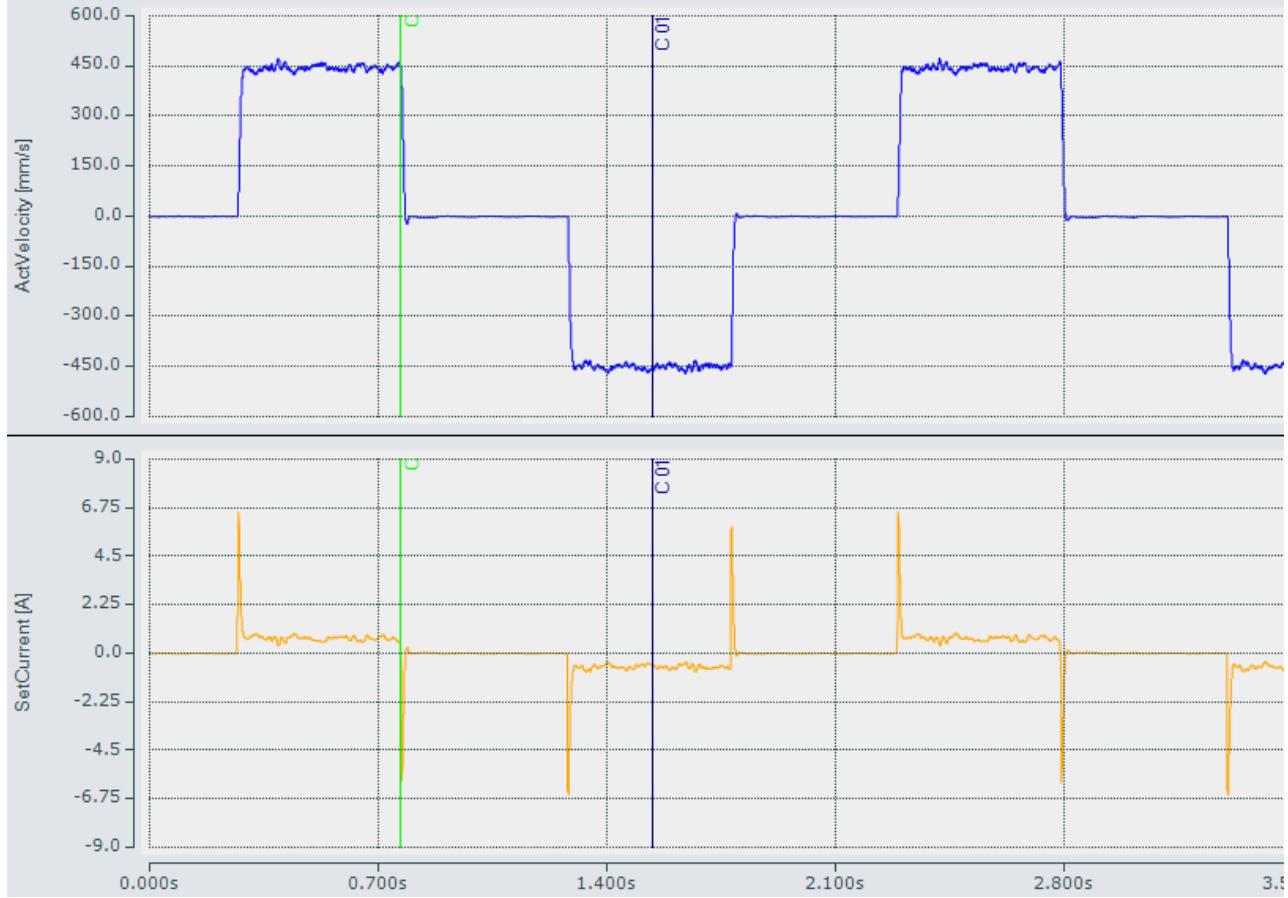


Velocity Control Loop

- Increase (or decrease) the velocity loop gain Kp until the actual velocity reaches
85 – 90 %

of the commanded velocity (e.g. here
500 mm/s)

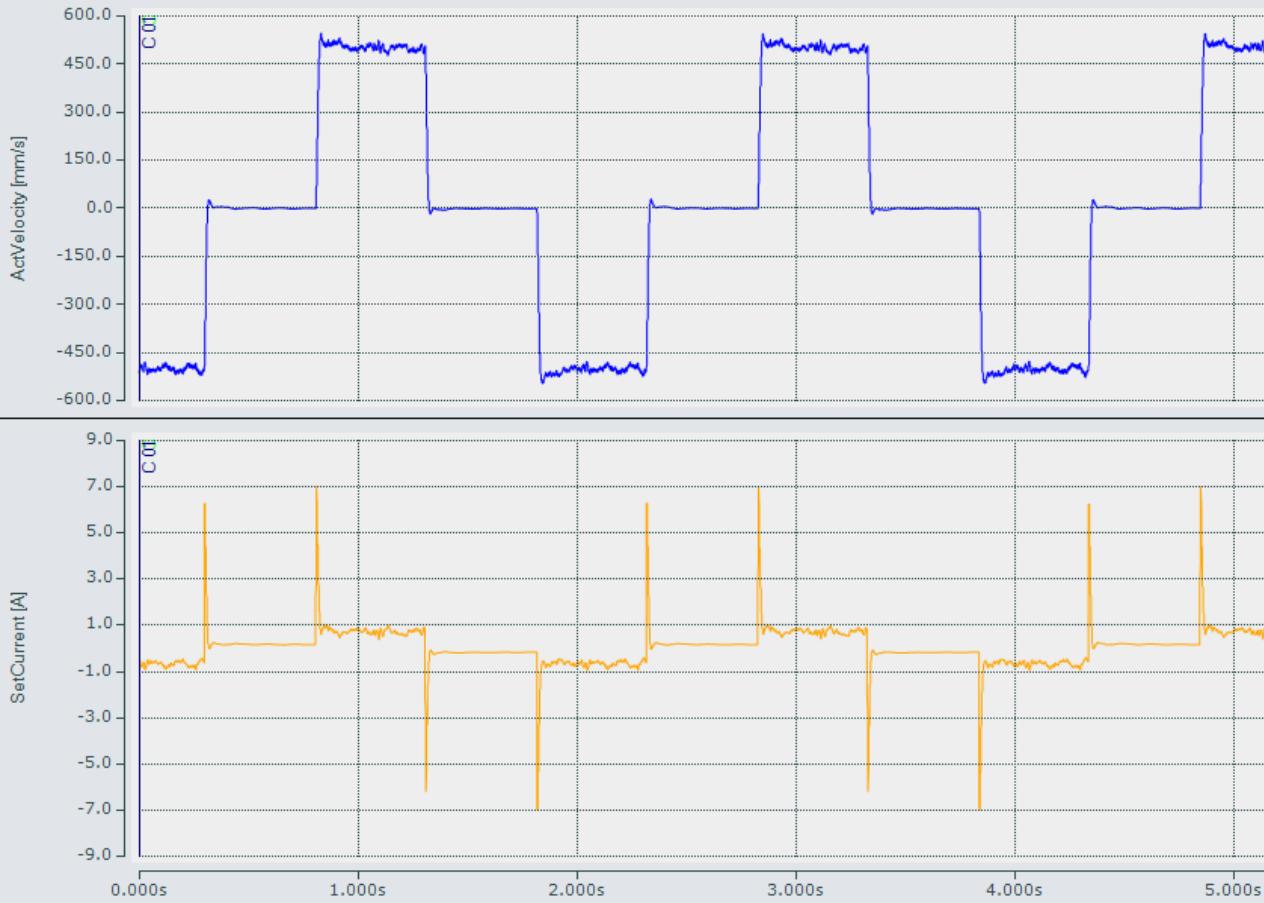
- Set Kp_standstill parameter to the same value or a bit less e.g. 75%



Set Kp to reach 90% of command velocity

Velocity Control Loop

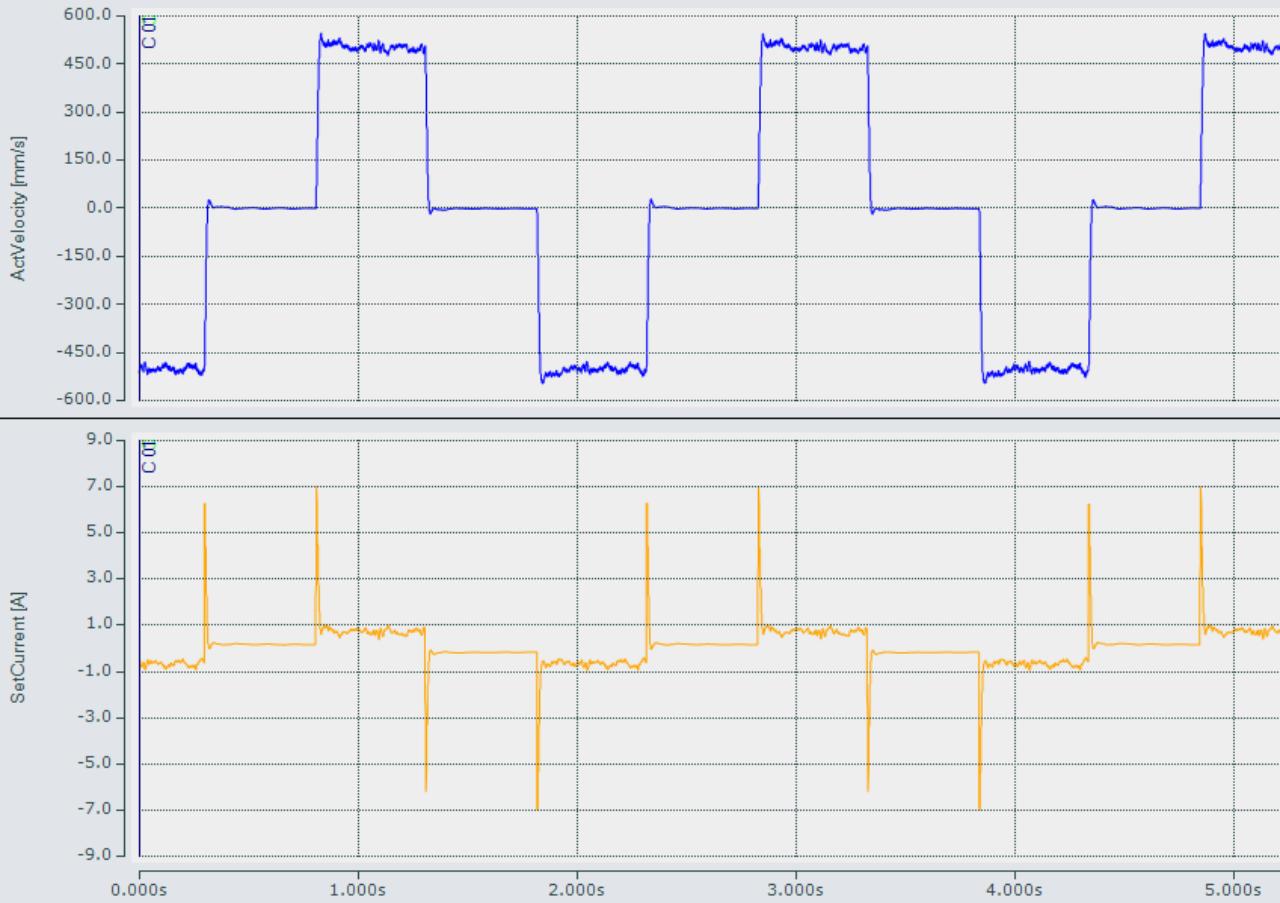
- Switch on Tn with a large time value
e.g. 0.2 s
and reduce this incrementally until the
actual velocity has a small overshoot
of
5 – 10% of the command
- Repeat procedure for the curve and
use area parameters in case of
differences in the straight and curve
sections
- Avoid saturating the current output



Set Tn to reach 5 -10 % overshoot

Velocity Control Loop

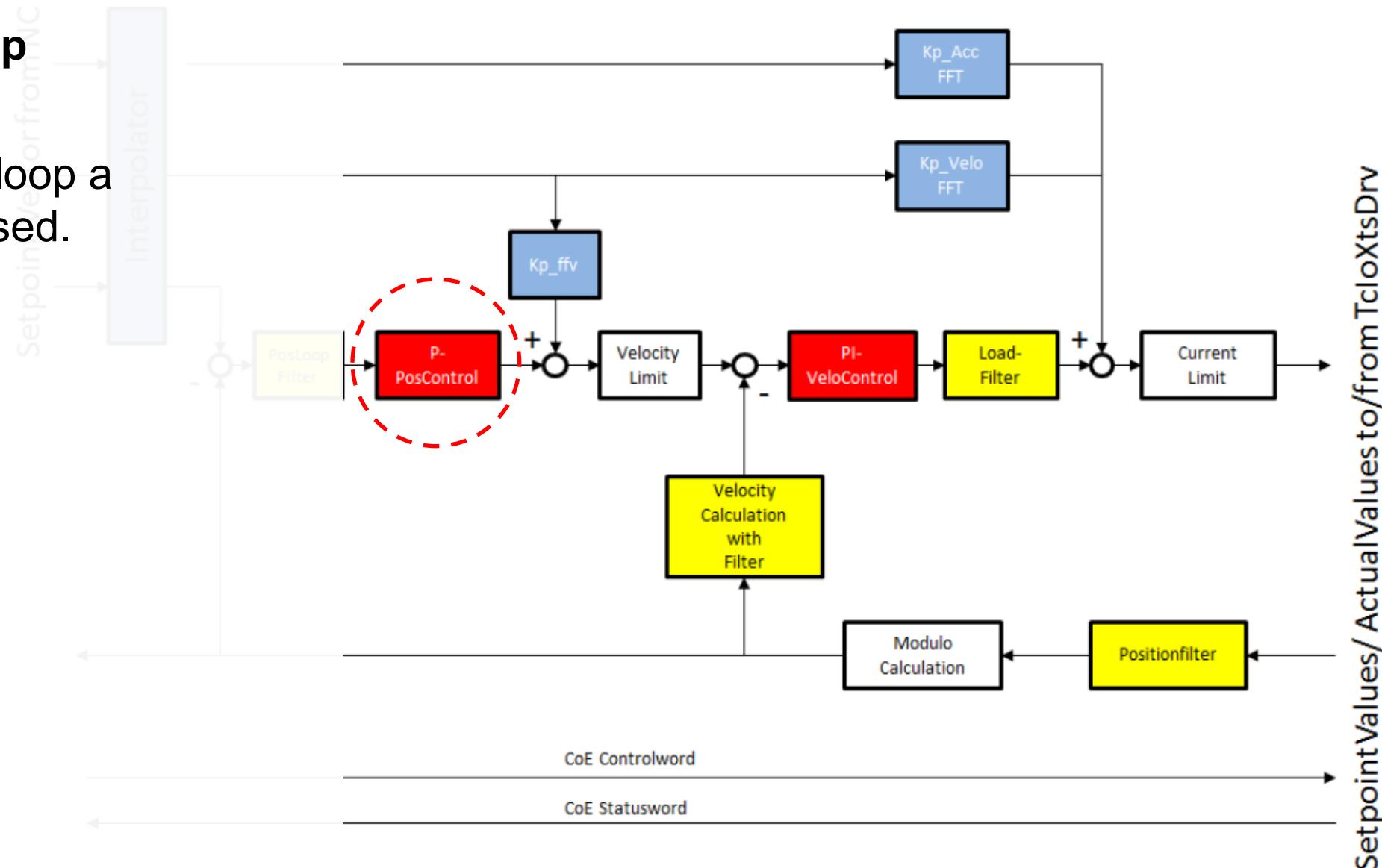
- Repeat procedure for the curve and use area parameters in case of differences in the straight and curve sections
- Avoid saturating the current output



Set Tn to reach 5 -10 % overshoot

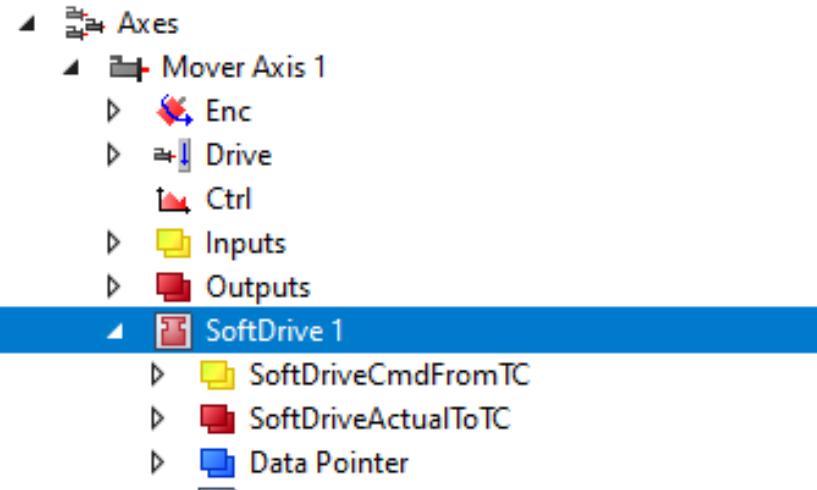
Position Control Loop

- For position control loop a “P” – Controller is used.
 - Setup Kp



Position Control Loop

- Set the SoftDrive “OperationMode” parameter in the main object to 8 (cyclic synchronous position mode)

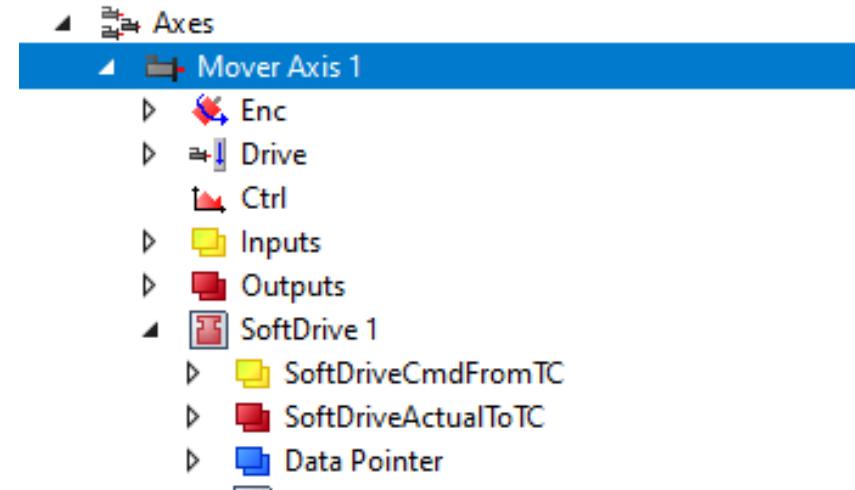


First_XTS_Project

Data Area		Interfaces		Interface Pointer		Data Pointer	
Object	Context	Parameter (Init)	Parameter (Online)	Parameter (Init)	Parameter (Online)	P	Co...
-	General						
	AdsPort	0x015e				W...	0.
	HardwareModulo	3000.0				LR...	0.
	OperationMode	8				UD...	0.
	MaxCurrentOutput	12.0				LR...	0.
	EmergencyRamp	10000.0				LR...	0.
	EmergencyTimeOut	0.5				LR...	0.
	StandstillSwitchTime	0.1				LR...	0.
	EmergencyStop	DIRECT_AT_SWI				S...	0.

Position Control Loop

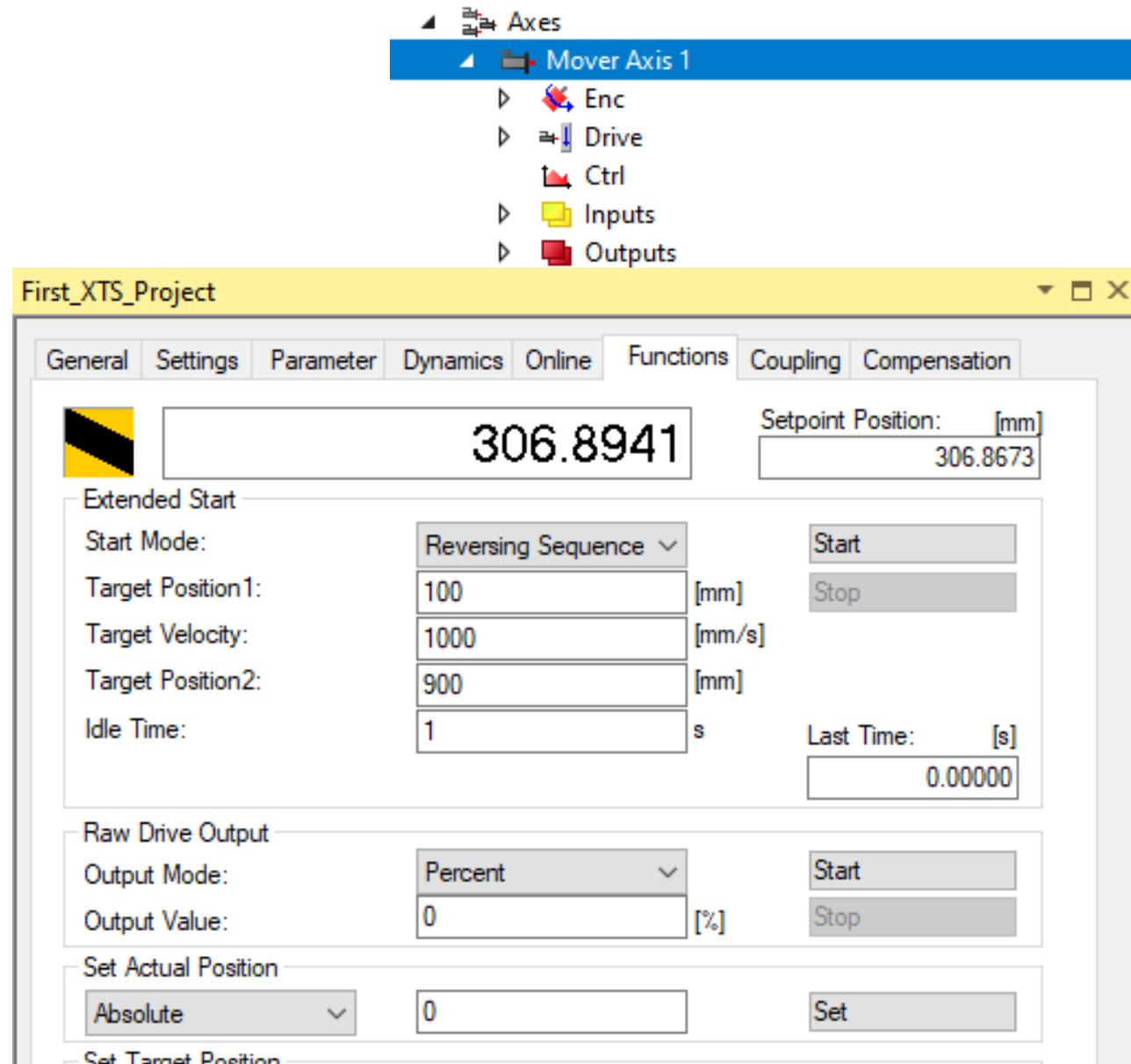
- Set the following error monitoring back to “normal” values



	Parameter	Offline Value	Online Value
+	Maximum Dynamics:		
+	Default Dynamics:		
+	Manual Motion and Homing:		
+	Fast Axis Stop:		
+	Limit Switches:		
-	Monitoring:		
	Position Lag Monitoring	TRUE	TRUE
	Maximum Position Lag Value	10.0	10.0
	Maximum Position Lag Filter Time	0.02	0.02

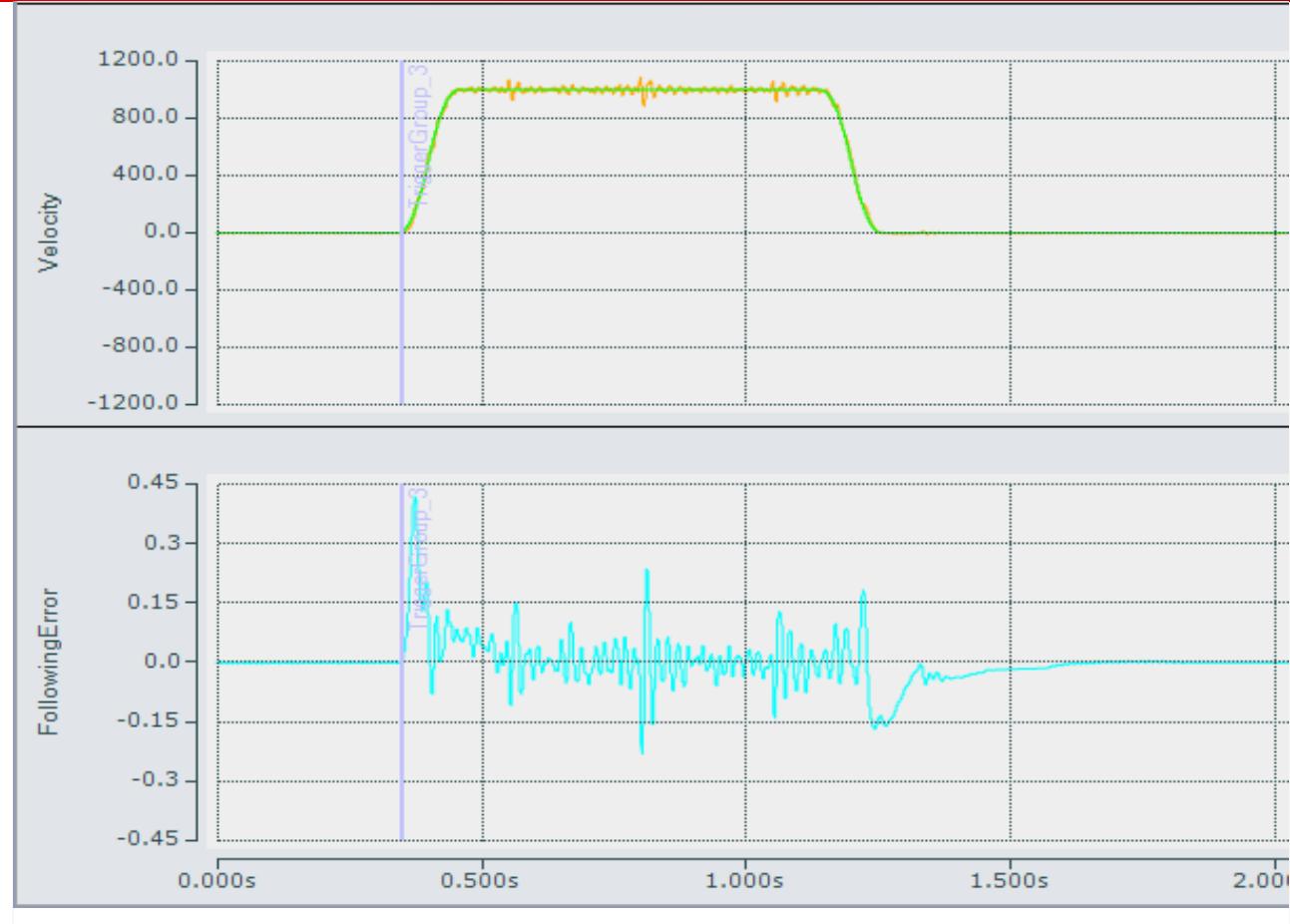
Position Control Loop

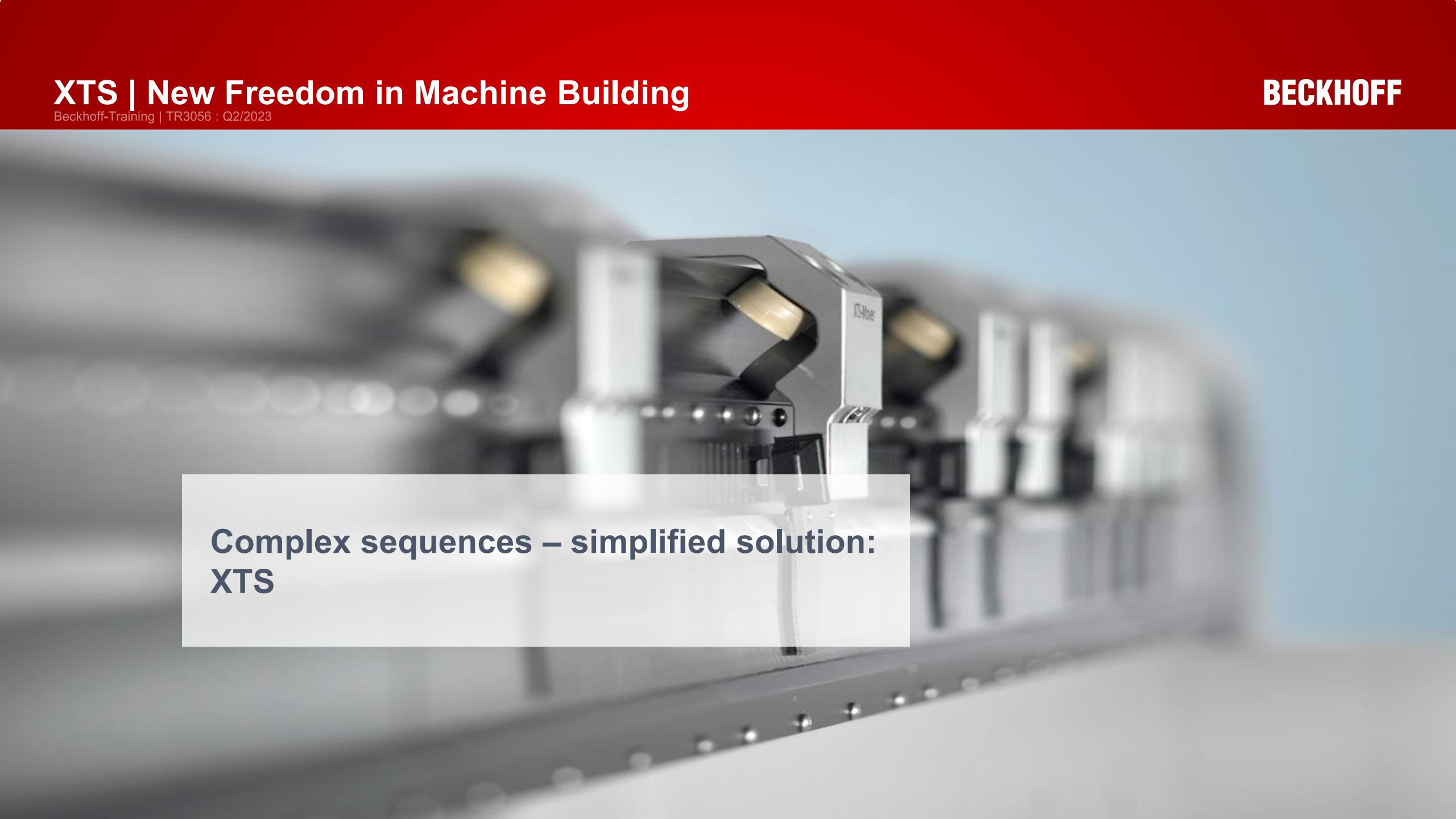
- Enable the NC axis and start the service mode “Reversing Sequence” with achievable (or necessary) values for velocity, acceleration and jerk
- Also scope the following error parameter of the SoftDrive



Position Control Loop

- Increase Kp of position loop to reduce following error as much as possible but stop before getting more noise or oscillation
- Set Kp_standstill parameter to the same value or maybe a bit less e.g. 75%
- Repeat procedure for the curve and use area parameter in case of differences in the straight and curve





Complex sequences – simplified solution:
XTS

This training material is provided to complement the presented training content. Outside the actual training the material may only be used for internal purposes at the company of the course participant. In addition, the material or extracts thereof may be used in end customer training for products containing Beckhoff products, or for presentations, provided the presentation refers to Beckhoff products. Extracts or copies of the training material must contain the following copyright acknowledgement: “© Beckhoff Automation GmbH & Co. KG”.

The same applies to extracts from presentation material. The user of the material is solely responsible for the completeness of extracts and copies. It is explicitly not permitted to offer commercial or free training for Beckhoff products. This applies to training with and or without the training material. The training material must not be edited, manipulated or modified.

Passing on of the aforementioned rights to third parties is not permitted.

Beckhoff Automation GmbH & Co. KG

Beckhoff Automation GmbH & Co. KG

Headquarters
Huelshorstweg 20
33415 Verl
Germany

Phone: +49 5246 963-0
E-mail: info@beckhoff.com
Web: www.beckhoff.com

© Beckhoff Automation GmbH & Co. KG 02/2021

All images are protected by copyright. The use and transfer to third parties is not permitted.

Beckhoff®, TwinCAT®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered trademarks of and licensed by Beckhoff Automation GmbH. Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

The information provided in this presentation contains merely general descriptions or characteristics of performance which in case of actual application do not always apply as described or which may change as a result of further development of the products. An obligation to provide the respective characteristics shall only exist if expressively agreed in the terms of contract.