New Automation Technology
Beckhoff Automation

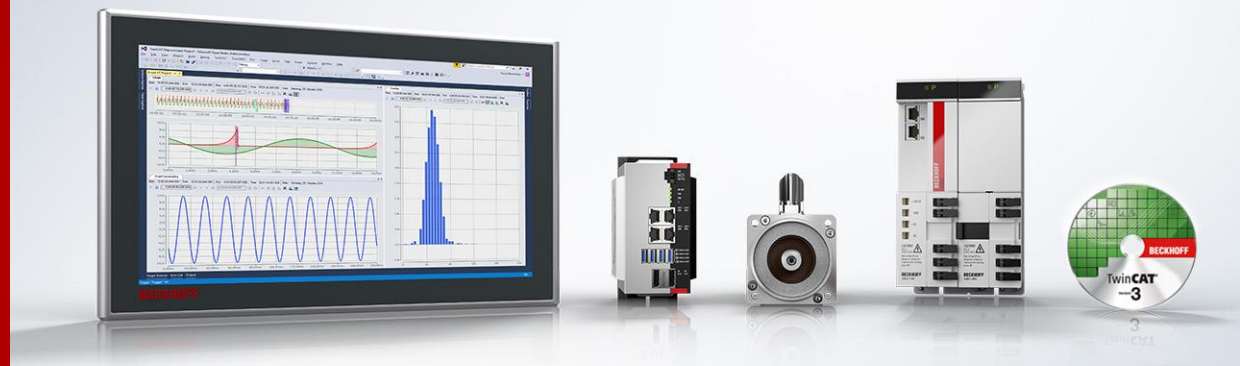
BECKHOFF

XTS Training

BECKHOFF

BECKHOFF

XTS – TcSoftDrive



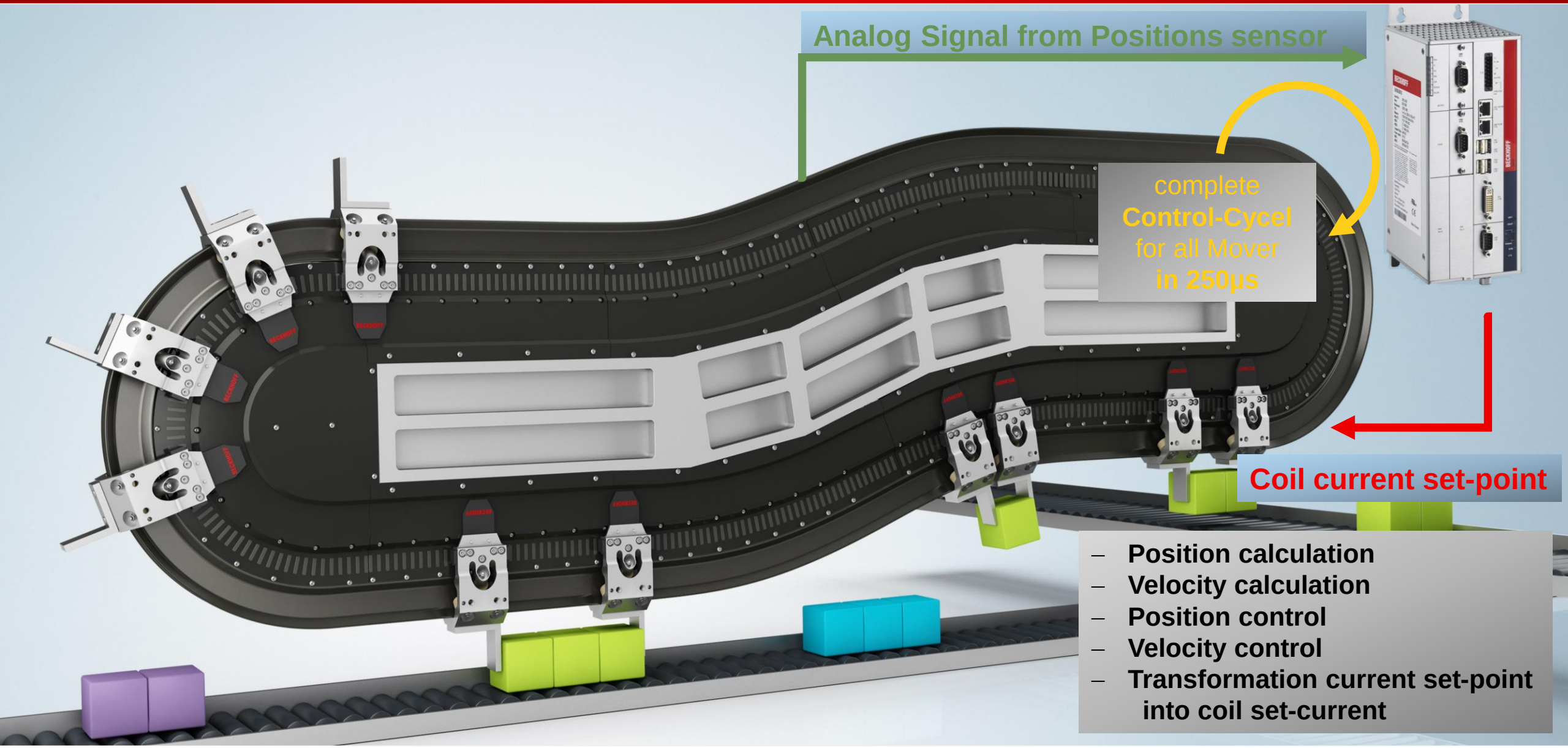
Agenda | XTS- TcSoftDrive

BECKHOFF

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

XTS – Overview and timing

BECKHOFF



XTS – EtherCAT timing and data size

BECKHOFF

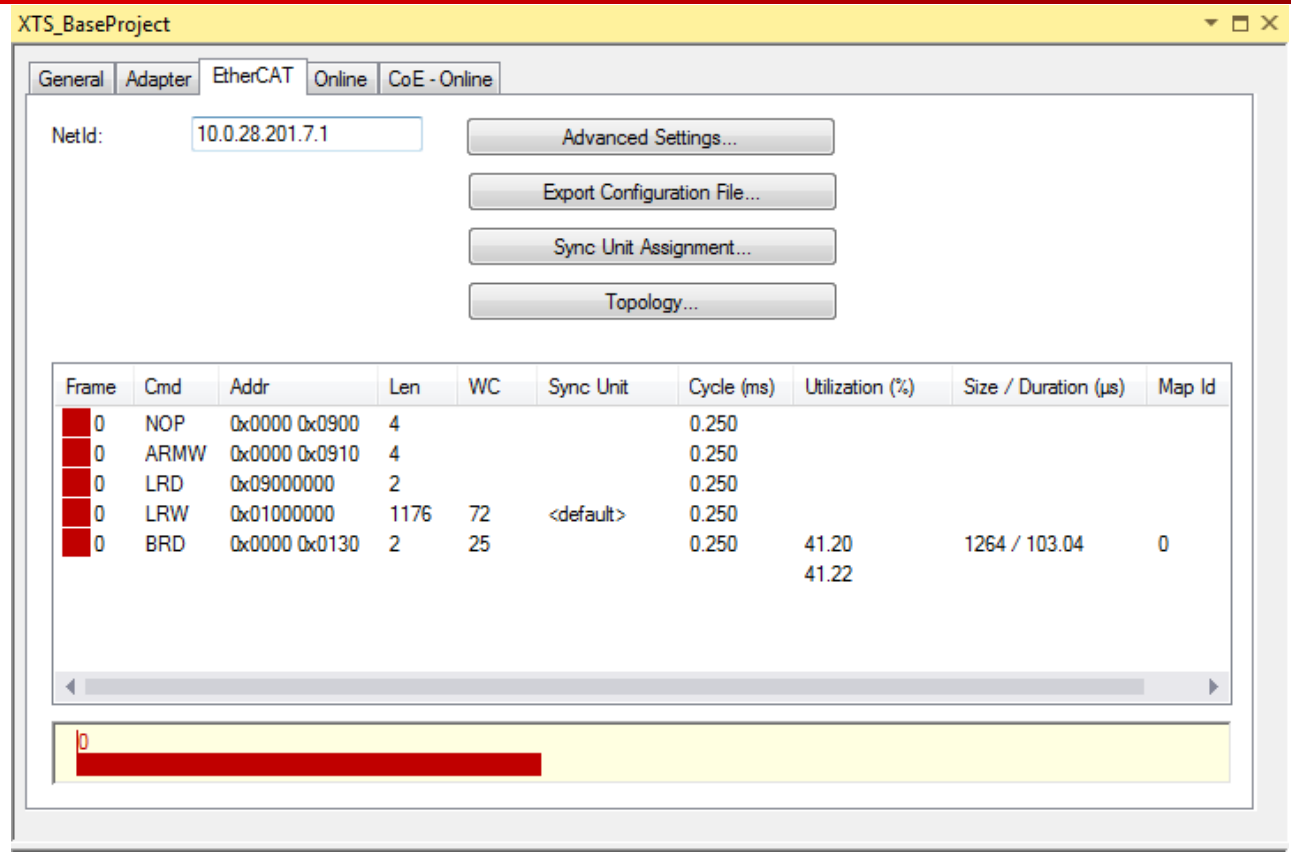
each Motor module has

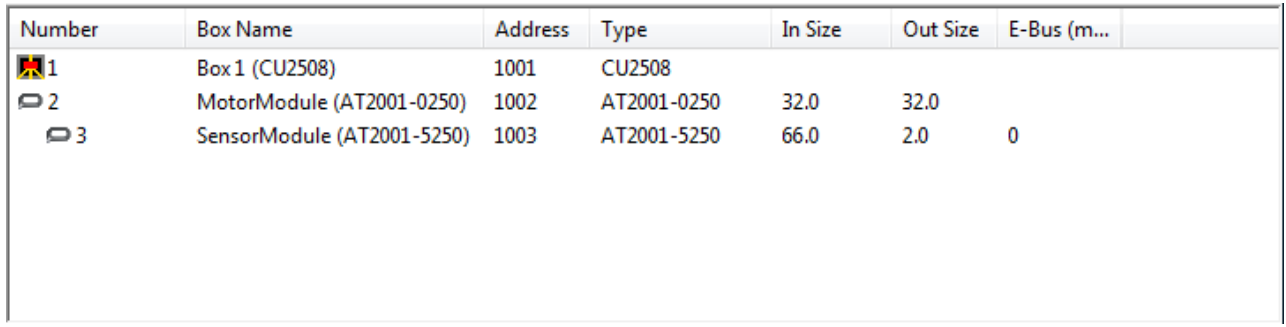
- 15 Coils → 15 current set-values
  → 15 current act-values
- 2 Byte Status & 2 Byte Control
  → 32 Byte Process Image

each Sensor Module has

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

EtherCAT data size **<u>98 Byte</u>**





XTS – EtherCAT timing and datasize

BECKHOFF

per Frame max. data size of 1500 Byte

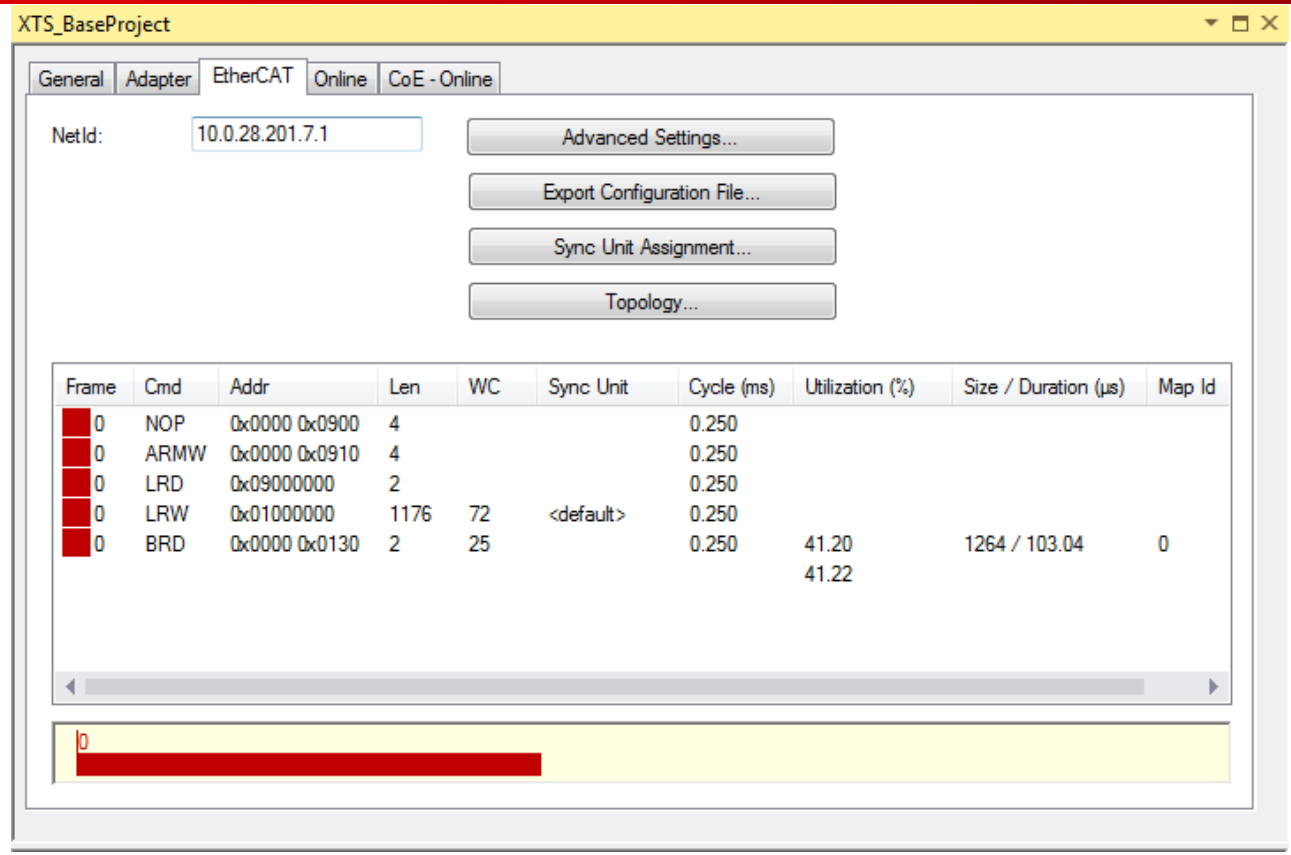
per Module (Motor & Sensor)
data size of 98 Byte

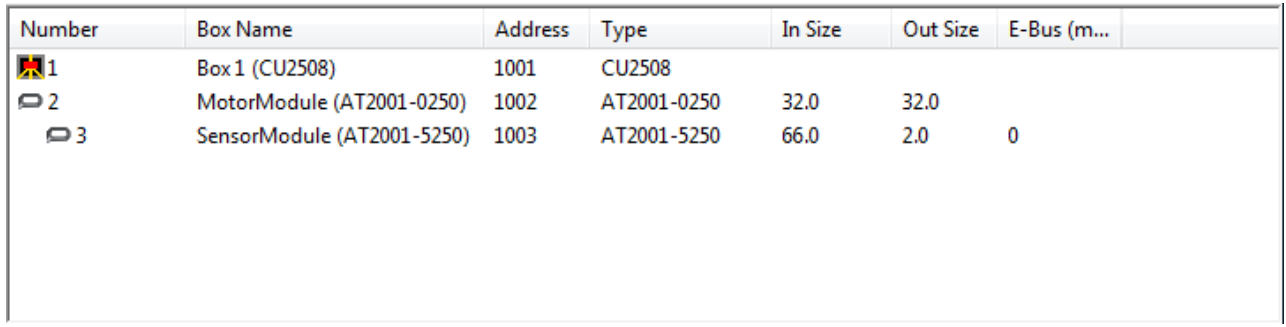
3m XTS-Track → 12 Modules

12 x 98 Byte = **1176 Byte Data**

Full Frame size = **1264 Byte Data**

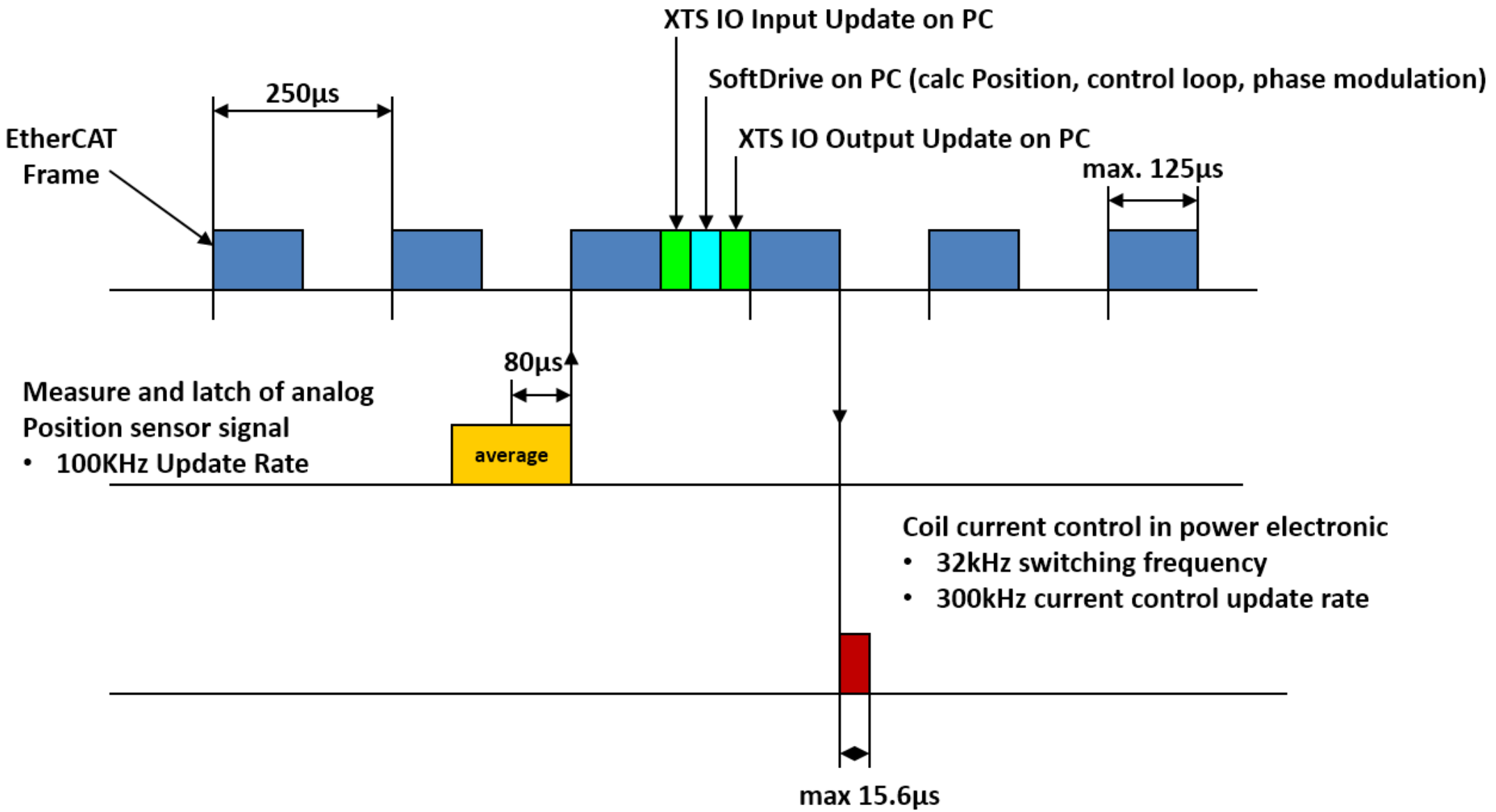
Frame runtime = **103 µs**





XTS – Basic Timing

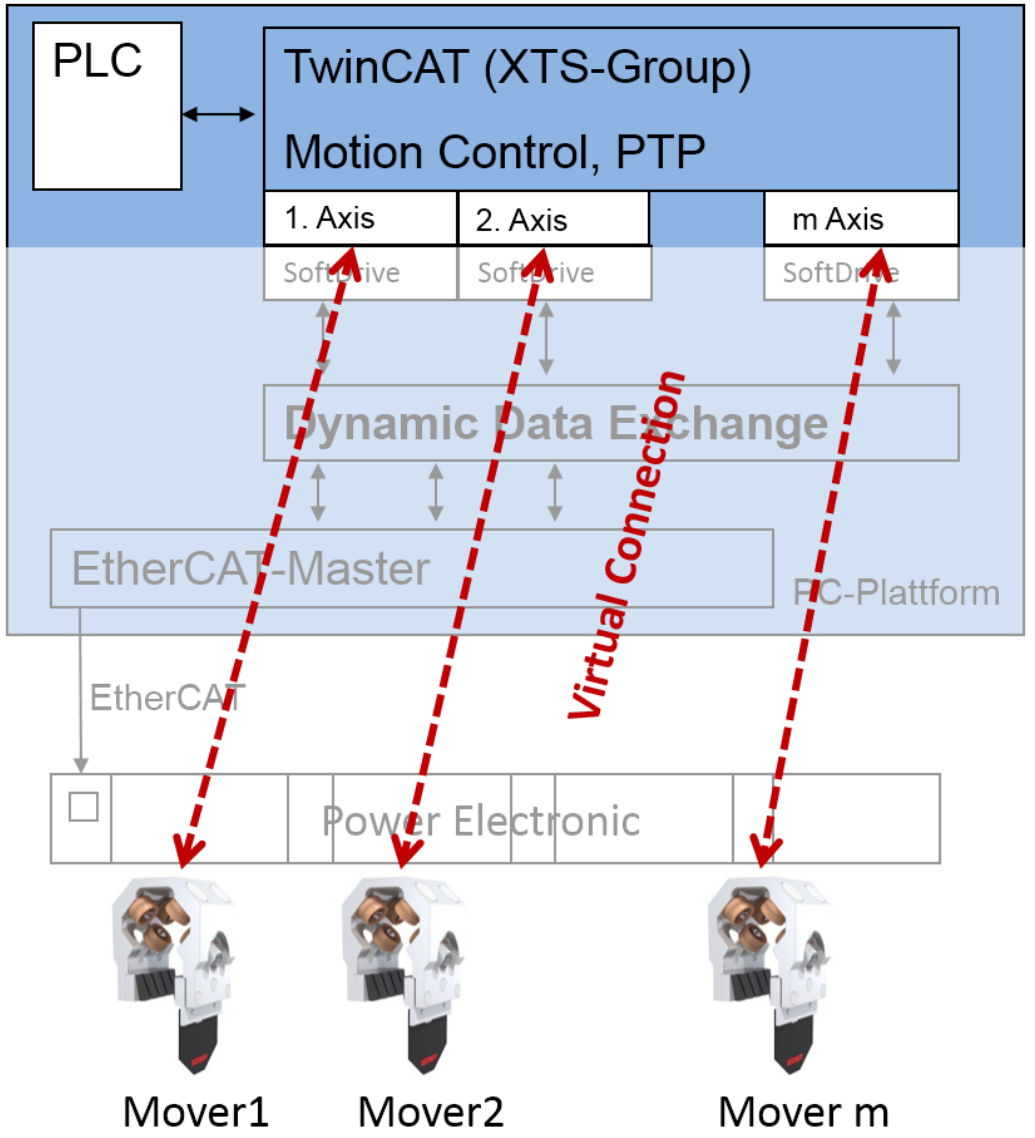
BECKHOFF



XTS – TwinCAT integration

BECKHOFF

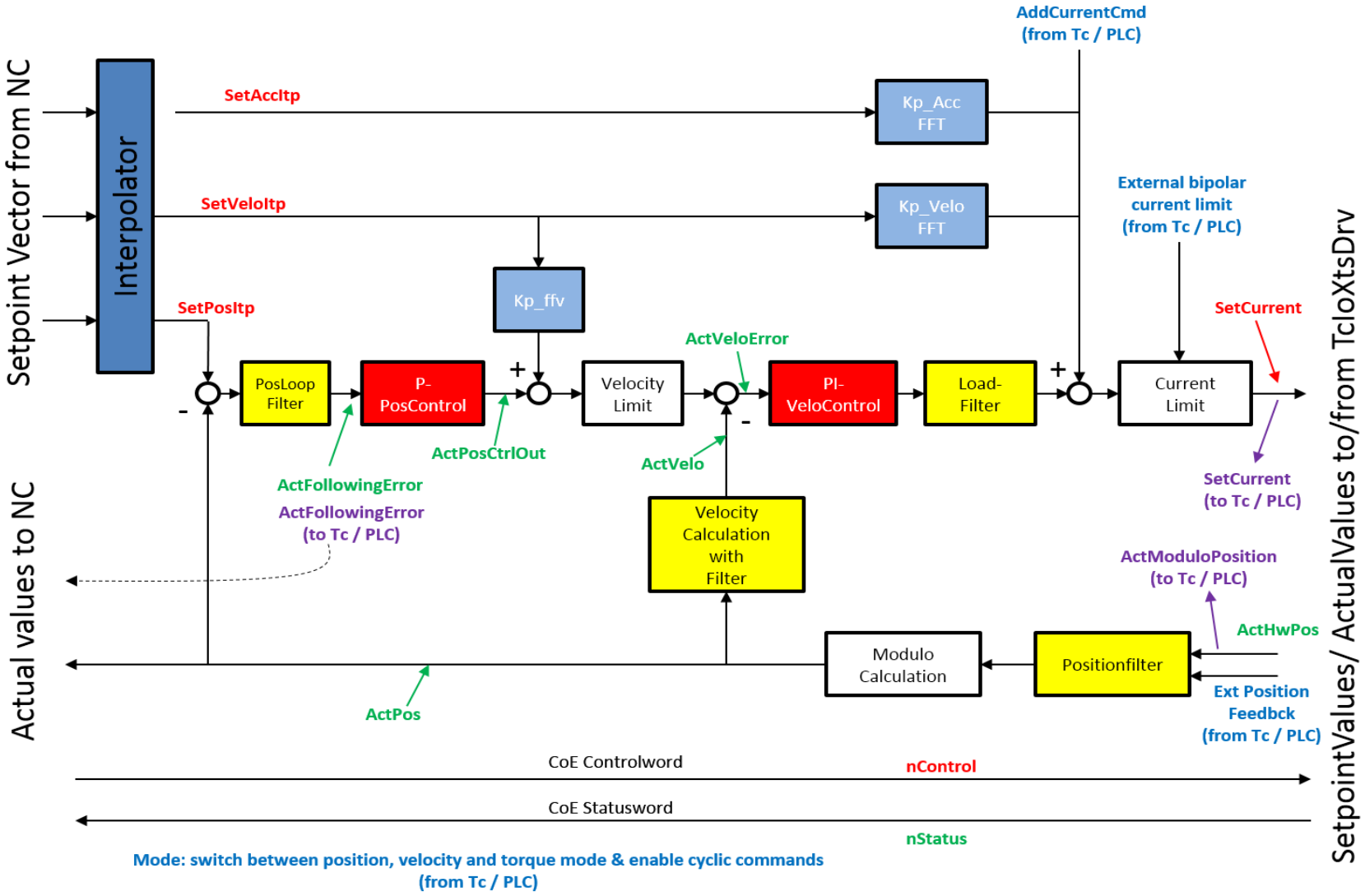
- From the point of view of application programming, a mover looks like a „standard“ servo NC axis.
- New standard tasks are available:
  - Collision avoidance CA
  - Group building
  - Synchronous mechanisms
- Runs on powerful Beckhoff Standard IPCs with EtherCAT-Port
- Simulation mode is possible for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



XTS – TcSoftDrive control loop structure

BECKHOFF

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



Agenda | XTS- TcSoftDrive

BECKHOFF

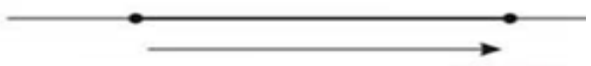
1. Short XTS basics
2. **XTS Accuracy**
3. XTS IPC & capabilities
4. Scope for
   Mover monitoring
5. TcSoftdrive
   structure & parameter
6. Tuning

XTS - Definition of Accuracy

BECKHOFF

Start Position Target Position

Ideal Positioning



High Accuracy
High Repeatability

Low Accuracy
High Repeatability

→ **Low accuracy with high repeatability can be compensated.**

Low Accuracy
Low Repeatability

→ **Low repeatability cannot be compensated**

XTS - Position Accuracy (Sensor Rev. 18)

BECKHOFF

XTS Datasheet	
Absolute Position Accuracy	± 250µm (within one straight Module) *
Tested but not specified Accuracy	
Achievable Position Accuracy	± 150µm (within one straight Module) **

* Typical achievable absolute accuracy, this can become larger due to thermal expansion of the module ($\Delta\vartheta \geq 30°C$) or Parallelism of the flag to the encoder module and the orthogonality of the Encoder Flag to the Motor Module.
** typically achievable accuracy in a straight module between 15 - 235mm (Encoder flag completely in a single module) a parallel and orthogonal Encoder flag and a thermal expansion of while in operation ($\Delta\vartheta \leq 15°C$)

XTS Datasheet	
Position accuracy while at speed	± 150µm @ 1.5m/s (in a straight module) *
Tested but not specified Accuracy	
Position accuracy while at speed in the curve	± 400µm @ 1m/s (in a 180° Curve Module) **

* the synchronization accuracy is very dependent on the mechanical stiffness and the load on the mover and the controller settings. The mechanical displacement between the modules also plays an important role
** the deviation in the curve can be much, much worse if the center of gravity is not directly between the magnets of the mover

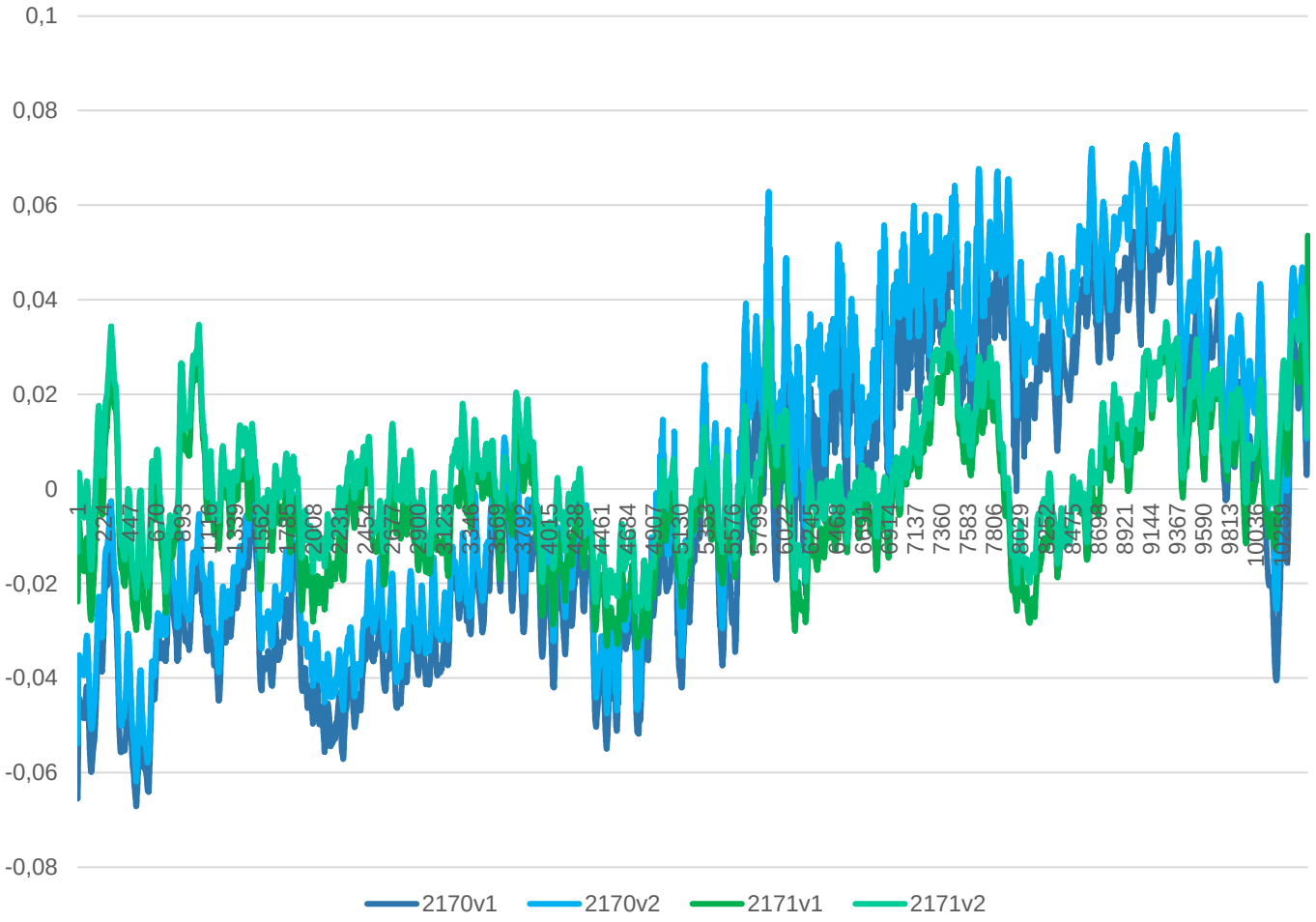
XTS Datasheet	
Stand Still Repeatablity	± 10µm (unidirectional) *

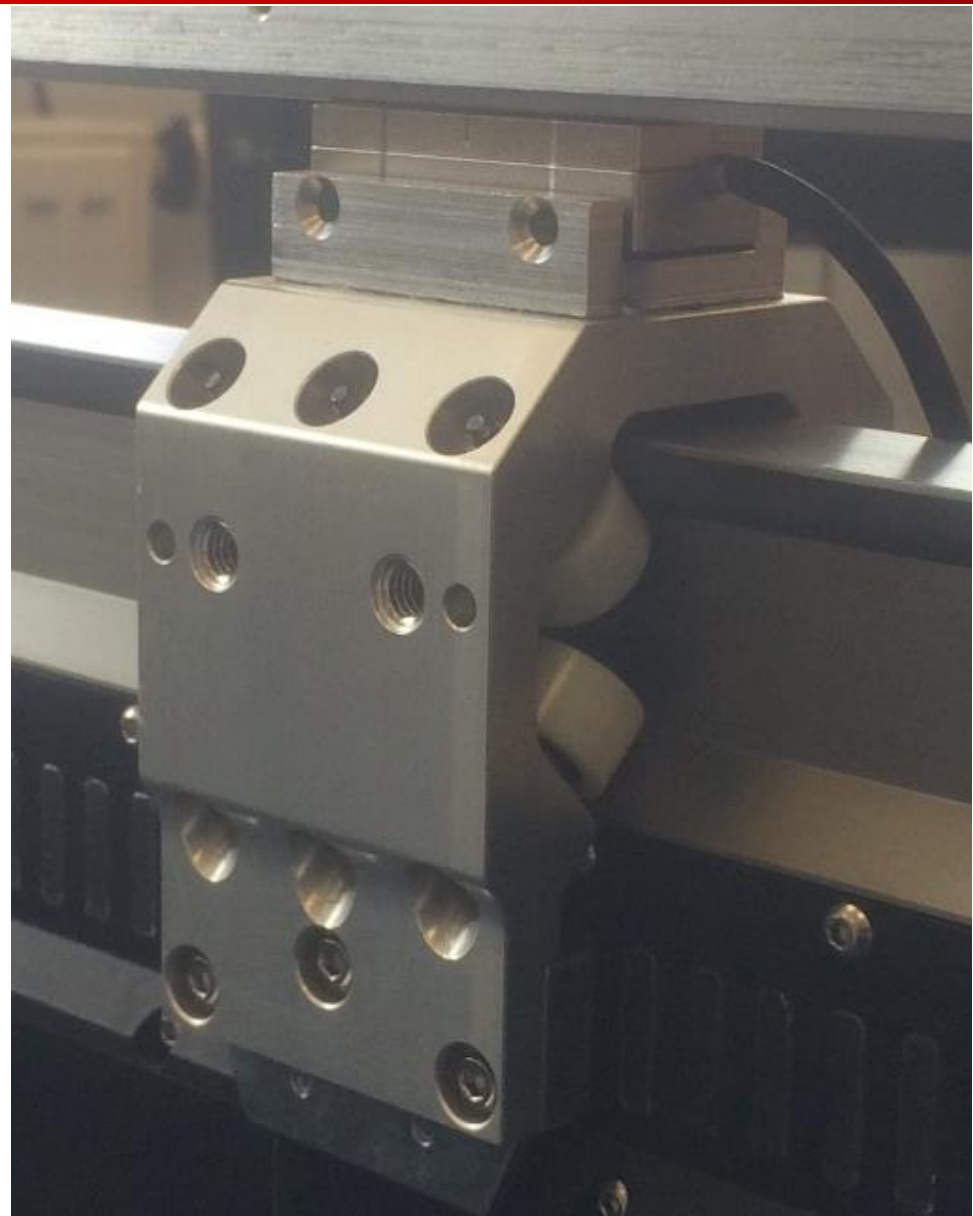
* repeatability for the encoder flag the stand still repeatability may fail due to the defects in the rail system or a Roller developing a flat spot or bearing failure or thermal extension

XTS - Position Accuracy measurements

BECKHOFF

Absolute Position Accuracy measured
against an very precise optical encoder



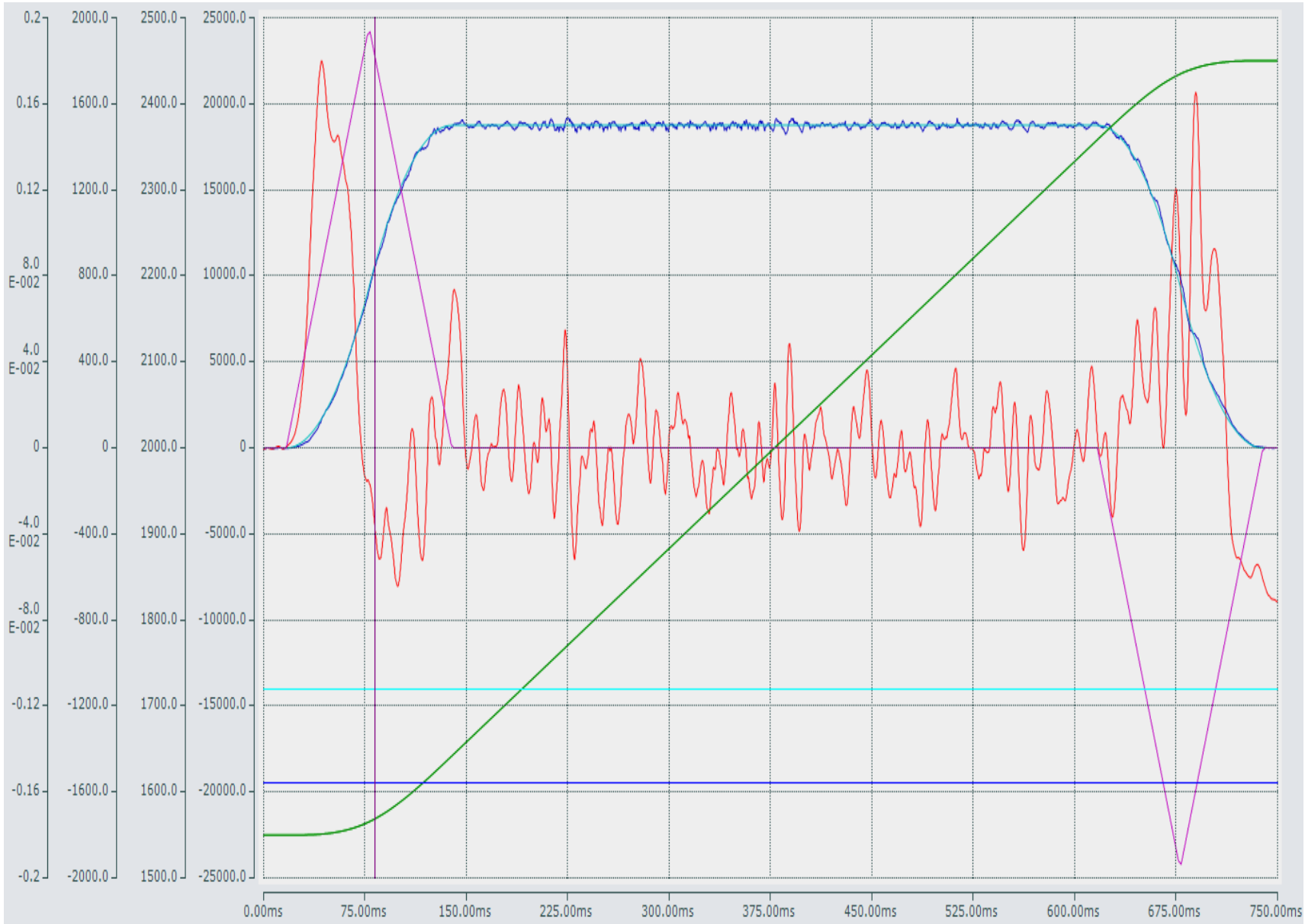


XTS - Position Accuracy while moving

BECKHOFF

Measurement in
the straight section
at 1.5m/s
with a tuned 12 Roller mover
and no load

→Position deviation
in Lag Distance
is less than ± 60µm



XTS - Increasing Accuracy best Practices

BECKHOFF

Possible solutions if the accuraccy is not sufficient	
Absolute accuracy of all Movers	- Adapt the target position of the commands from the PLC based on previously measured and stored values. - Mechanically position the tooling at the processing station, e.g. a pin to center the tooling. - Use an External encoder feedback such as a laser distance sensor or a highly accurate quick Vision System - a balance during positioning would thereby therefore Possible
Absolute Accuracy between movers	- Position offset in the NC. Each mover must be teached and a unique identification required - External encoder or a laser distance sensor or a highly accurate quick Vision System - a correction during positioning would thereby also possible
Positional accuracy over several modules / synchronization accuracy	- Setting a position offset in TcIoXts drivers per module (very time consuming) - Sometimes AREA control parameters in TcSoftDrive can be adjusted to ensure a smoother ride - Sometimes an additional counter-weight mass on the Mover can help bring the center of gravity to the middle of the magnets, thus improving the synchronous accuracy and travel through the curve

Agenda | XTS-TcIoXts

BECKHOFF

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

XTS IPC & capabilities

BECKHOFF

Performance class

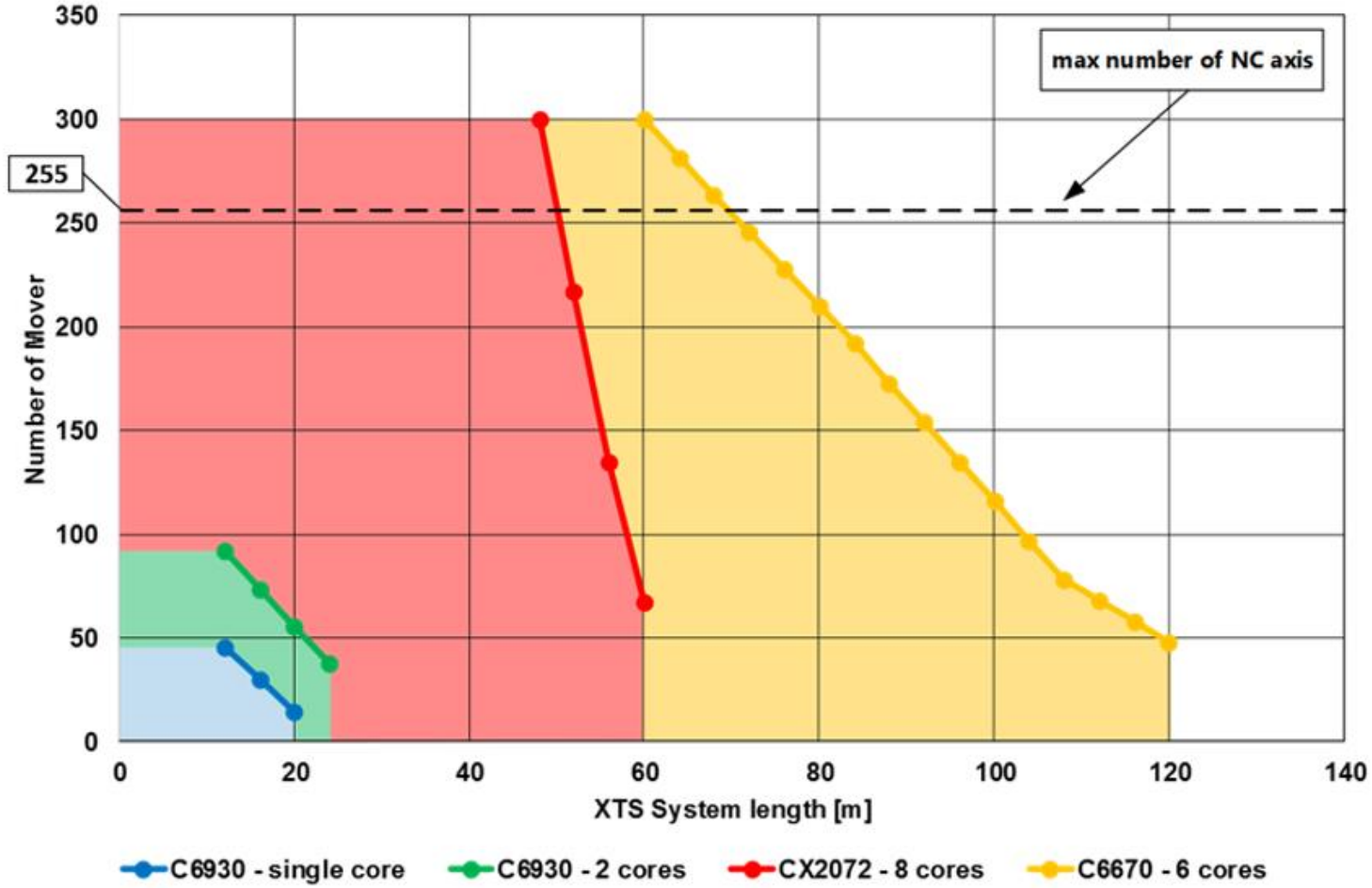
C6670-0000
6 cores for XTS

NEU

CX2072-0155
8 cores for XTS

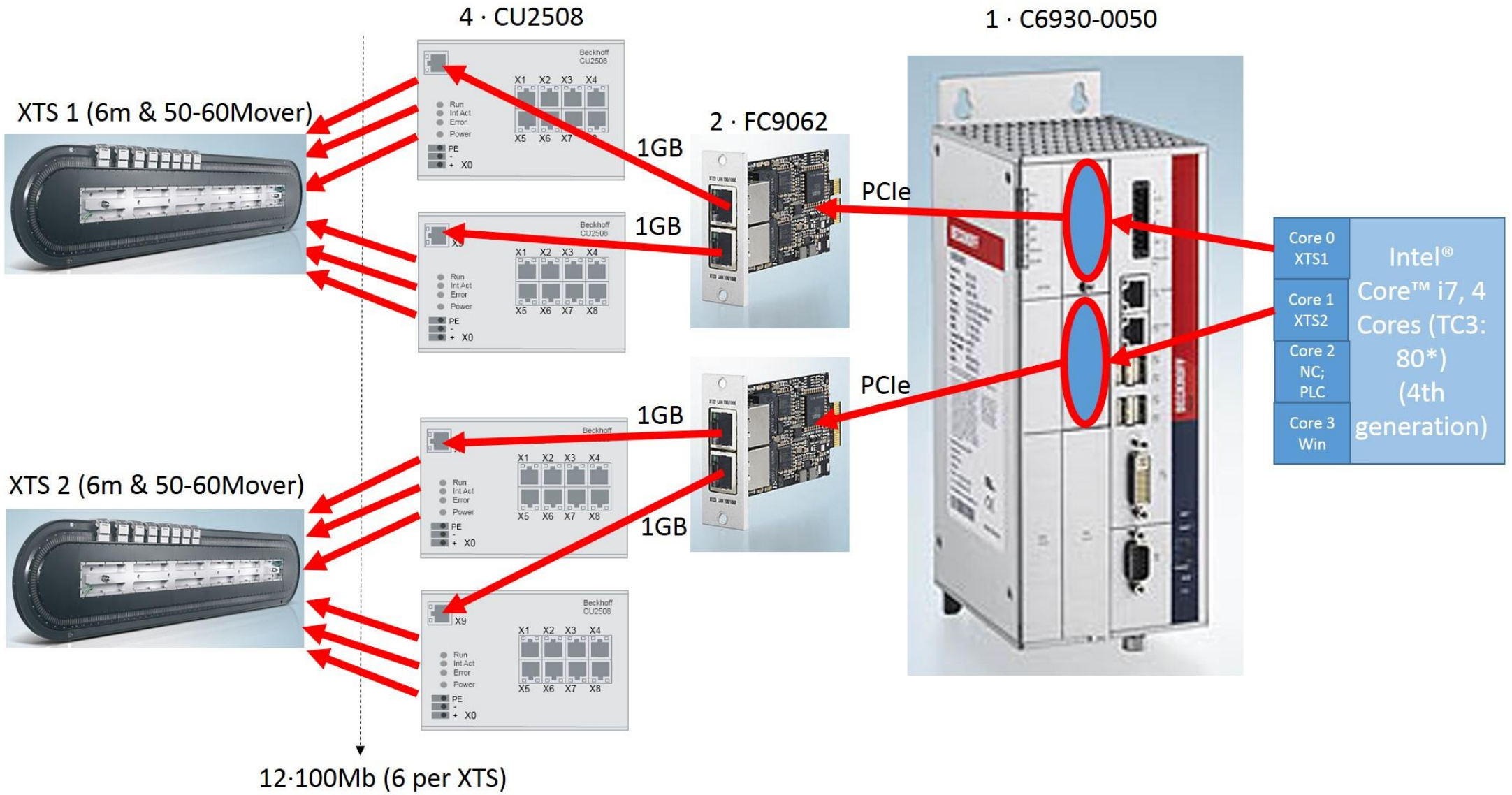
C6930-1106-0050
2 cores for XTS

C6930-1106-0050
single core for XTS



XTS – IPC C6930 Core™ i7 application examples

BECKHOFF



XTS – Capabilities coming soon

BECKHOFF

- Maximum circumference of 18 m
- Maximum 80 movers on a track

Restrictions are purely due to data gathering and processing requirements

The mover count and circumference will continue to increase in coming years

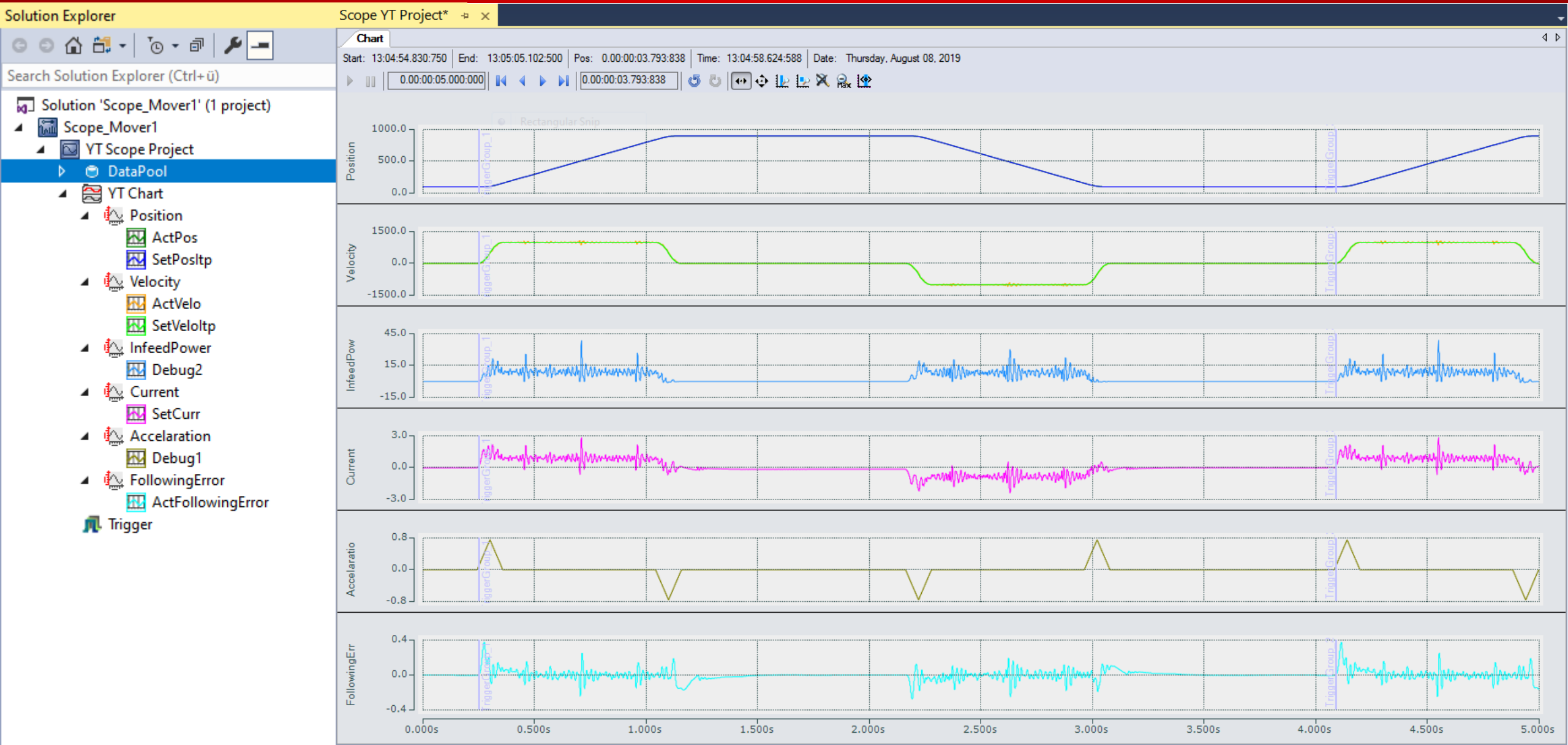
Agenda | XTS- TcSoftDrive

BECKHOFF

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

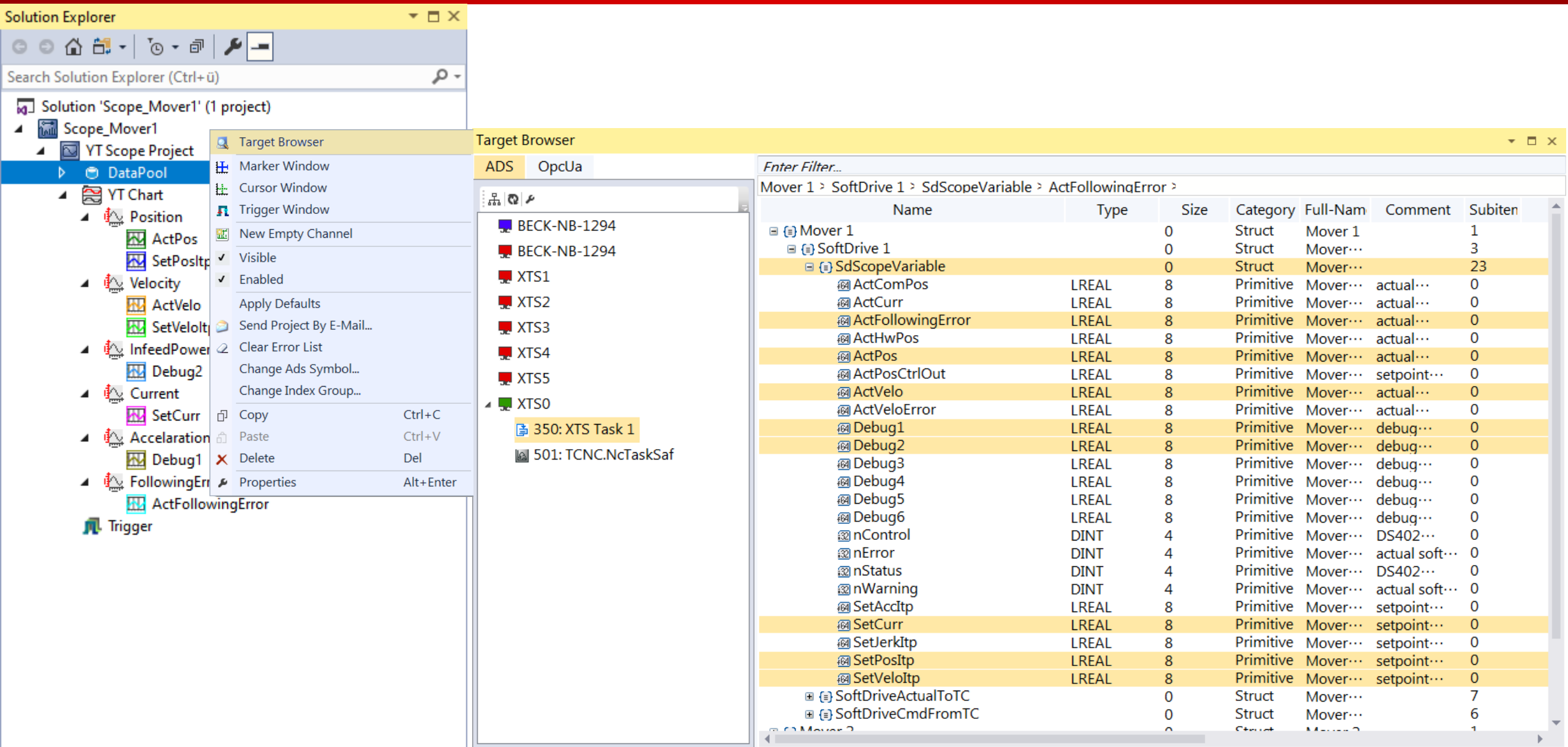
XTS TcSoftDrive – Scope for Mover monitoring

BECKHOFF



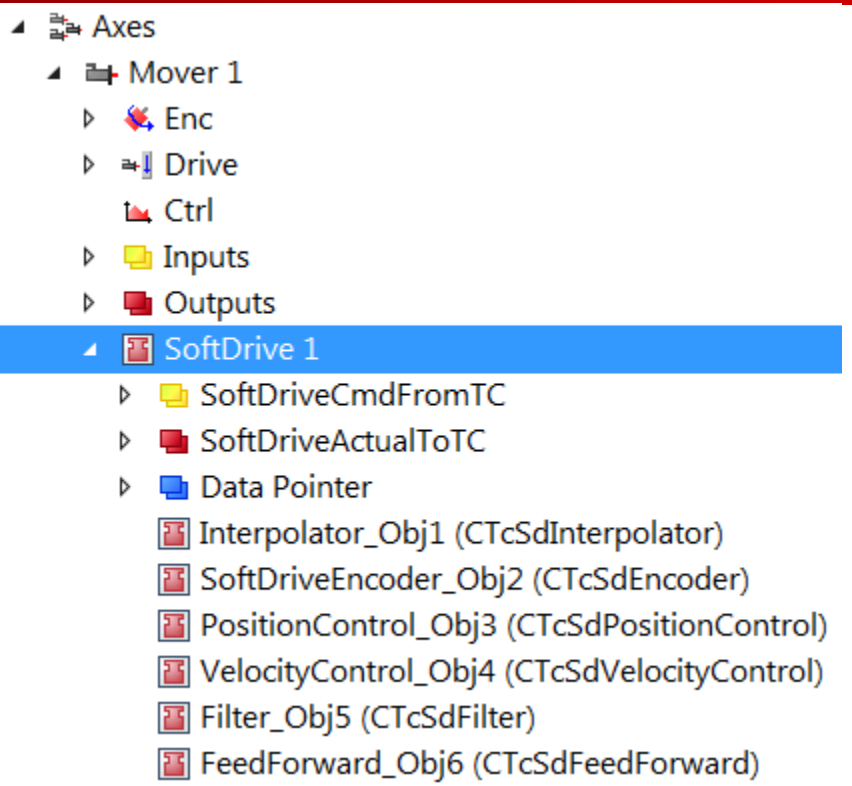
XTS TcSoftDrive – Signal selection for monitoring

BECKHOFF



XTS TcSoftDrive – Setup Motor-Parameter for monitoring

BECKHOFF



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

set “Show Hidden Parameter” first

XTS

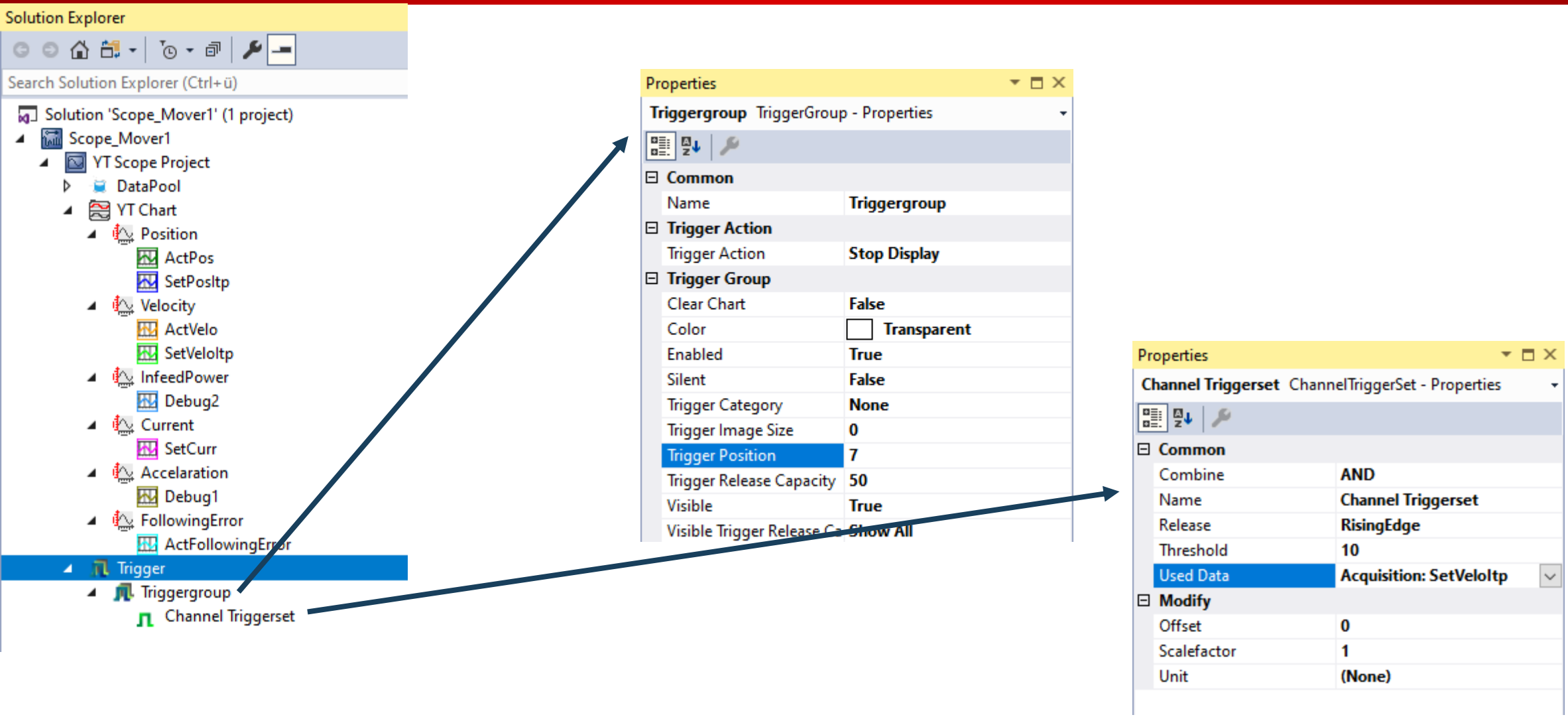
Object | Context | Parameter (Init) | Parameter (Online) | Data Area | Interfaces | Interface Pointer | Data Pointer

	Name	Value	Online	CS	Unit	Type
	AdsPort	0x015e	0x015e			WORD
	TraceLevelMax	tlAlways	tlAlways			TcTraceLevel
	HardwareModulo	3000.0	3000.0		mm	LREAL
	OperationMode	8	8			UDINT
	MaxCurrentOutput	12.0	12.0		A	LREAL
	EmergencyRamp	10000.0	10000.0		mm/s^2	LREAL
	EmergencyTimeOut	0.5	0.5		s	LREAL
	StandstillSwitchTime	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
	.ElThermalTimeCon...	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 | Expand All | Collapse All

XTS TcSoftDrive – Trigger settings for monitoring

BECKHOFF



XTS TcSoftDrive – Power monitoring example

BECKHOFF

Position [mm]

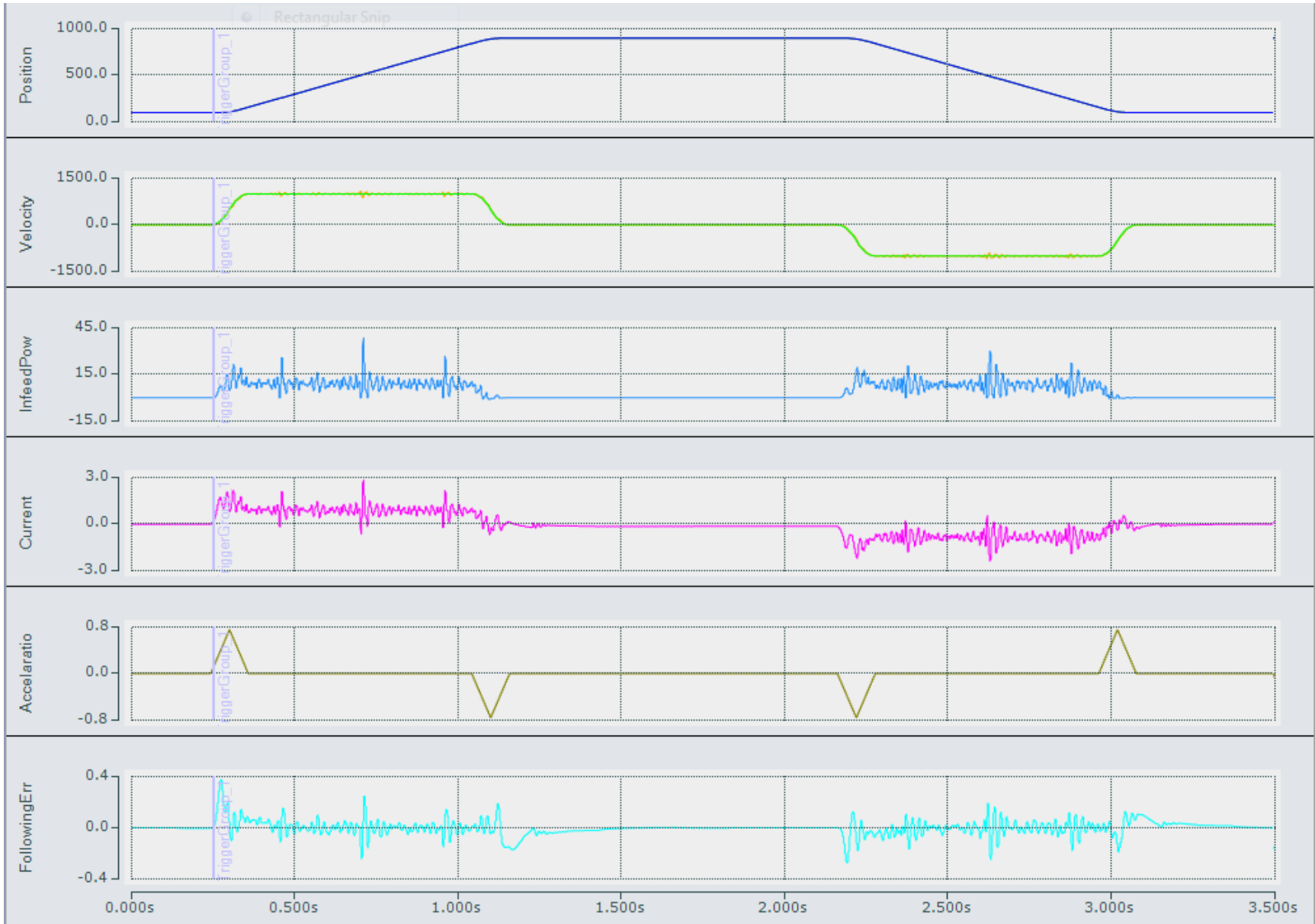
Velocity [mm/s]

Infeed Power [W]

Mover Current [A]
(this is different to the infeed current on the 48V DC!!!)

Acceleration [mm/s²]

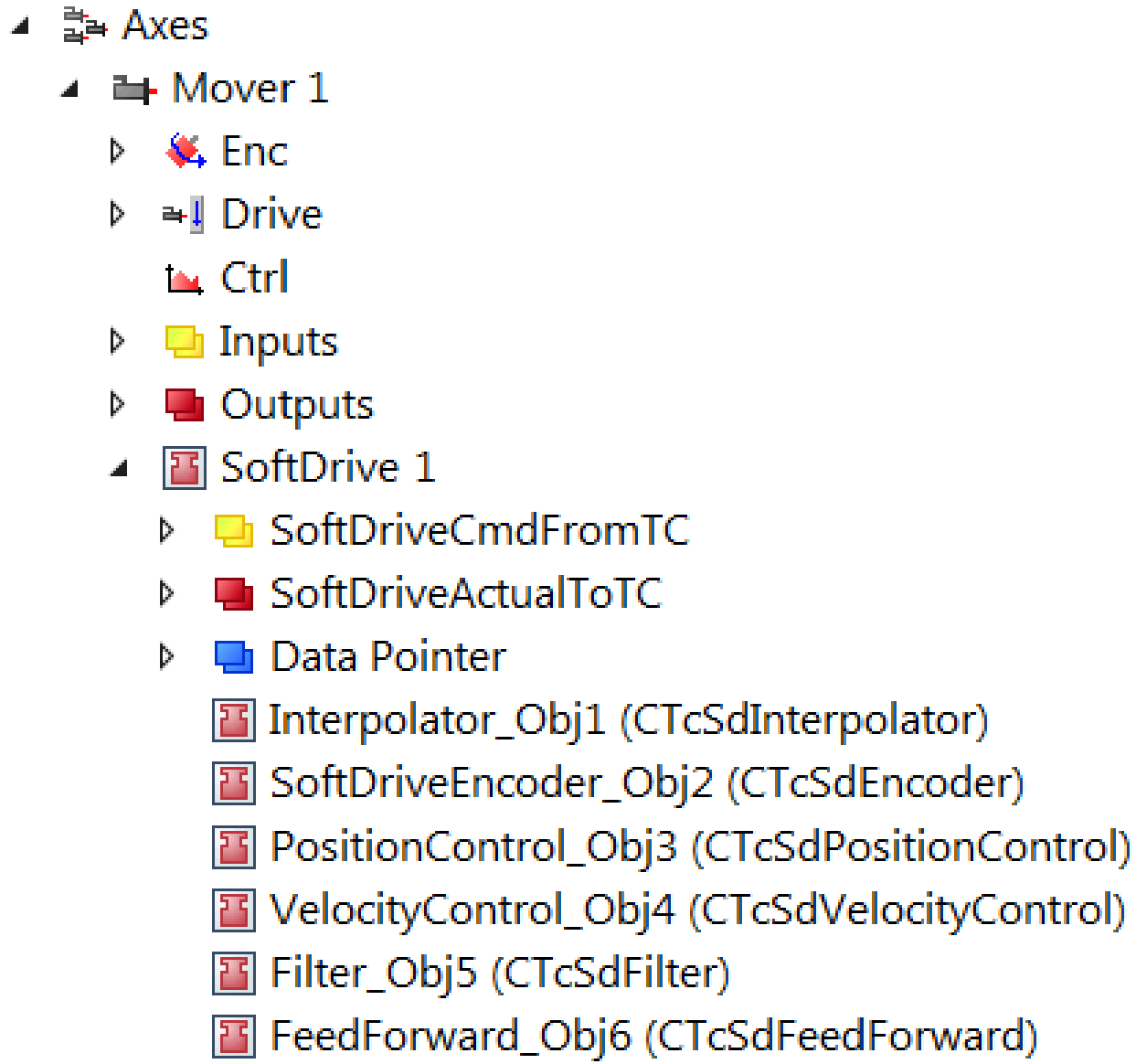
FollowingError [mm]



Agenda | XTS- TcSoftDrive

BECKHOFF

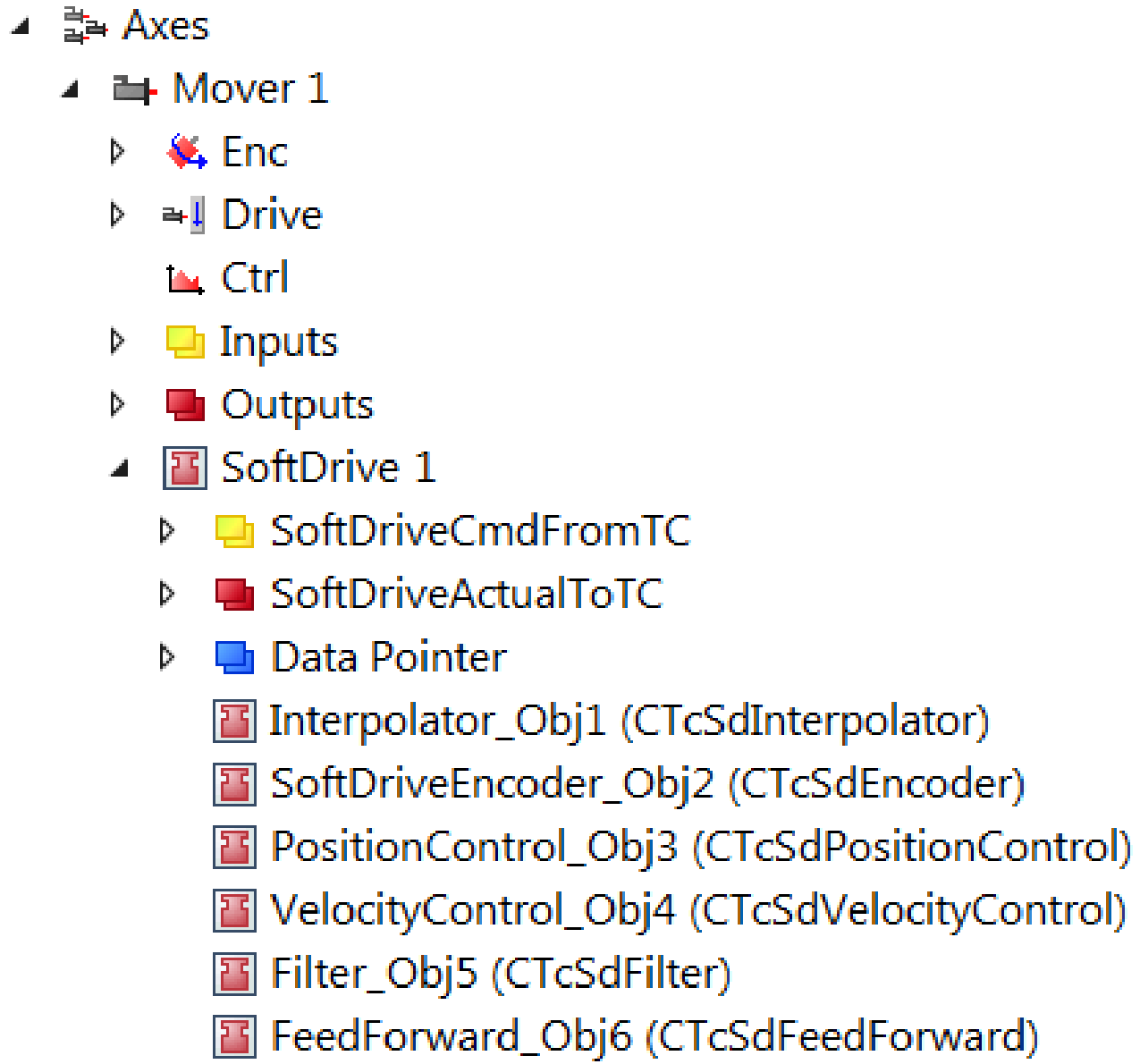
1. Short XTS basics
2. XTS Accuracy
3. XTS IPC & capabilities
4. Scope for Mover monitoring
5. **TcSoftdrive structure & parameter**
6. Tuning


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)

XTS TcSoftDrive - parameter structure

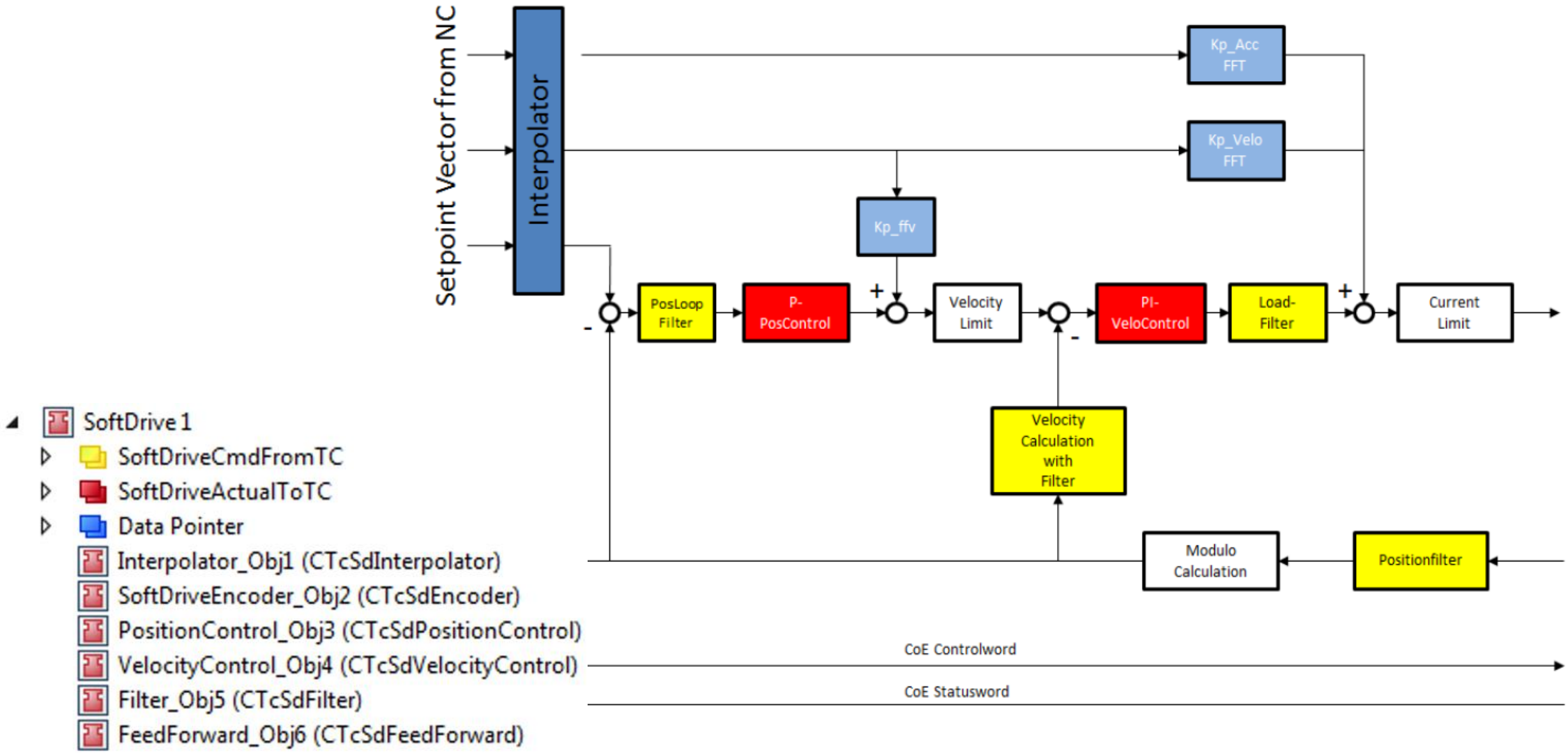
BECKHOFF

- 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



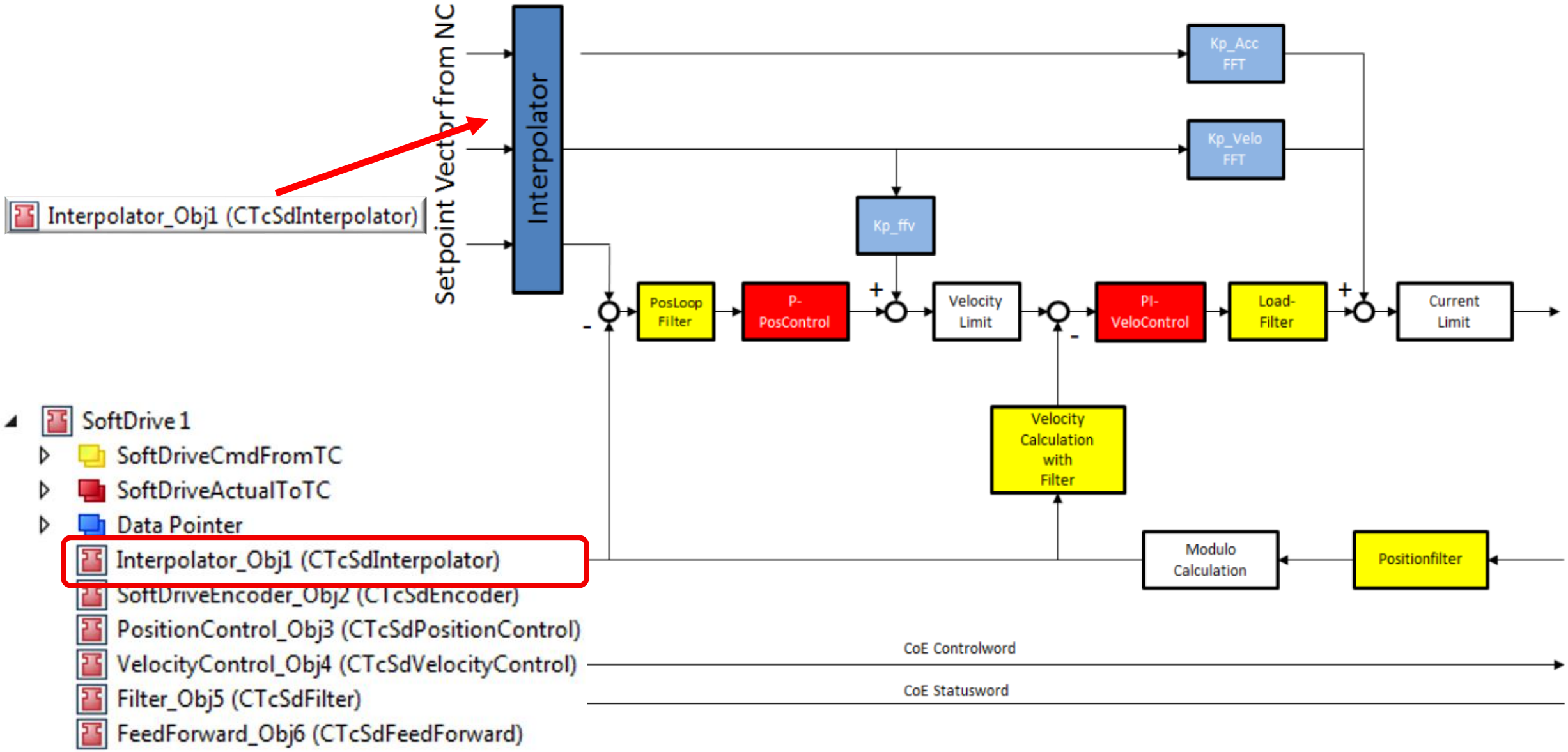
XTS TcSoftDrive - parameter structure

BECKHOFF



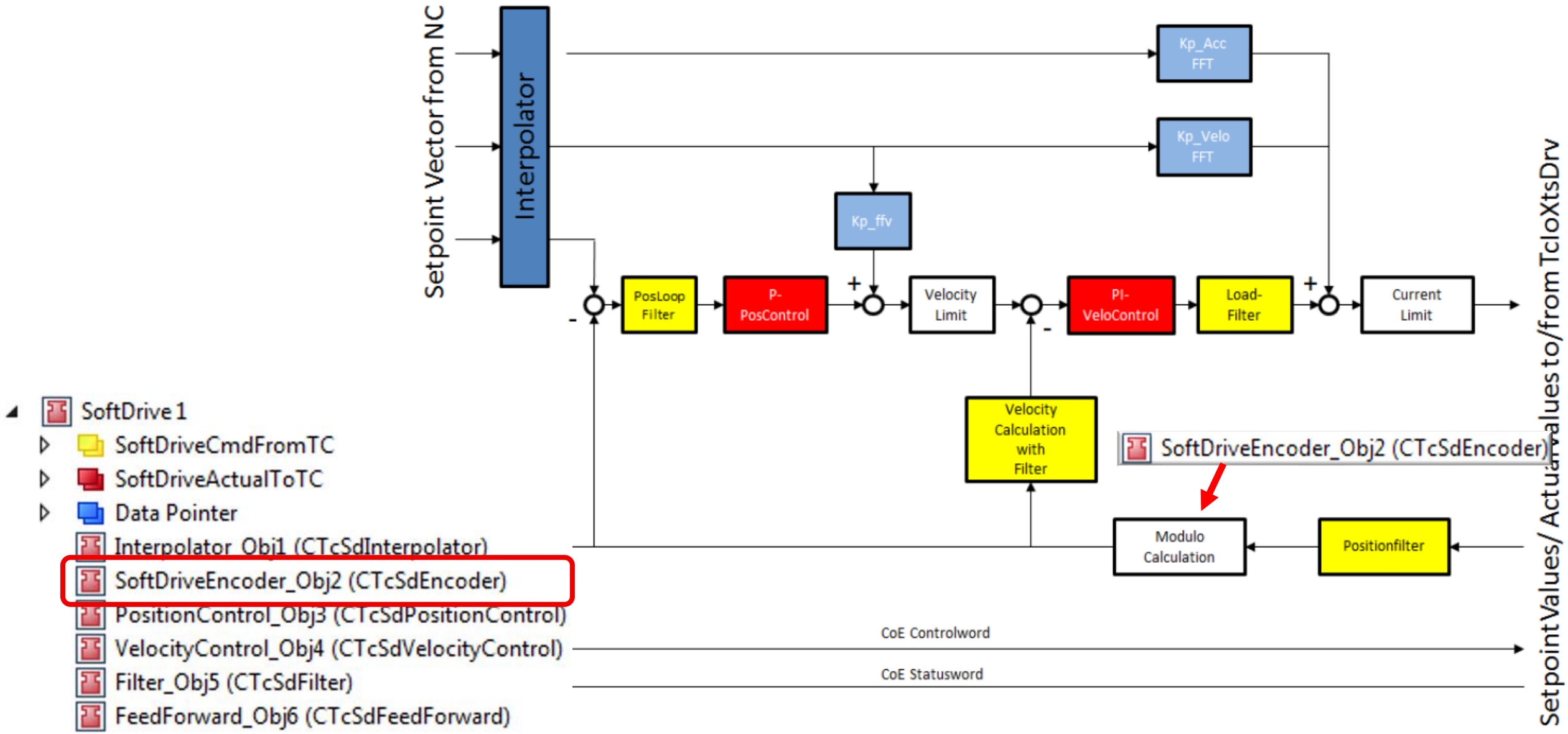
XTS TcSoftDrive - parameter structure

BECKHOFF



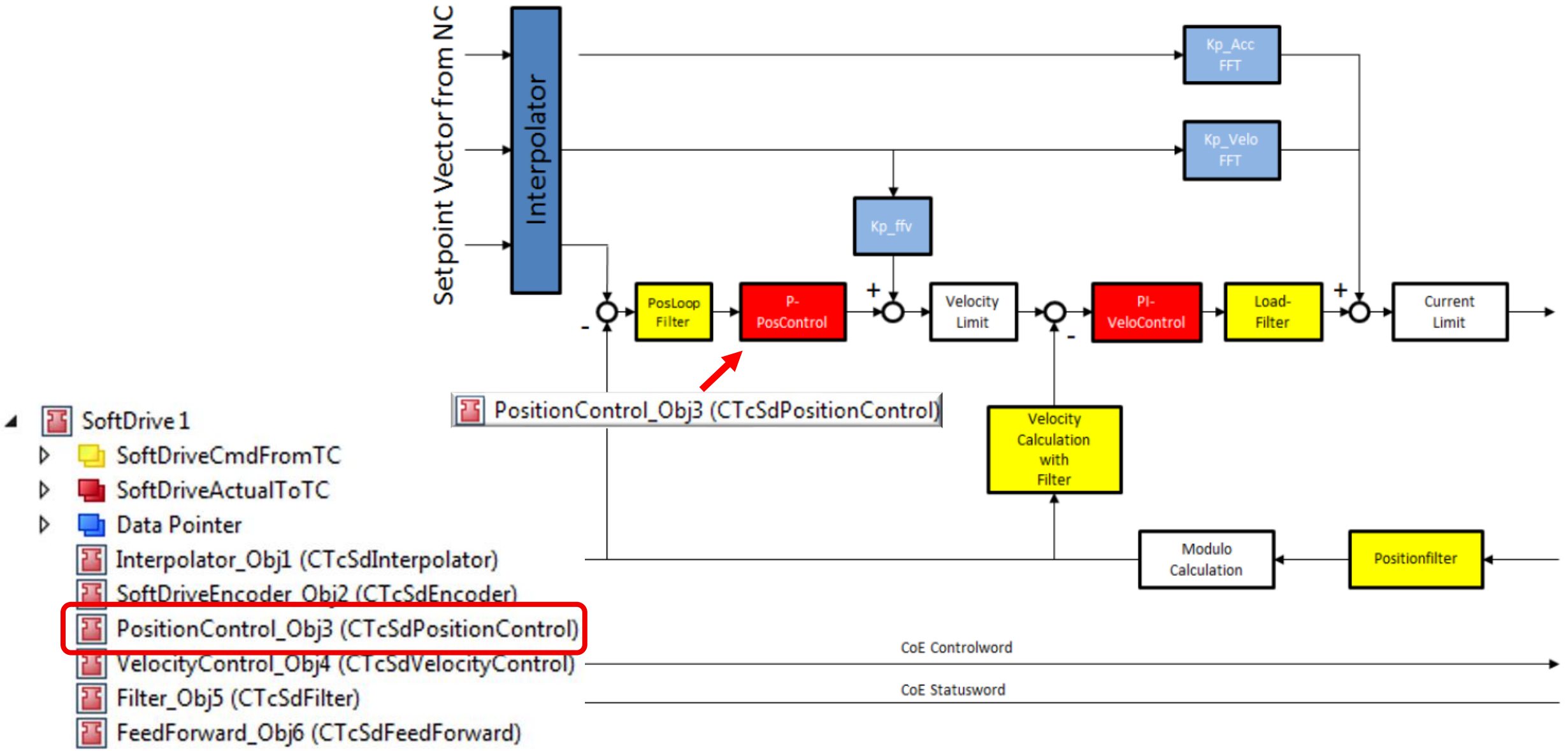
XTS TcSoftDrive - parameter structure

BECKHOFF



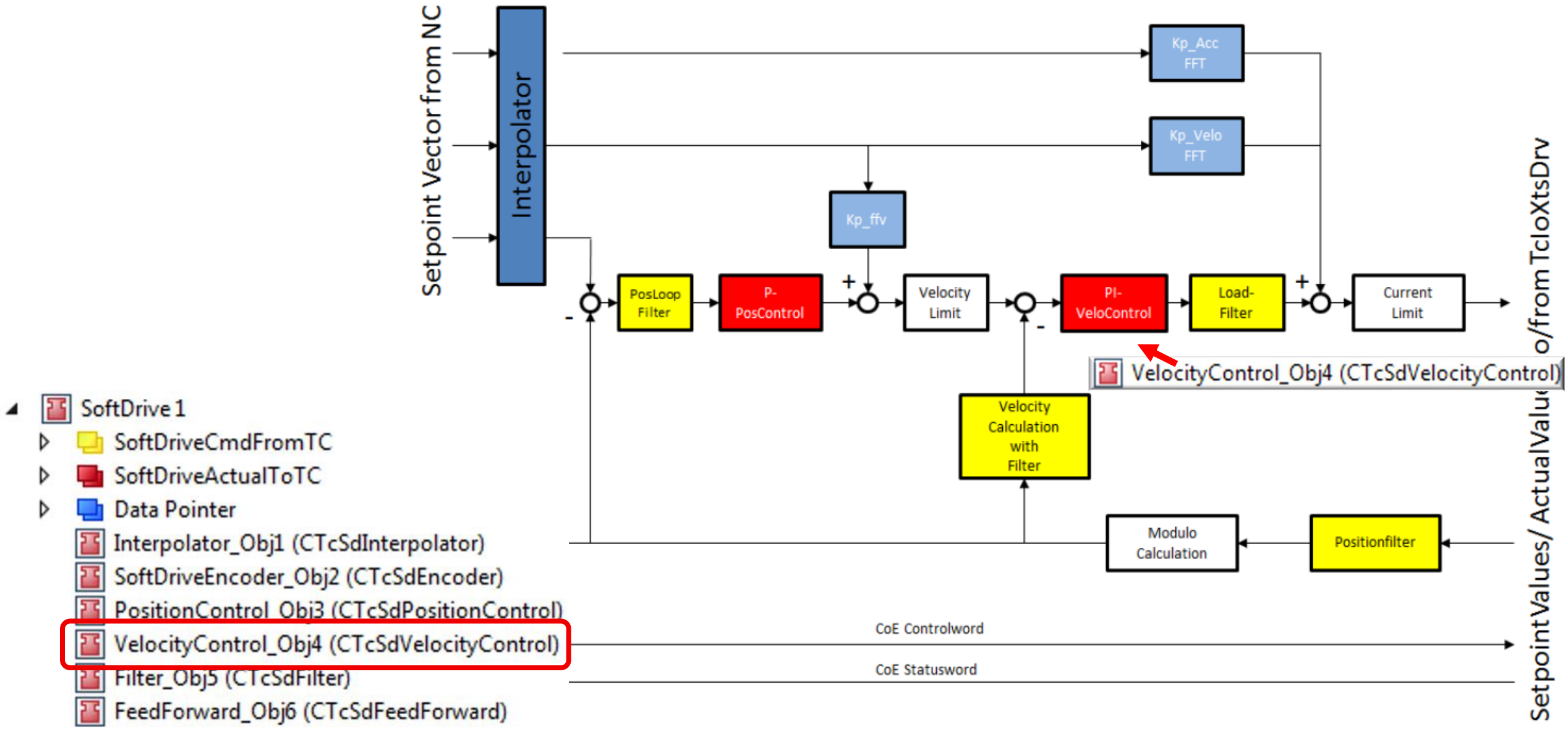
XTS TcSoftDrive - parameter structure

BECKHOFF



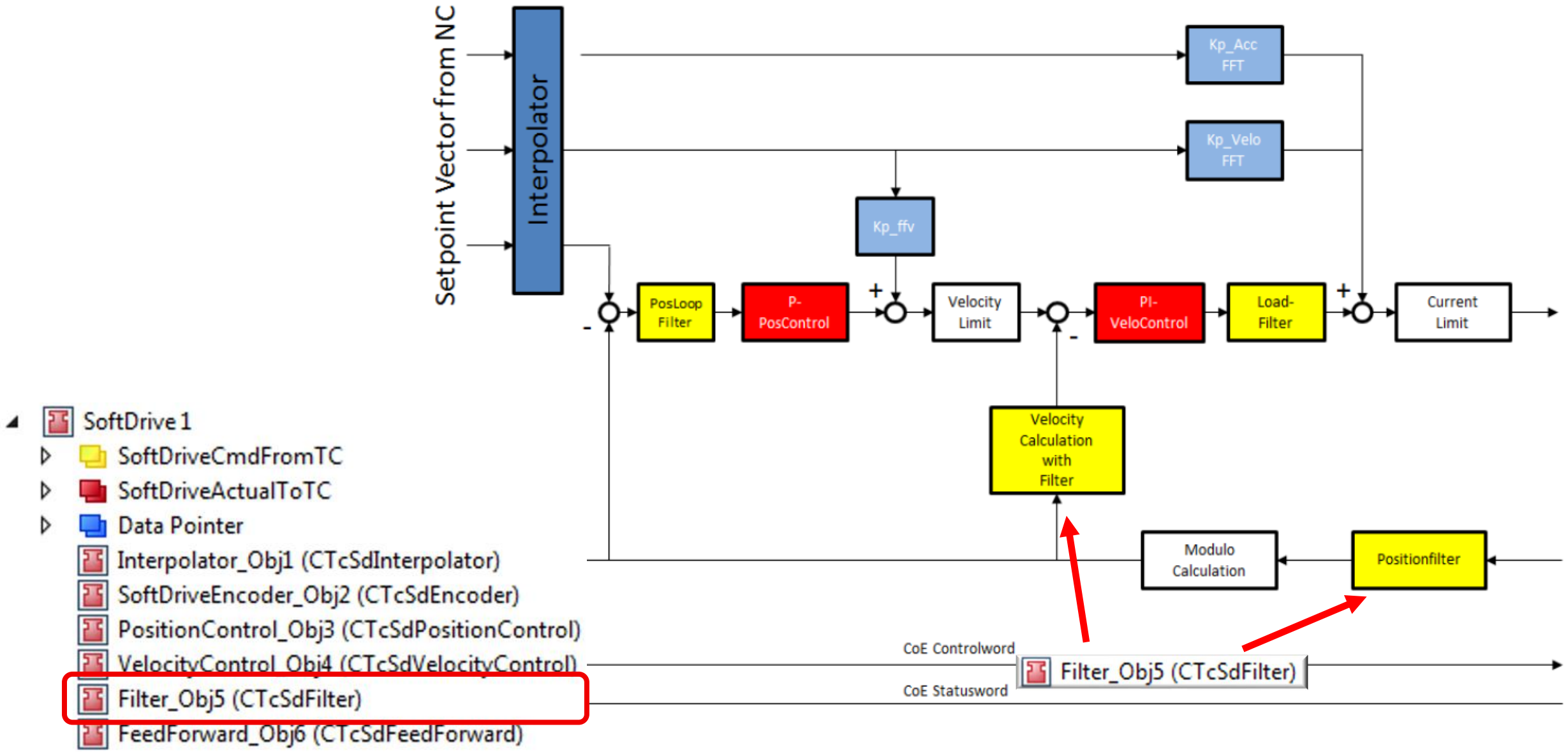
XTS TcSoftDrive - parameter structure

BECKHOFF



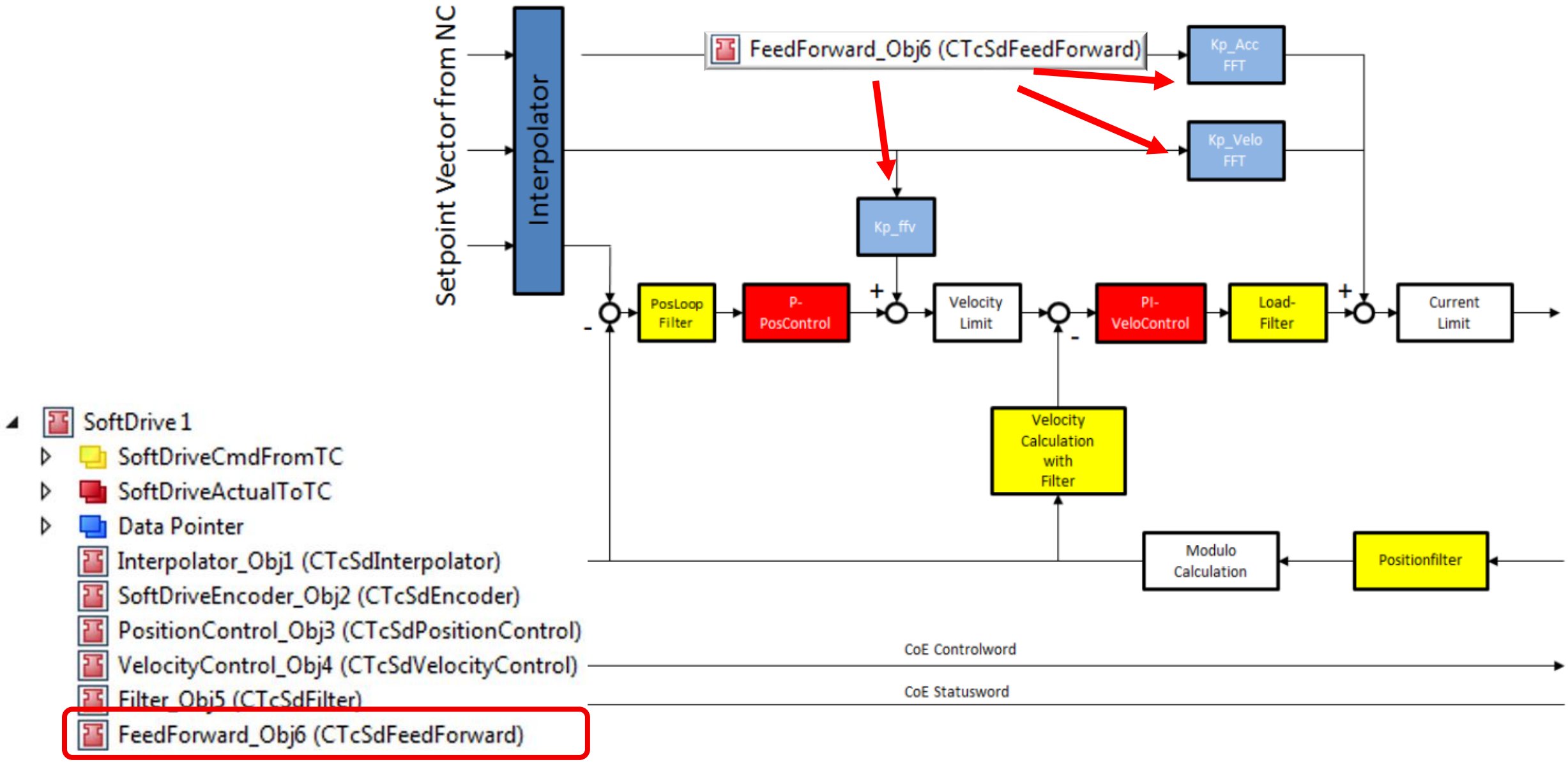
XTS TcSoftDrive - parameter structure

BECKHOFF



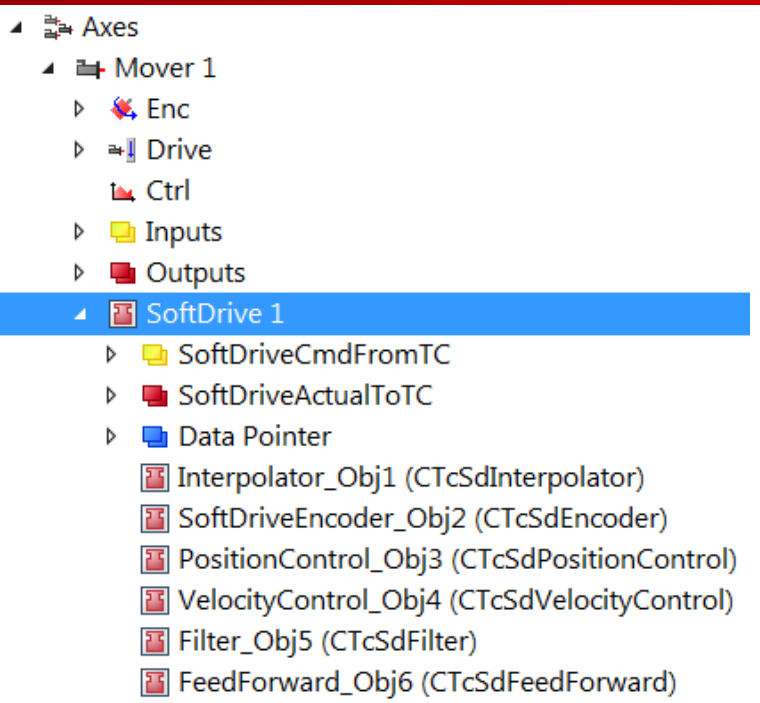
XTS TcSoftDrive - parameter structure

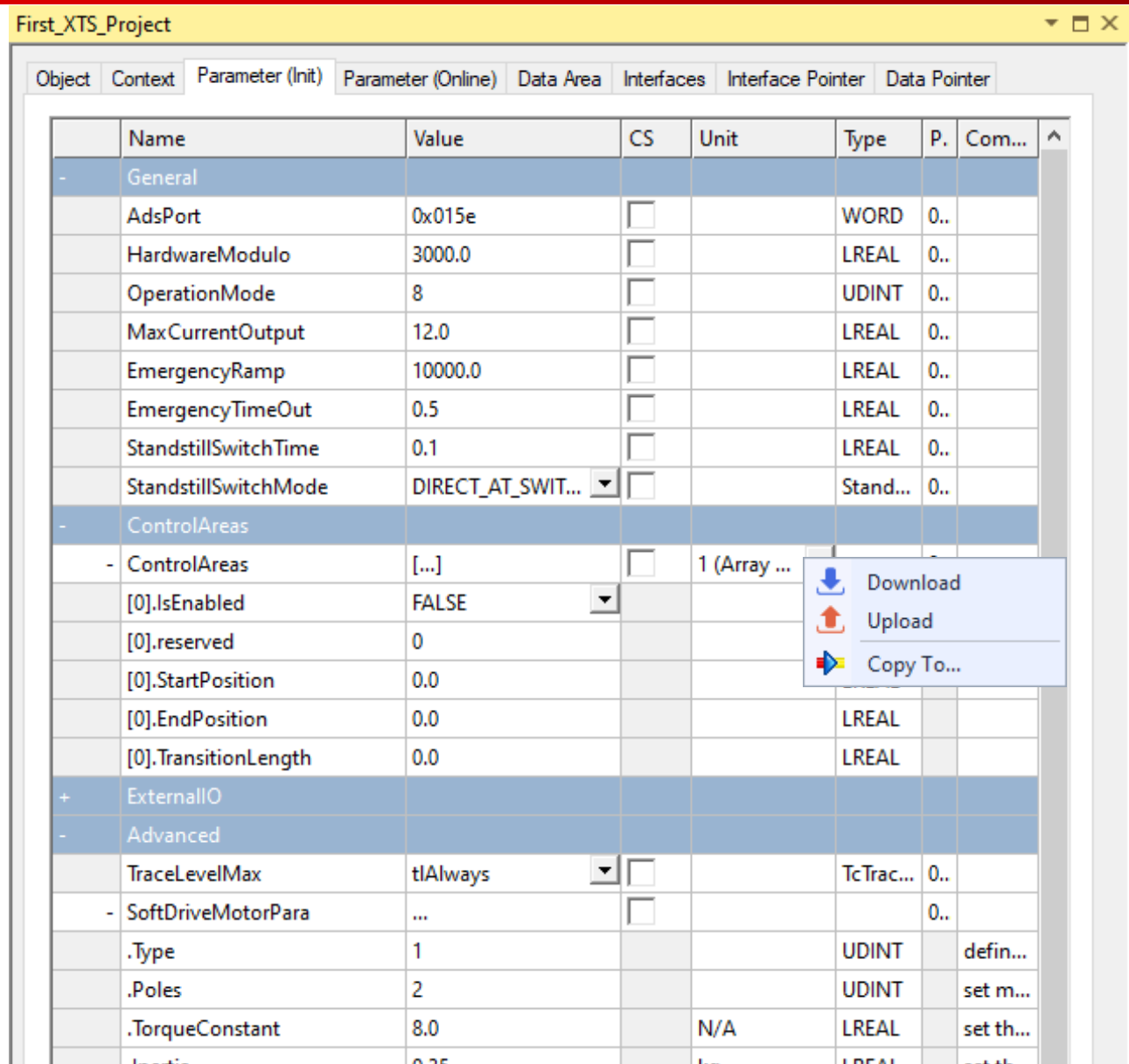
BECKHOFF



XTS TcSoftDrive - General SoftDrive Parameter

BECKHOFF





XTS TcSoftDrive - 32 different control areas

BECKHOFF

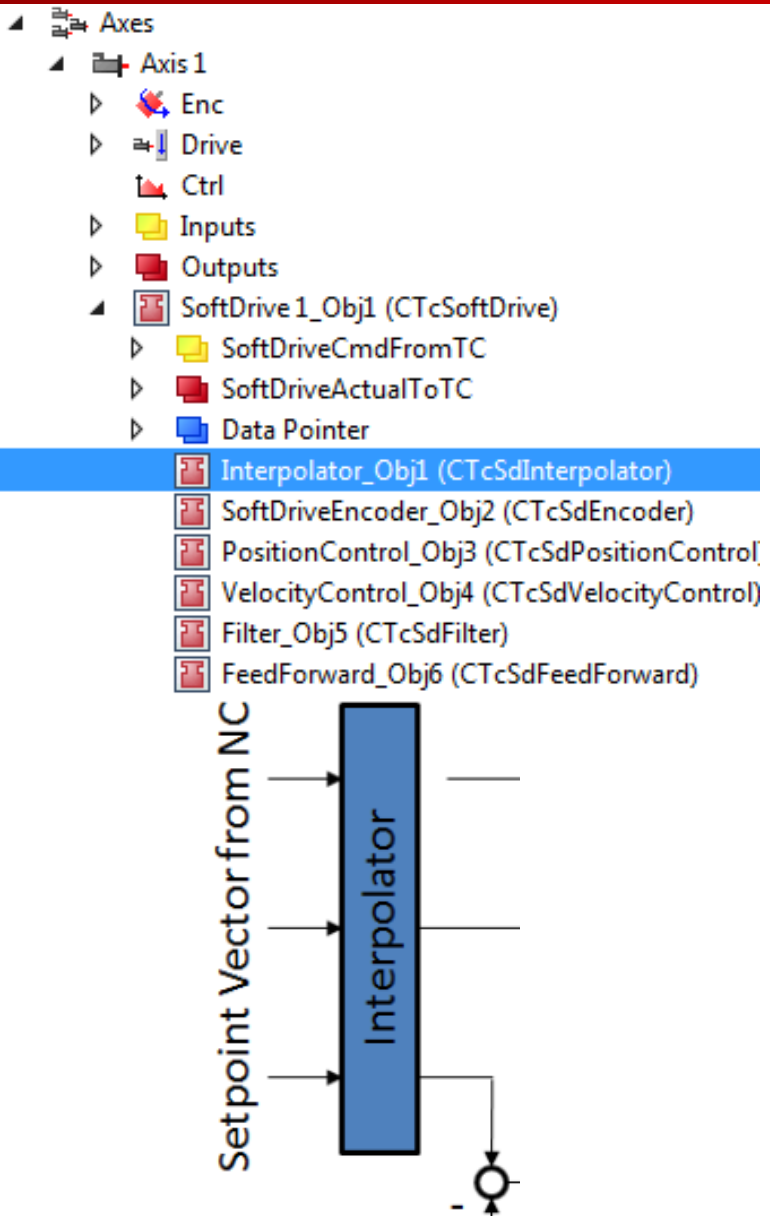
- 1 up to 32 different control areas
- Different parameter for position and velocity control
- Different current limit could be set in Feedforward module

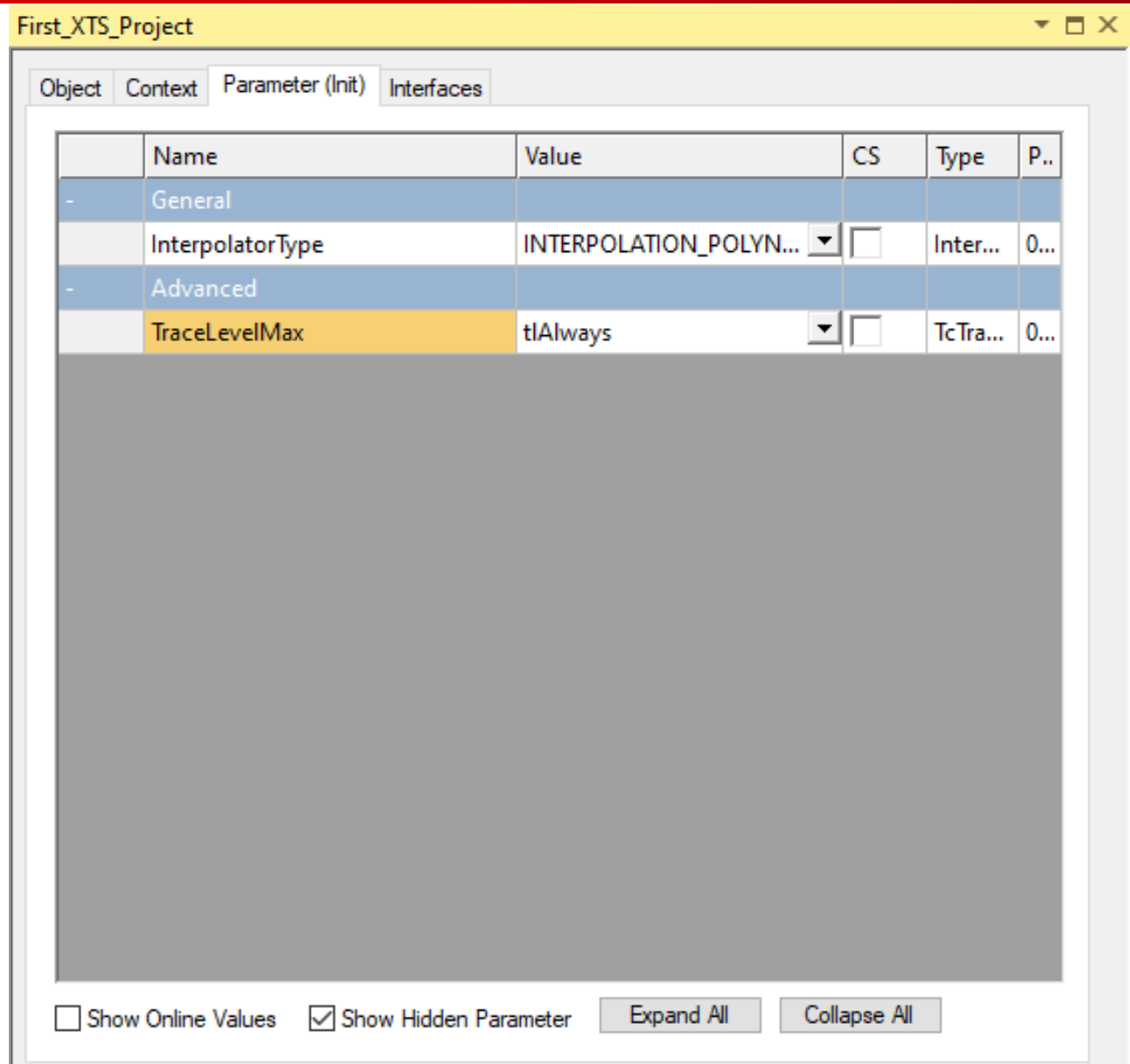
- To use a certain control area [X].IsEnabled must be set to TRUE and Activate Configuration

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

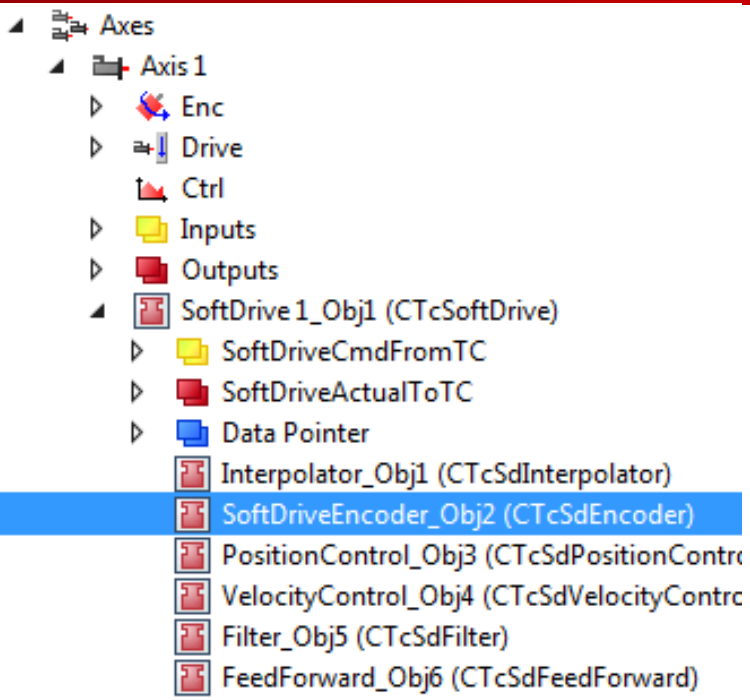
BECKHOFF





XTS TcSoftDrive - Encoder

BECKHOFF



First_XTS_Project

Object | Context | Parameter (Init) | Interfaces | Interface Pointer

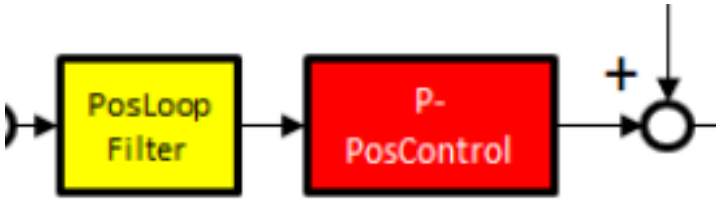
	Name	Value	CS	Unit	Type	P..
-	General					
	VelocityFeedbackMode	OBSERVER			Velo...	0...
	PositionFeedbackMode	MODULO_START			Posit...	0...
	PositionLowPassFilter	500.0		Hz	LREAL	0...
	VelocityFilterBandwidth	160.0		Hz	LREAL	0...
	StartUpPositionType	PART			Start...	0...
-	Advanced					
	TraceLevelMax	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

- Axes
  - Axis 1
    - Enc
    - Drive
    - Ctrl
    - Inputs
    - Outputs
    - SoftDrive 1_Obj1 (CTcSoftDrive)
      - SoftDriveCmdFromTC
      - SoftDriveActualToTC
      - Data Pointer
      - Interpolator_Obj1 (CTcSdInterpolator)
      - SoftDriveEncoder_Obj2 (CTcSdEncoder)
      - PositionControl_Obj3 (CTcSdPositionCont
      - VelocityControl_Obj4 (CTcSdVelocityContr
      - Filter_Obj5 (CTcSdFilter)
      - FeedForward_Obj6 (CTcSdFeedForward)



First_XTS_Project

Object | Context | Parameter (Init) | Interfaces | Interface Pointer

	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 Expand All Collapse All

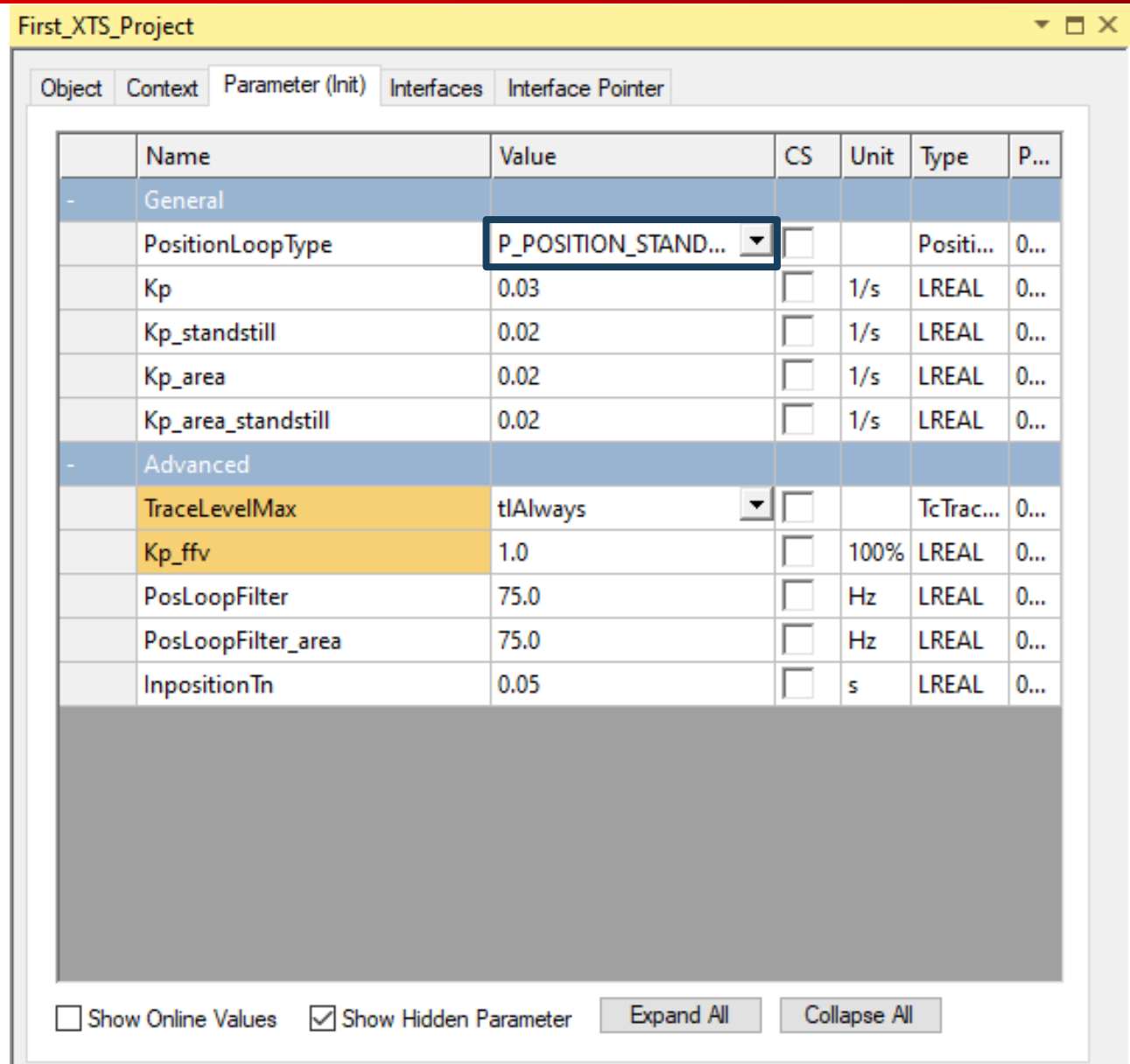
XTS TcSoftDrive - parameter for position control

BECKHOFF

- Type: P_Position
  only Kp is used

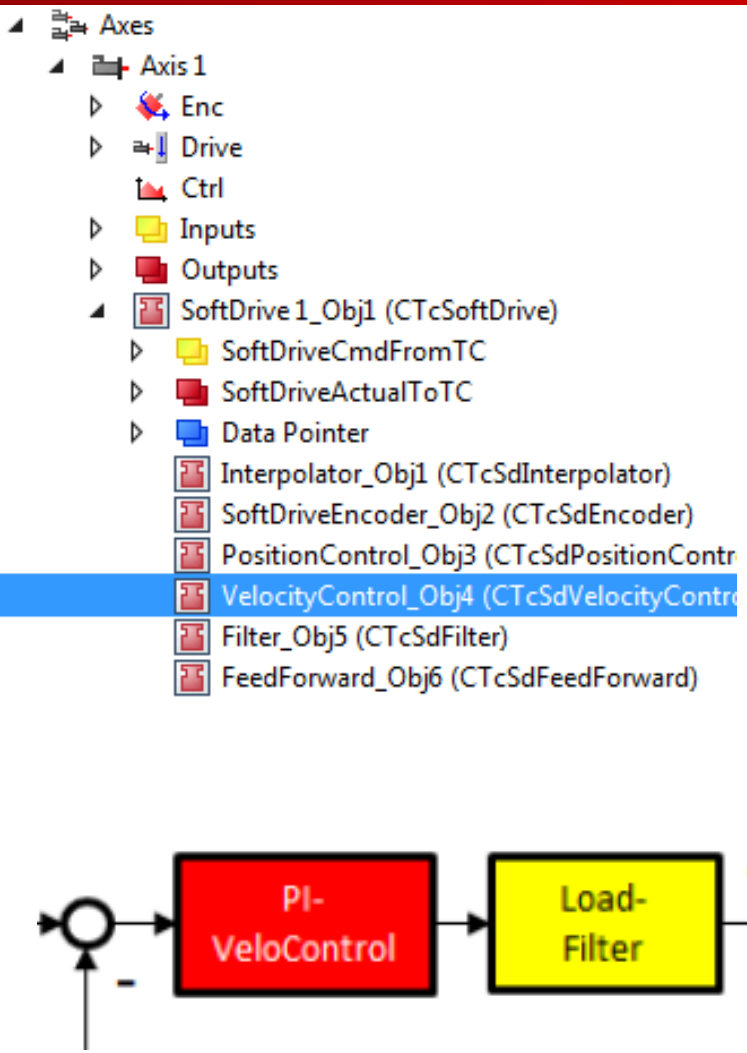
- Type: P_Position_Standstill
  Kp &
  Kp_standstill is used

- Type: P_Position_Standstill_Area
  all parameter are used



XTS TcSoftDrive - velocity control

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					
	ResetIPartAtMotionStart	OFF			Rese...	0..
-	Advanced					
	TraceLevelMax	tlAlways			TcTr...	0..

Show Online Values | Show Hidden Parameter | Expand All | Collapse All

XTS TcSoftDrive - parameter for velocity control

BECKHOFF

- Type: PI_Position

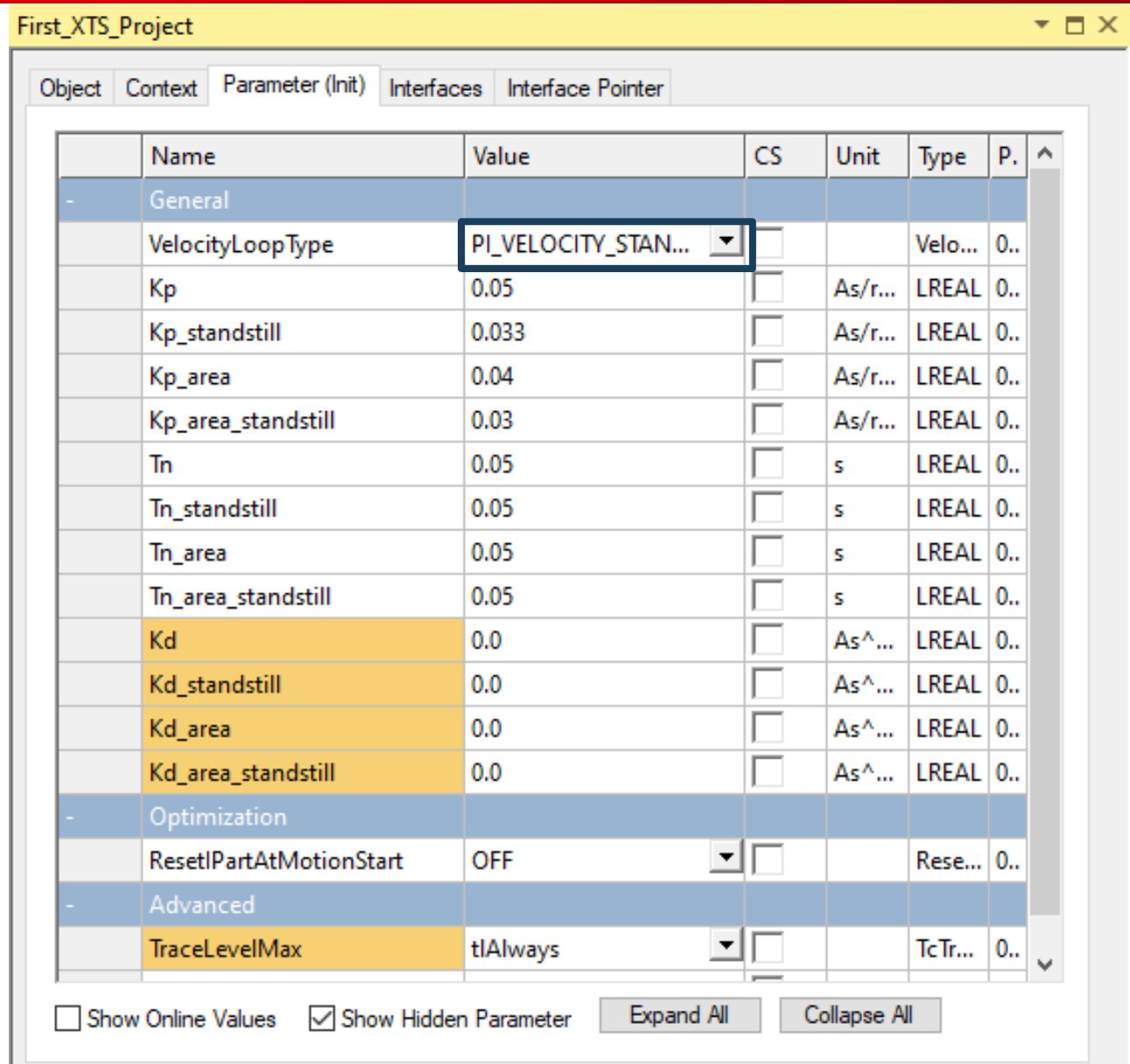
  only Kp & Tn is used

- 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)

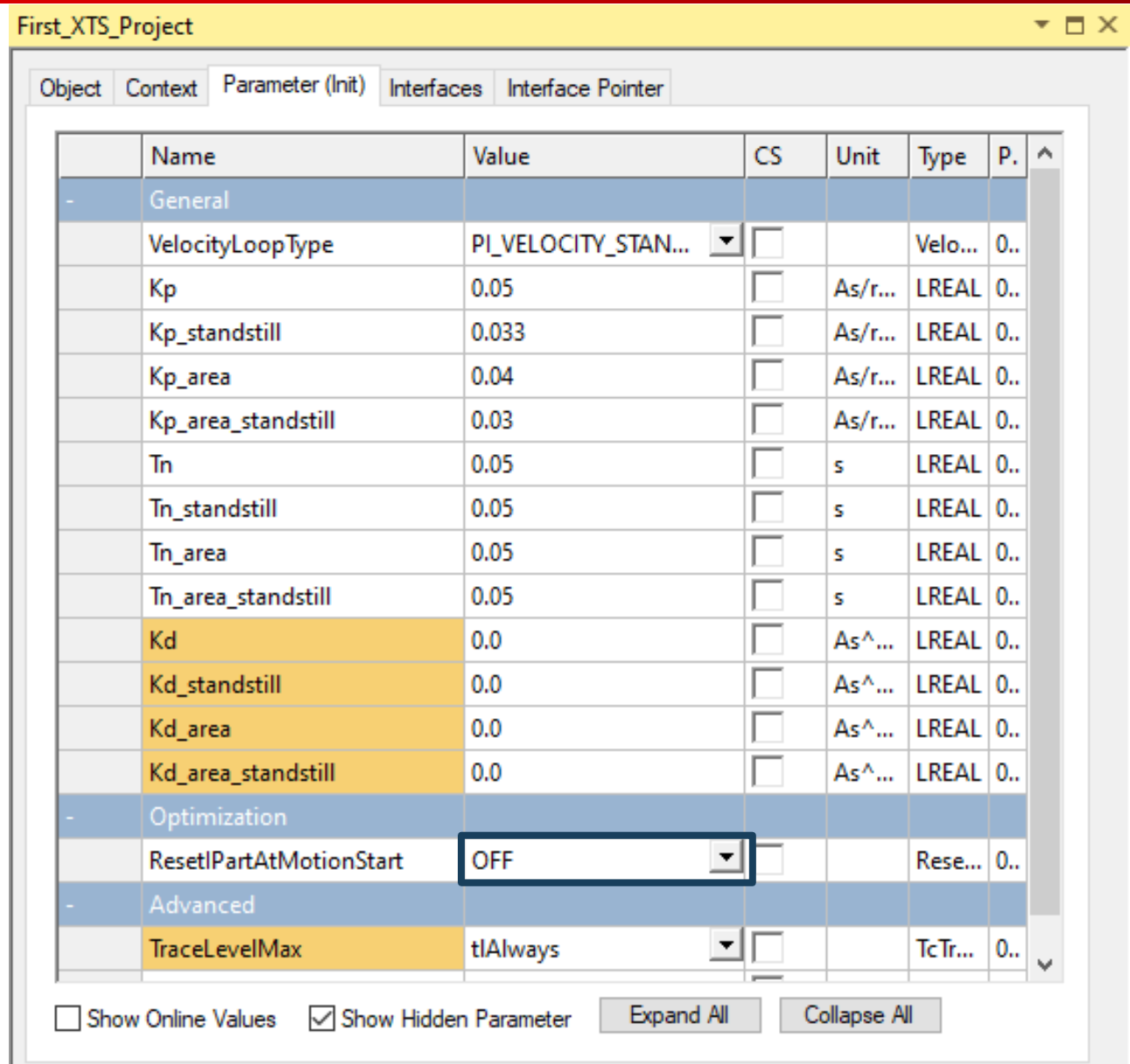


XTS TcSoftDrive - parameter for velocity control

BECKHOFF

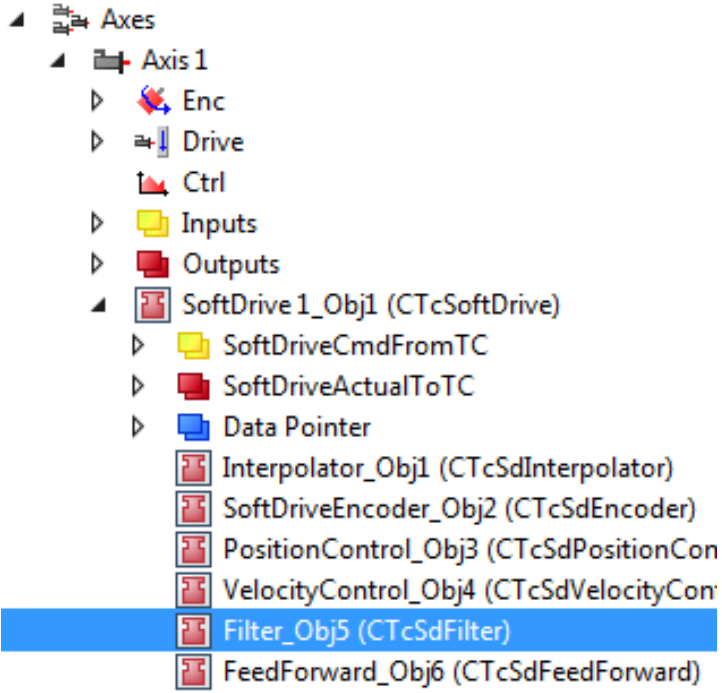
- If one integral parameter is set to zero then the calculated value is also reset to zero.

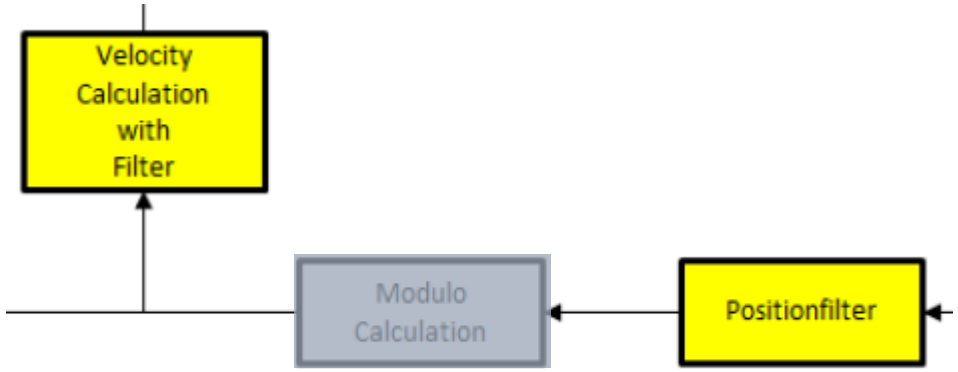
- If an old tmc is used the functionality is backward compatible



XTS TcSoftDrive - filter parameter

BECKHOFF





First_XTS_Project

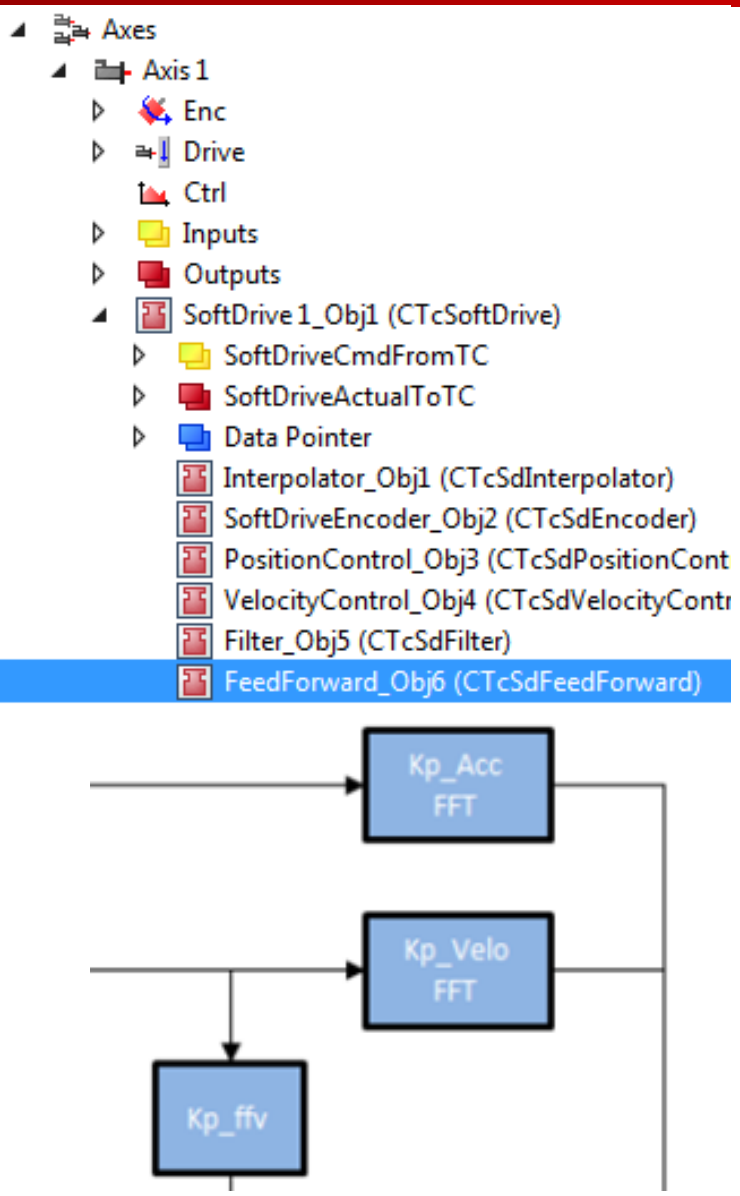
Object | Context | Parameter (Init) | Interfaces | Interface Pointer

	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



First_XTS_Project

Object | Context | Parameter (Init) | Parameter (Online) | Interfaces | Interface Pointer

	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..

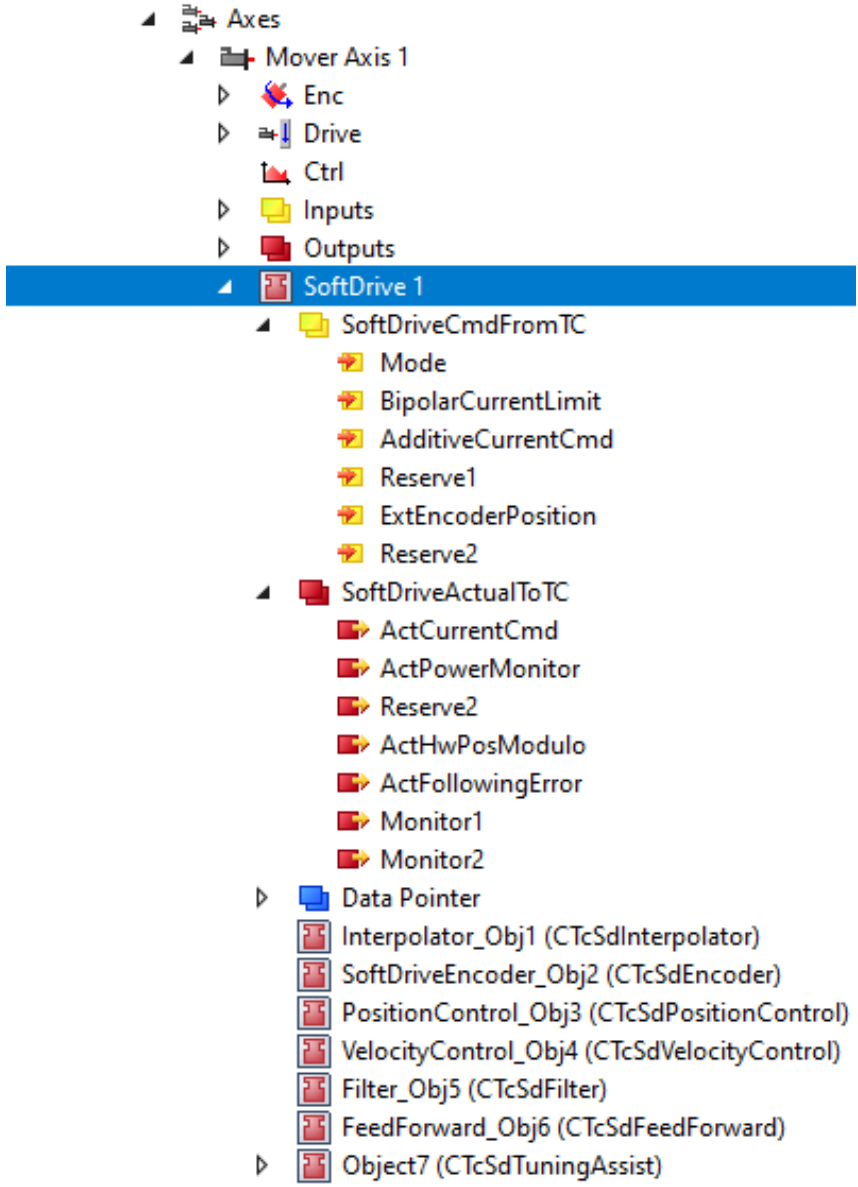
Show Online Values | Show Hidden Parameter | Expand All | Collapse All

XTS TcSoftDrive - cyclic variables

BECKHOFF

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

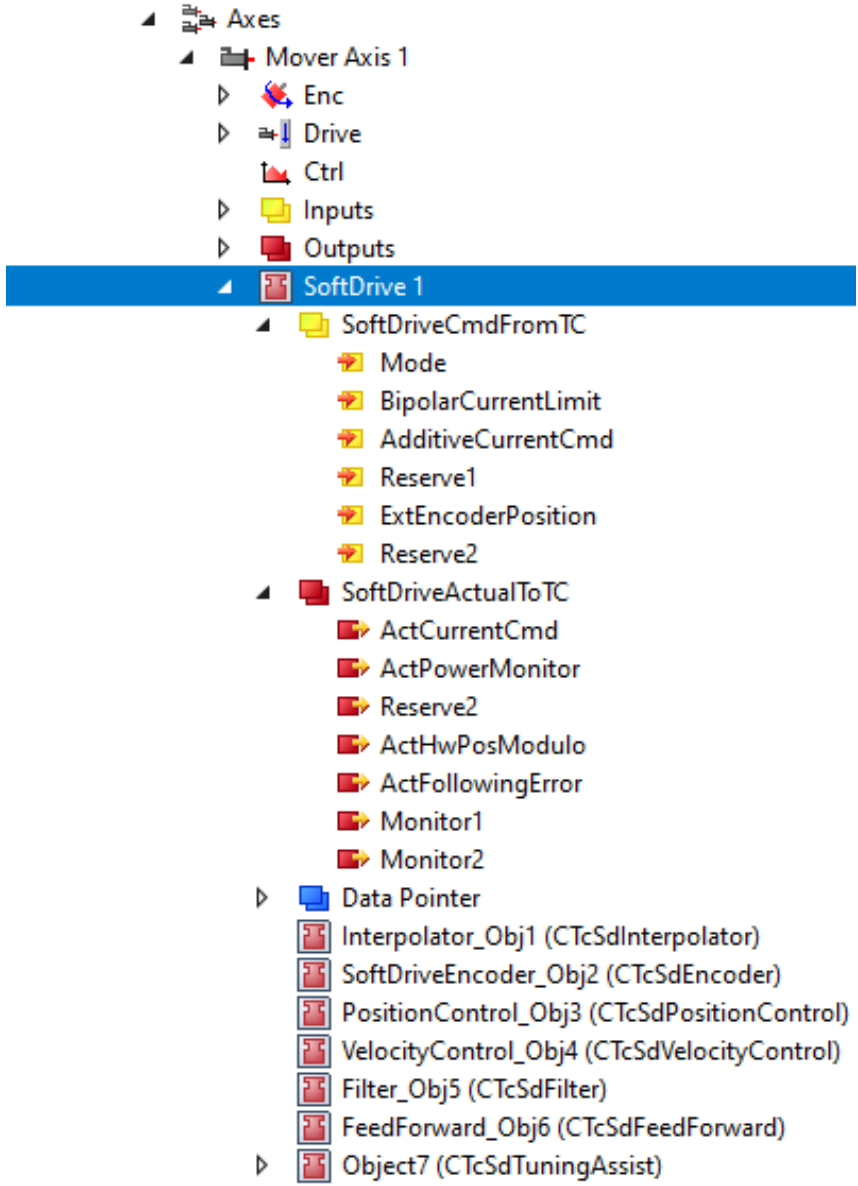


XTS TcSoftDrive - cyclic variables

BECKHOFF

From TcSoftDrive → NC / PLC

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



XTS TcSoftDrive - setting for cyclic data

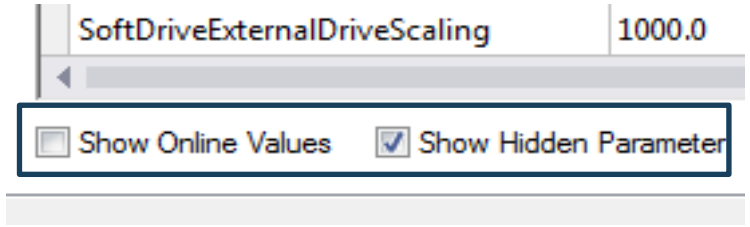
BECKHOFF

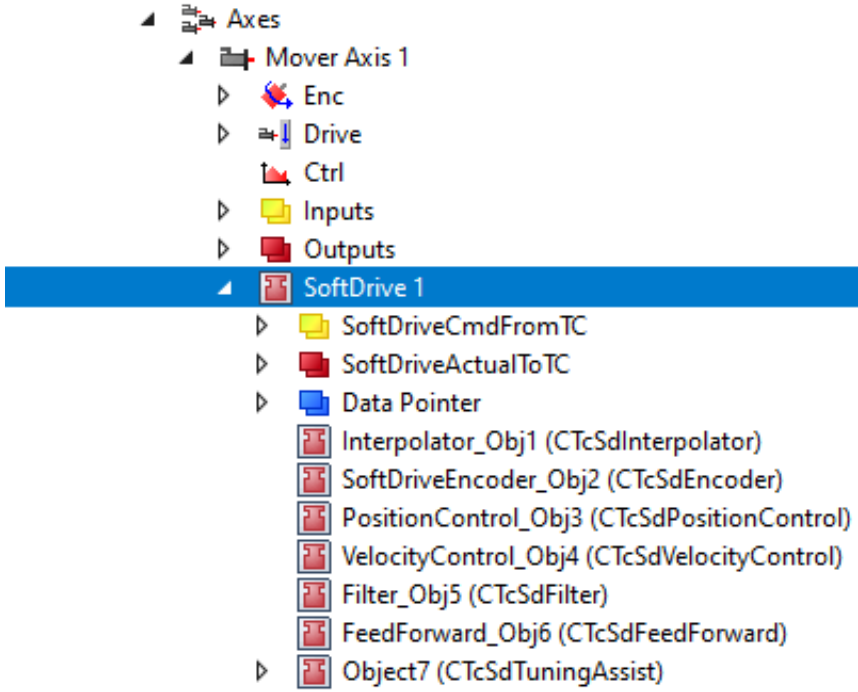
- SoftDriveExternalEncoder

  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





	ExternalIO				
-	SoftDriveExternalEncoder	...			
	.InvertExtEncoder	OFF			UDINT
	.Reserved	0			UDINT
	.ExtEncoderScale	0.0		mm/Inc	LREAL
	.ExtEncoderOffset	0.0		mm	LREAL
	SoftDriveExternalDriveScaling	1000.0			LREAL
+	IoChildAreaLocation	[..., ...]		2 (Array ...	
	AreaOwner	00000000			OTCID

Agenda | XTS- TcSoftDrive

BECKHOFF

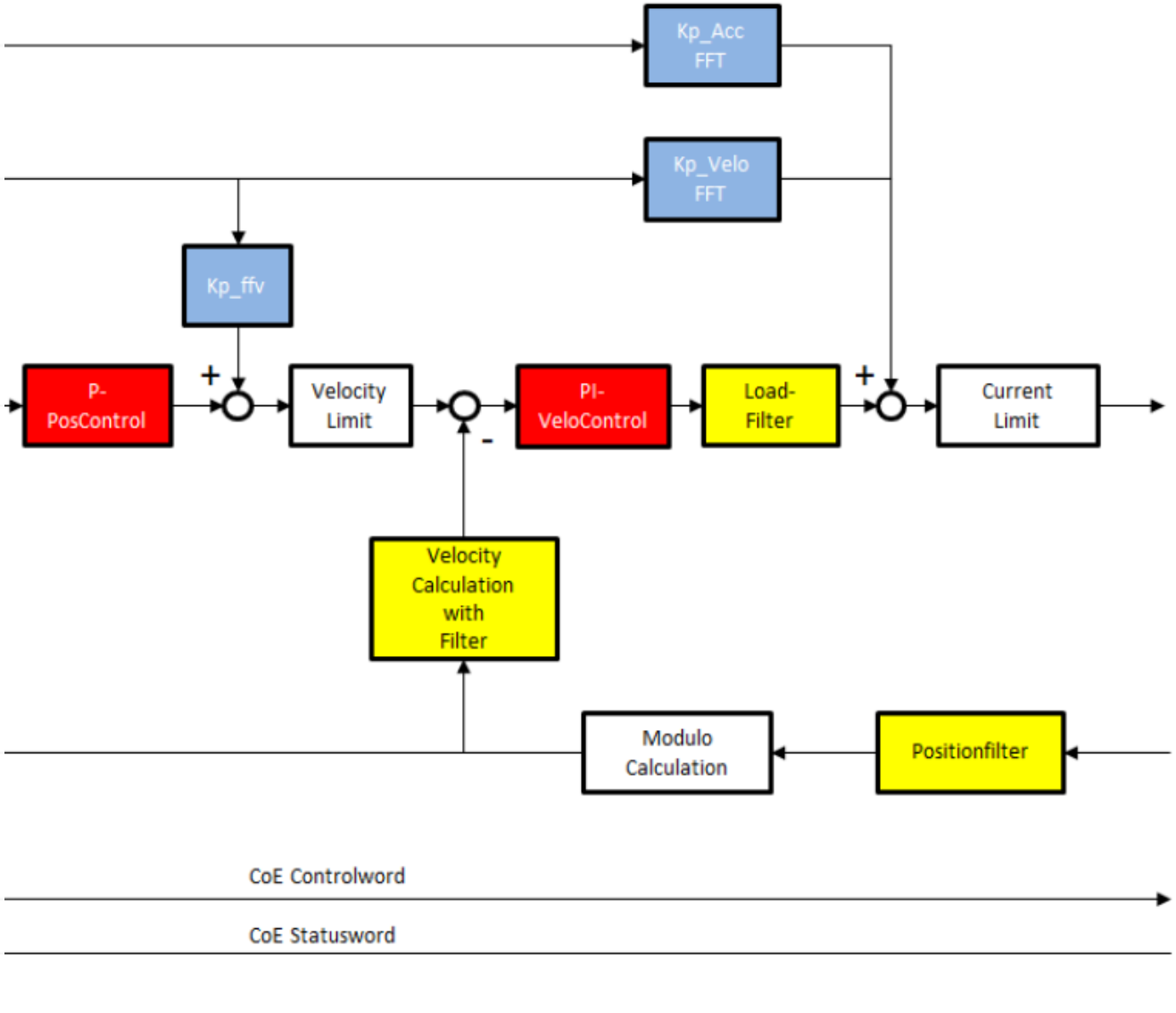
1. Short XTS basics
2. XTS Accuracy
3. XTS IPC & capabilities
4. Scope for
   Mover monitoring
5. TcSoftdrive
   structure & parameter
6. **Tuning**

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)

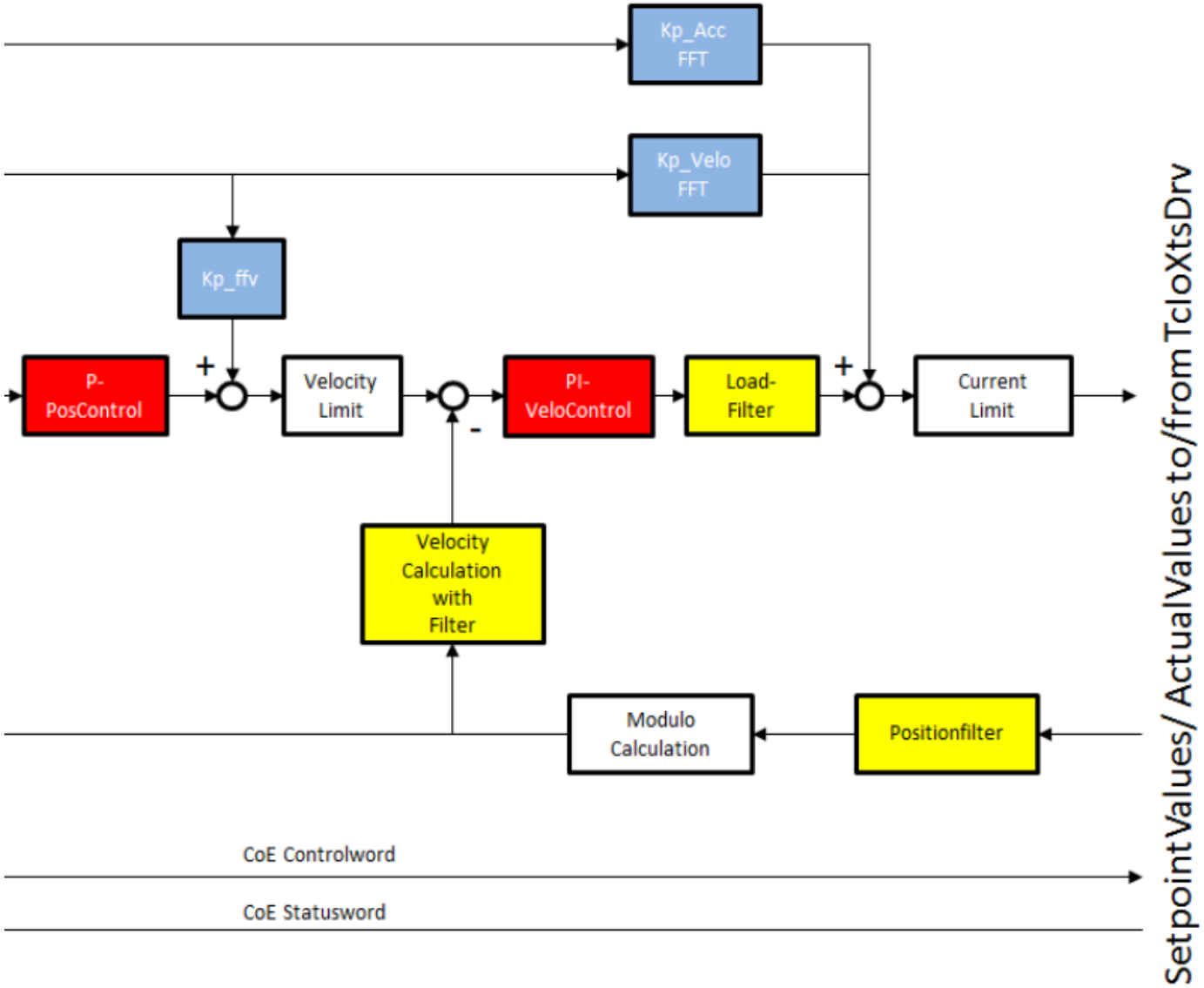


Tuning Sequence

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

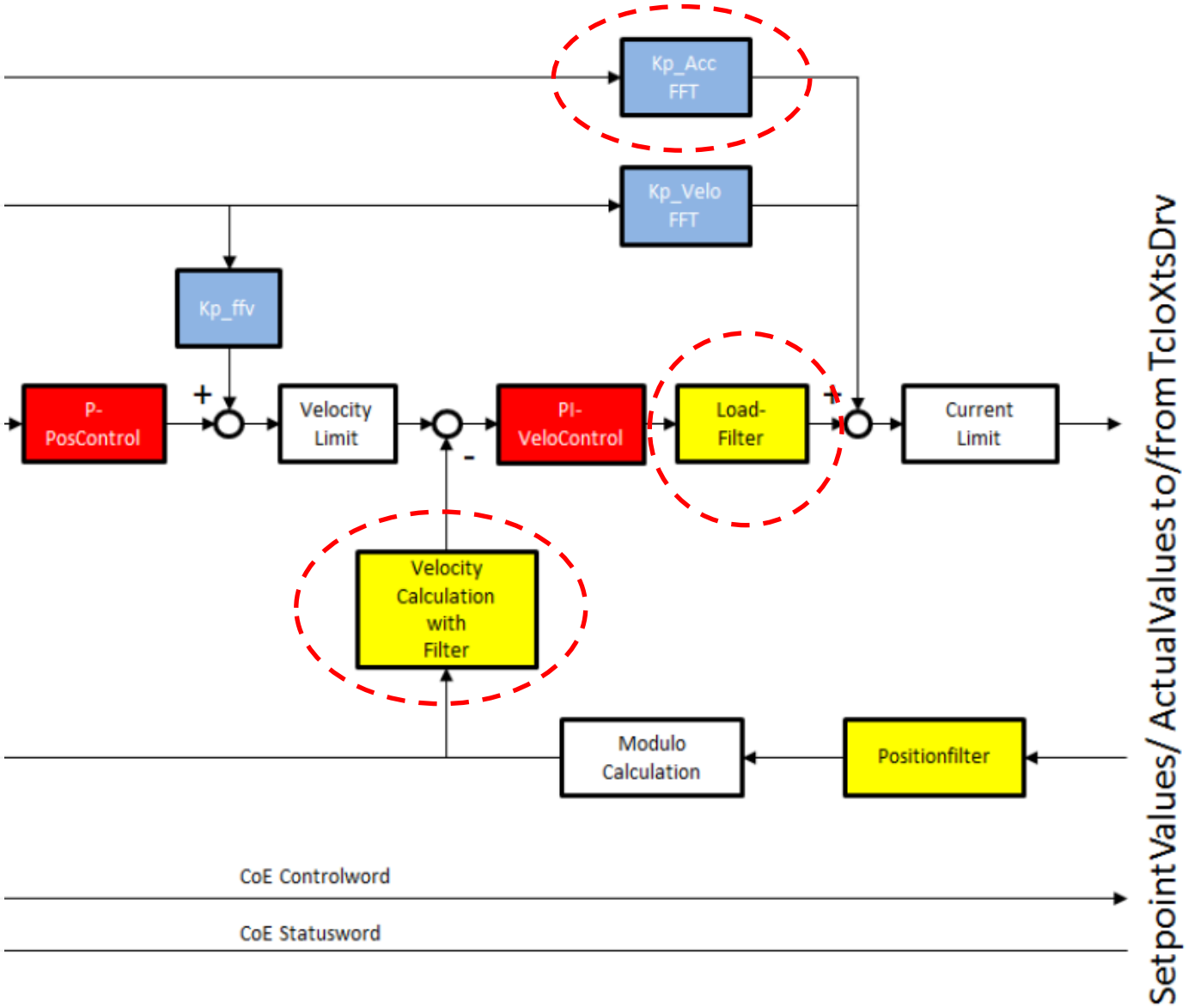


Tuning Sequence

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

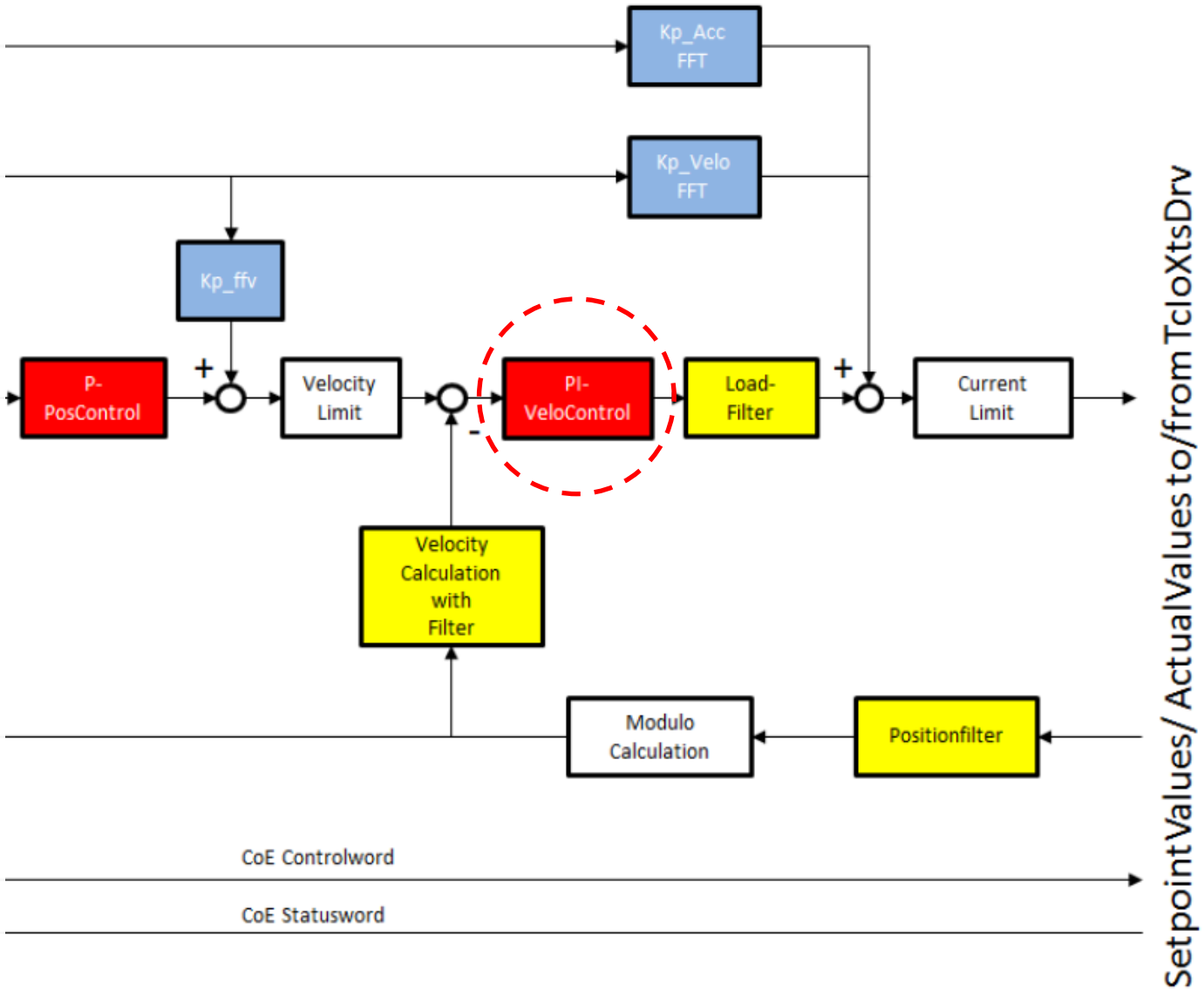


Tuning Sequence

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

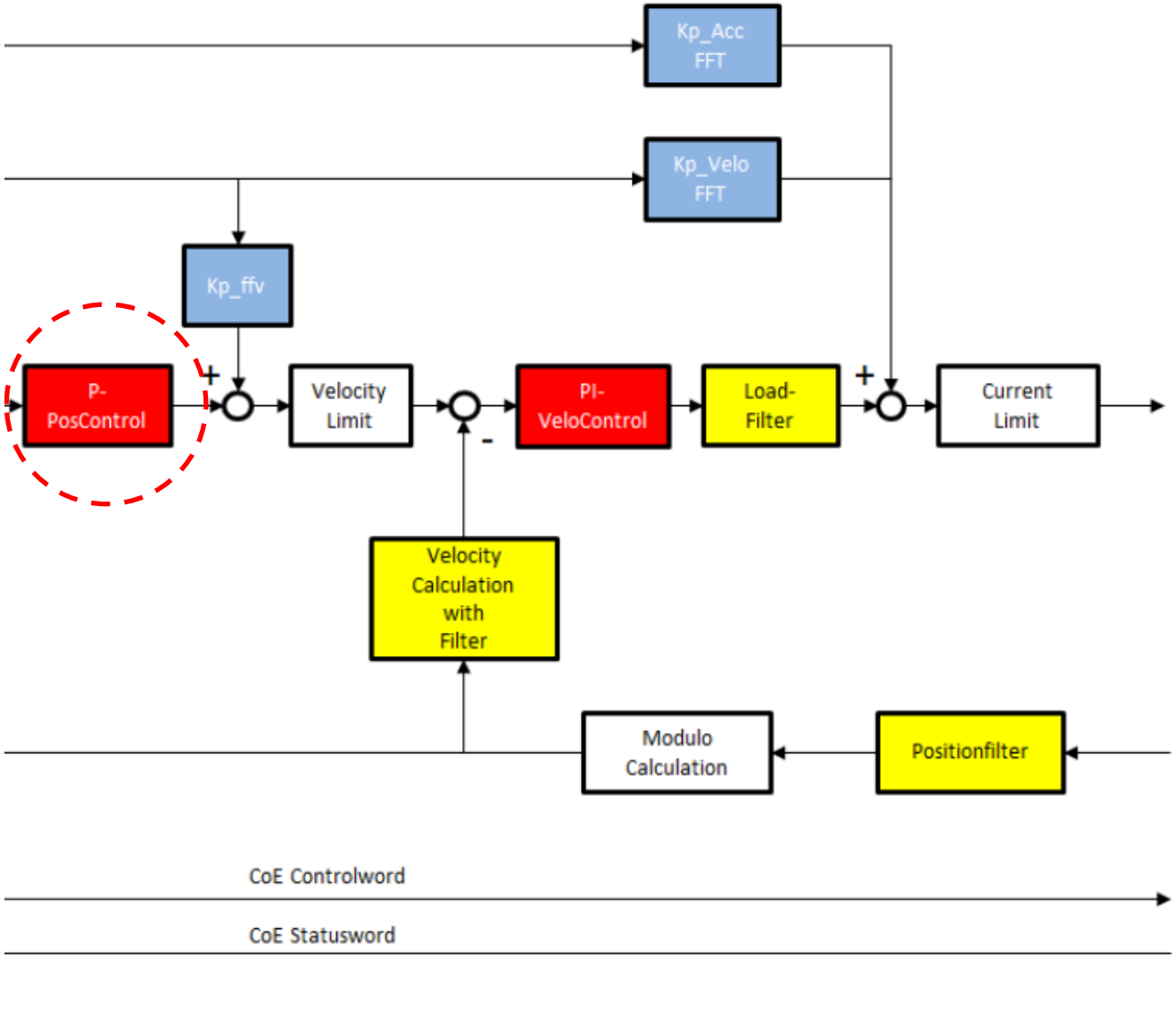


- Tuning Sequence

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

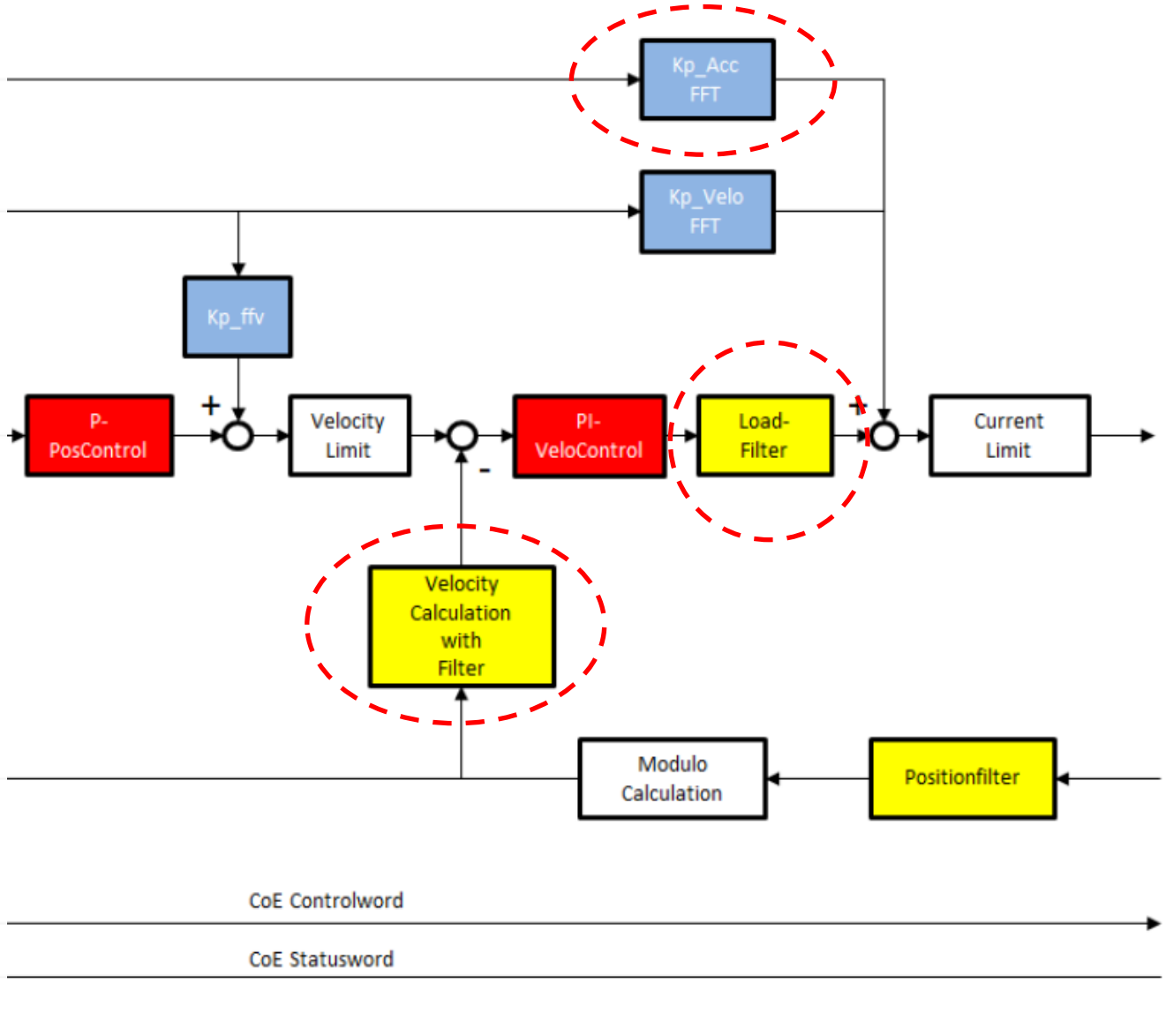
2. Setup Velocity-Control
   I. on the straight section
   II. on the curve section

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



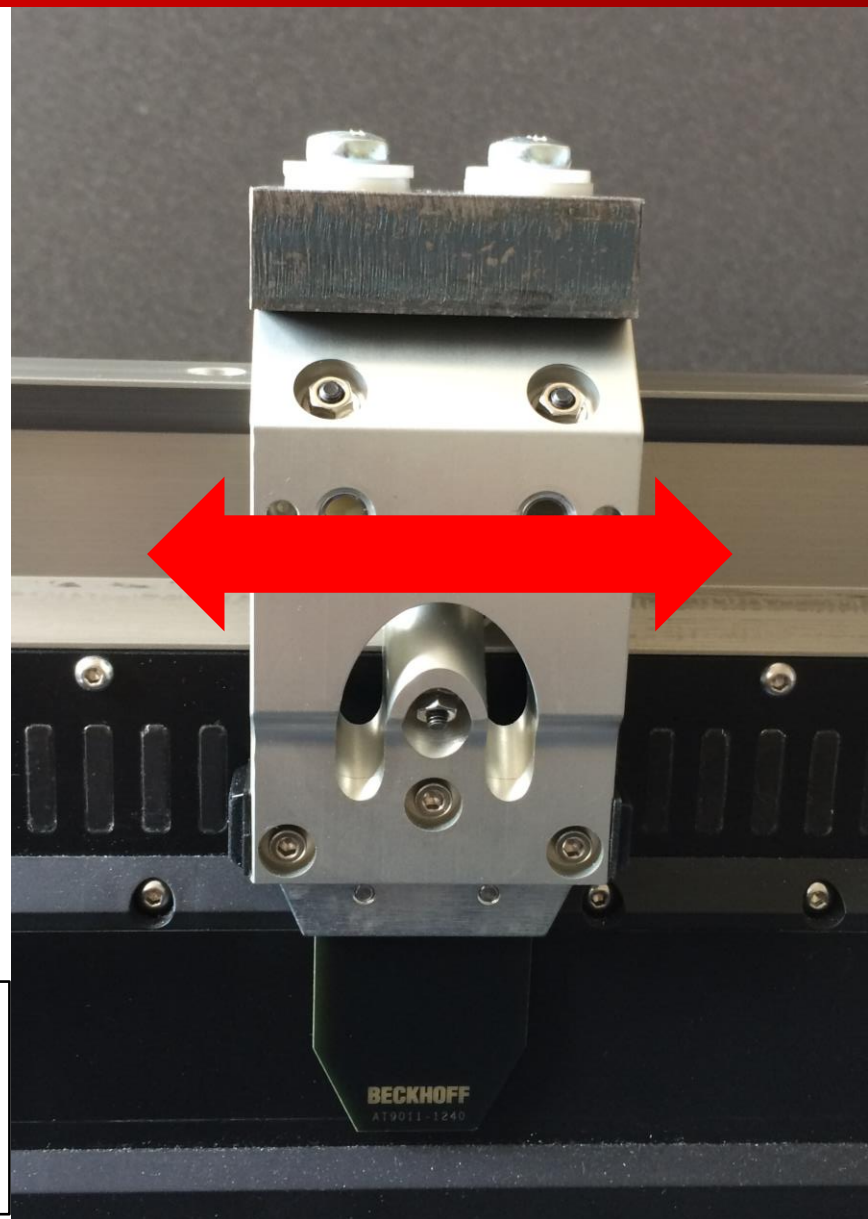
Setup Filter Settings

- 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

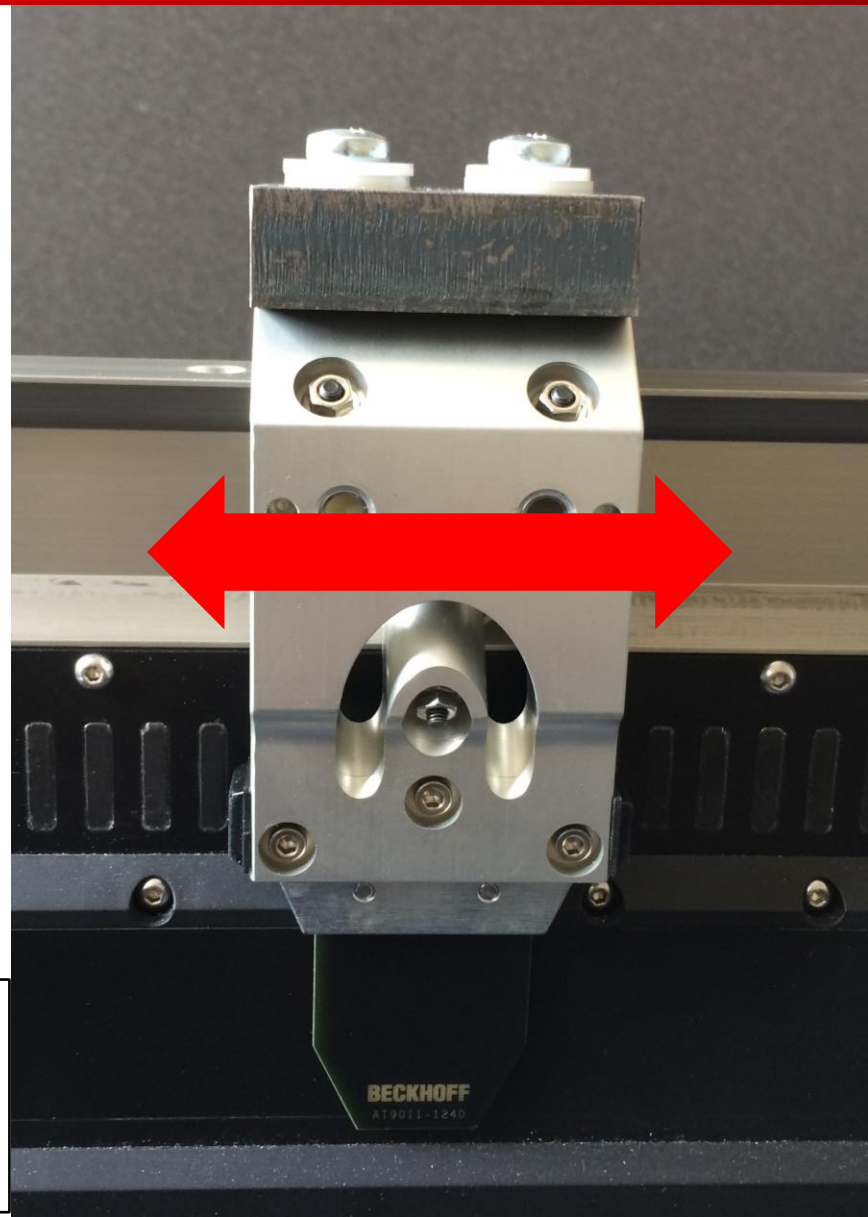
- The Tuning Assist (TA) TcCom object is added to the existing TcSoftDrive module (Version ≥ 3.10.43.0)
- The TA function operates in torque mode and generates a short current to the mover, followed by coasting to a stop. The Mover will be driven in both positive and negative directions and two measurements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



WARNING	**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.

Determining Filter Settings using Tuning Assist

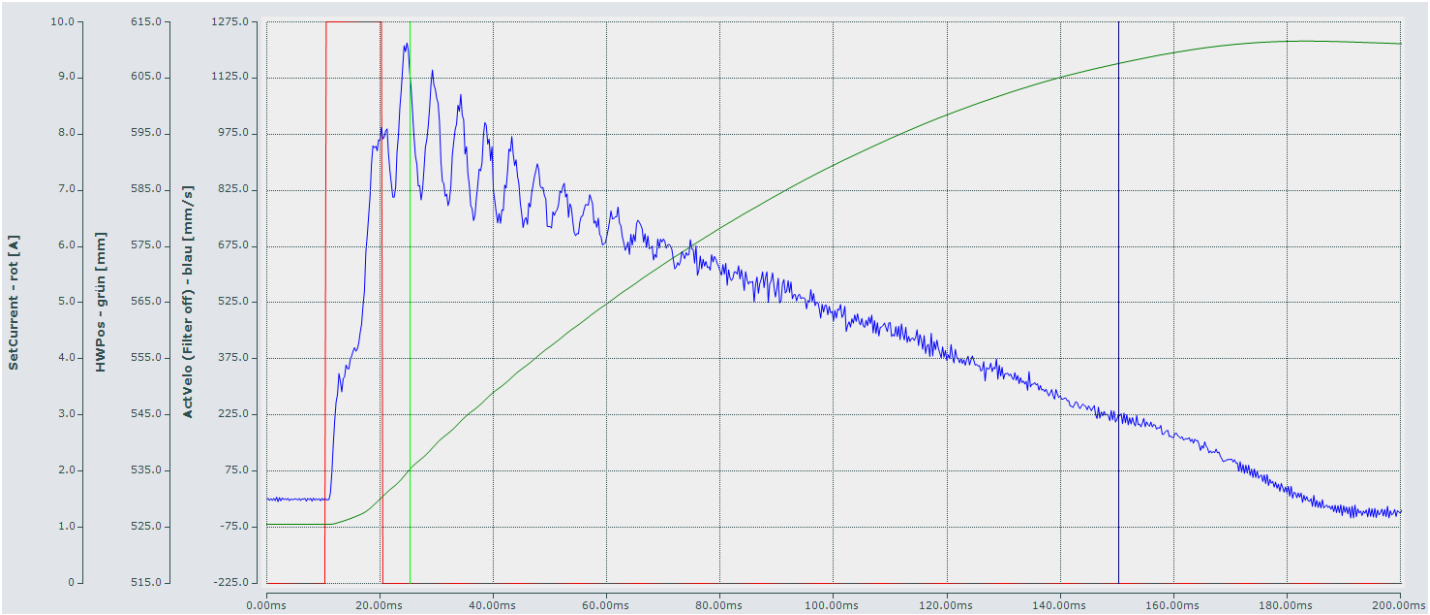
- The response of the system (Mover with tooling) will be measured and a Fast Fourier Transformation (FFT) is used to determine the frequency components
- The result could be visualized with the array bar chart functionality of TwinCAT 3 Scope Views (Version ≥ 3.2.3136 starting with TwinCAT 3.1.4020.14)

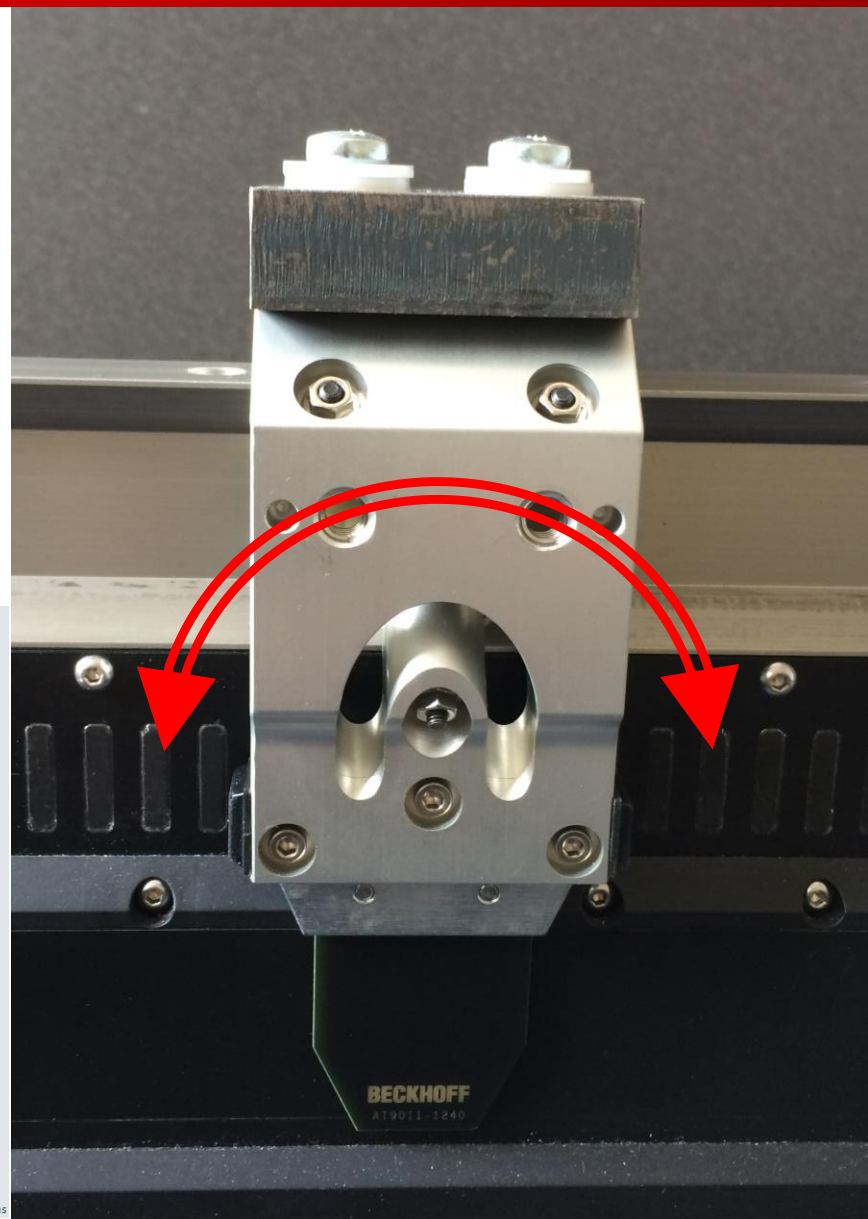


WARNING	**Risk of injury from moving movers** When the Tuning Assist function is started the mover starts to move open loop with a jump. There is a risk of injury to body parts. Keep an appropriate safety distance, and stay clear outside of the operating space.

Determining Filter Settings using Tuning Assist

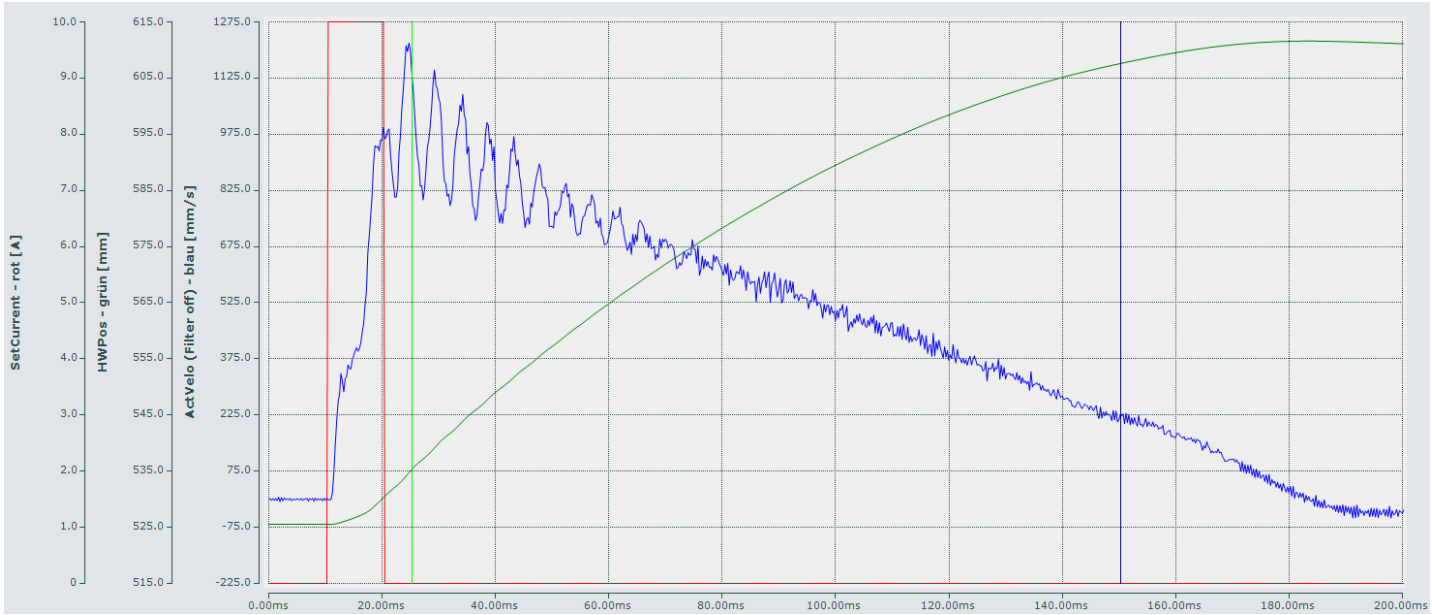
- The behaviour (torsional oscillation) of the mechanical system is analyzed. The normal direction of motion for the application should be used to ensure the best parameterization of the control loops for optimal motion performance.

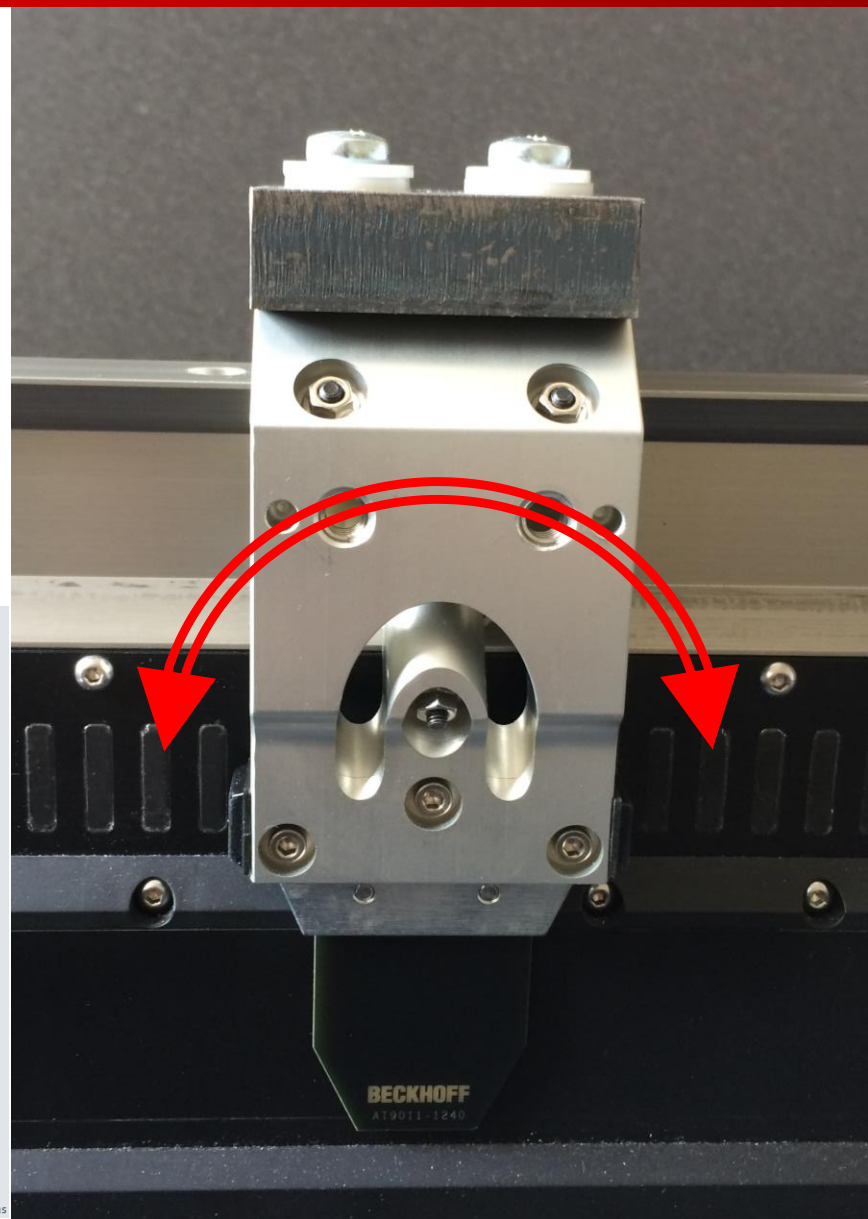




Determining Filter Settings using Tuning Assist

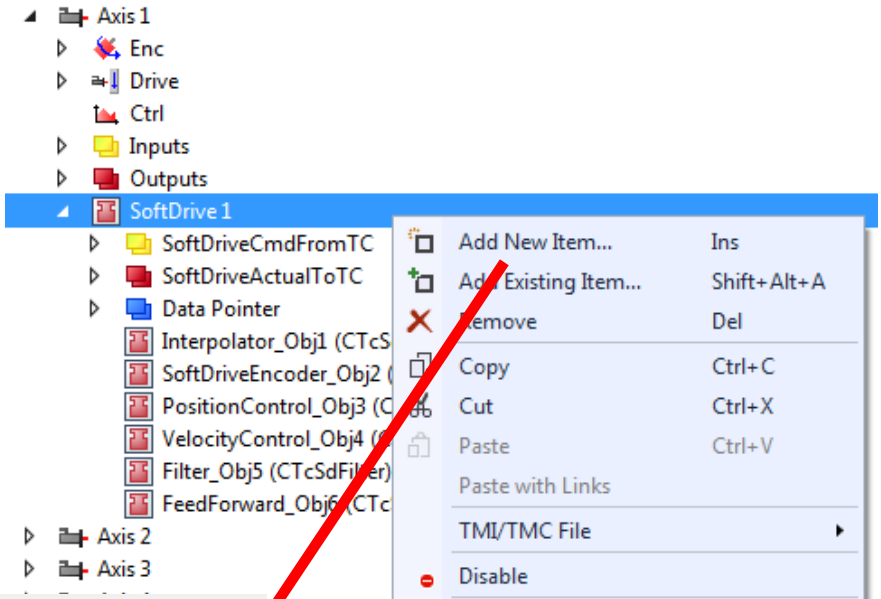
- The direction of torsional oscillations is shown in the picture on the right by the red double arrow
- The scope view example shows the oscillation response over time when a current is applied to the mover.

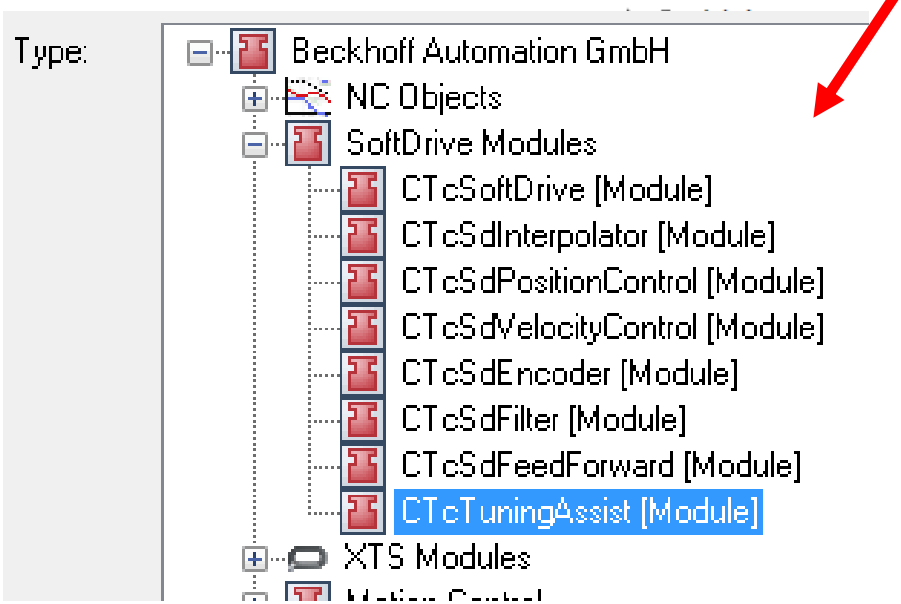




Determining Filter Settings using Tuning Assist

- Add a TuningAssist object to an existing TcSoftDrive

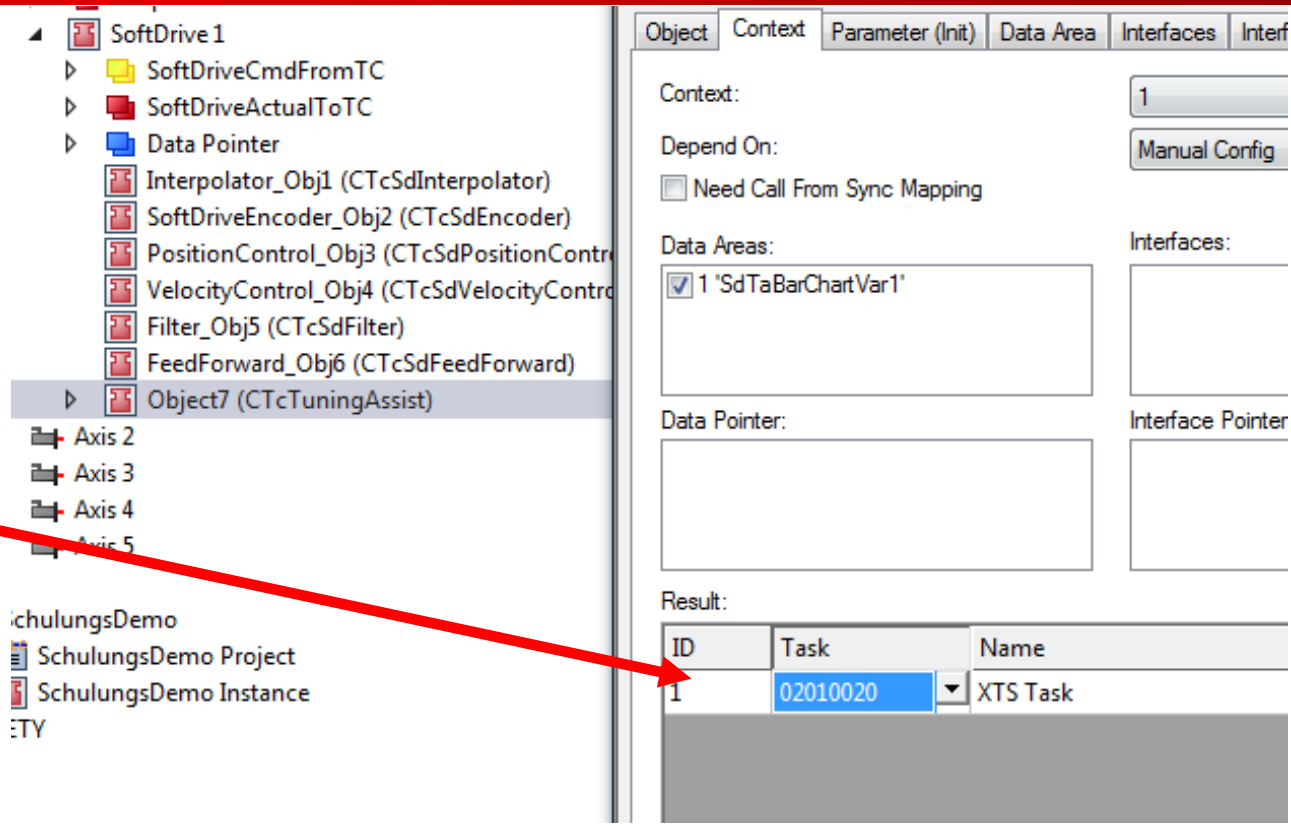




Determining Filter Settings using Tuning Assist

- Set the context task of the TuningAssist object to the same XTS task the TcSoftDrive is using

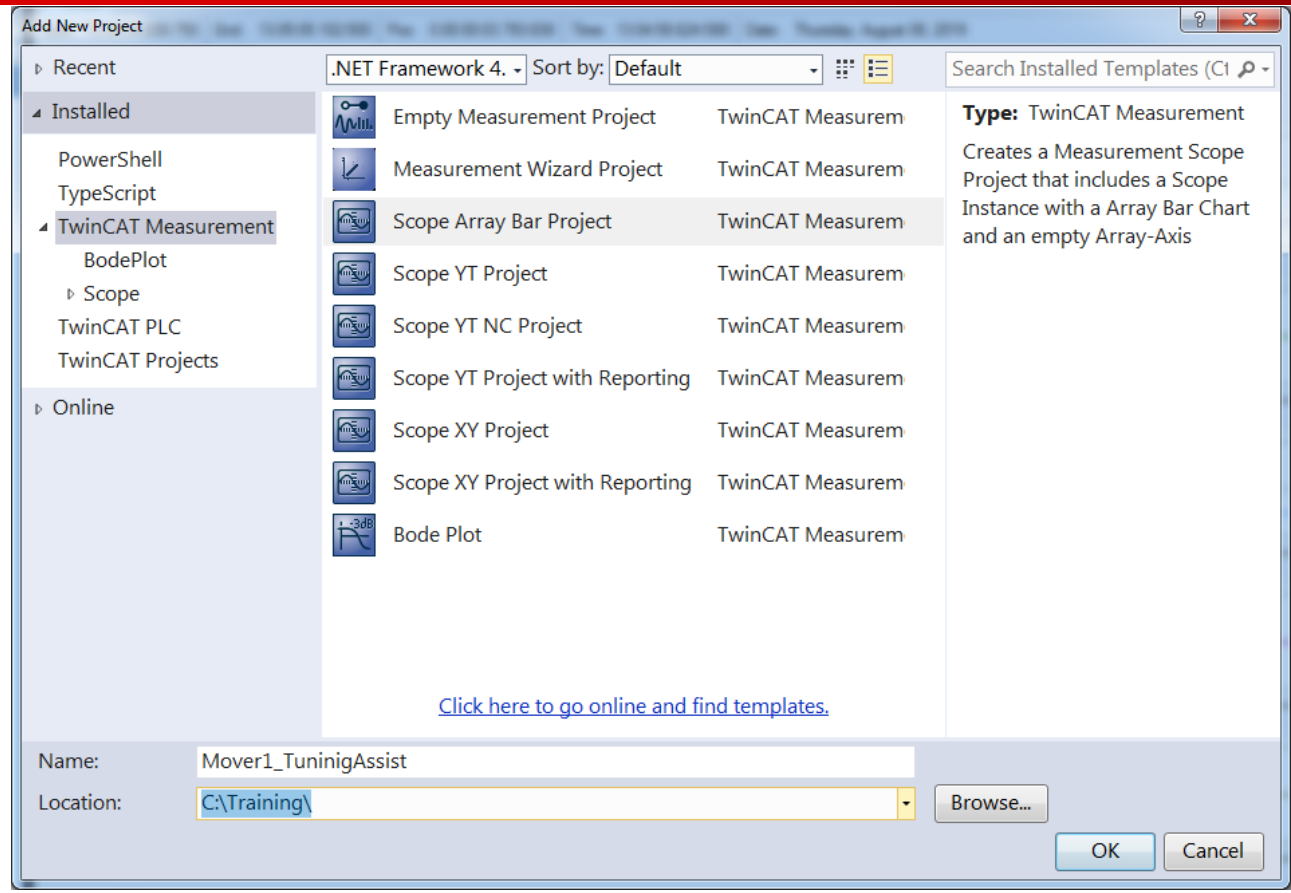
- Activate the configuration and restart TwinCAT



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

Determining Filter Settings using Tuning Assist

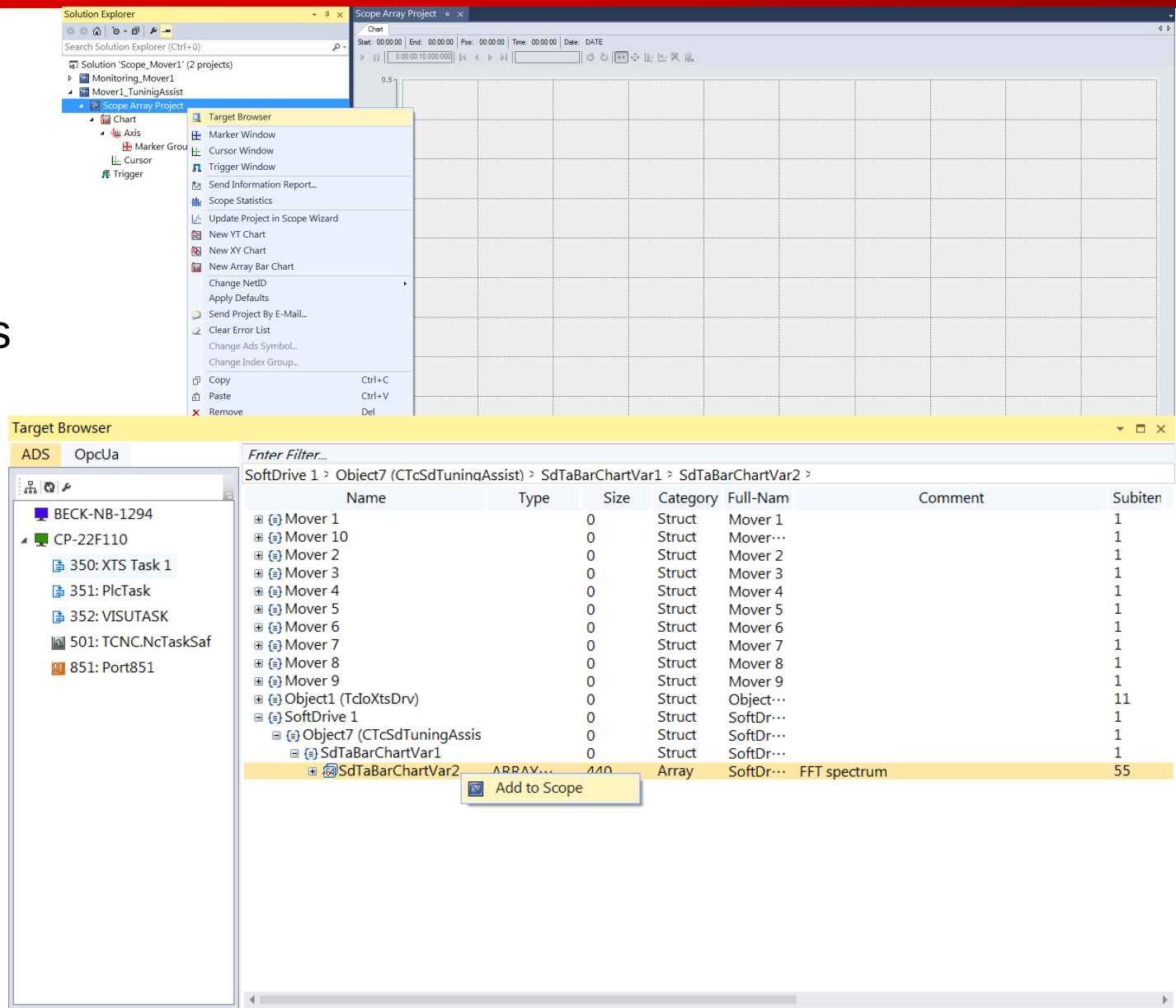
- Create a new measurement project and choose “Scope Array Bar Project” as the type



BECKHOFF

Determining Filter Settings using Tuning Assist

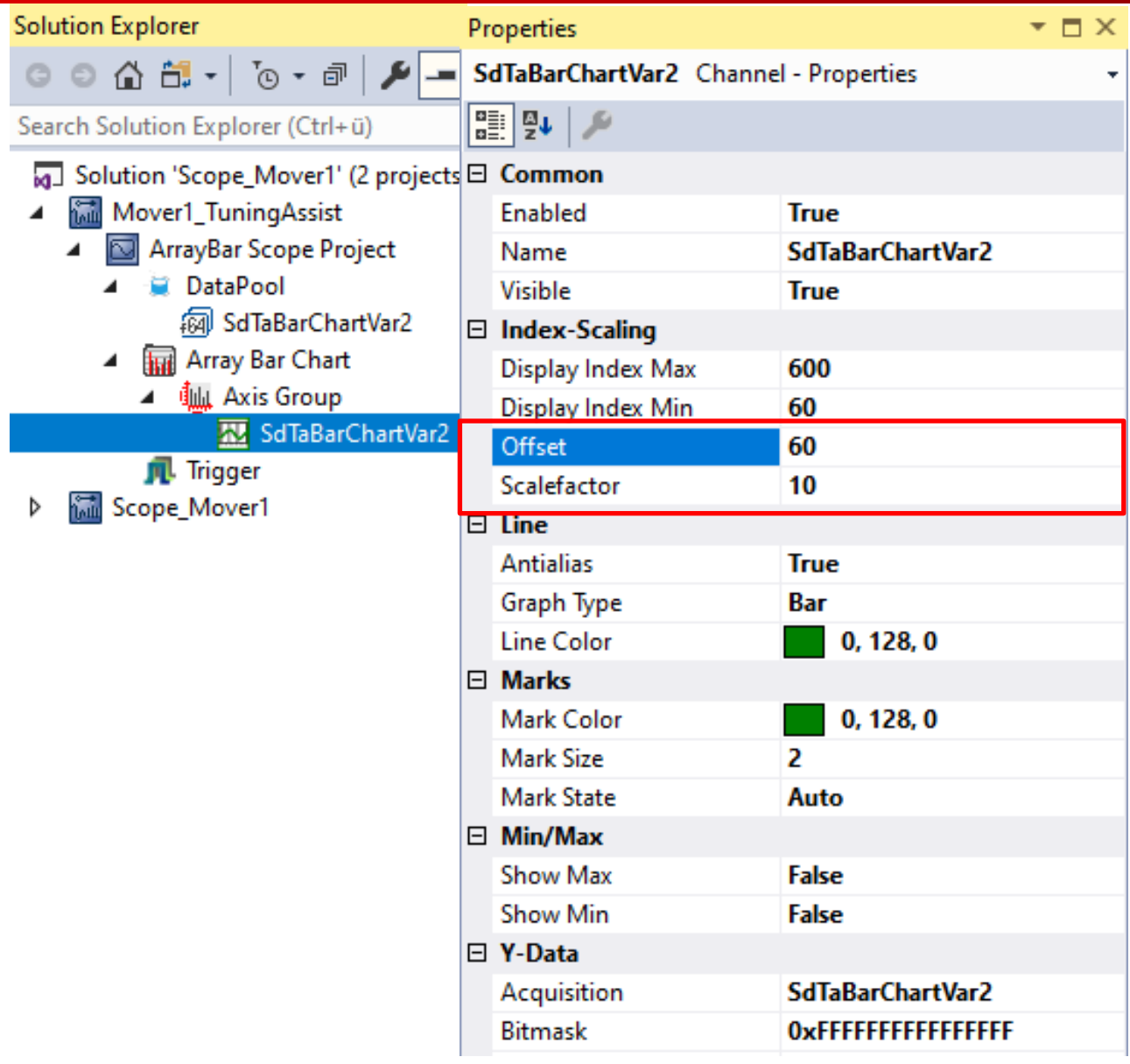
- Add the array variable “SdTaBarChartVar2” to the Scope Axis



Determining Filter Settings using Tuning Assist

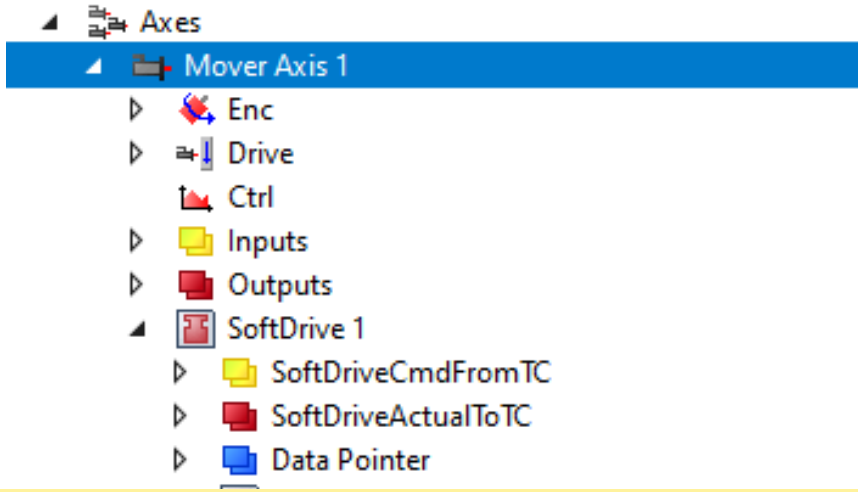
- Set the properties of the variable “SdTaBarChartVar2”:
  - X Offset is set to 60 and
  - X Scale Factor is set to 10

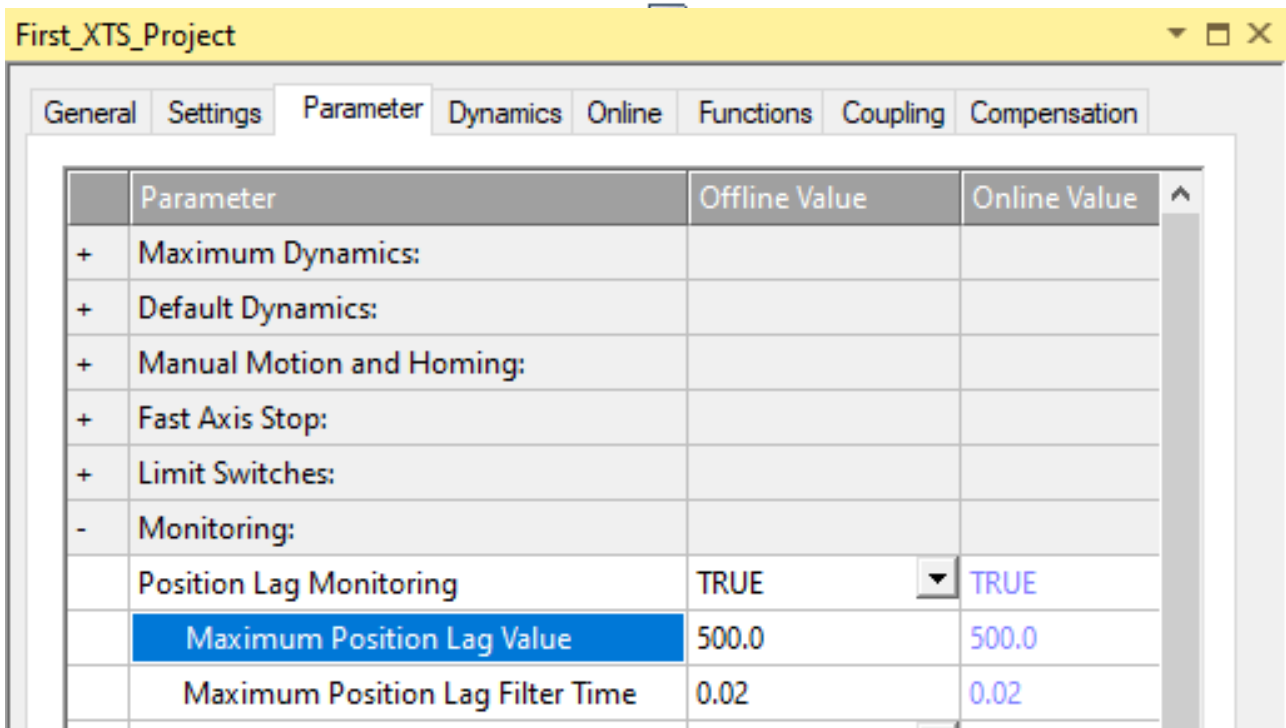
The calculated frequency spectrum by the FFT is always calculated from 60 Hz to 600 Hz in 10 Hz steps



Setup Position Leg Monitoring

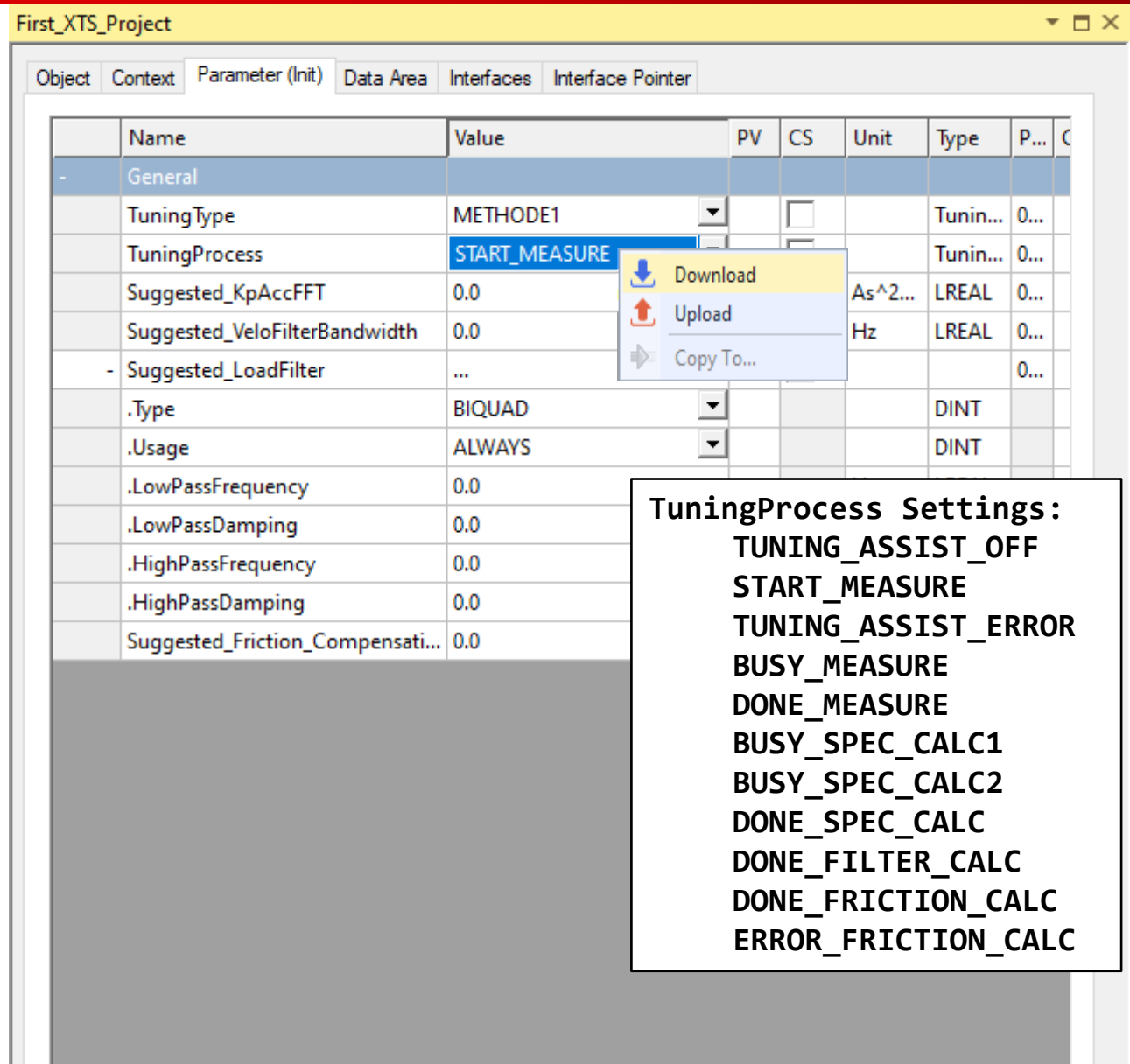
- Set the following error monitoring to a high value e.g. 500mm (or disable it)





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”

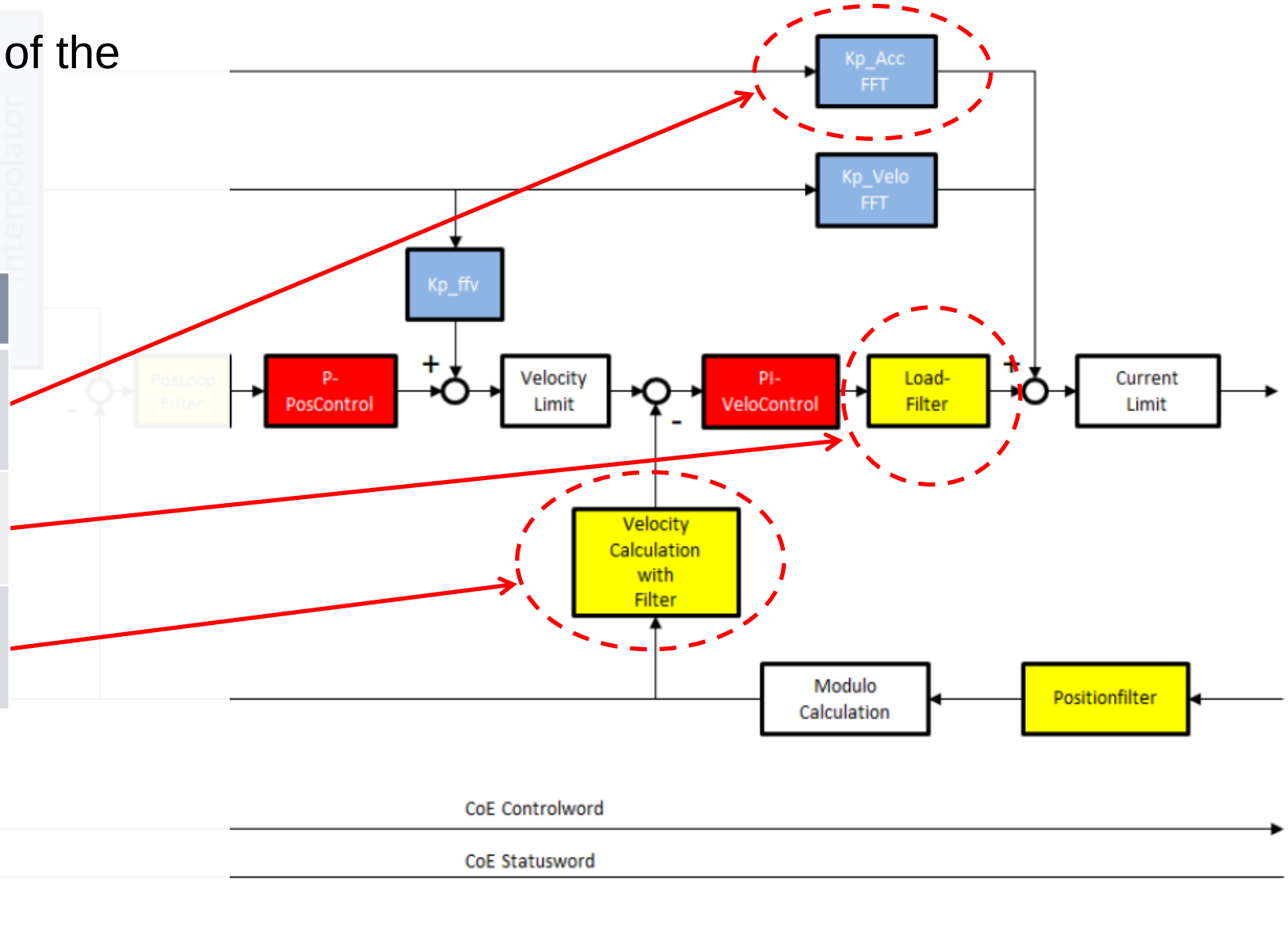


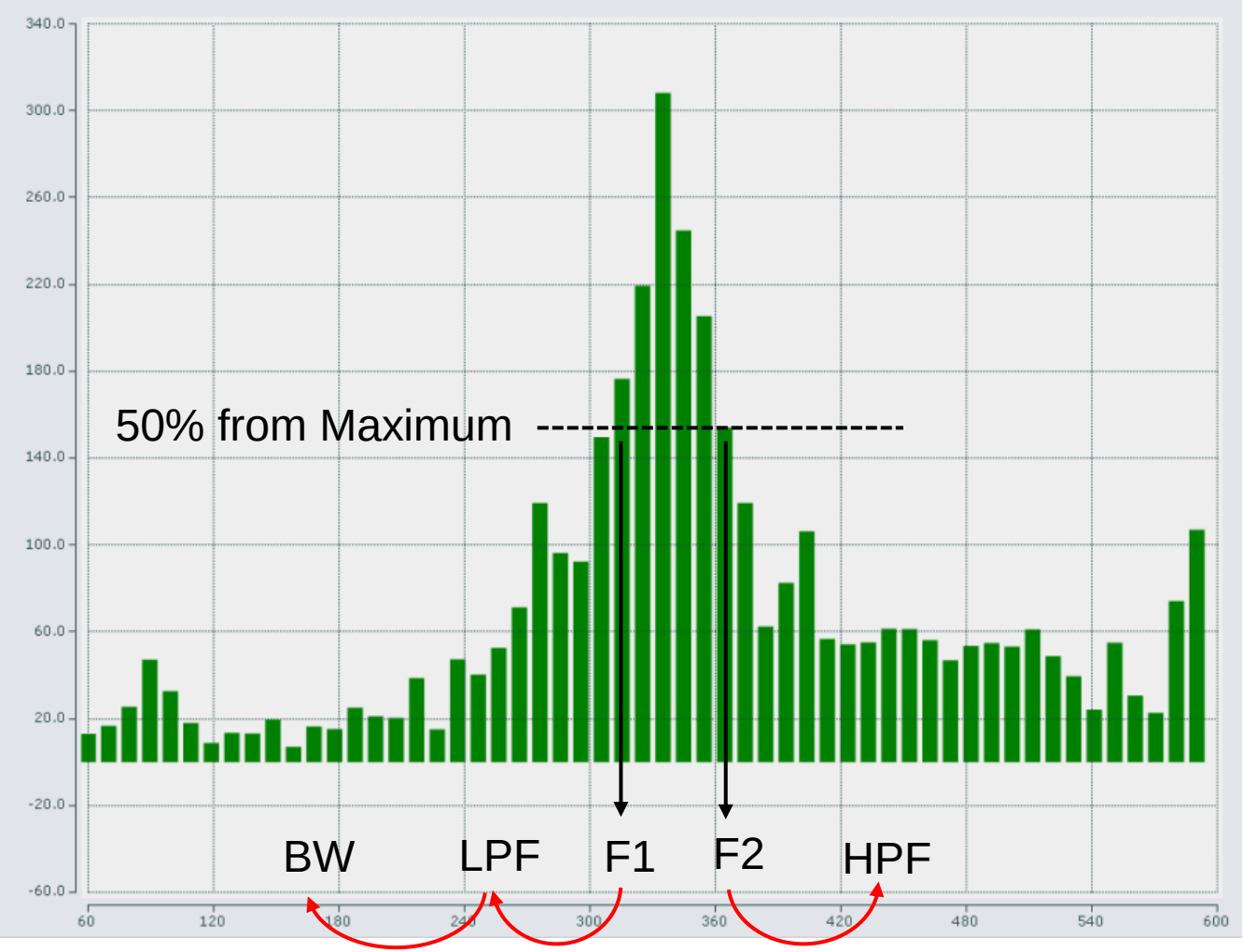
- The Tuning Assist object contain seven parameter

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

- The Suggested parameter of the Tuning Assist

Parameter
Suggested_KpAccFFT
Suggested_LoadFilter
Suggested_VeloFilterBandwidth



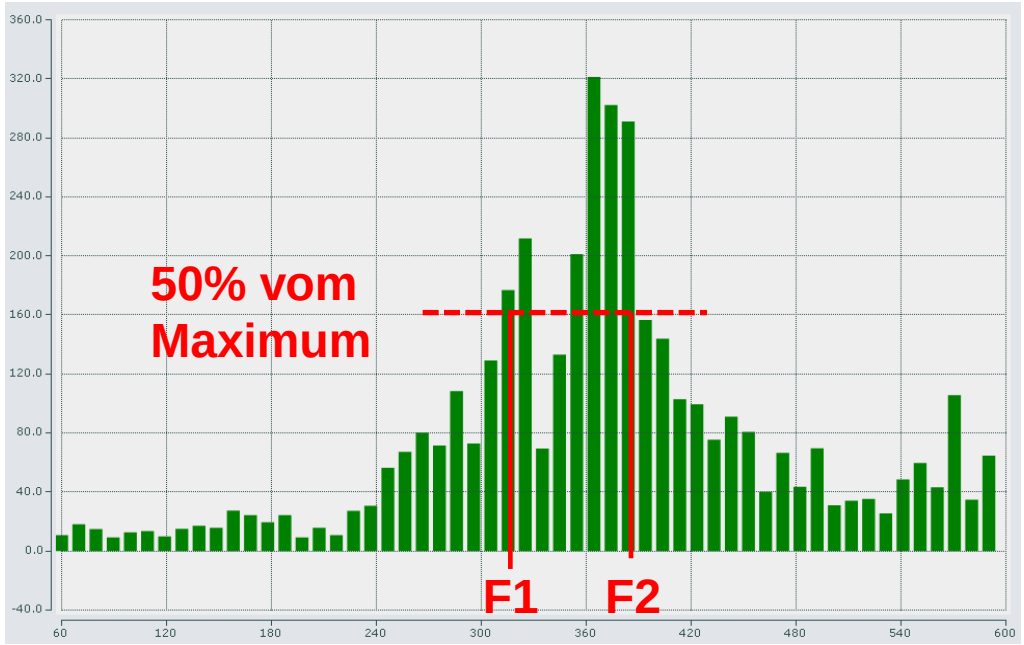


Name	Value
TraceLevelMax	tlAlways
TuningType	METHODE1
TuningProcess	DONE_FILTER_CALC
Suggested_KpAccFFT	1.6
Suggested_VeloFilterBandwidth	146.0
Suggested_LoadFilter	...
.Type	BIQUAD
.Usage	ALWAYS
.LowPassFrequency	256.0
.LowPassDamping	0.6
.HighPassFrequency	437.0
.HighPassDamping	0.3

Result of calculation

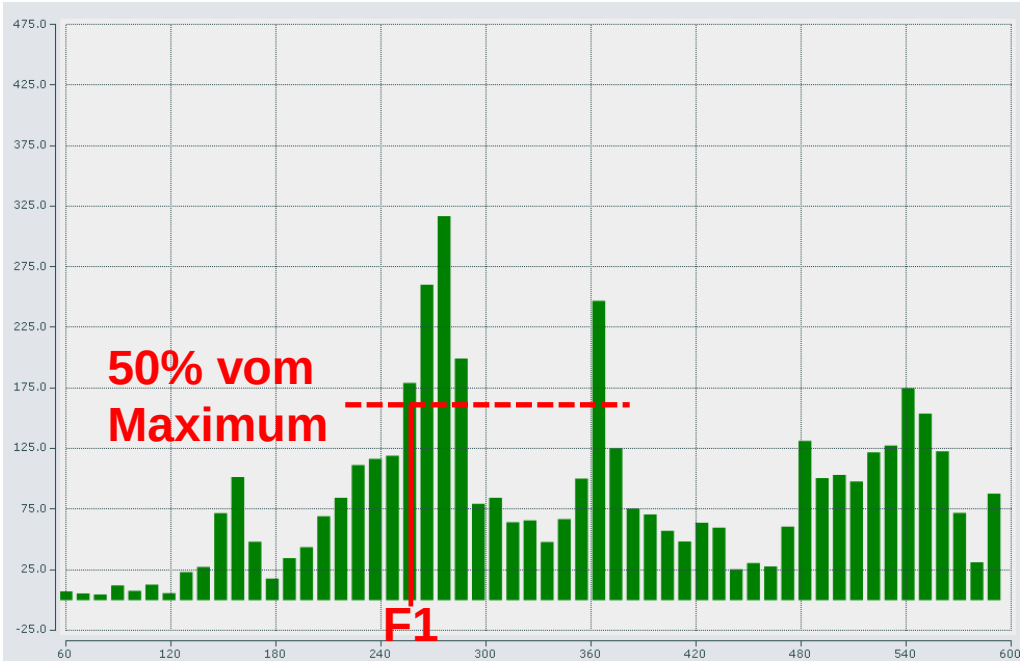
This graphic shows how the calculation for the filter suggestion is done with one FFT result

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



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

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

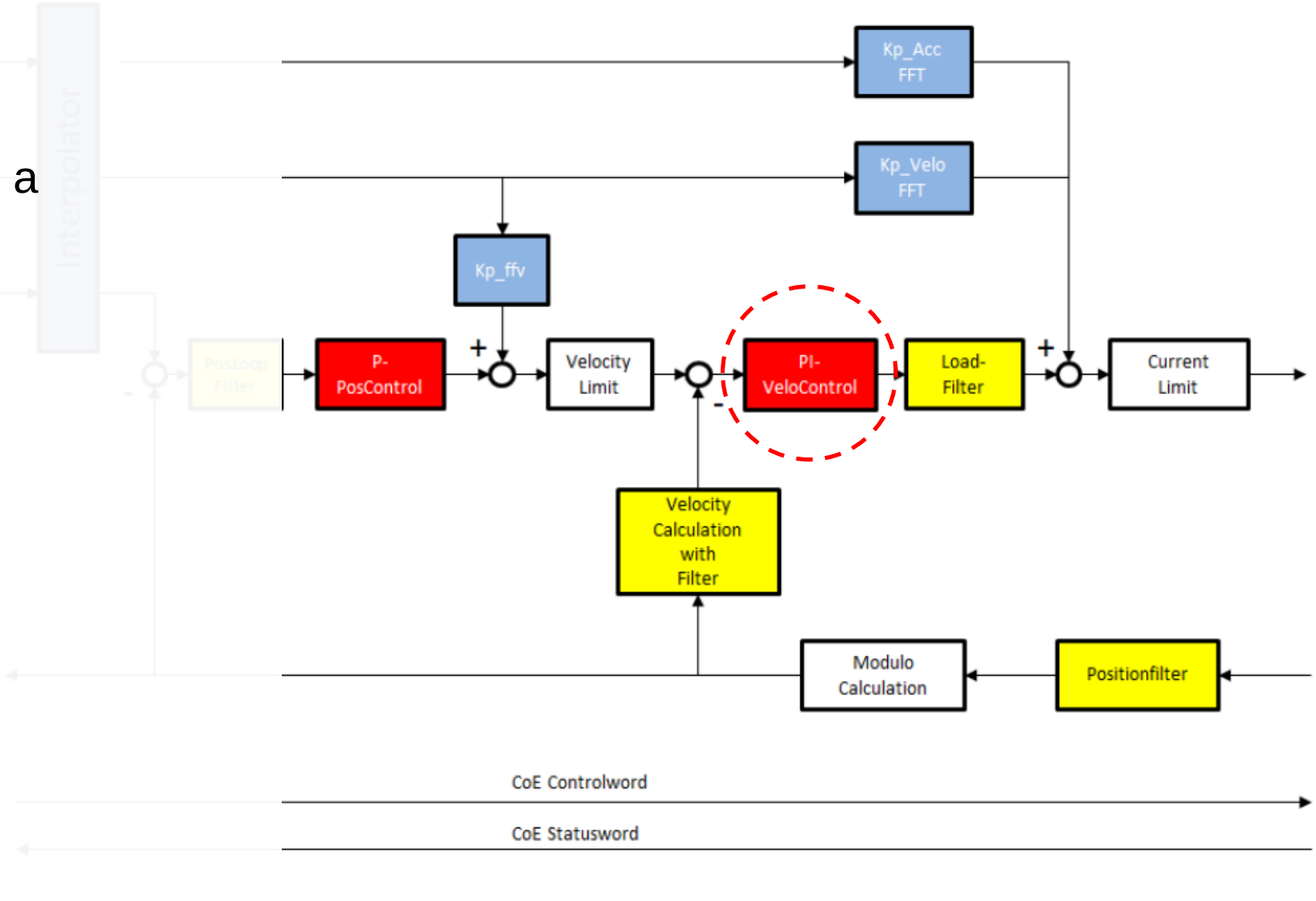


- Steps / Tips for Tuning Assist
  - Enable the NC axis first and set the following error monitoring in the corresponding NC axis to a high value e.g. 500mm (or disable it)
  - Execute some more measurements e.g. three on the straight and three on the curve and maybe also with / without product on the 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 “LowPassFreqeuncy”
    - Use highest value for suggested “HighPassFreqeuncy”

Velocity Control Loop

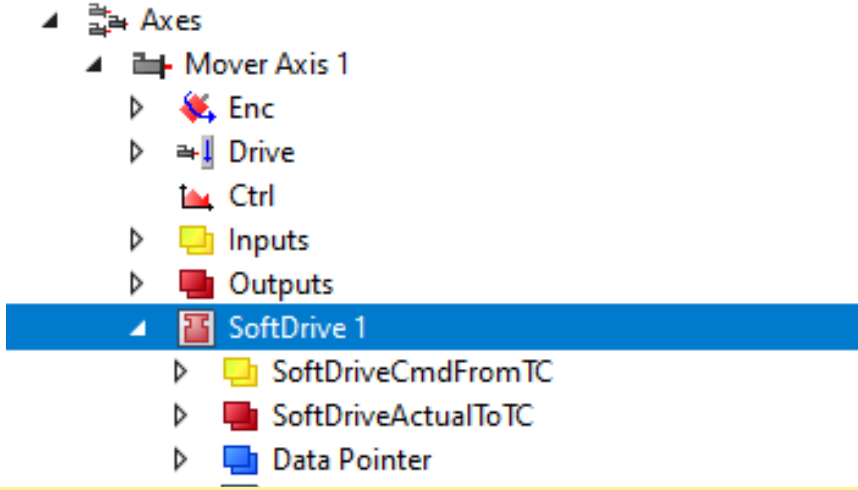
- For velocity control loop a "PI" – Loop is used.
  - Setup Kp
  - Setup Tn

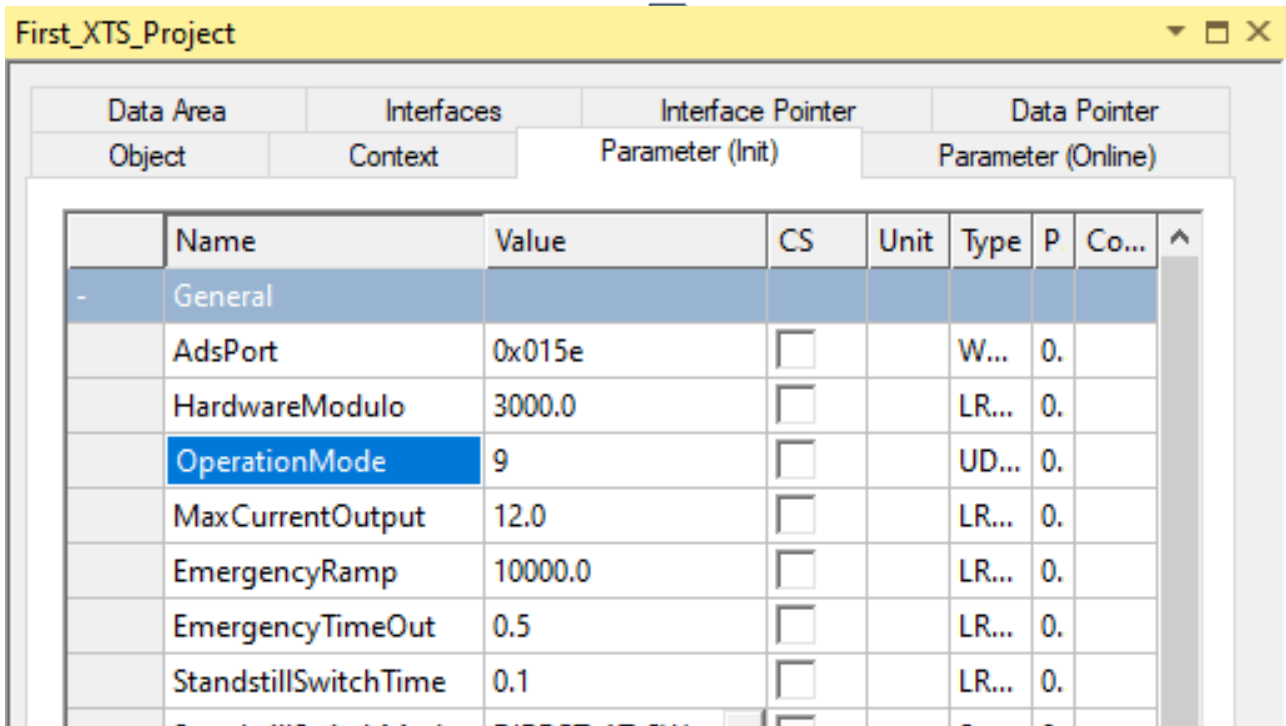


Velocity Control Loop

- Disable or remove the Tuning assist object
  (if not already done)

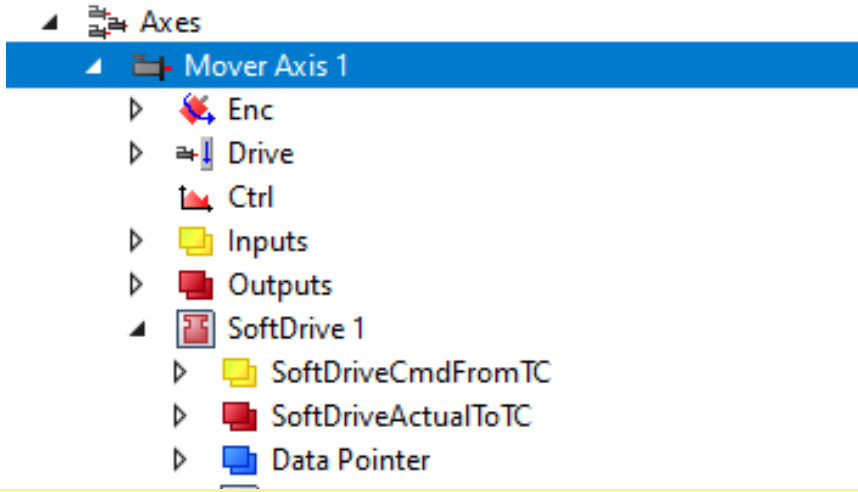
- Set the SoftDrive “OperationMode” parameter in the main object to 9 (cyclic synchronous velocity mode)

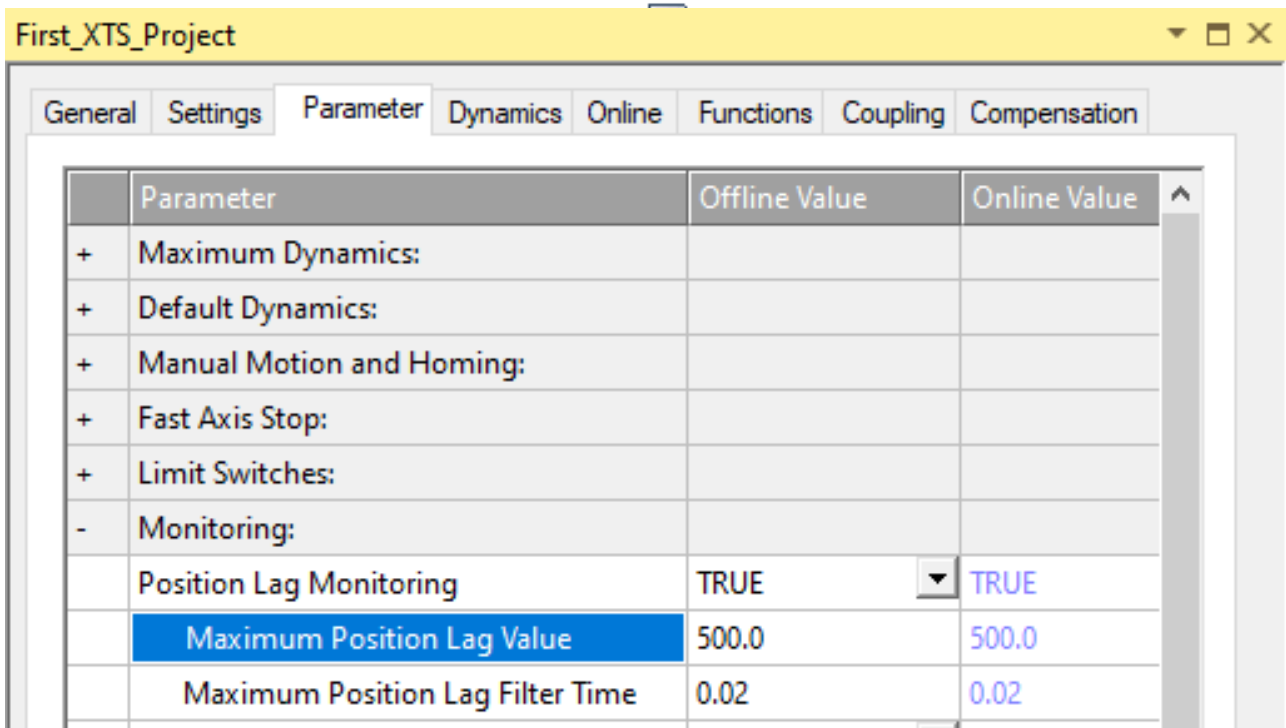




Velocity Control Loop

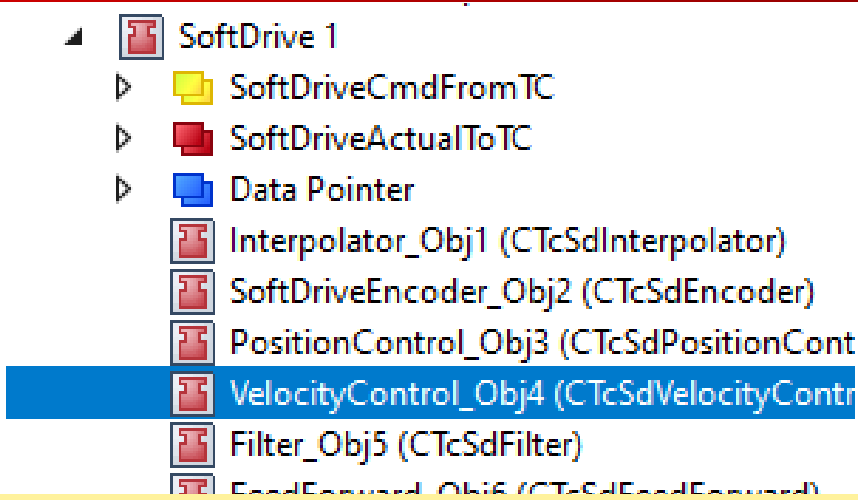
- Set the following error monitoring to a high value e.g. 500mm (or disable it)





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

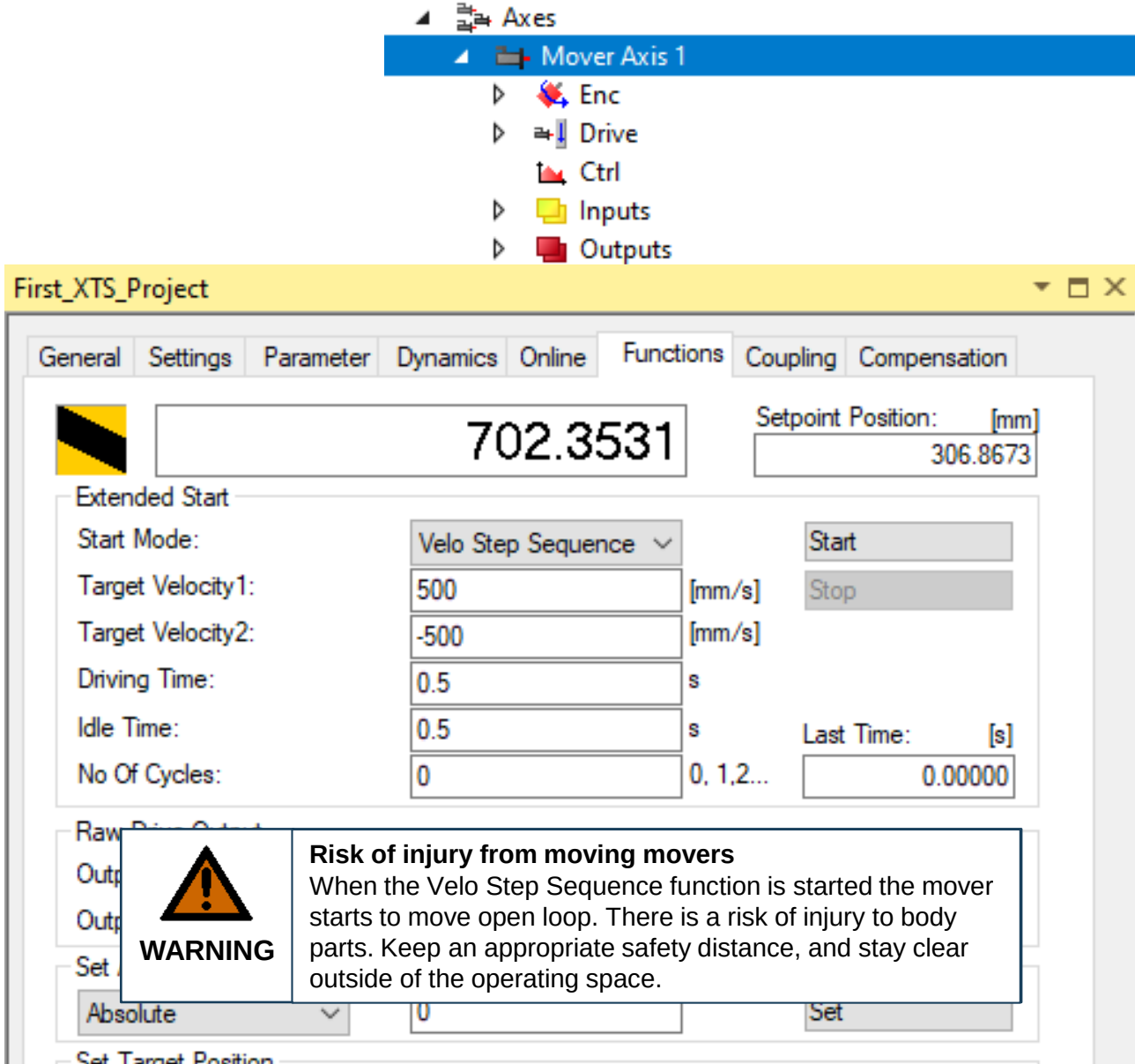
	Name	Value	CS	Unit	Type	P.
-	General					
	VelocityLoopType	PI_VELOCITY_STAN...			Velo...	0..
	Kp	0.05		As/r...	LREAL	0..
	Kp_standstill	0.033		As/r...	LREAL	0..
	Kp_area	0.04		As/r...	LREAL	0..
	Kp_area_standstill	0.03		As/r...	LREAL	0..
	Tn	0.05		s	LREAL	0..
	Tn_standstill	0.05		s	LREAL	0..
	Tn_area	0.05		s	LREAL	0..
	Tn_area_standstill	0.05		s	LREAL	0..

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)



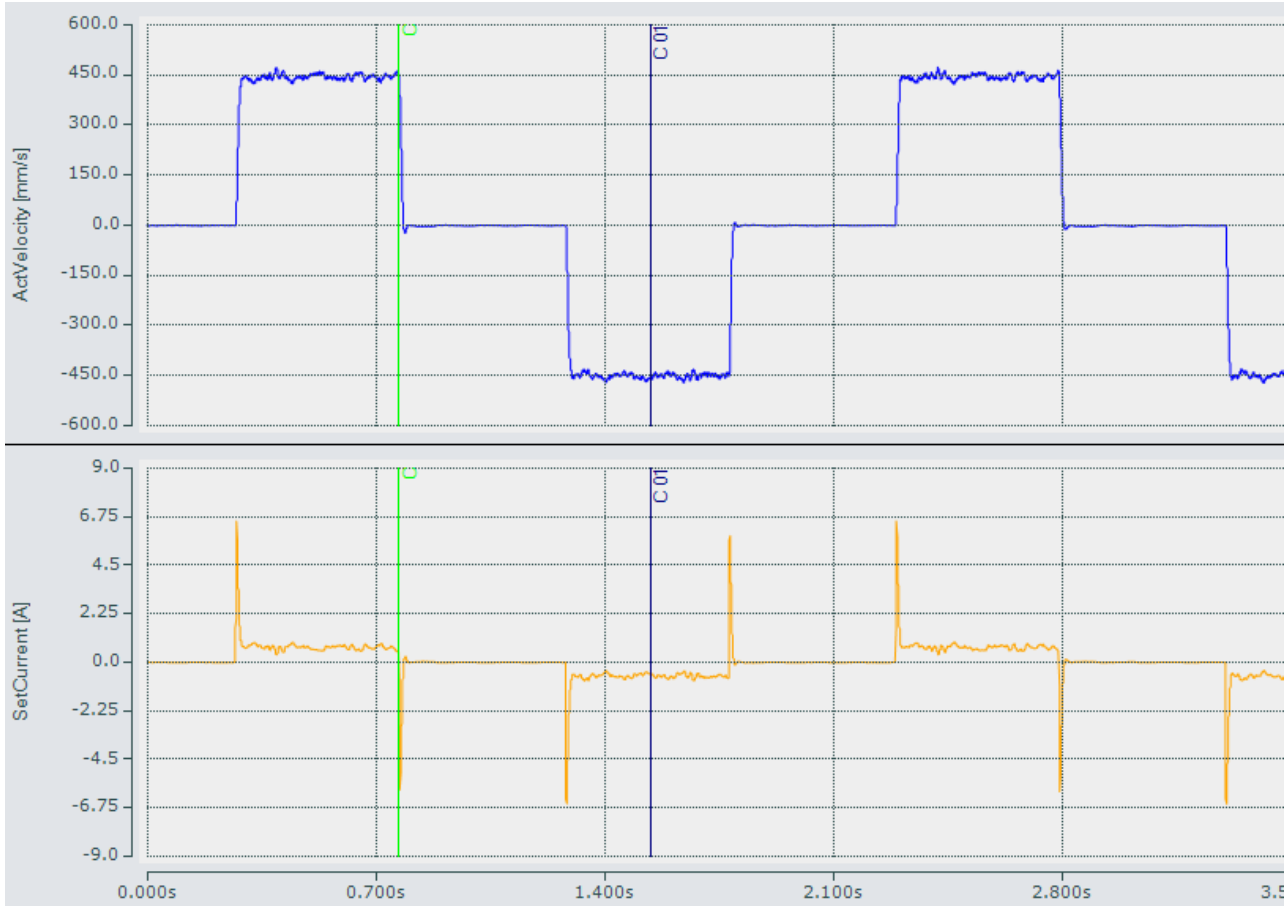
Velocity Control Loop

- 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

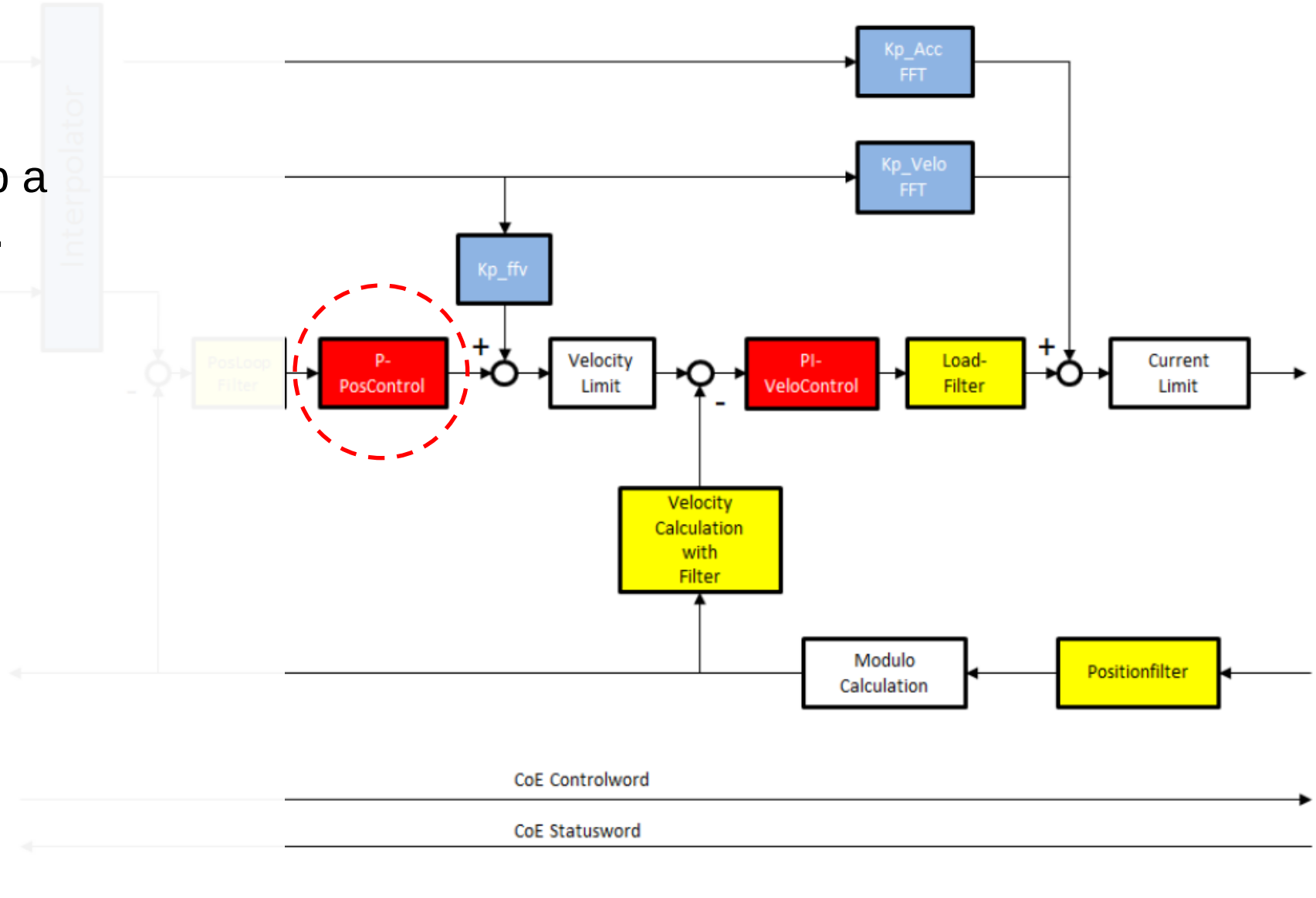
Velocity Control Loop

- 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

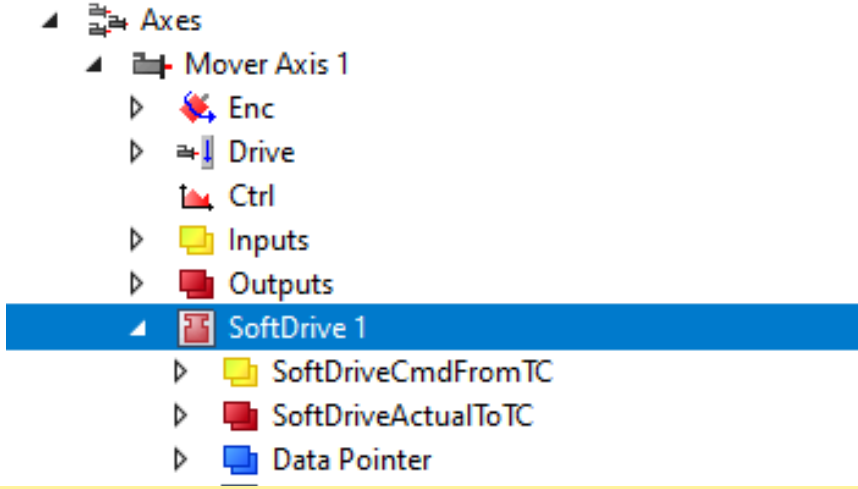
Position Control Loop

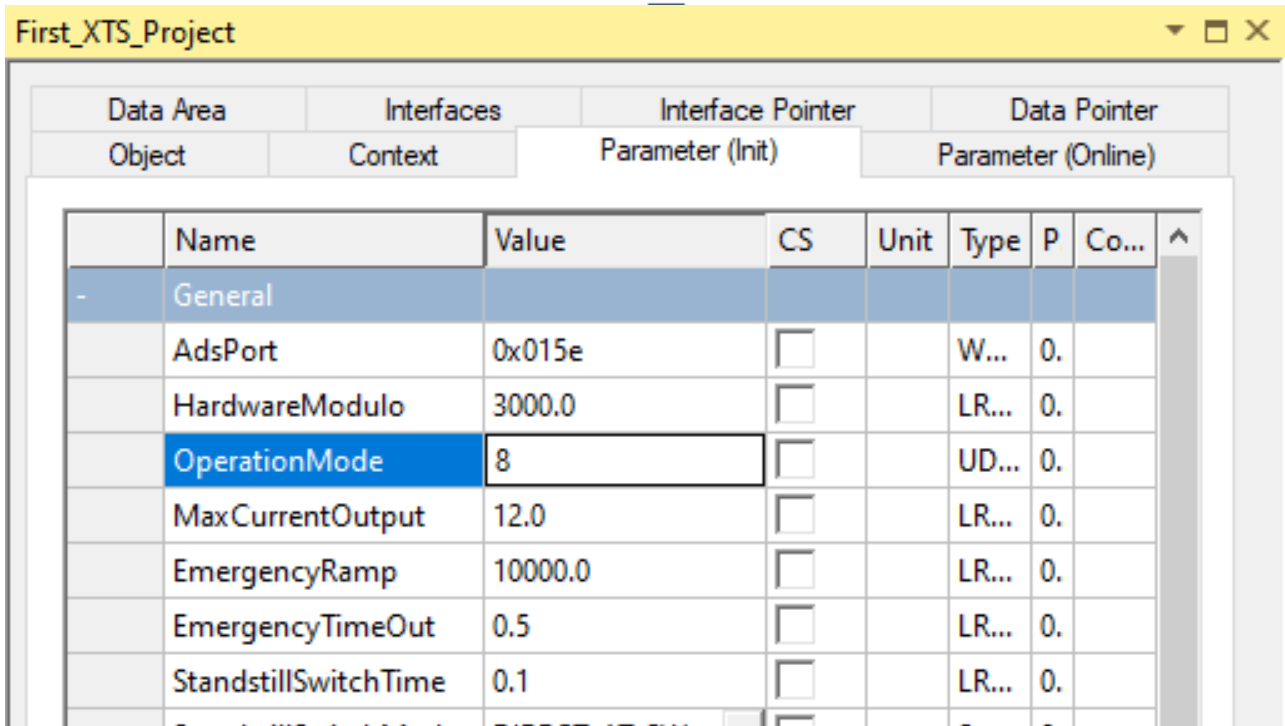
- For position control loop a "P" – Controler is used.
  - Setup Kp



Position Control Loop

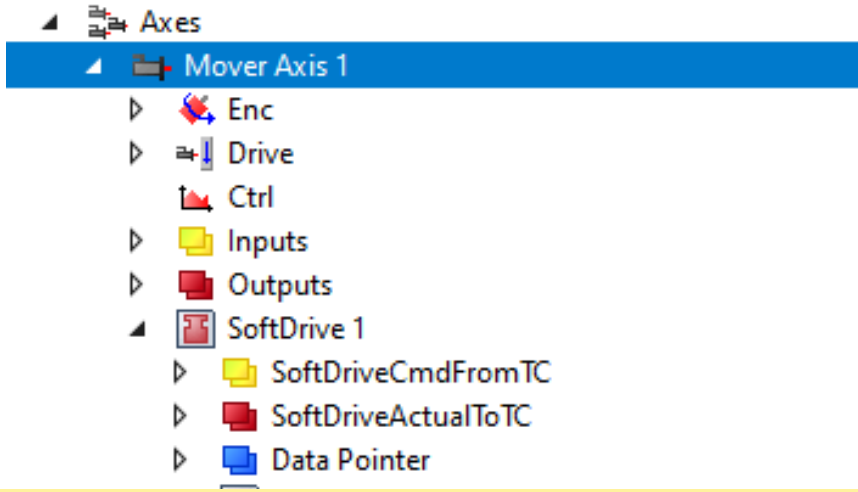
- Set the SoftDrive “OperationMode” parameter in the main object to 8 (cyclic synchronous position mode)

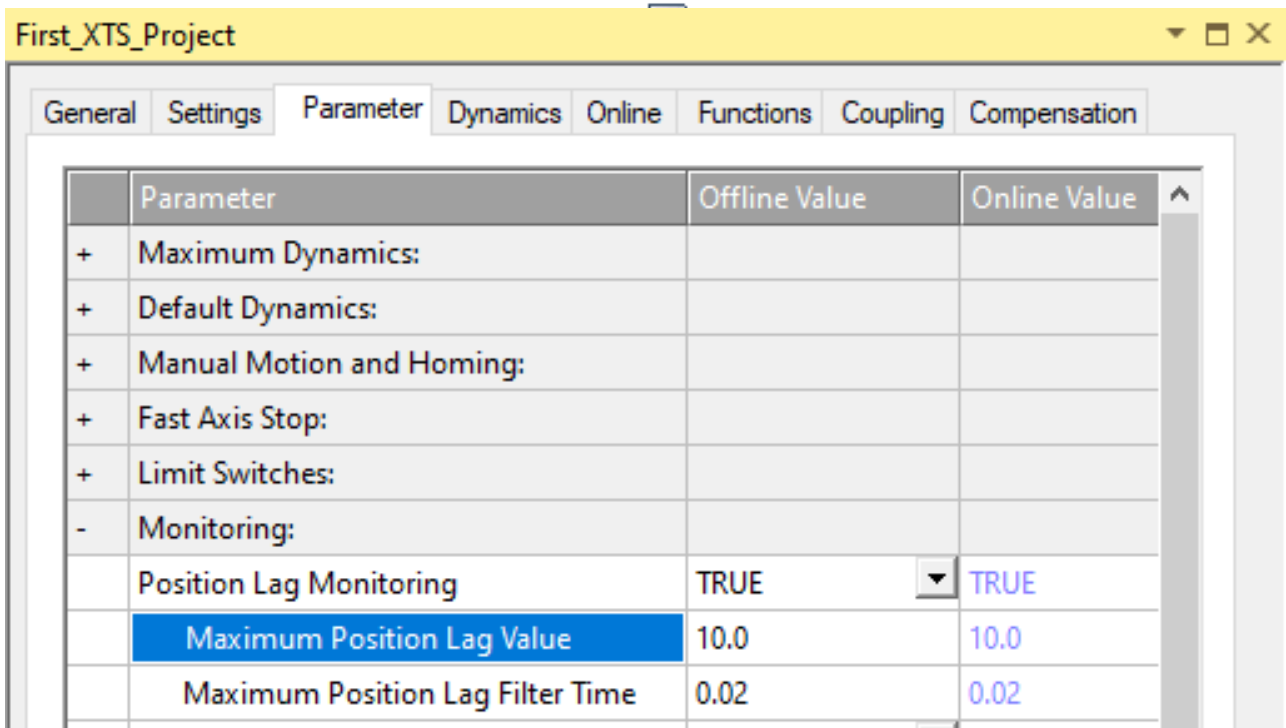




Position Control Loop

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

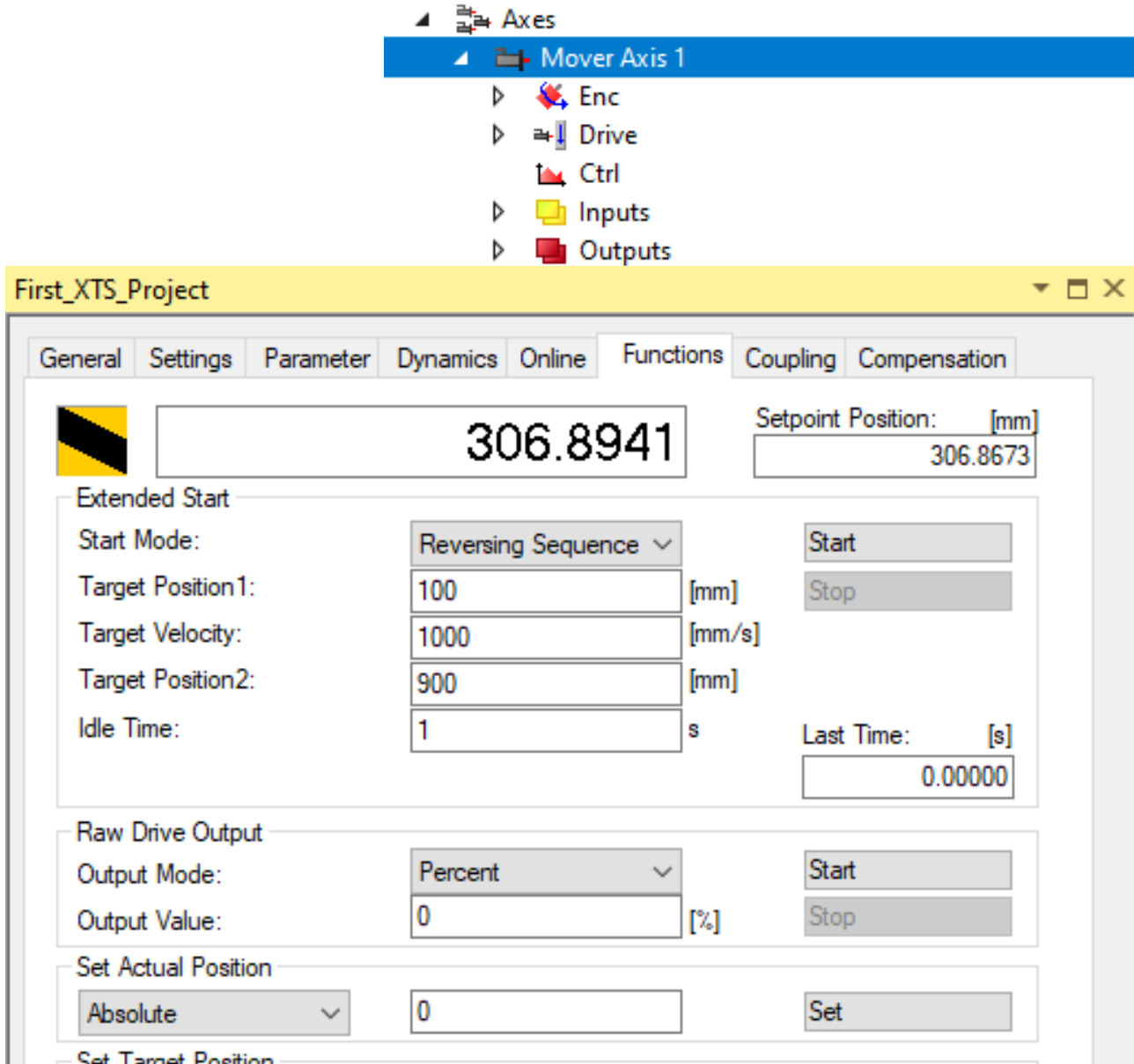




Position Control Loop

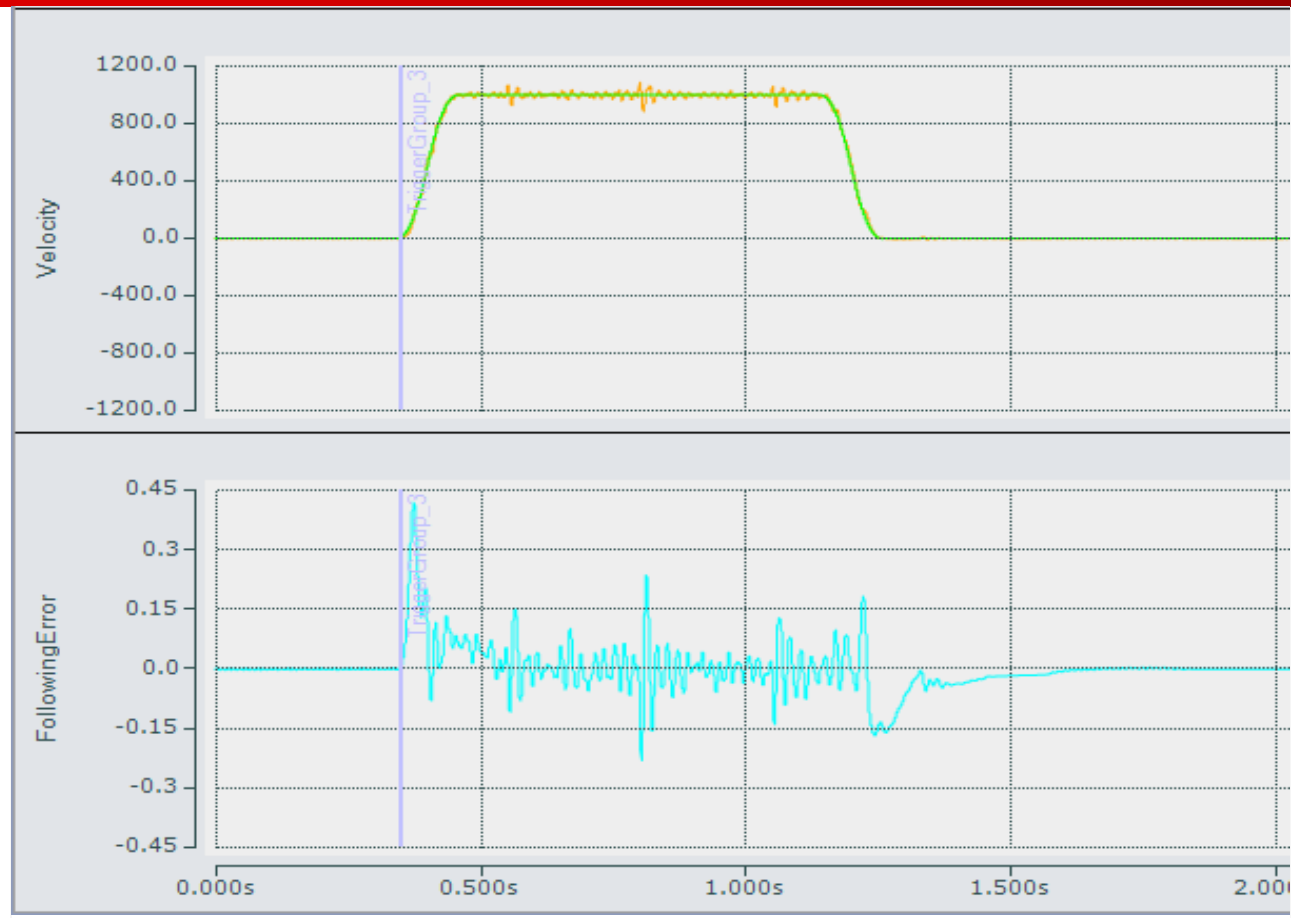
- Enable the NC axis
  and start the service mode
  “Reversing Sequence” with
  achievable (or necessary) values for
  velocity, acceleration and jerk

- 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



BECKHOFF

Complex sequences – simplified solution: XTS

Training material

BECKHOFF

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

Contact

BECKHOFF

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