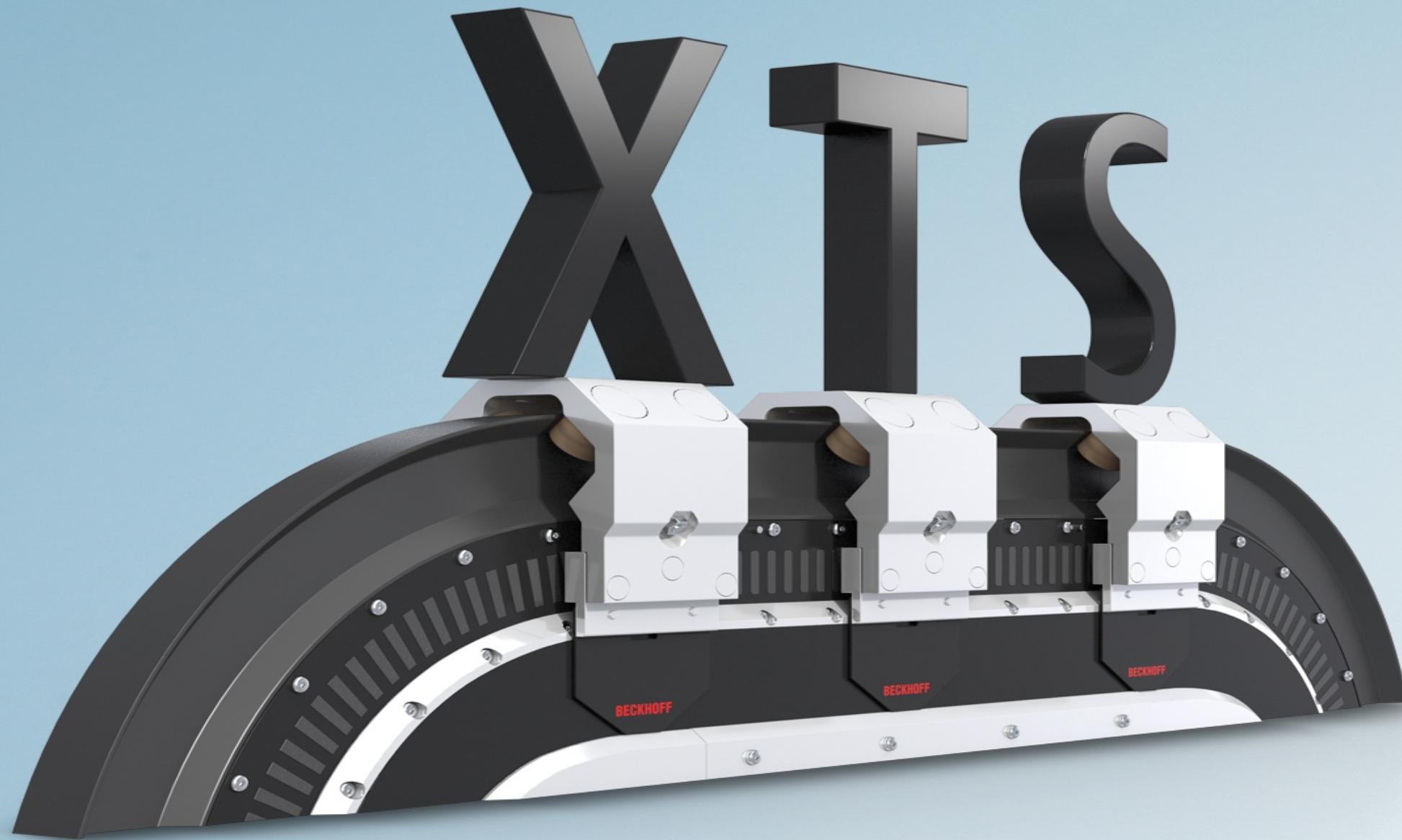


New Automation Technology

Beckhoff Automation

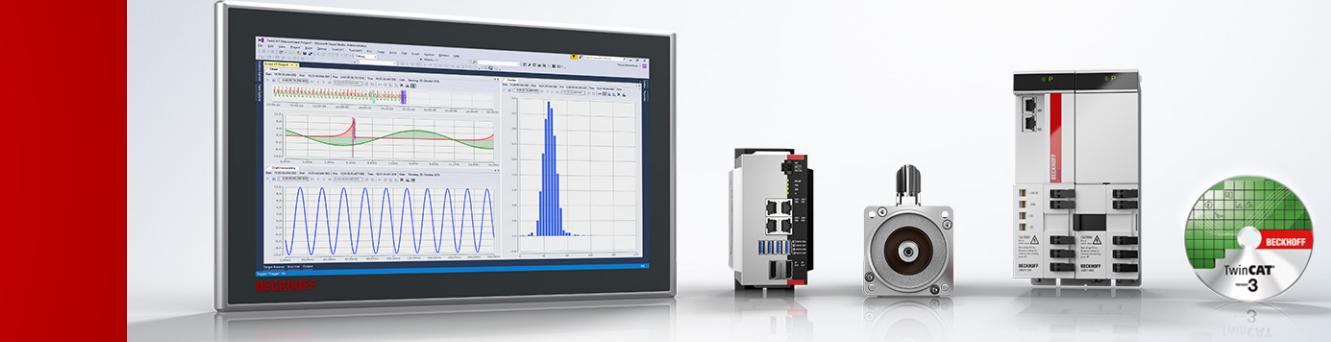
BECKHOFF





BECKHOFF

XTS – TcSoftDrive

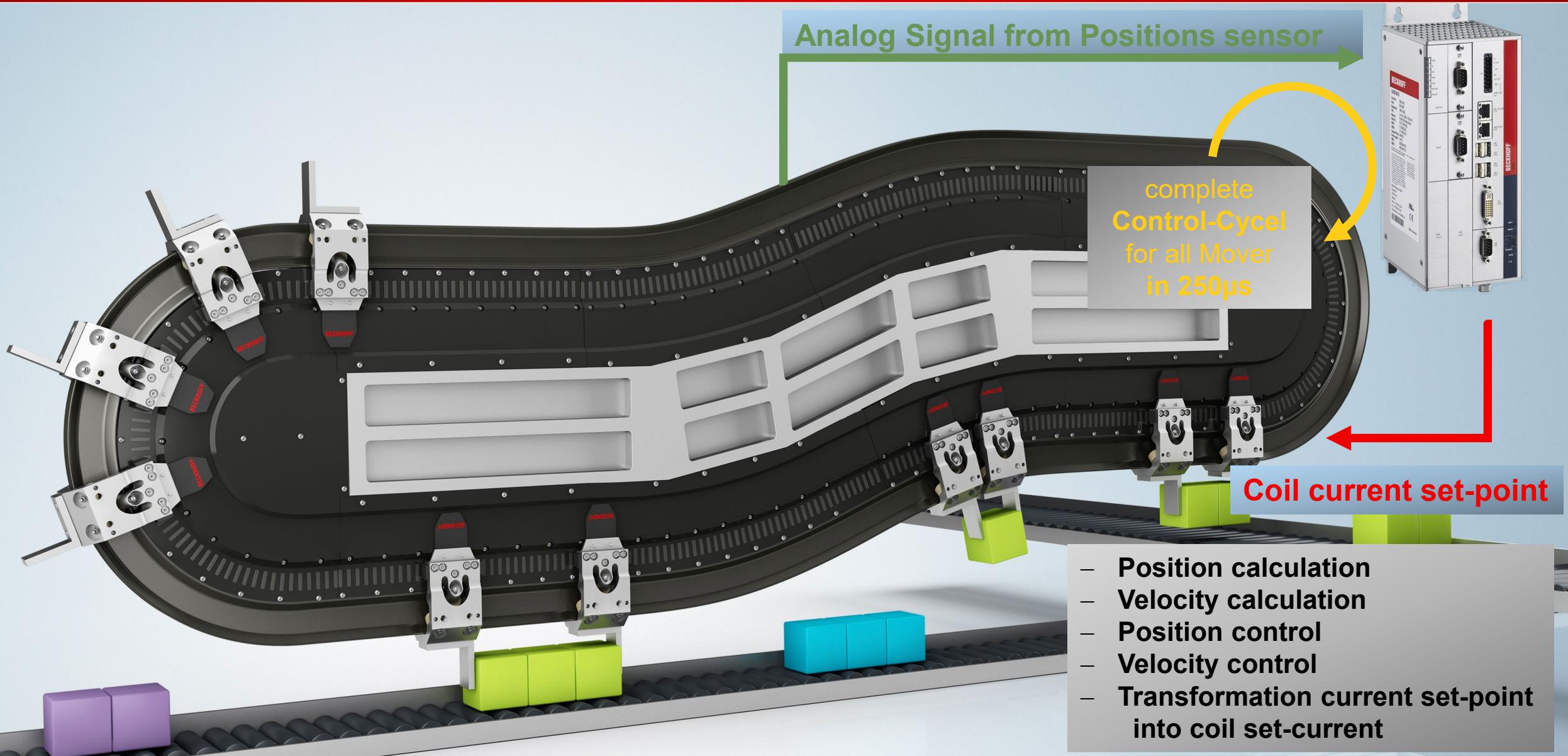


1. Short XTS basics
2. XTS Accuracy
3. XTS IPC & capabilities
4. Scope for
Mover monitoring
5. TcSoftdrive
structure & parameter
6. Tuning



XTS – Overview and timing

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each Motor module has

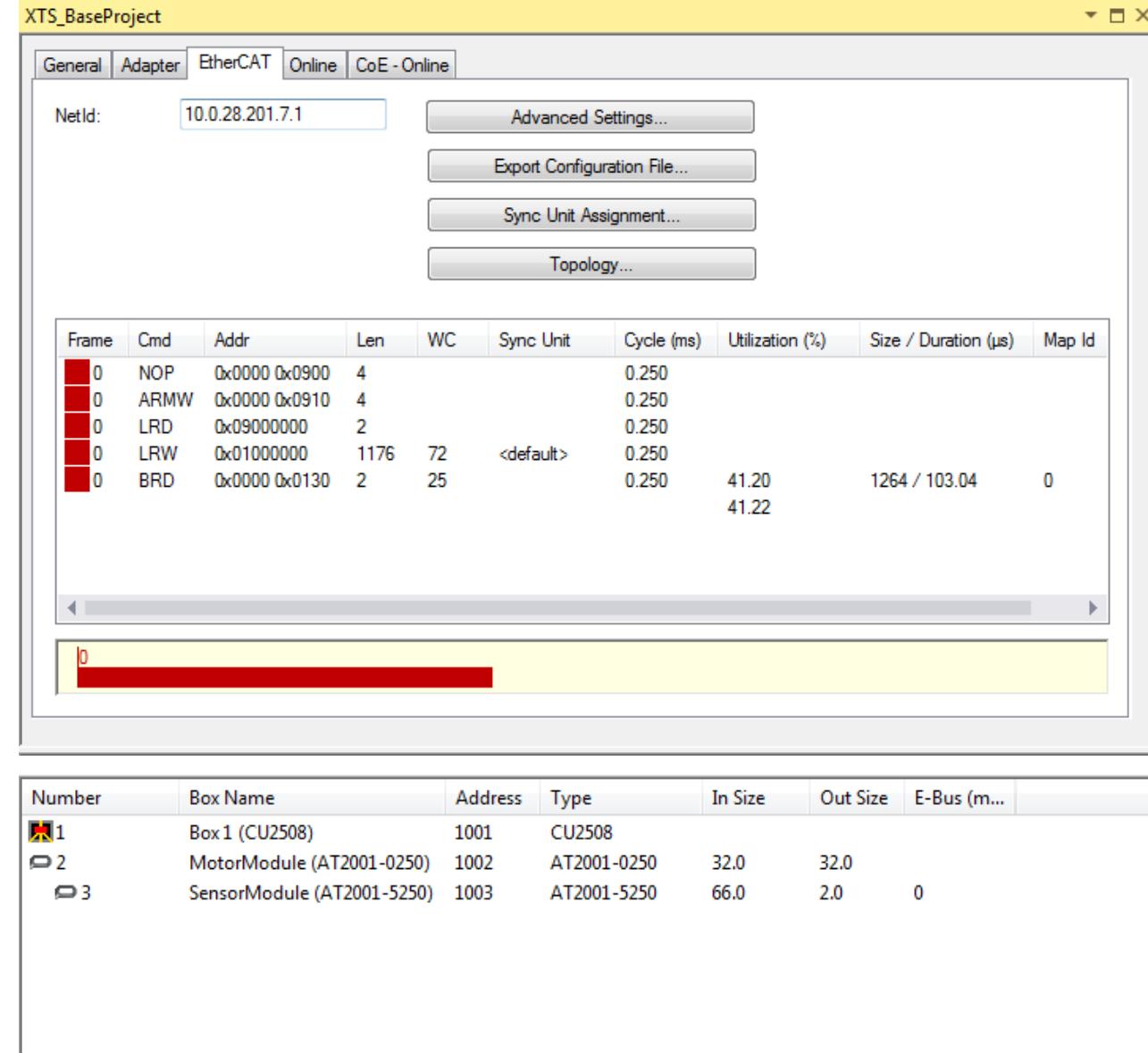
- 15 Coils → 15 current set-values
→ 15 current act-values
- 2 Byte Status & 2 Byte Control
→ 32 Byte Process Image

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

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per Frame max. data size of 1500 Byte

per Module (Motor & Sensor)

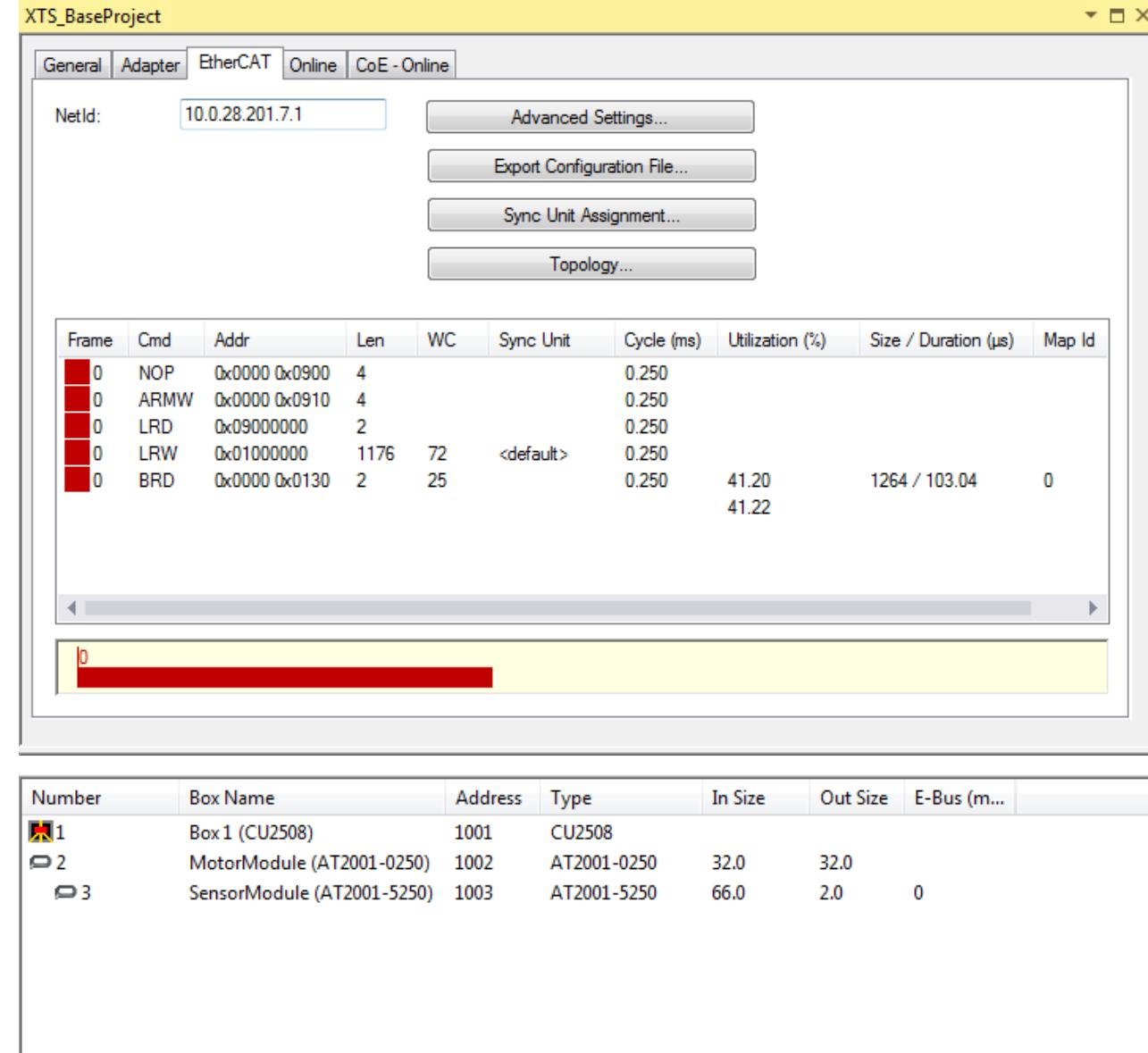
data size of 98 Byte

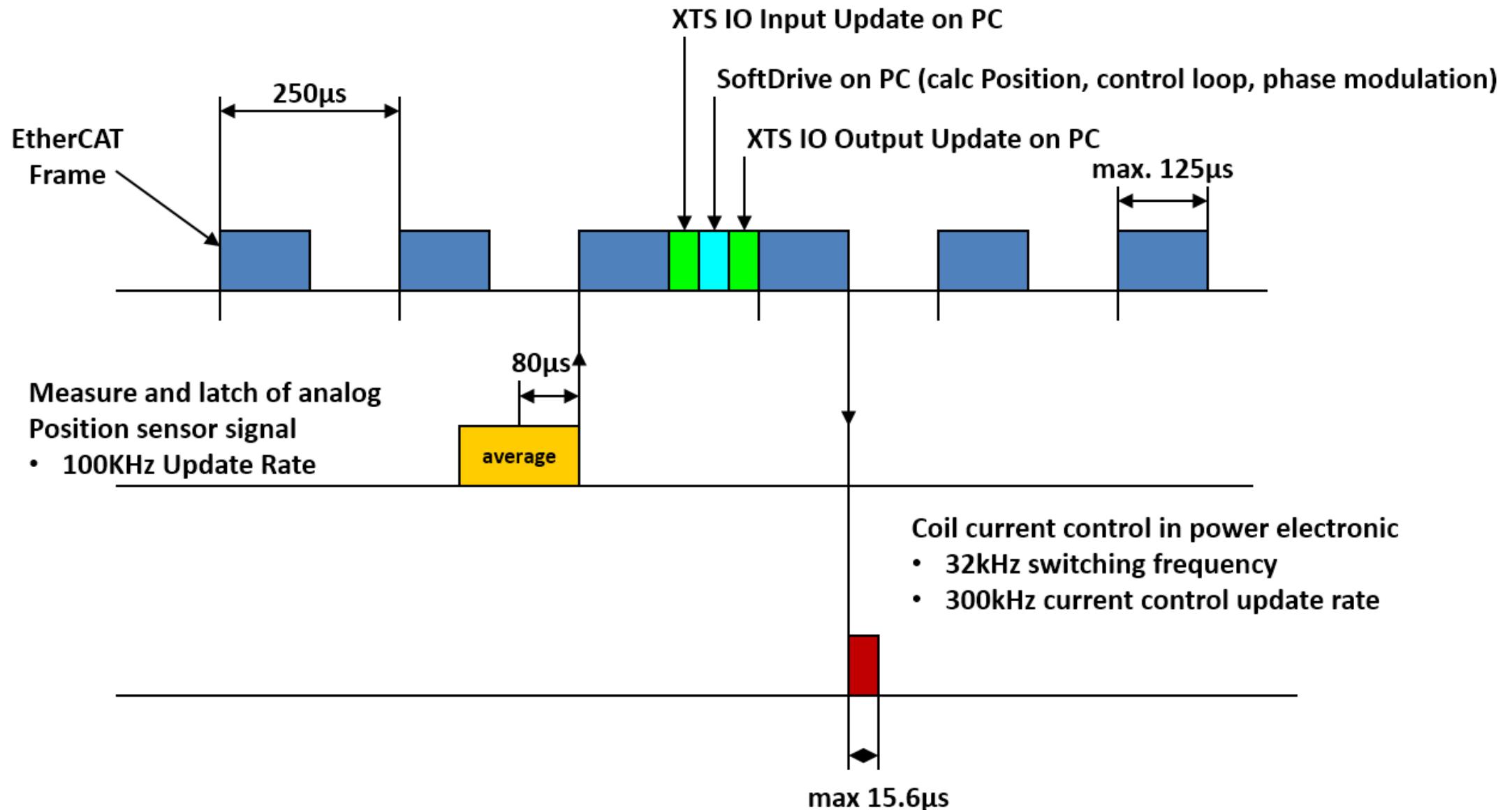
3m XTS-Track → 12 Modules

12 x 98 Byte = 1176 Byte Data

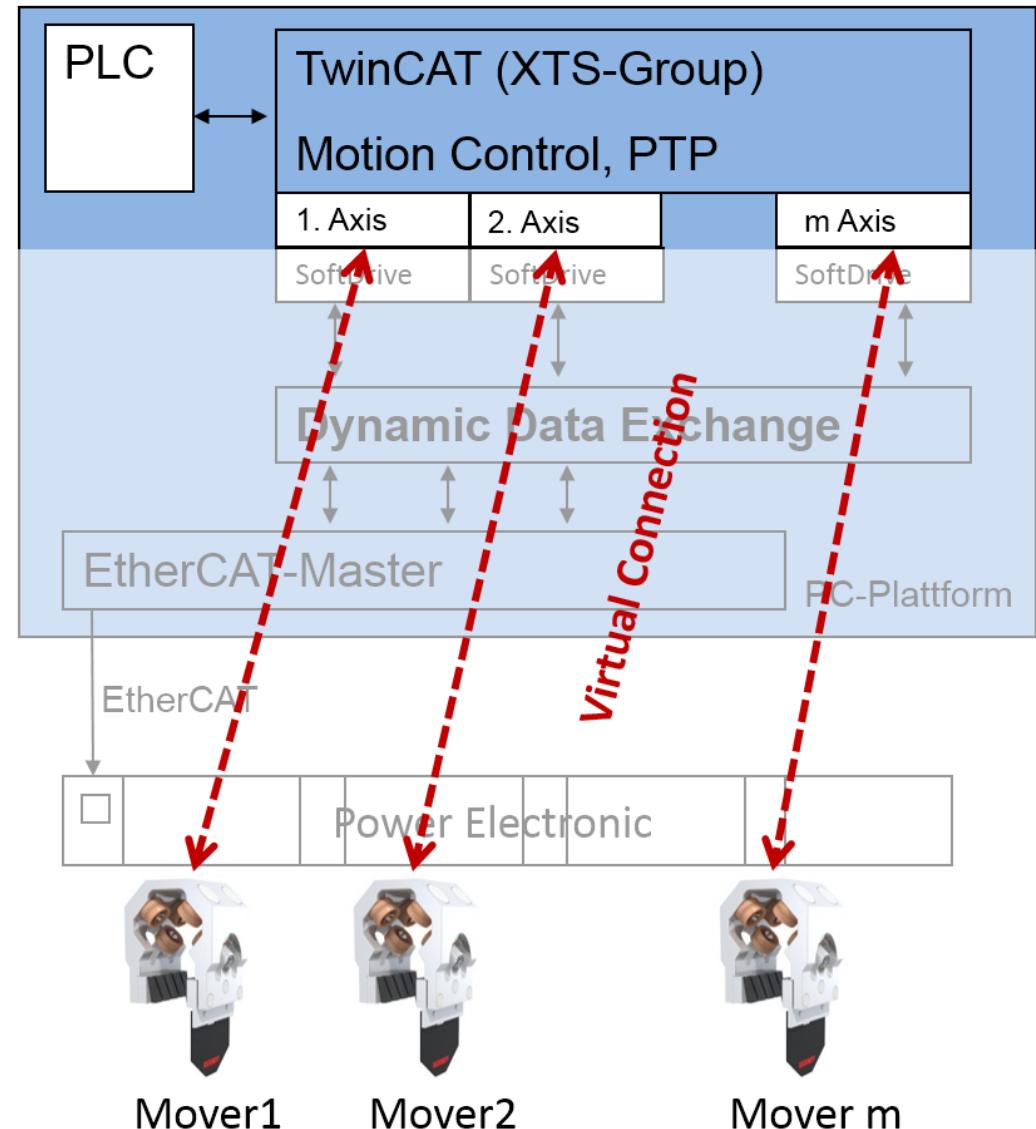
Full Frame size = 1264 Byte Data

Frame runtime = 103 µs





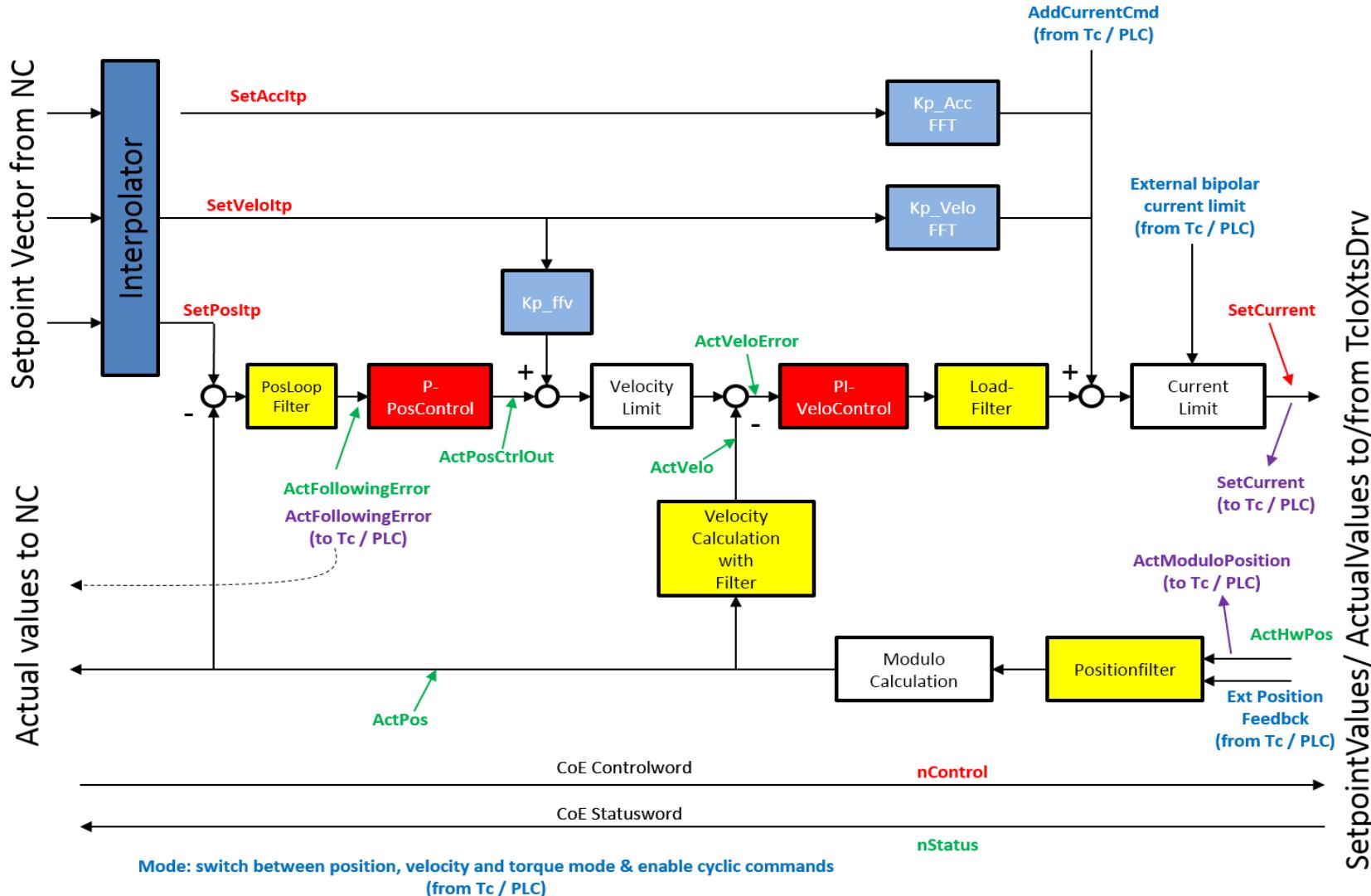
- From the point of view of application programming, a mover looks like a „standard“ servo NC axis.
- New standard tasks are available:
 - Collision avoidance CA
 - Group building
 - Synchronous mechanisms
- Runs on powerful Beckhoff Standard IPCs with EtherCAT-Port
- Simulation mode is possible for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



XTS – TcSoftDrive control loop structure

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



1. Short XTS basics
2. **XTS Accuracy**
3. XTS IPC & capabilities
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Ideal Positioning

Start Position Target Position



High Accuracy
High Repeatability



Low Accuracy
High Repeatability



Low Accuracy
Low Repeatability



→ Low accuracy with high repeatability
can be compensated.

→ Low repeatability cannot be
compensated

XTS - Position Accuracy (Sensor Rev. 18)

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| XTS Datasheet | |
|-----------------------------------|--|
| Absolute Position Accuracy | $\pm 250\mu\text{m}$ (within one straight Module) * |
| Tested but not specified Accuracy | |
| Achievable Position Accuracy | $\pm 150\mu\text{m}$ (within one straight Module) ** |

* Typical achievable absolute accuracy, this can become larger due to thermal expansion of the module ($\Delta\theta \geq 30^\circ\text{C}$) 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 ($\Delta\theta \leq 15^\circ\text{C}$)

| XTS Datasheet | |
|---|---|
| Position accuracy while at speed | $\pm 150\mu\text{m}$ @ 1.5m/s (in a straight module) * |
| Tested but not specified Accuracy | |
| Position accuracy while at speed in the curve | $\pm 400\mu\text{m}$ @ 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

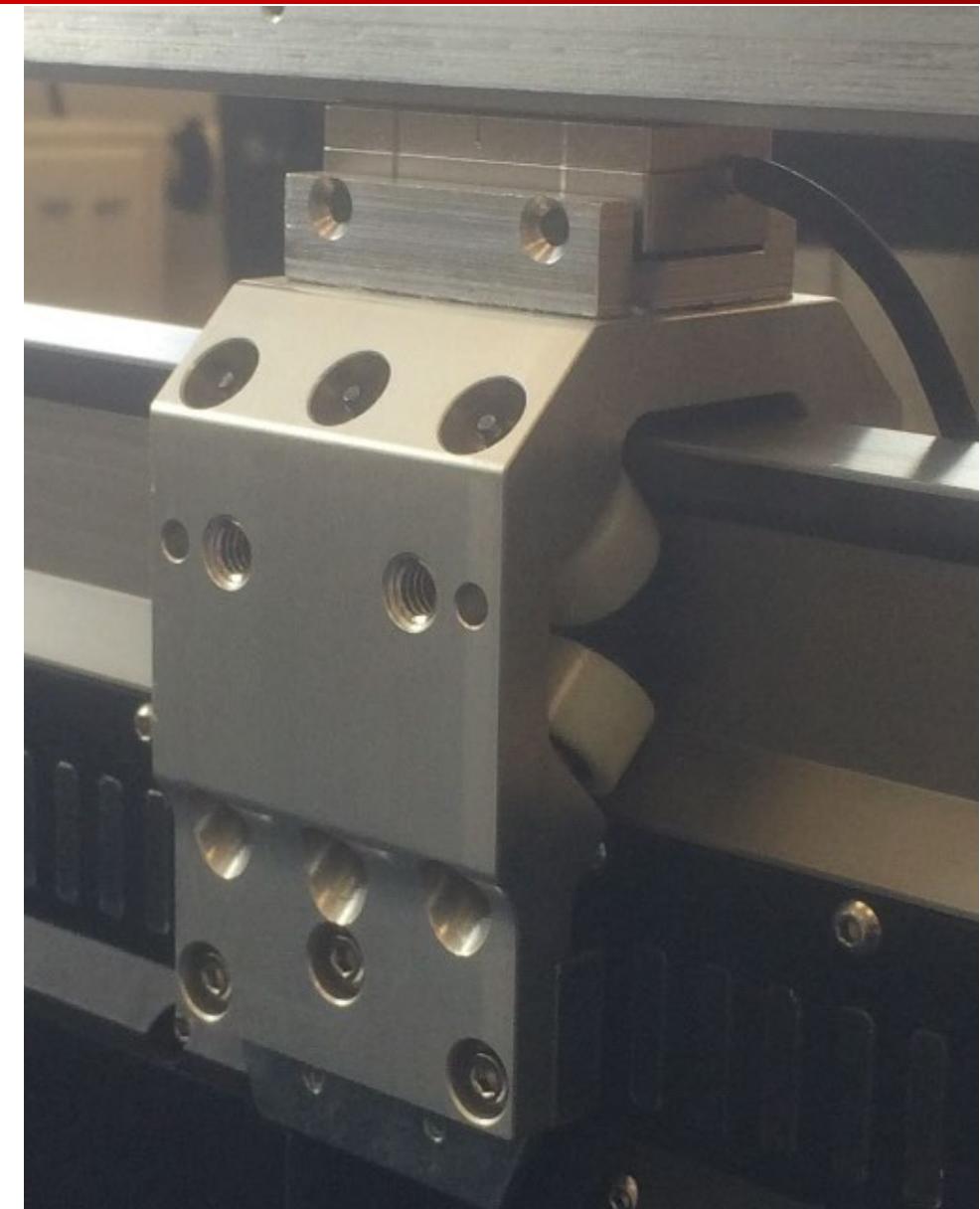
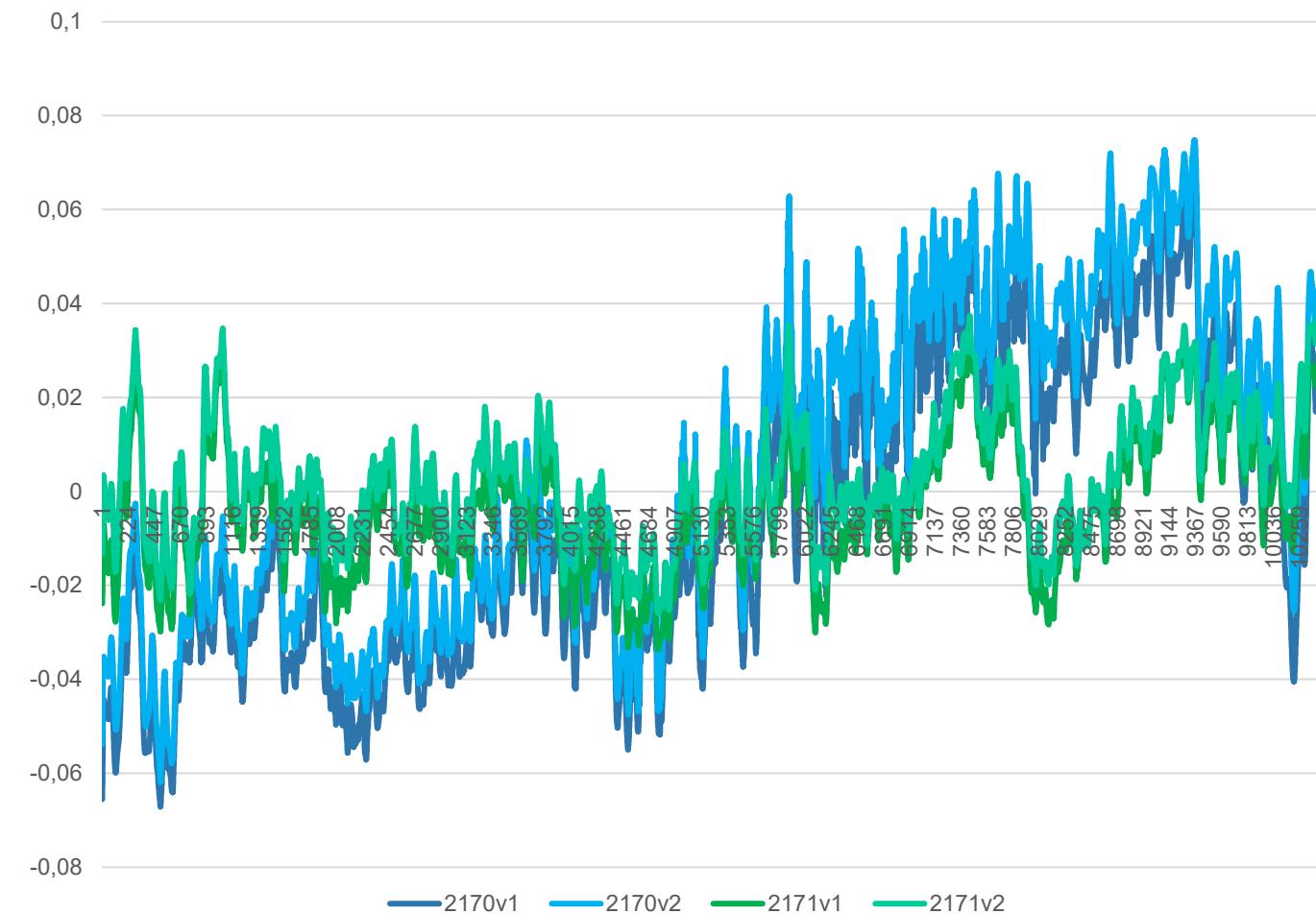
| XTS Datasheet | |
|---------------------------|--|
| Stand Still Repeatability | $\pm 10\mu\text{m}$ (unidirectional) * |

* 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

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Absolute Position Accuracy measured
against an very precise optical encoder

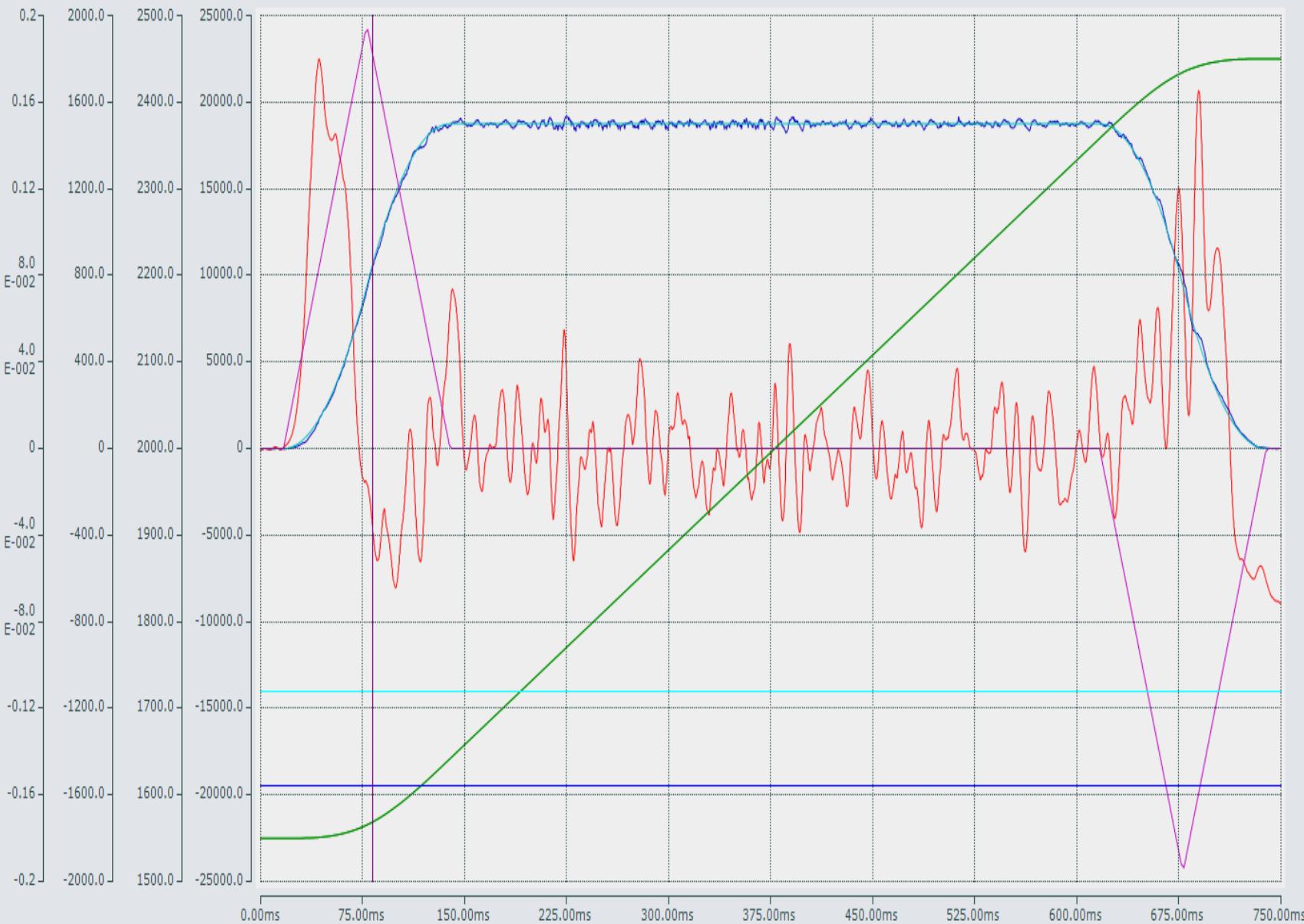


XTS - Position Accuracy while moving

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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 $\pm 60\mu\text{m}$



| Possible solutions if the accuracy is not sufficient | |
|---|---|
| Absolute accuracy of all Movers | <ul style="list-style-type: none">- 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 | <ul style="list-style-type: none">- 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 | <ul style="list-style-type: none">- Setting a position offset in TcloXts 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 |

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XTS IPC & capabilities

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Performance class ↑



C6670-0000
6 cores for XTS



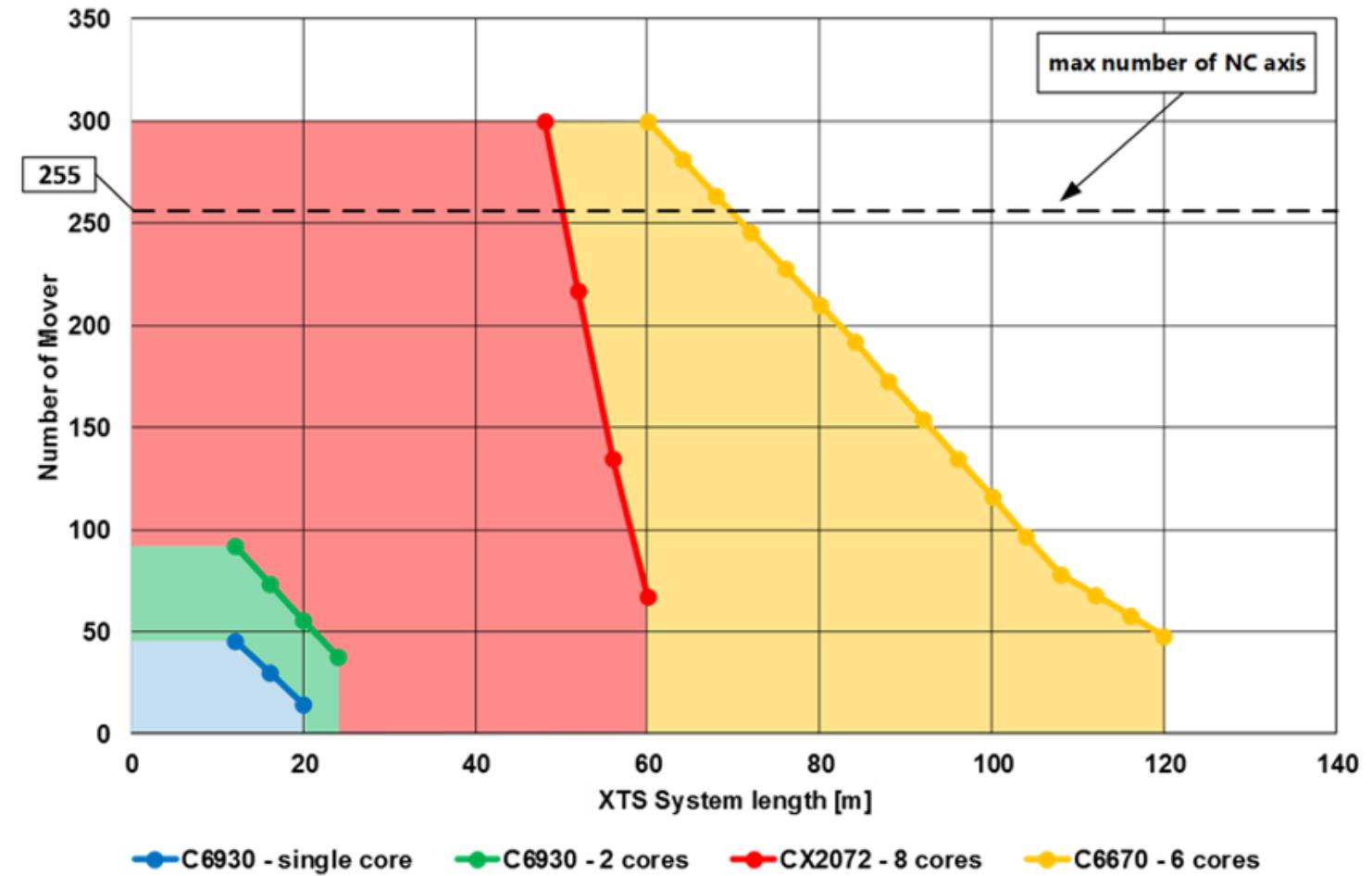
NEU
CX2072-0155
8 cores for XTS



C6930-1106-0050
2 cores for XTS

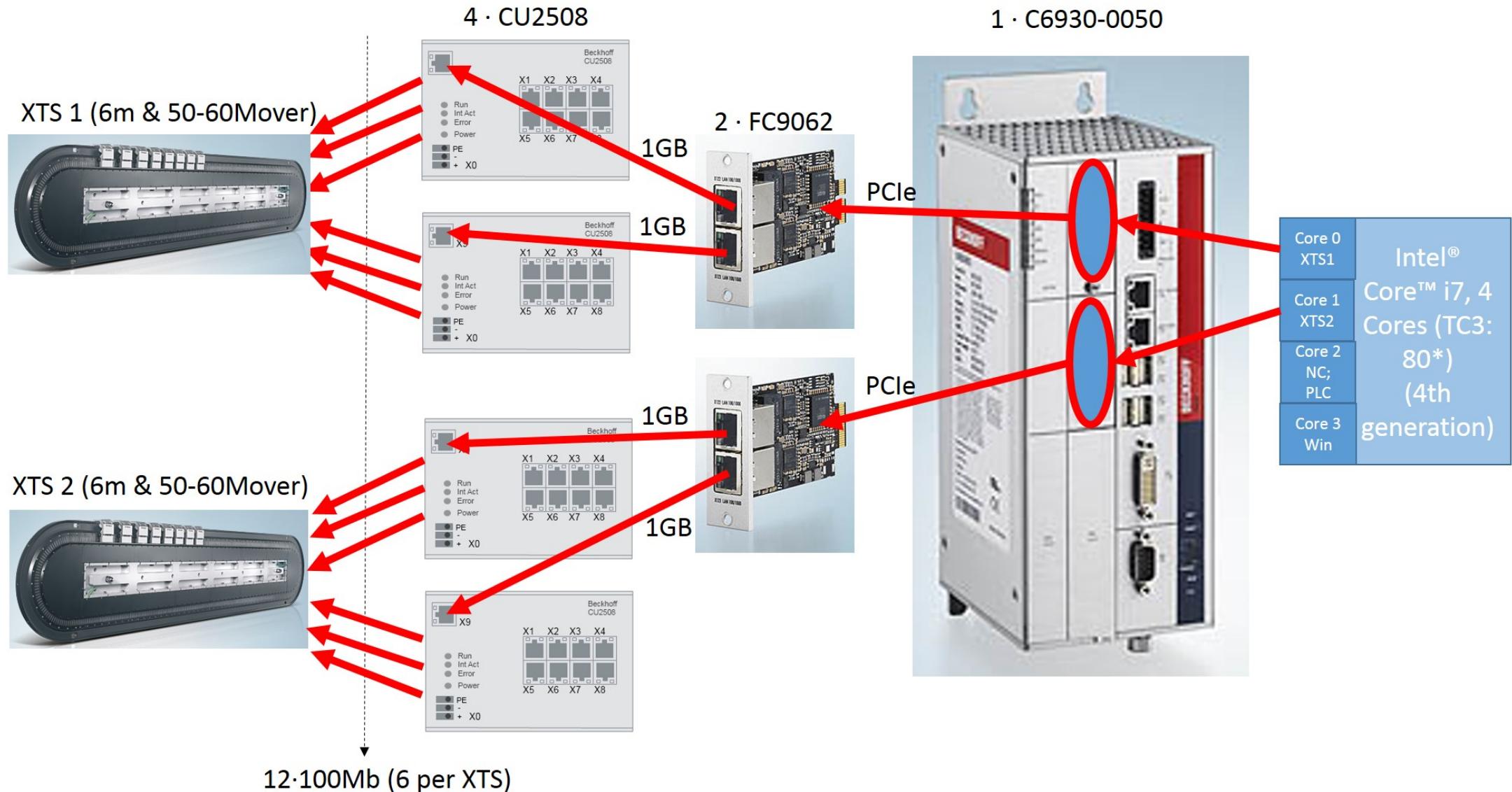


C6930-1106-0050
single core for XTS



XTS – IPC C6930 Core™ i7 application examples

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



Restrictions are purely due to data gathering and processing requirements

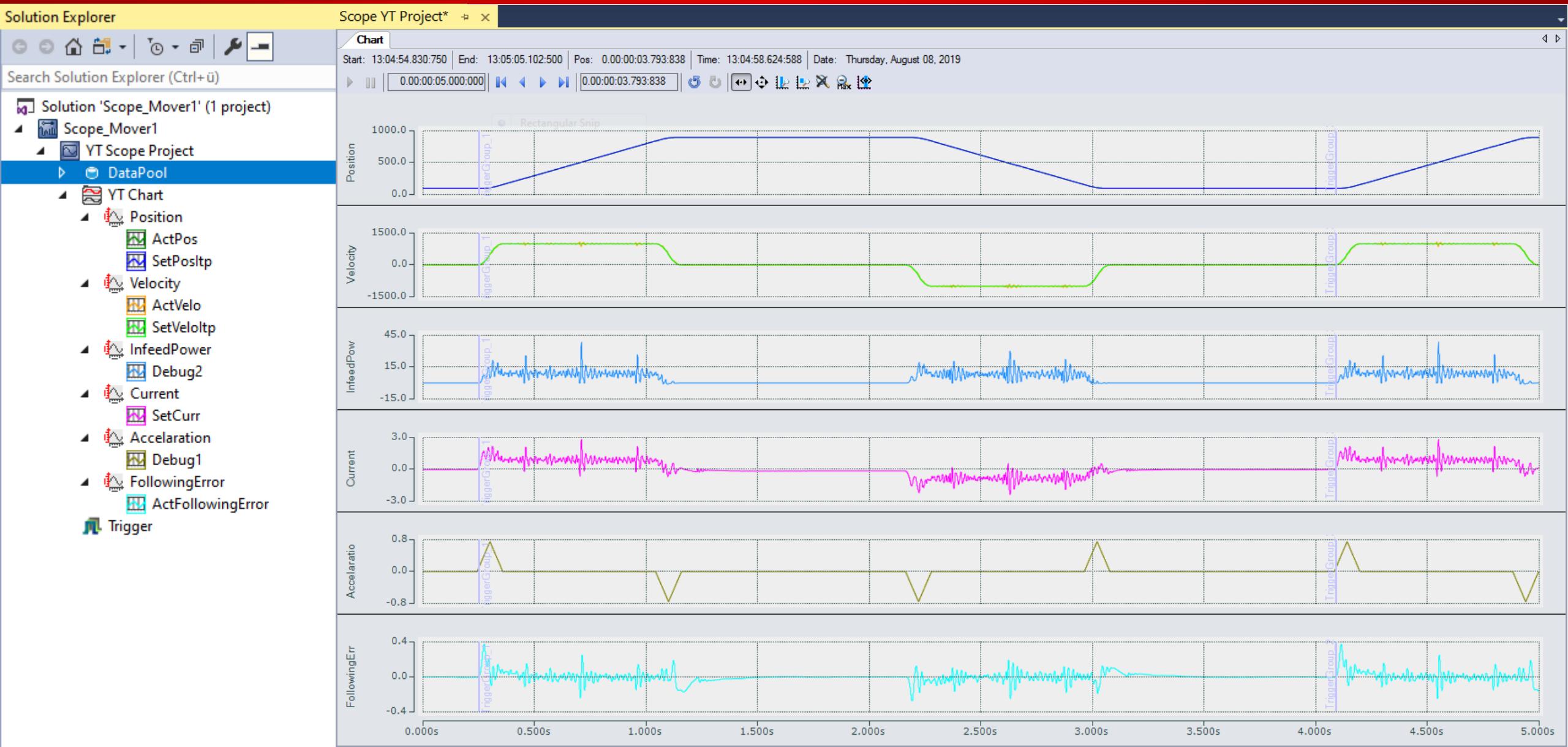
The mover count and circumference will continue to increase in coming years

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XTS TcSoftDrive – Scope for Mover monitoring

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XTS TcSoftDrive – Signal selection for monitoring

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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

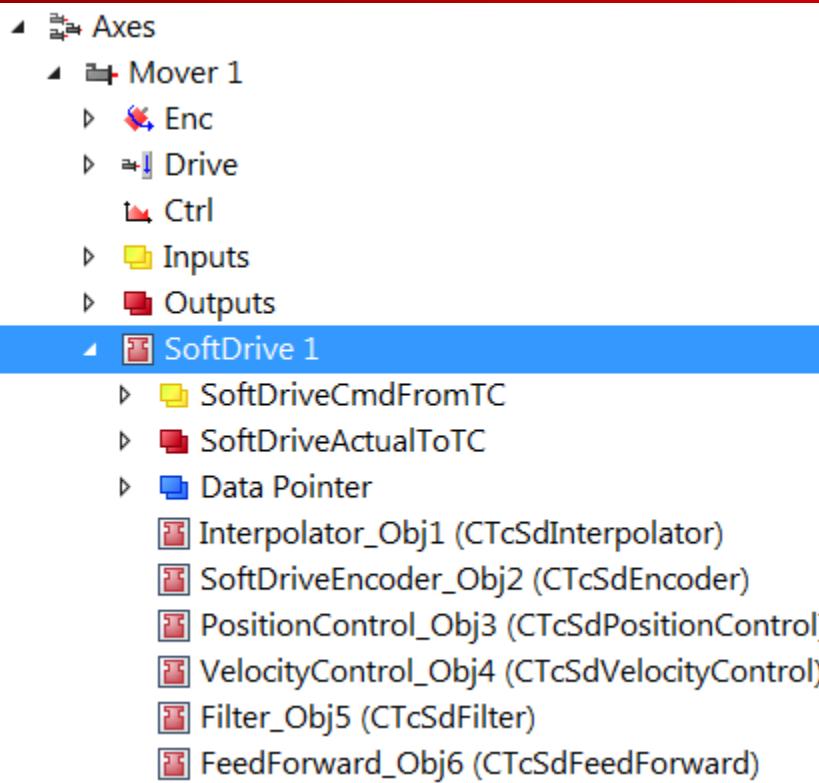
Enter Filter...

Mover 1 > SoftDrive 1 > SdScopeVariable > ActFollowingError >

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

XTS TcSoftDrive – Setup Motor-Parameter for monitoring

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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 |
| 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 |

XTS TcSoftDrive – Trigger settings for monitoring

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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 "Triggergroup" properties window.
- Properties Windows:**
 - Triggergroup - Properties:** Shows settings for a trigger group named "Triggergroup".

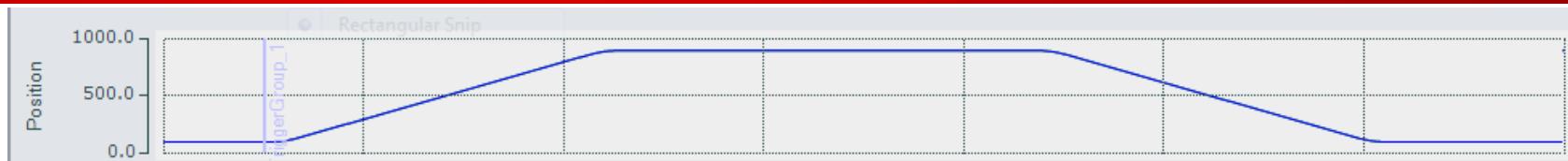
| | |
|------------------------------|--------------|
| Name | Triggergroup |
| Trigger Action | Stop Display |
| Trigger Group | |
| Clear Chart | False |
| Color | Transparent |
| Enabled | True |
| Silent | False |
| Trigger Category | None |
| Trigger Image Size | 0 |
| Trigger Position | 7 |
| Trigger Release Capacity | 50 |
| Visible | True |
| Visible Trigger Release C... | Show All |
 - Channel Triggerset - Properties:** Shows settings for a channel trigger set named "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 Trigger Release C..." row in the Triggergroup properties window, with the "Show All" option highlighted.

XTS TcSoftDrive – Power monitoring example

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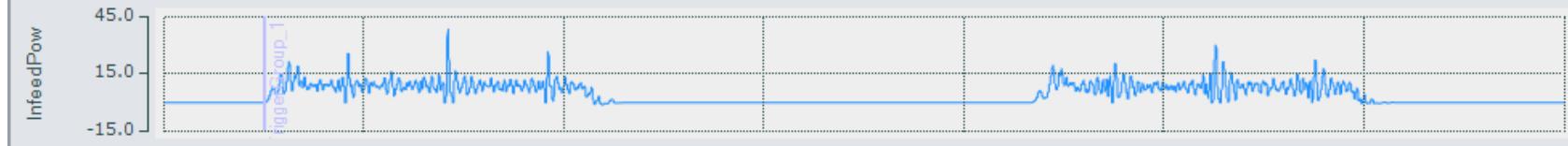
Position [mm]



Velocity [mm/s]



Infeed Power [W]

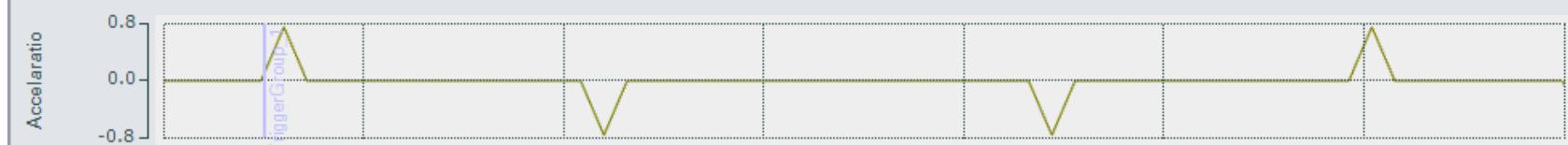


Mover Current [A]

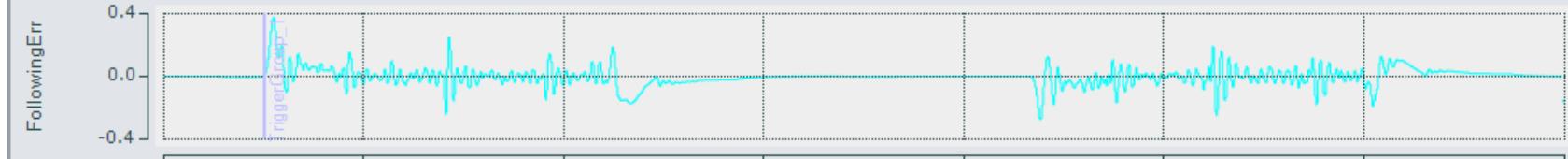
(this is different to the infeed current on the 48V DC!!!)



Acceleration [mm/s²]



FollowingError [mm]



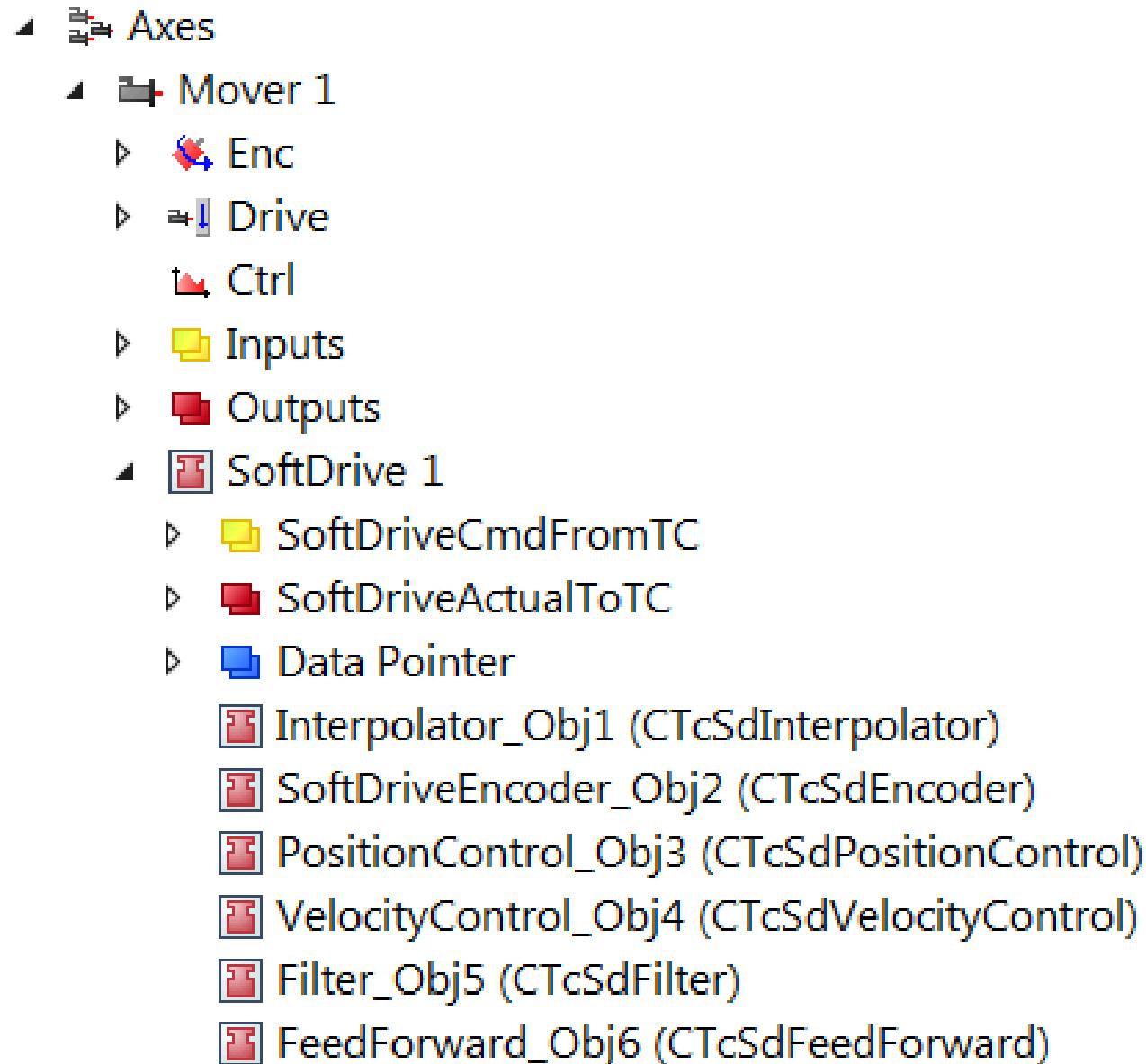
1. Short XTS basics
2. XTS Accuracy
3. XTS IPC & capabilities
4. Scope for
Mover monitoring
- 5. TcSoftdrive
structure & parameter**
6. Tuning



- ◀  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)

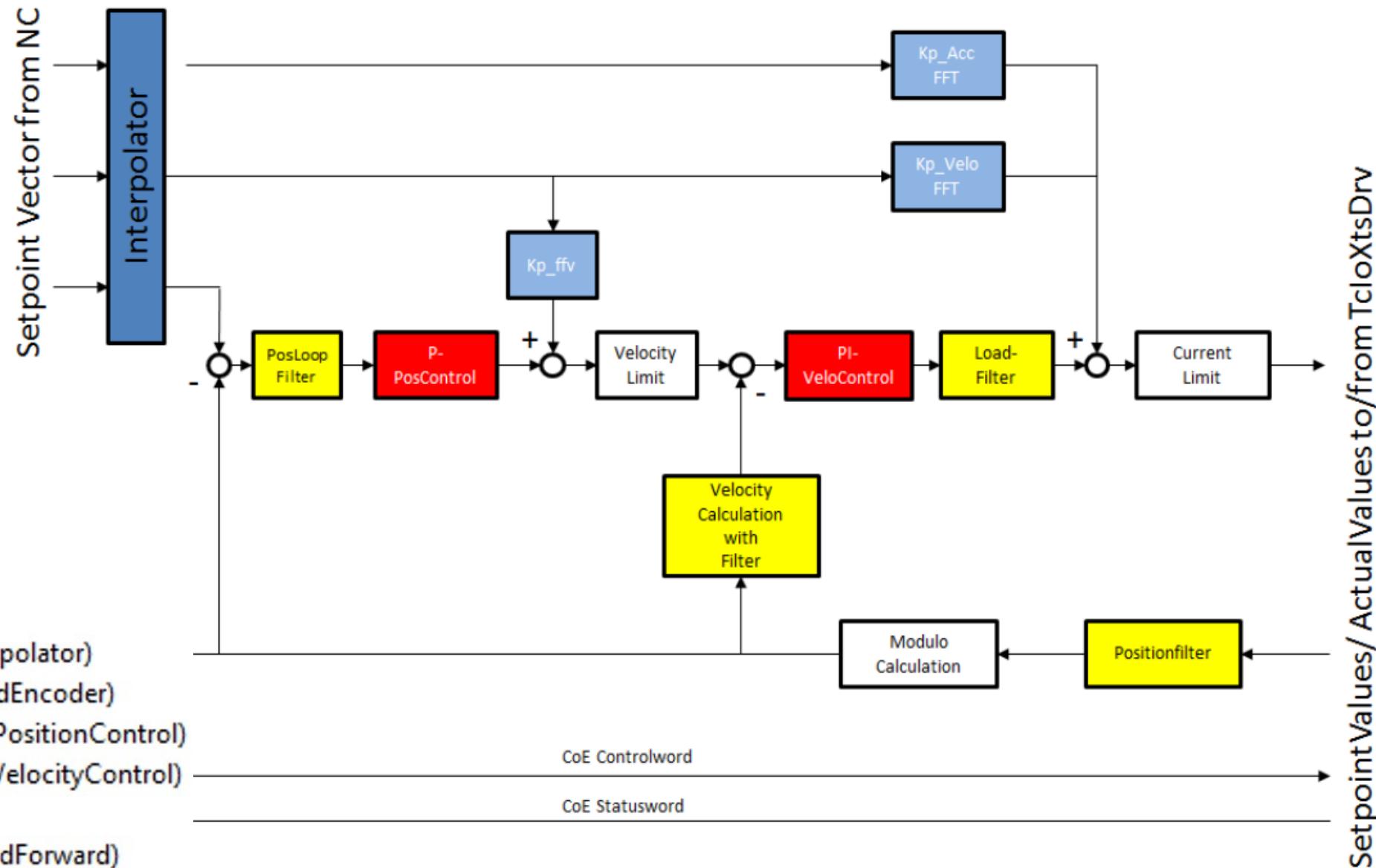
- General SoftDrive Parameter

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



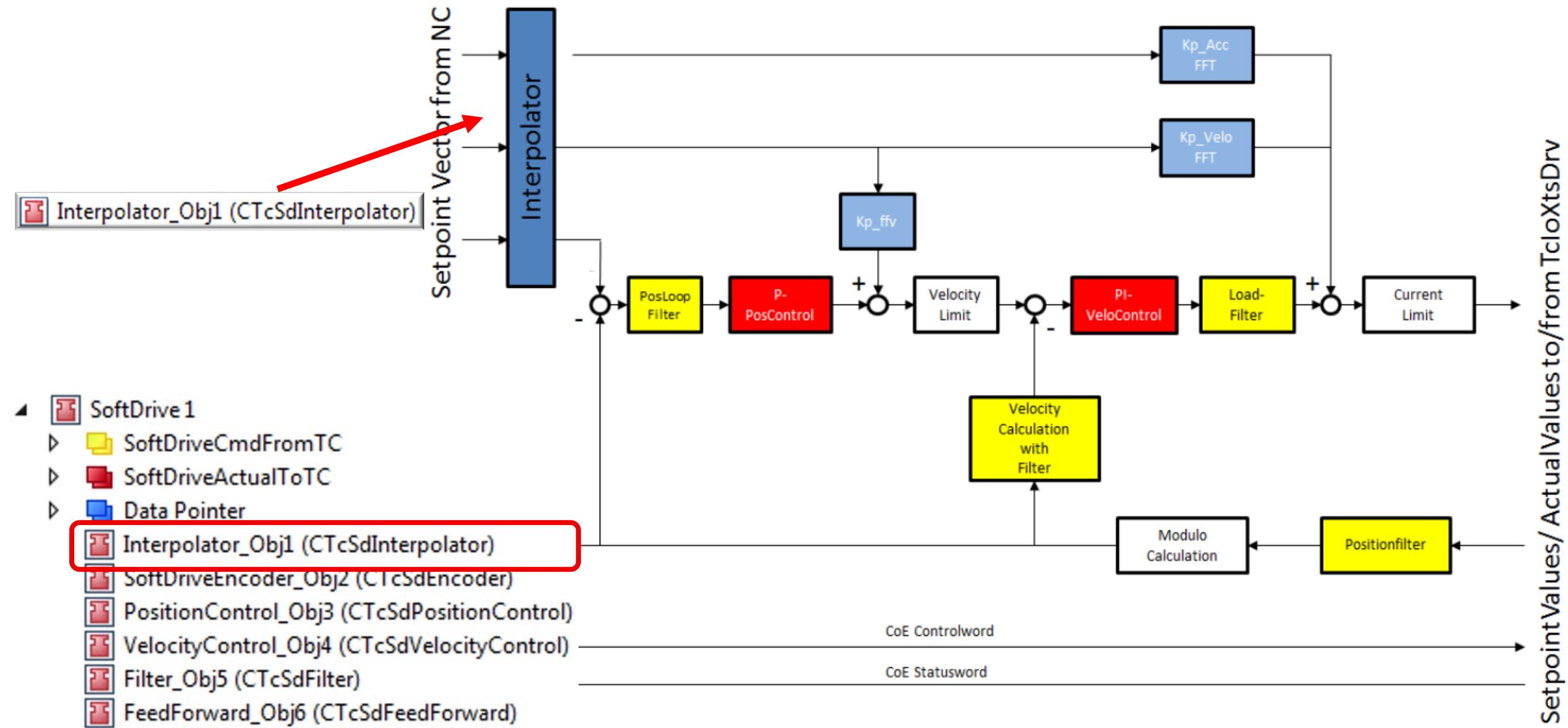
XTS TcSoftDrive - parameter structure

BECKHOFF



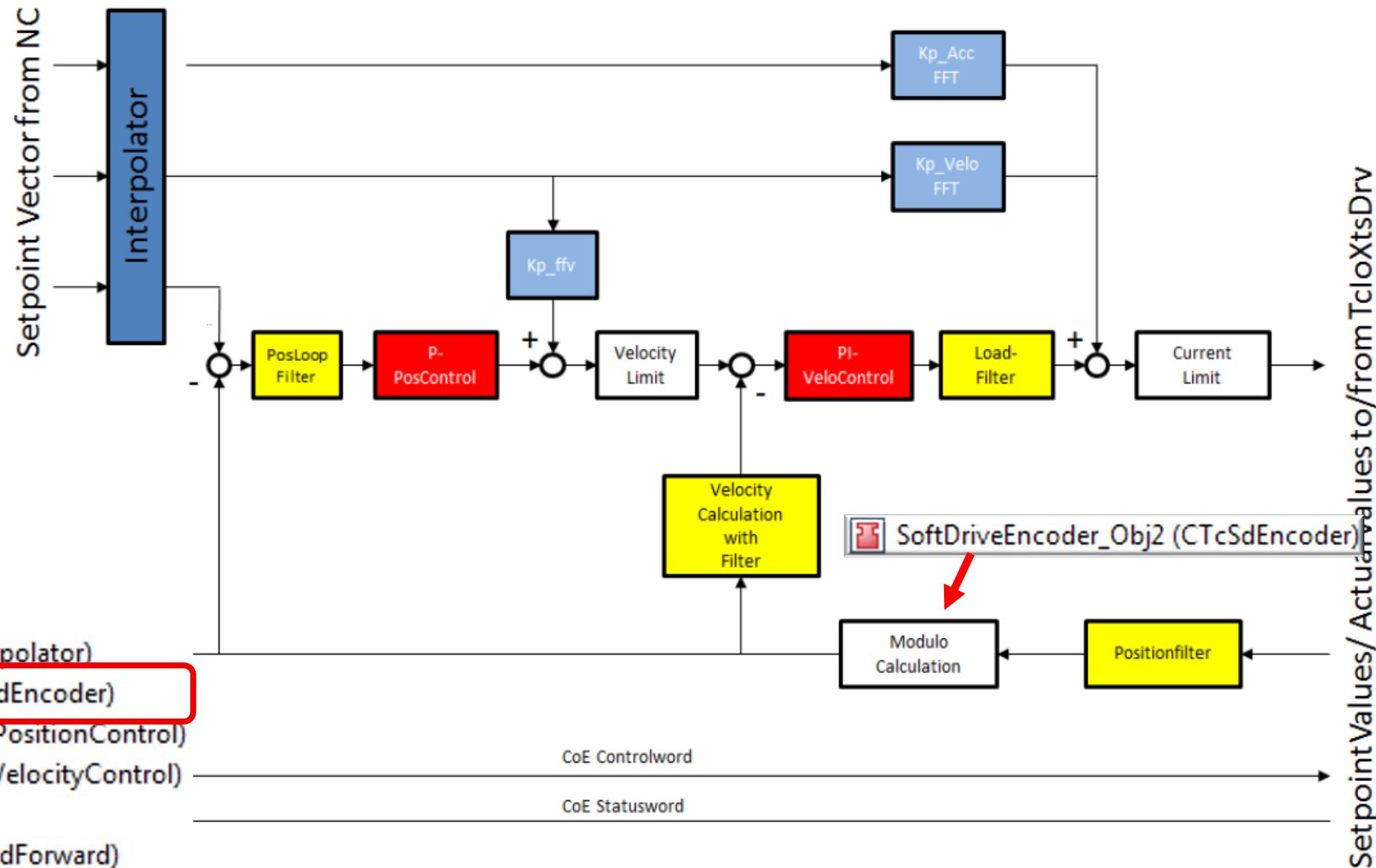
XTS TcSoftDrive - parameter structure

BECKHOFF



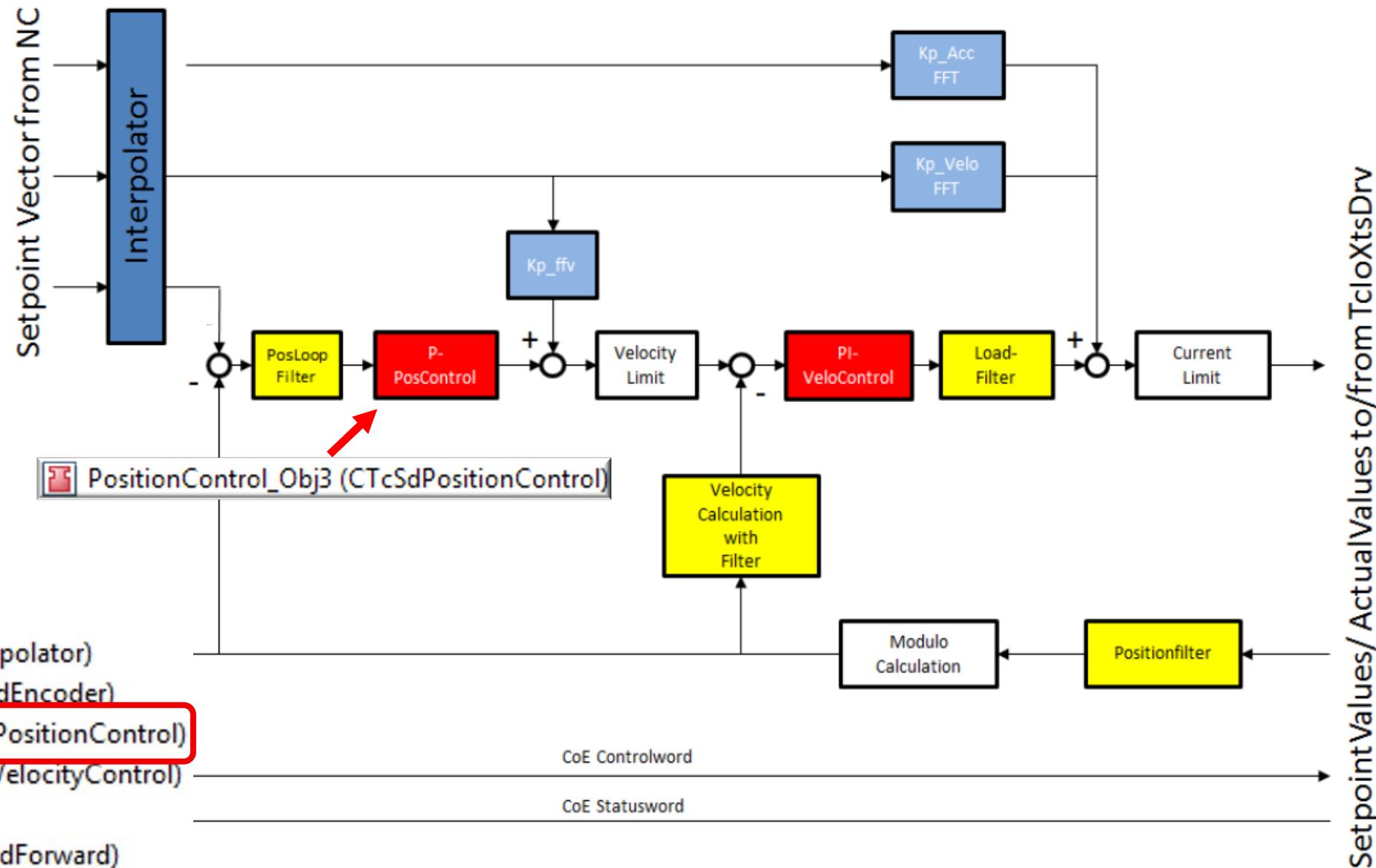
XTS TcSoftDrive - parameter structure

BECKHOFF



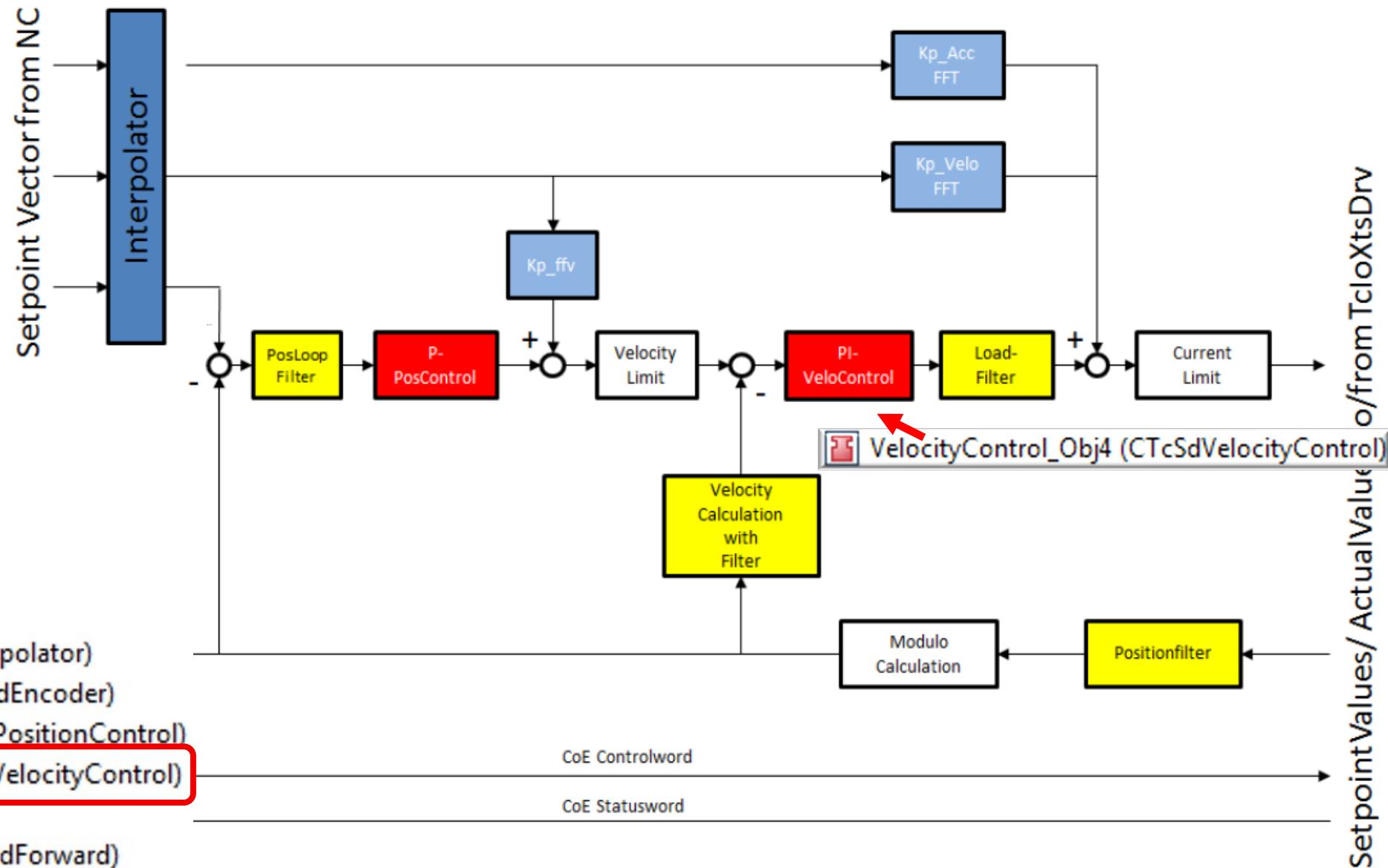
XTS TcSoftDrive - parameter structure

BECKHOFF



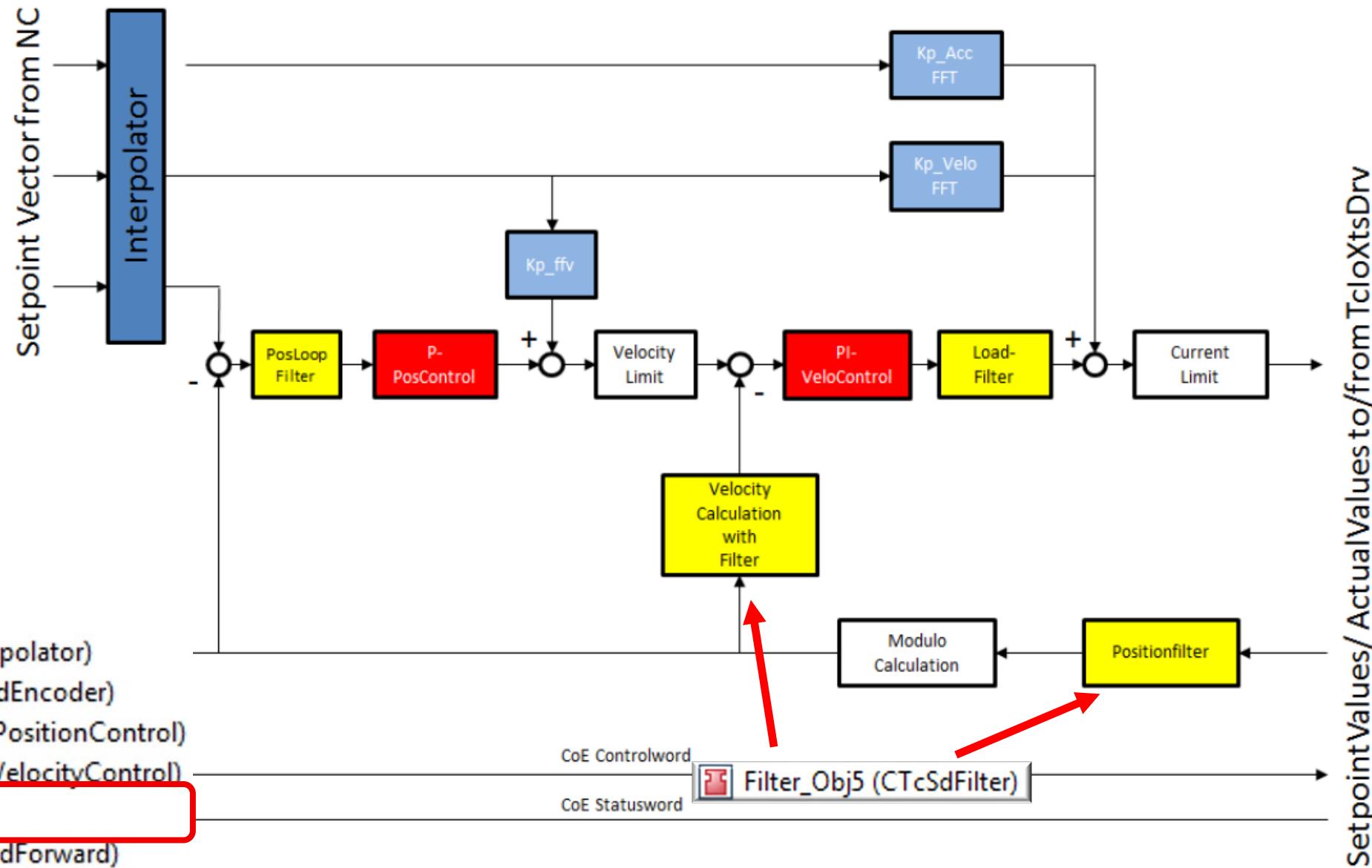
XTS TcSoftDrive - parameter structure

BECKHOFF



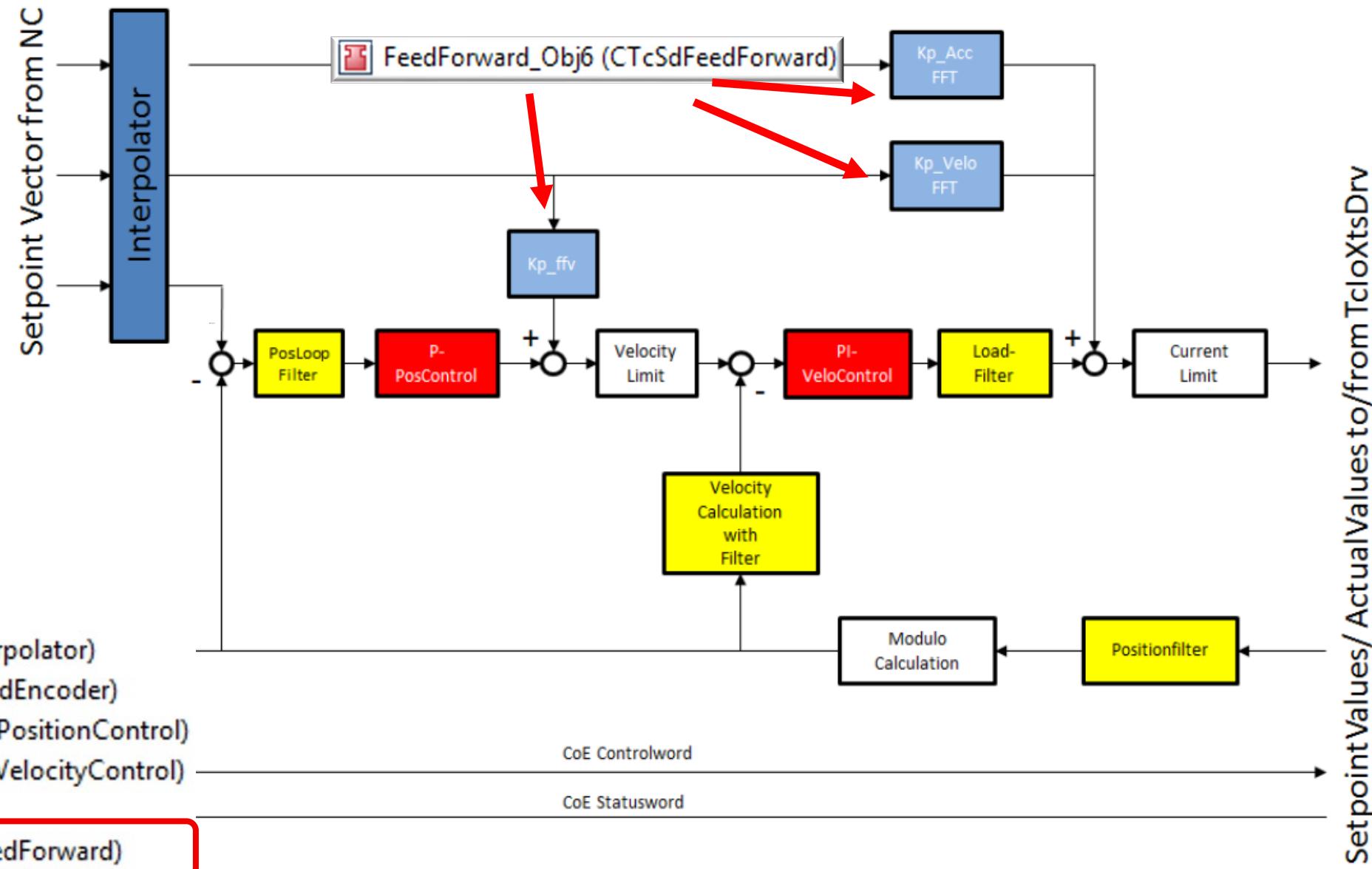
XTS TcSoftDrive - parameter structure

BECKHOFF



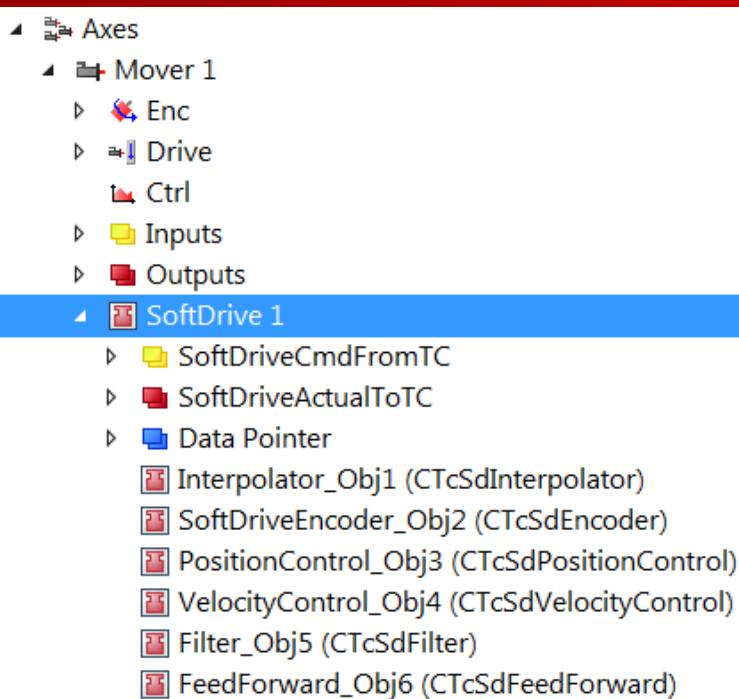
XTS TcSoftDrive - parameter structure

BECKHOFF



XTS TcSoftDrive - General SoftDrive Parameter

BECKHOFF



| 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 | tlAlways | | | 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 | | set in... |

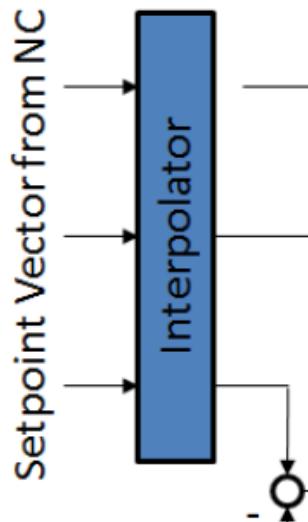
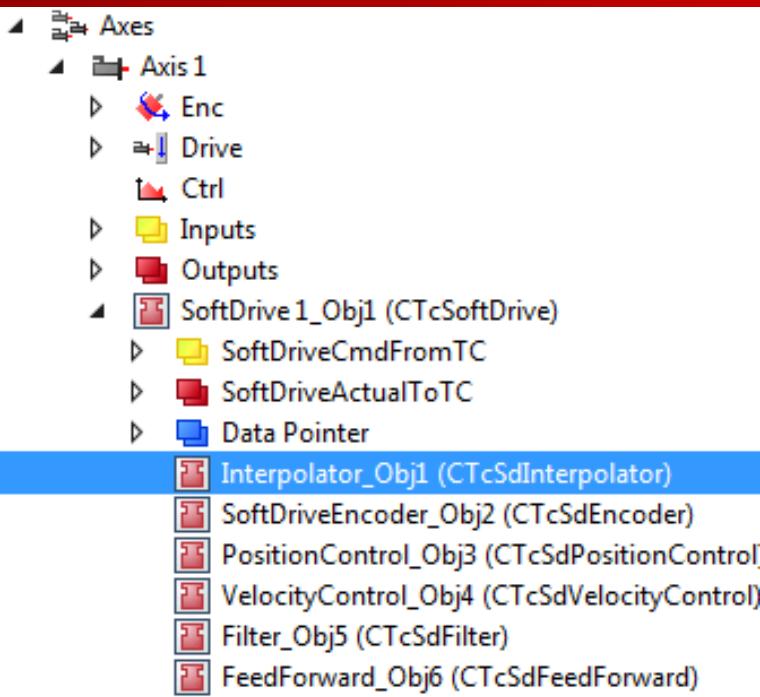
- 1 up to 32 different control areas
- Different parameter for position and velocity control
- Different current limit could be set in Feedforward module
- To use a certain control area [X].IsEnabled must be set to TRUE and Activate Configuration



| 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

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First_XTS_Project

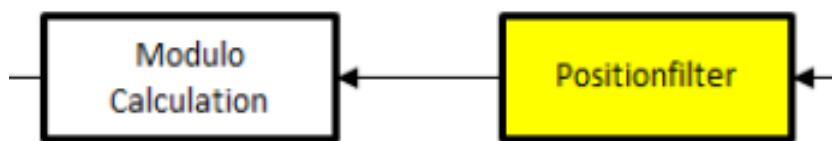
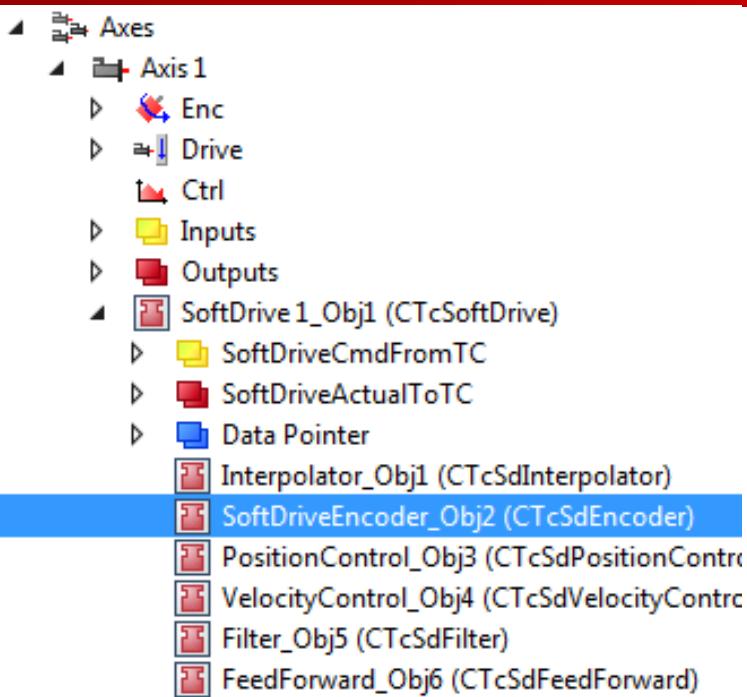
Object Context Parameter (Init) Interfaces

| | 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

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First_XTS_Project

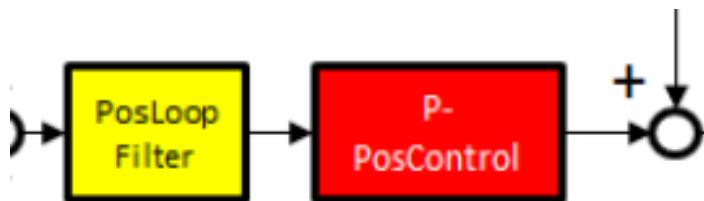
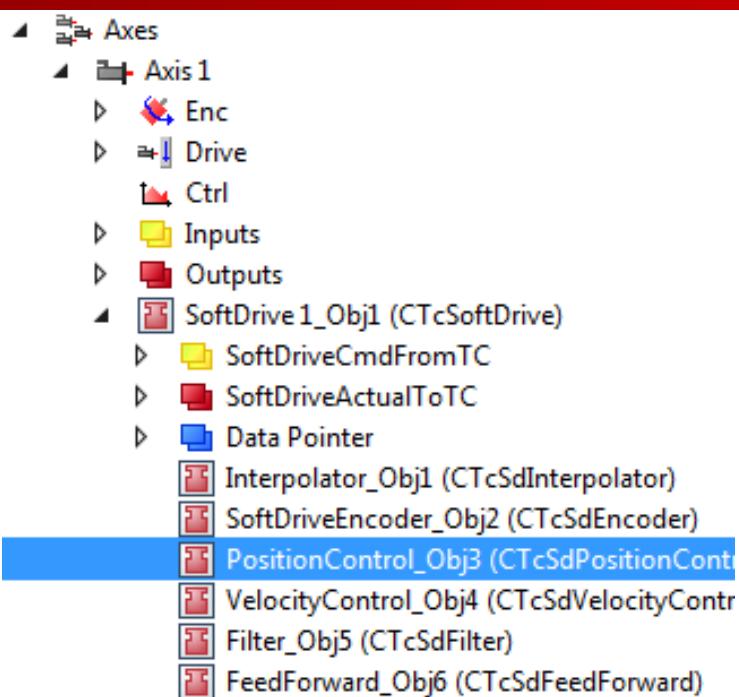
Object Context Parameter (Init) Interfaces Interface Pointer

| | 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... |
| - | Advanced | | | | | |
| | StartUpPositionType | PART | | | Start... | 0... |
| - | Advanced | | | | | |
| | TraceLevelMax | tIAlways | | | 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

XTS TcSoftDrive - position control

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

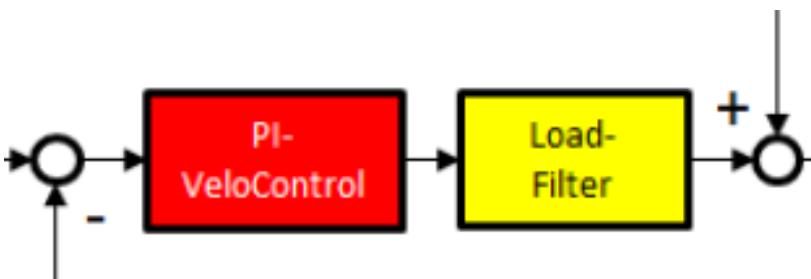
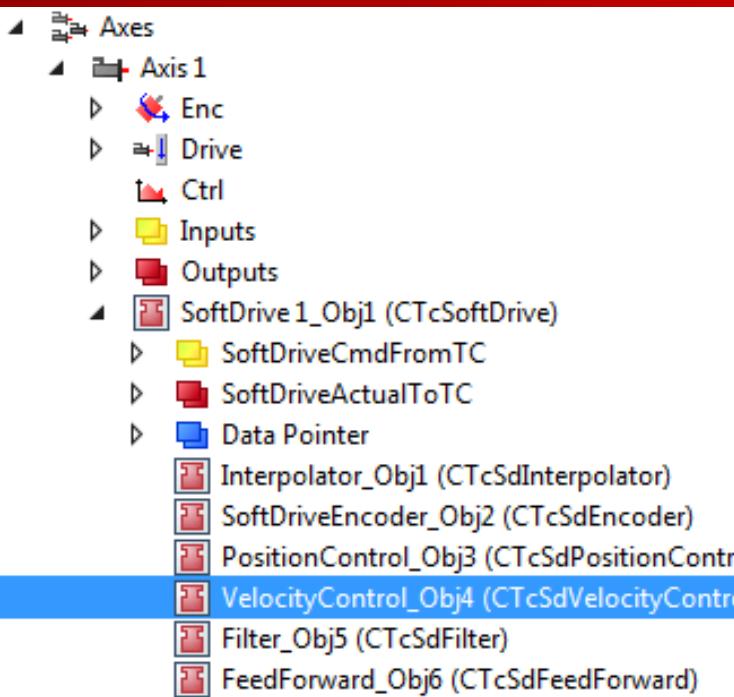
BECKHOFF

- 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... | |

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 | | | | | |
| | ResetPartAtMotionStart | OFF | | | Rese... | 0.. |
| - | Advanced | | | | | |
| | TraceLevelMax | tIAlways | | | 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)

| 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

- 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

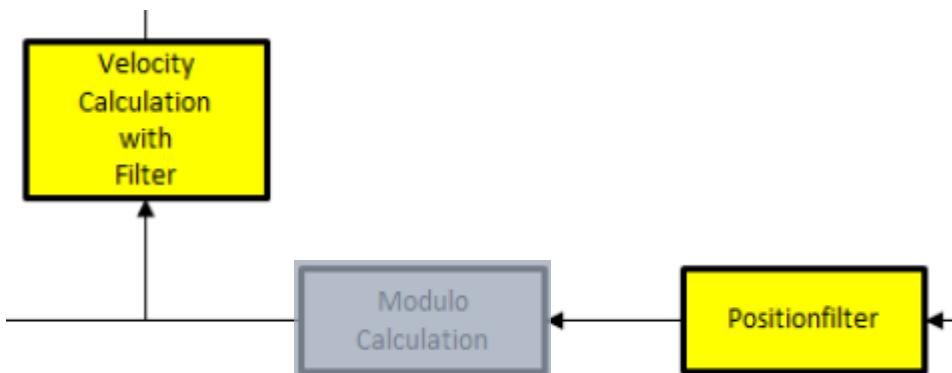
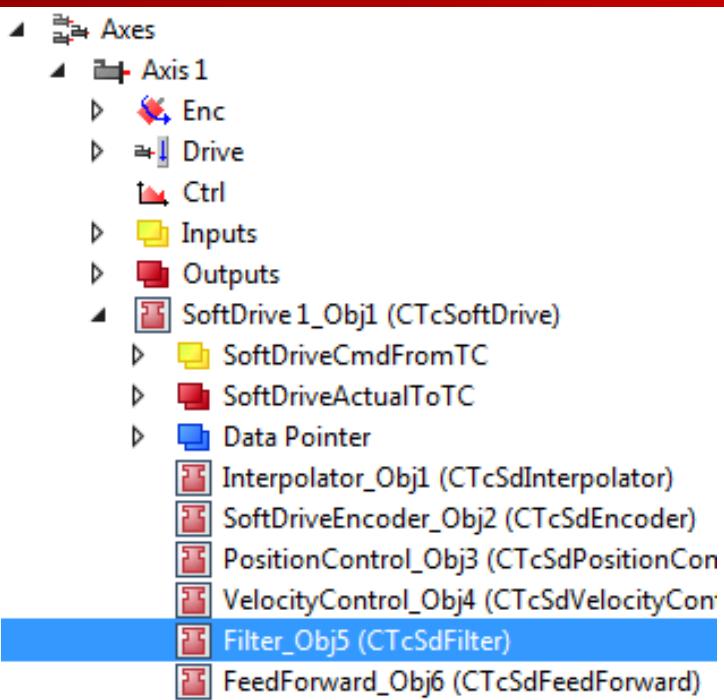
The screenshot shows a software application window titled "First_XTS_Project". The top menu bar includes "Object", "Context", "Parameter (Init)" (which is selected), "Interfaces", and "Interface Pointer". Below the menu is a table with columns: Name, Value, CS, Unit, Type, and P.. The table lists various parameters under sections like General, Optimization, and Advanced. Some parameters have dropdown menus or checkboxes next to their values. The "ResetPartAtMotionStart" parameter is currently set to "OFF". The "TraceLevelMax" parameter is set to "tIAlways".

| | 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



First_XTS_Project

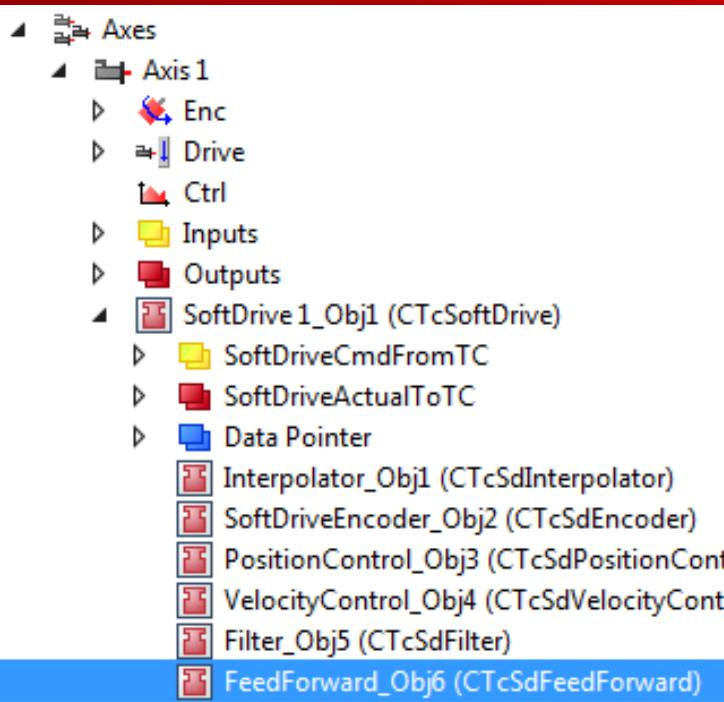
Object Context Parameter (Init) Interfaces Interface Pointer

| | 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



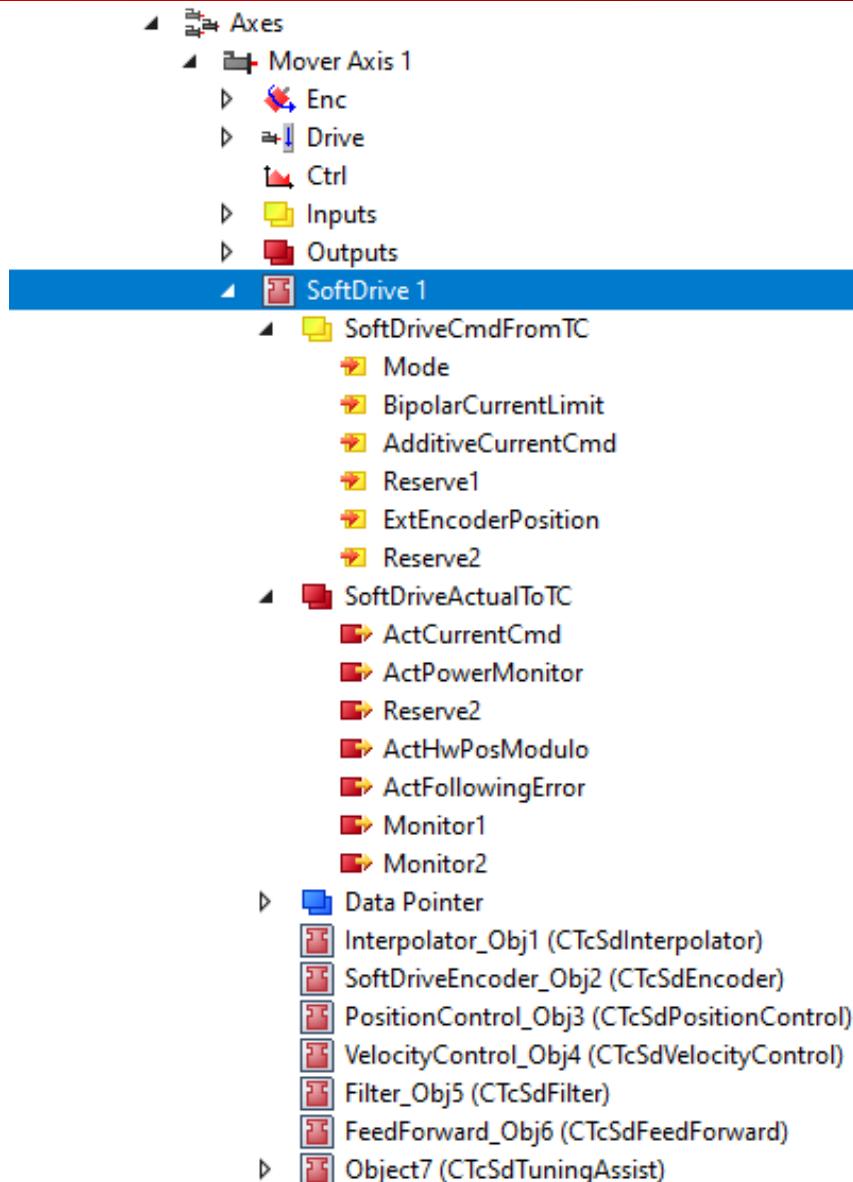
First_XTS_Project

| | 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

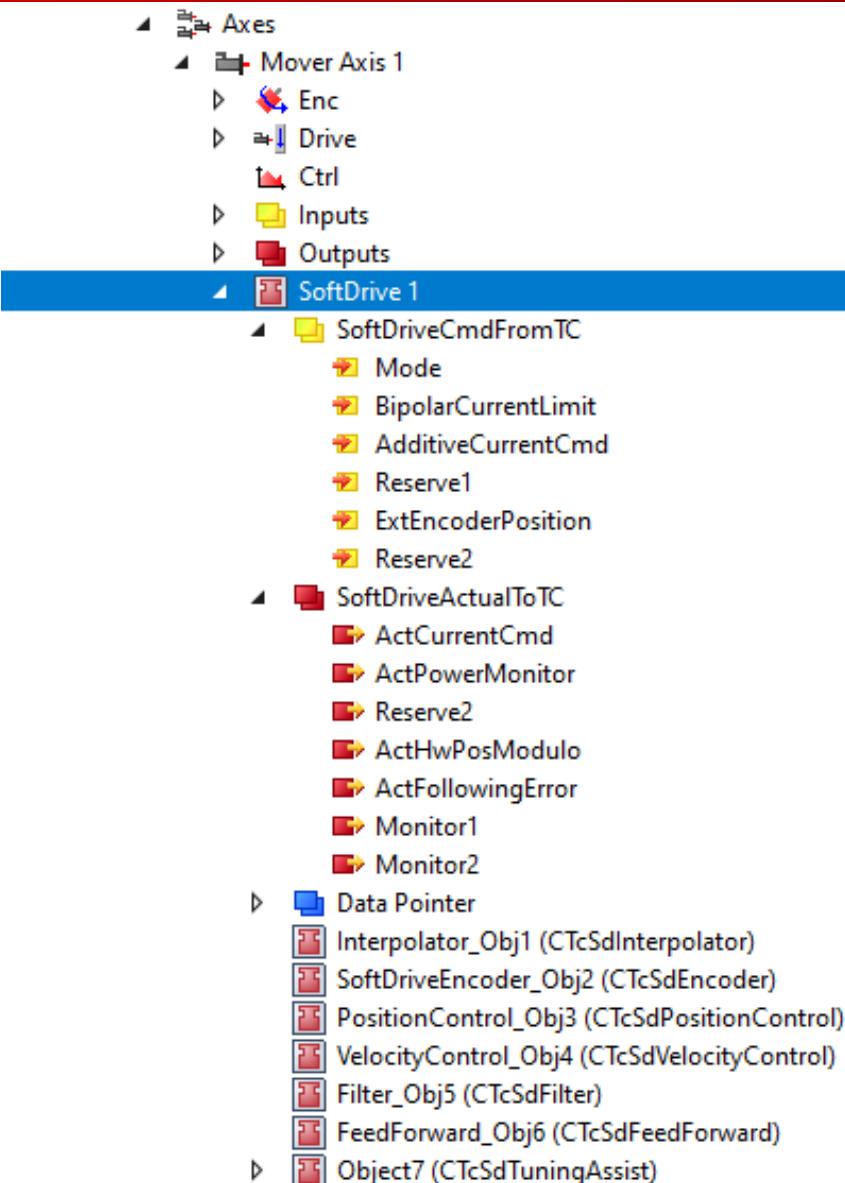
From NC / PLC → TcSoftDrive

- 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

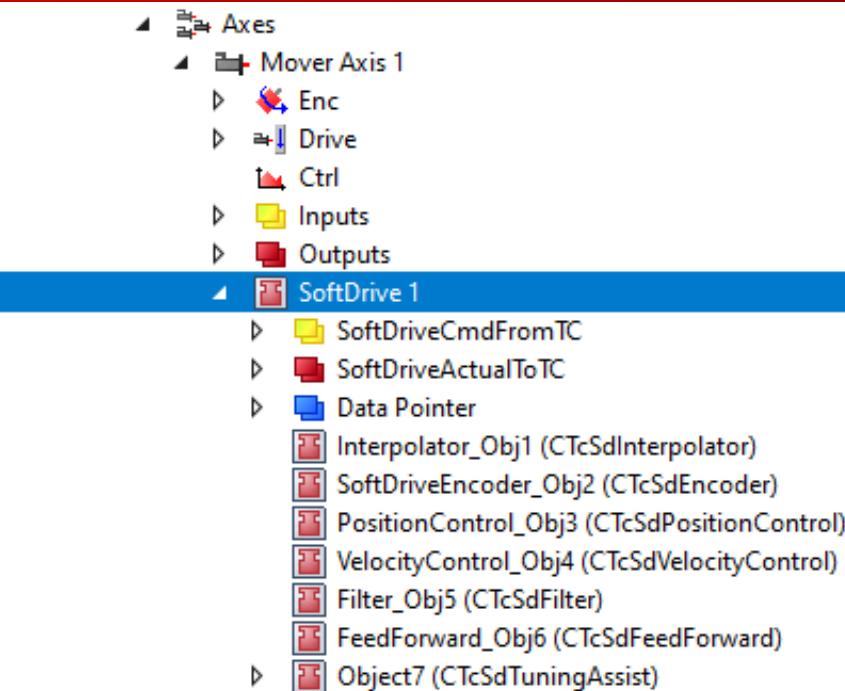
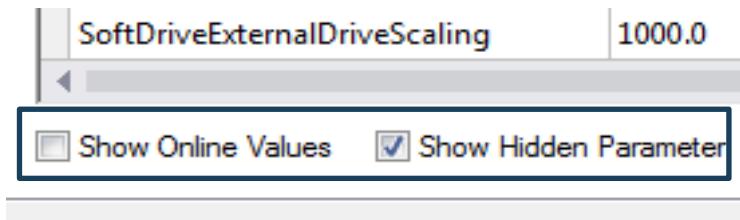


- SoftDriveExternalEncoder

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 | | |
| + | IoChildAreaLocation | [..., ...] | 2 (Array ...) | |
| | AreaOwner | 00000000 | | OTCID |

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

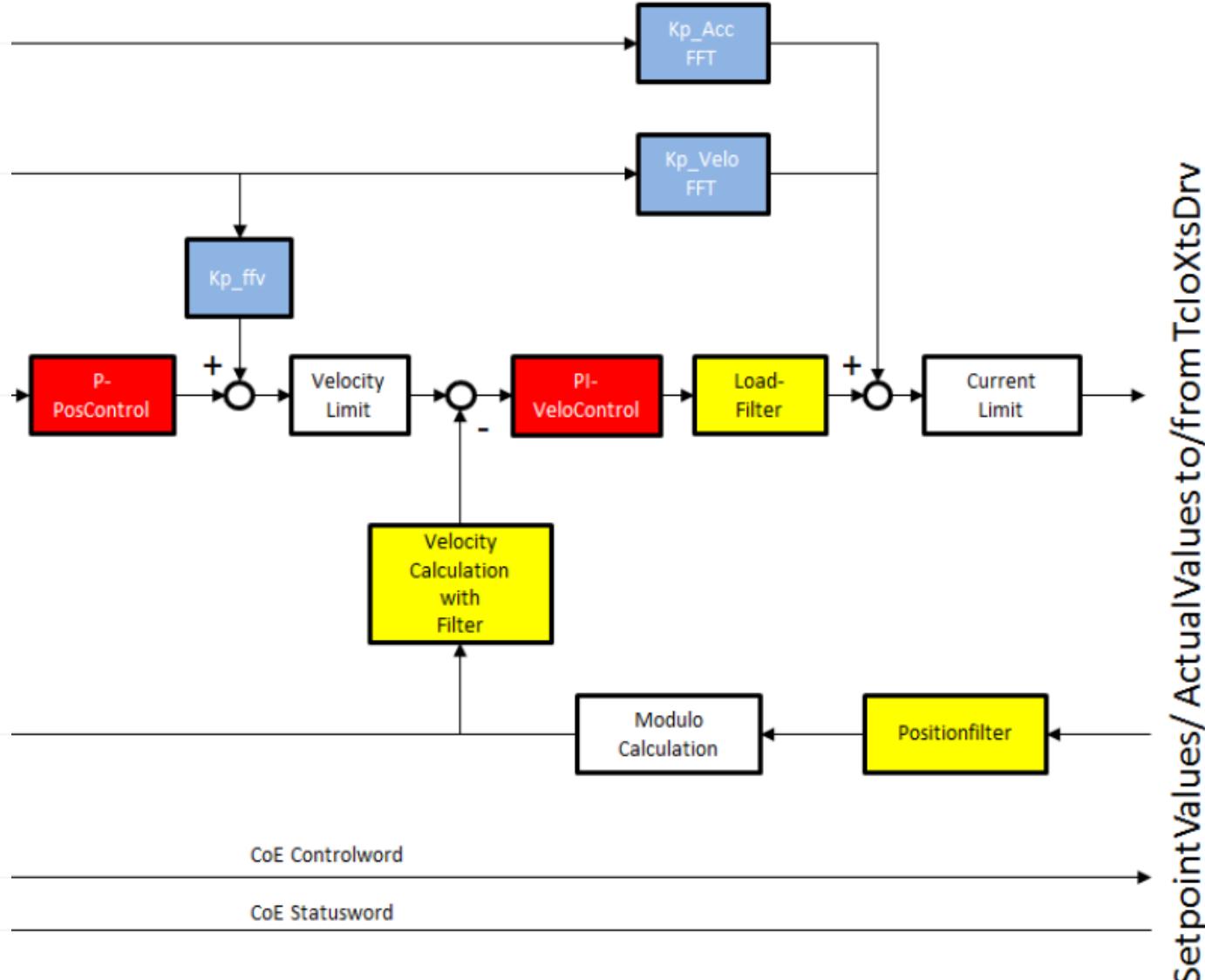


Servo systems typically use a combination (cascaded) of three types of control loops:

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

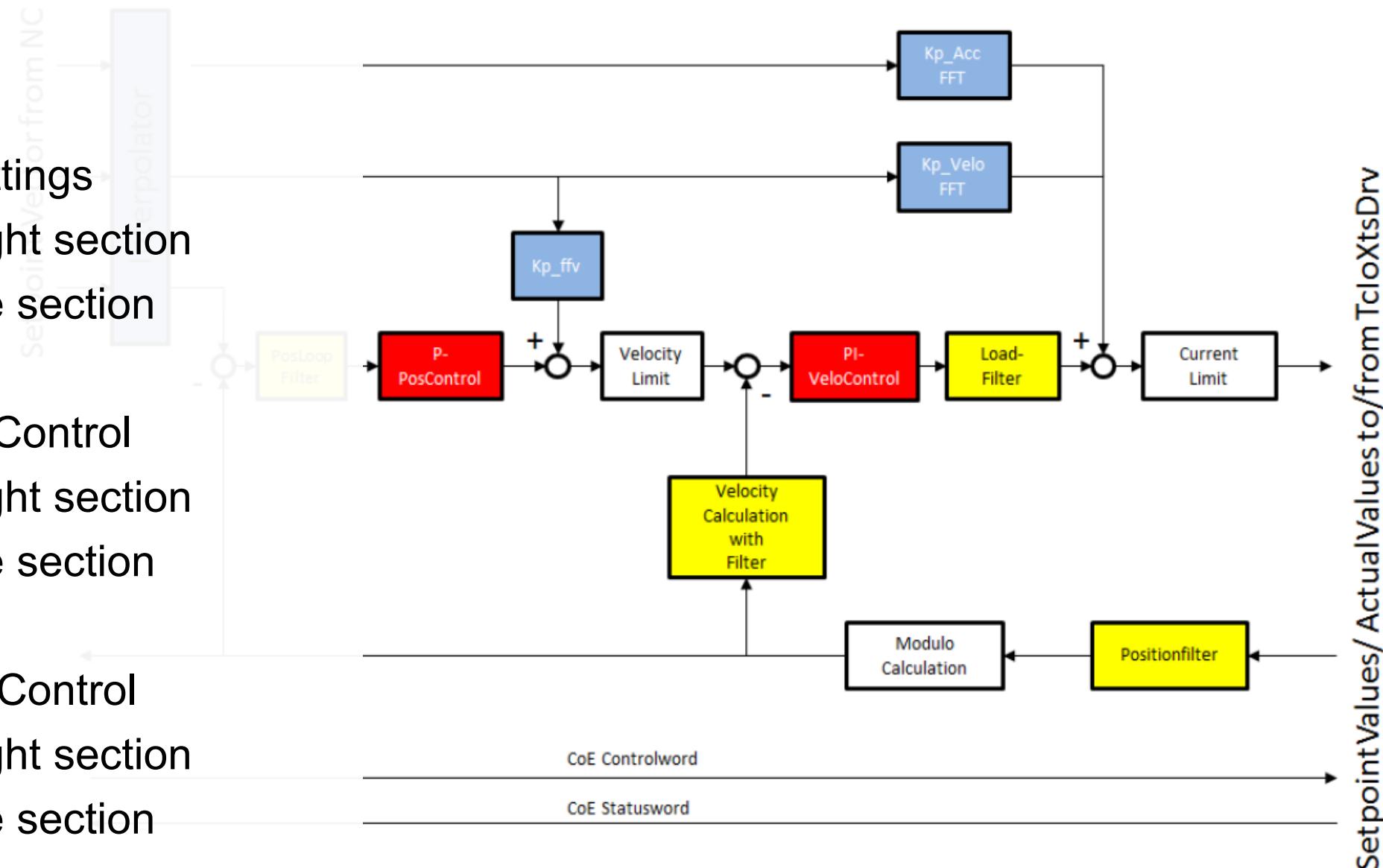
To tune the system, we have to tune each loop.

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

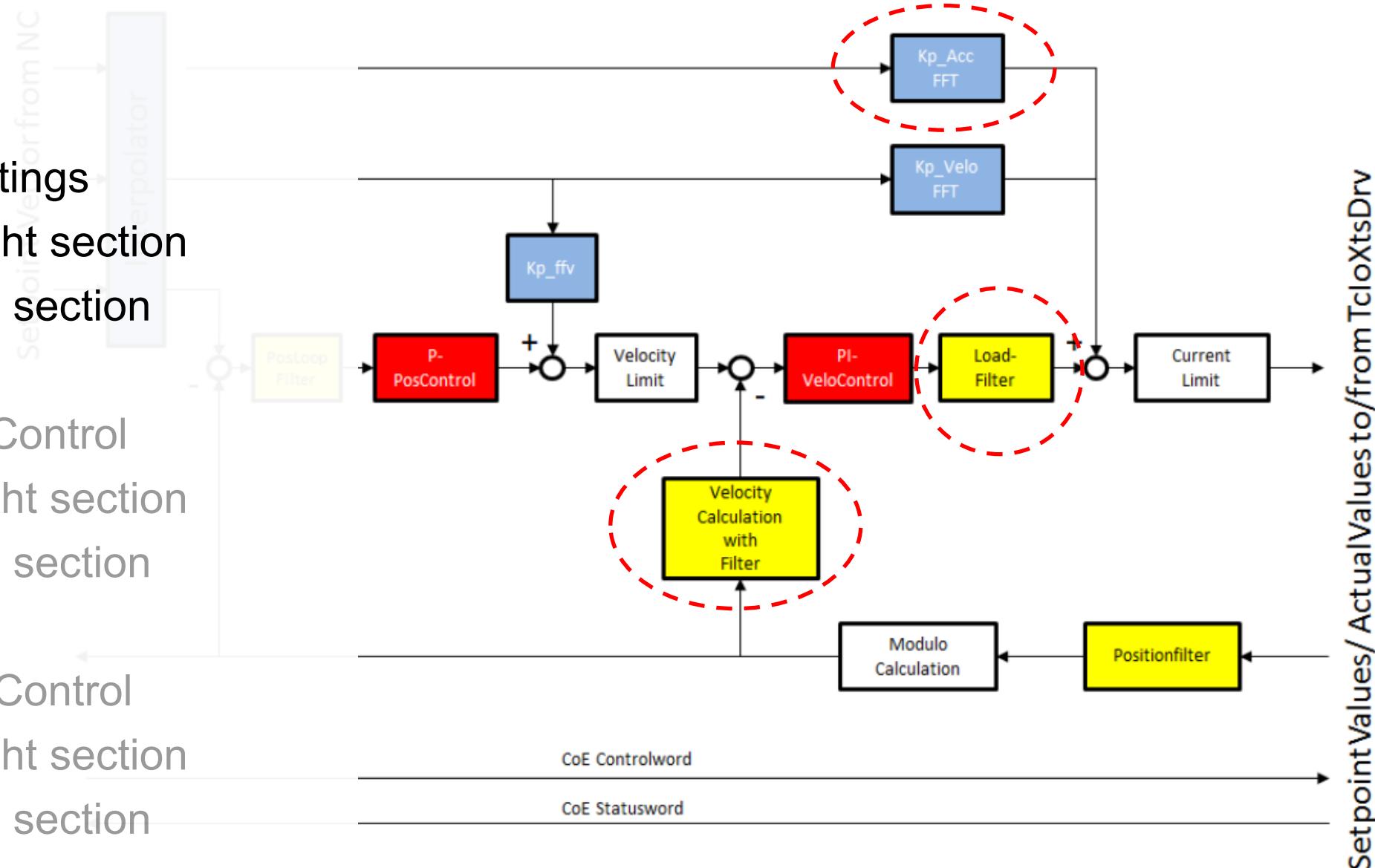


Tuning Sequence

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

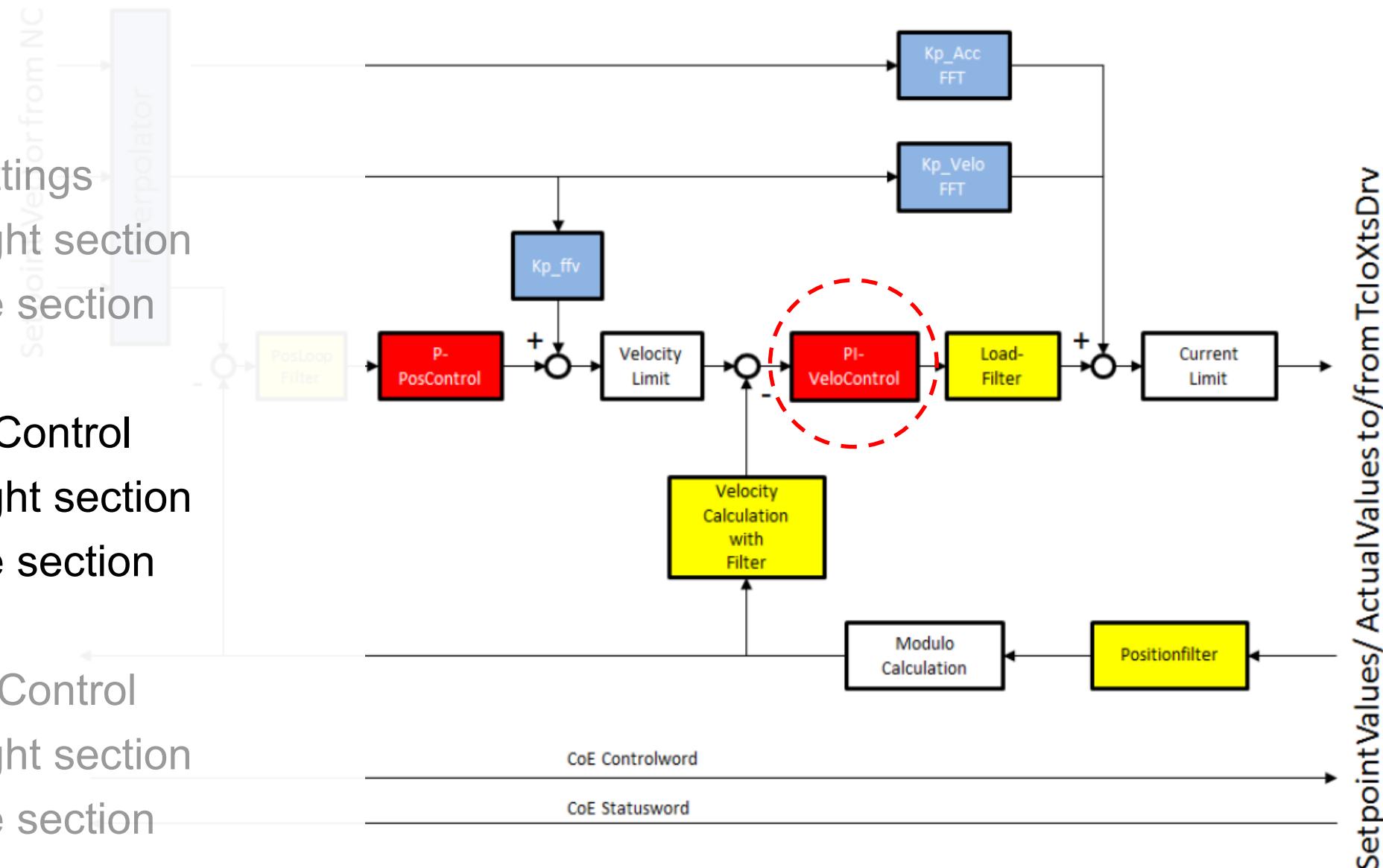


Tuning Sequence

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

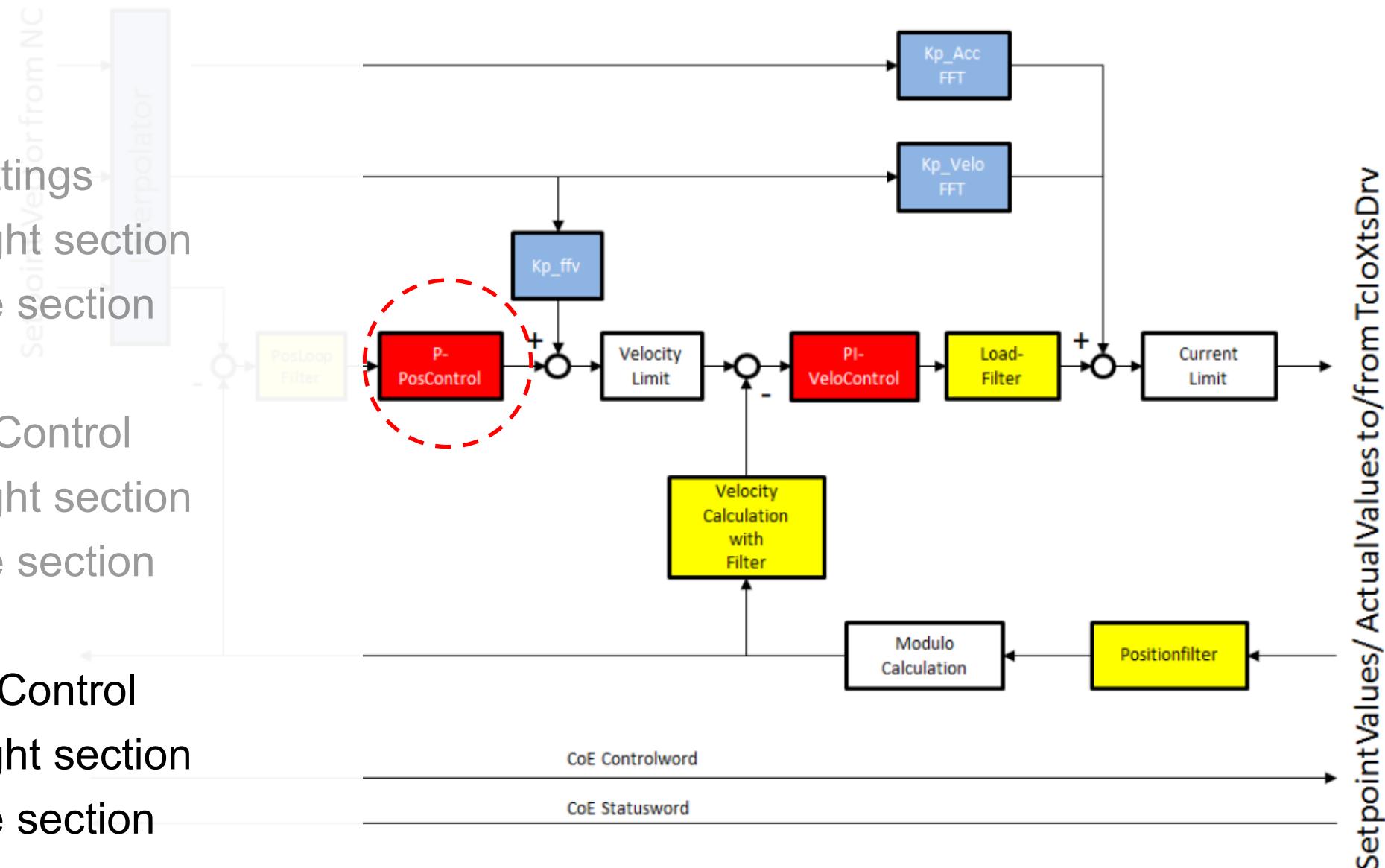


- Tuning Sequence

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

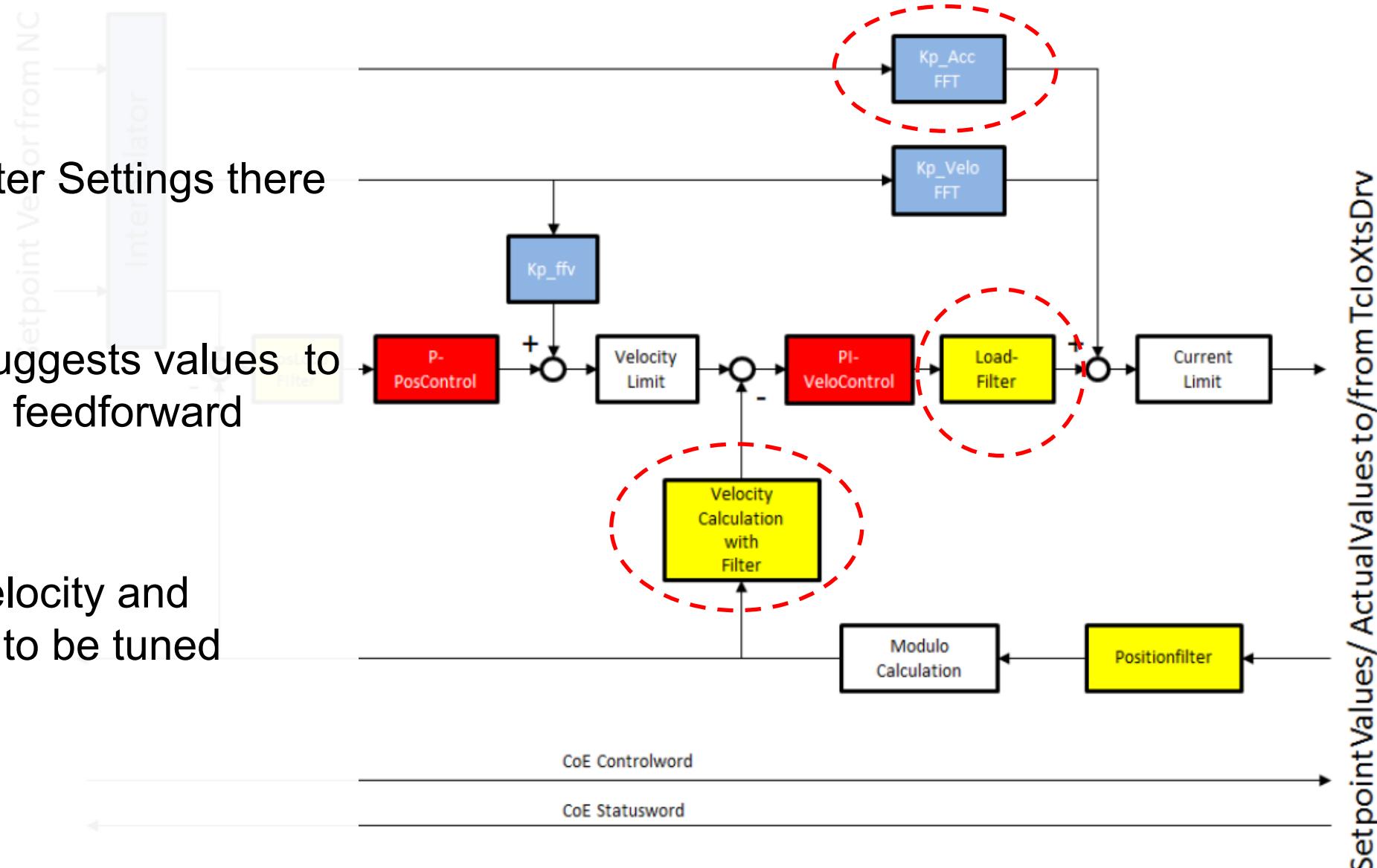
2. Setup Velocity-Control
 - I. on the straight section
 - II. on the curve section

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



Setup Filter Settings

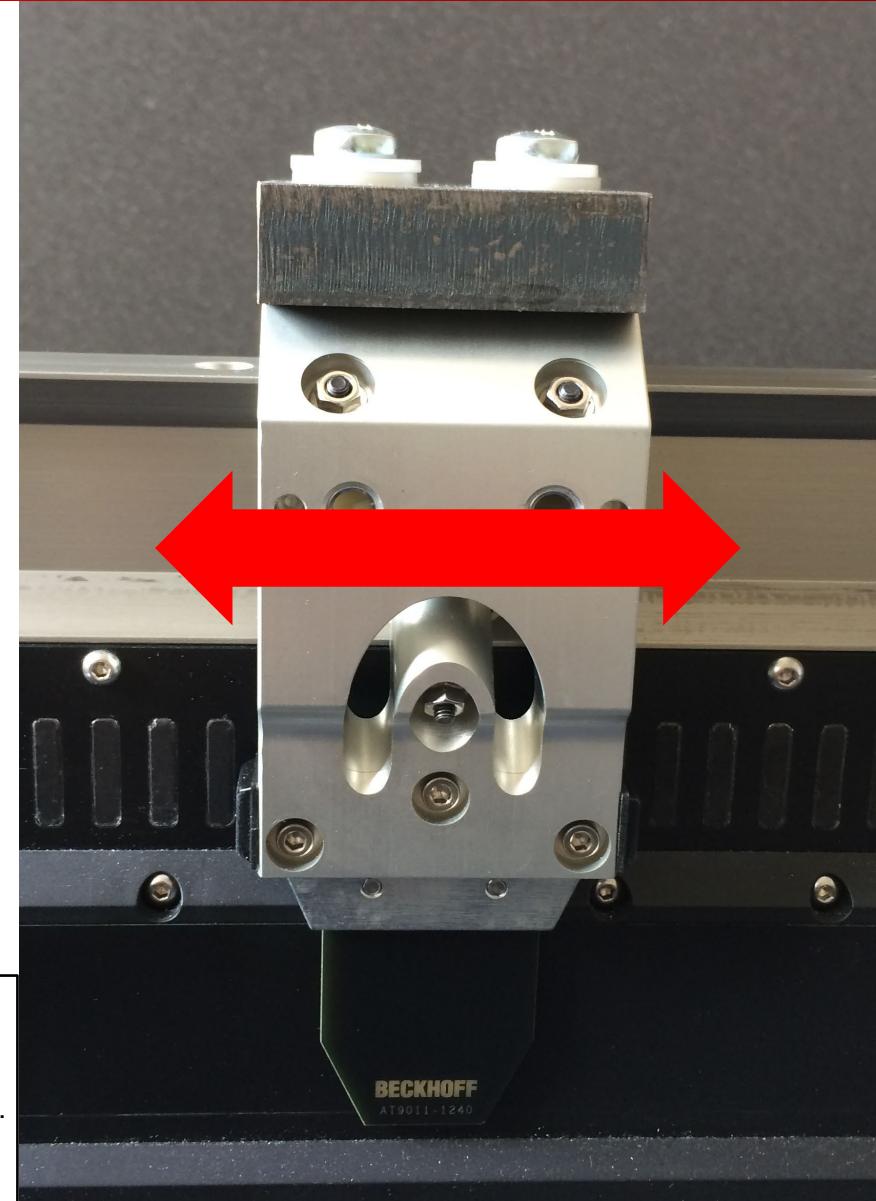
- To determine the Filter Settings there is a Tuning Assist
- The Tuning Assist suggests values to adjust the filters and feedforward parameters
- Typically only the Velocity and Position loops need to be tuned afterwards



Determining Filter Settings using Tuning Assist

- The Tuning Assist (TA) TcCom object is added to the existing TcSoftDrive module (Version \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.

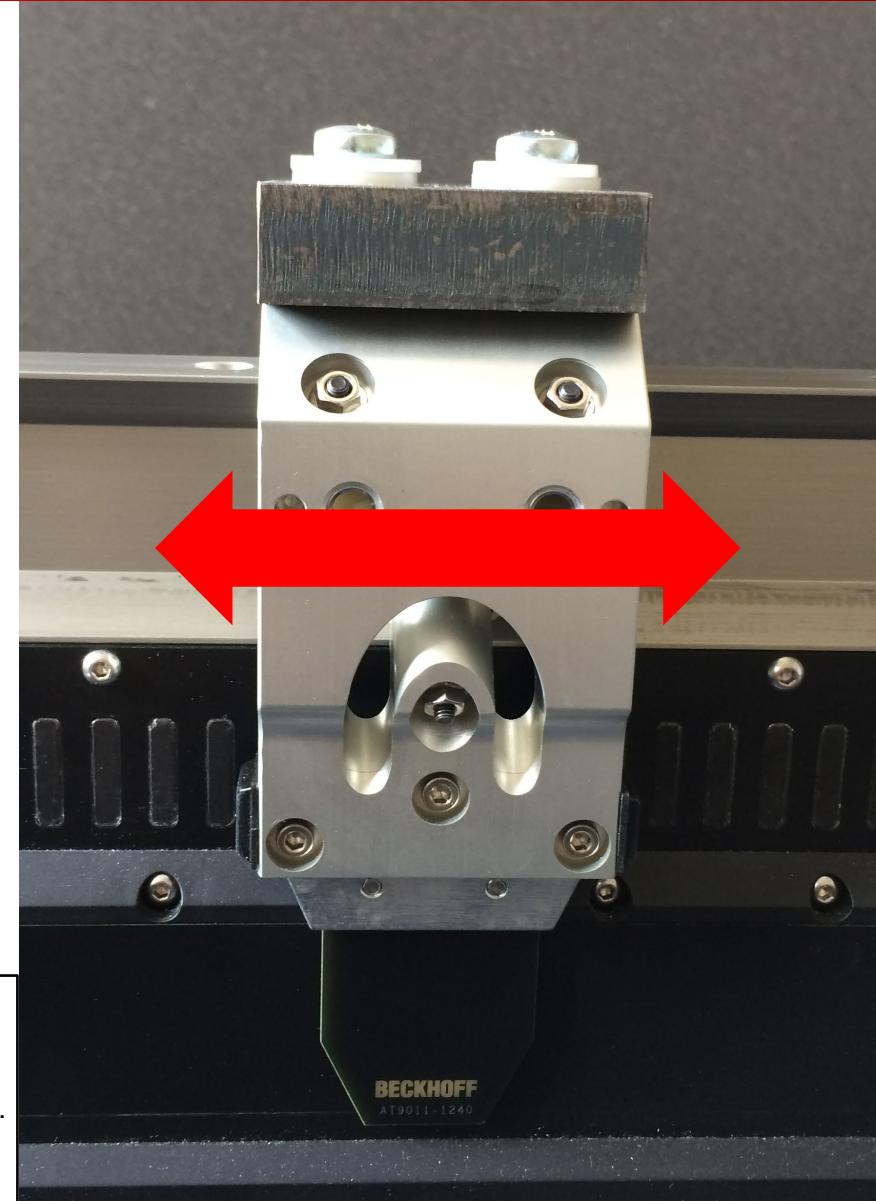
| | |
|--|---|
|  | Risk of injury from moving movers When the Tuning Assist function is started the mover starts to move open loop with a jump. There is a risk of injury to body parts. Keep an appropriate safety distance, and stay clear outside of the operating space. |
| WARNING | |



Determining Filter Settings using Tuning Assist

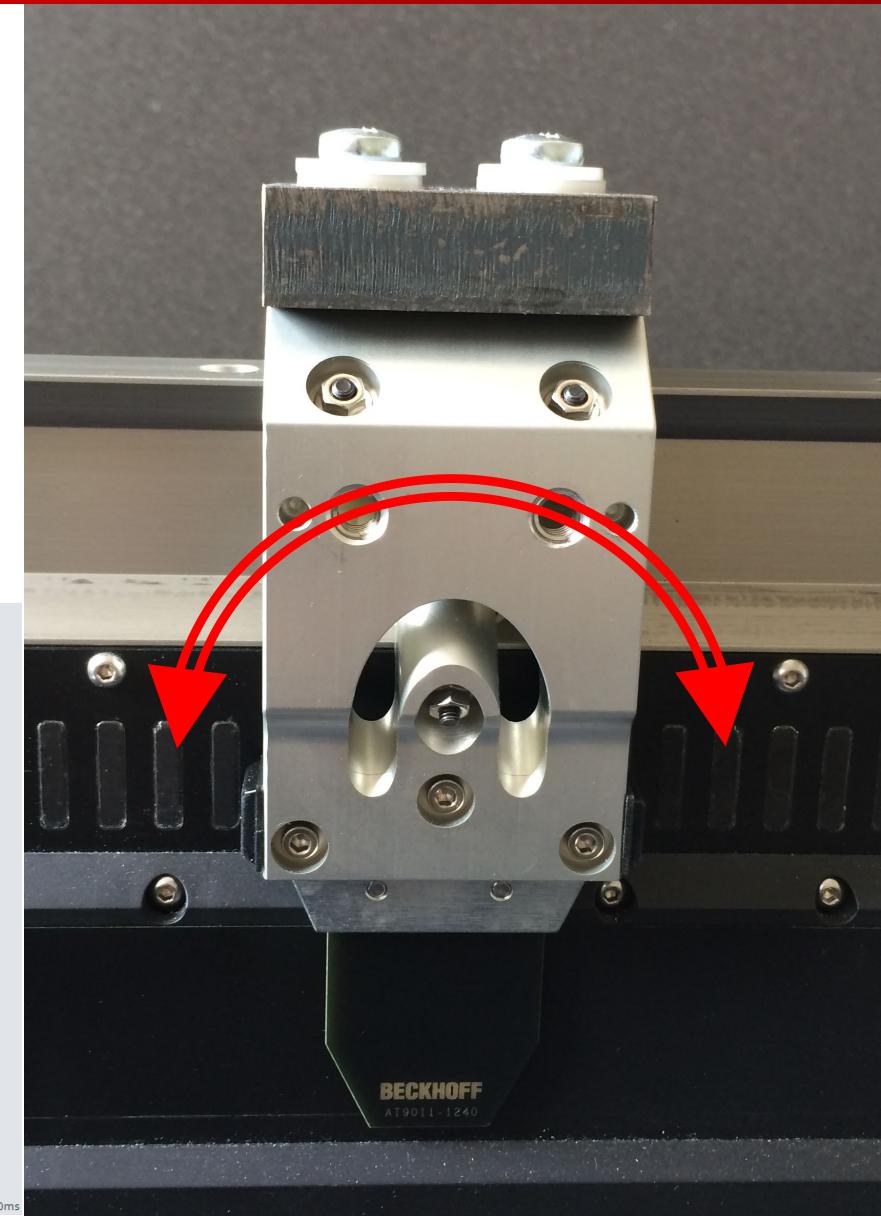
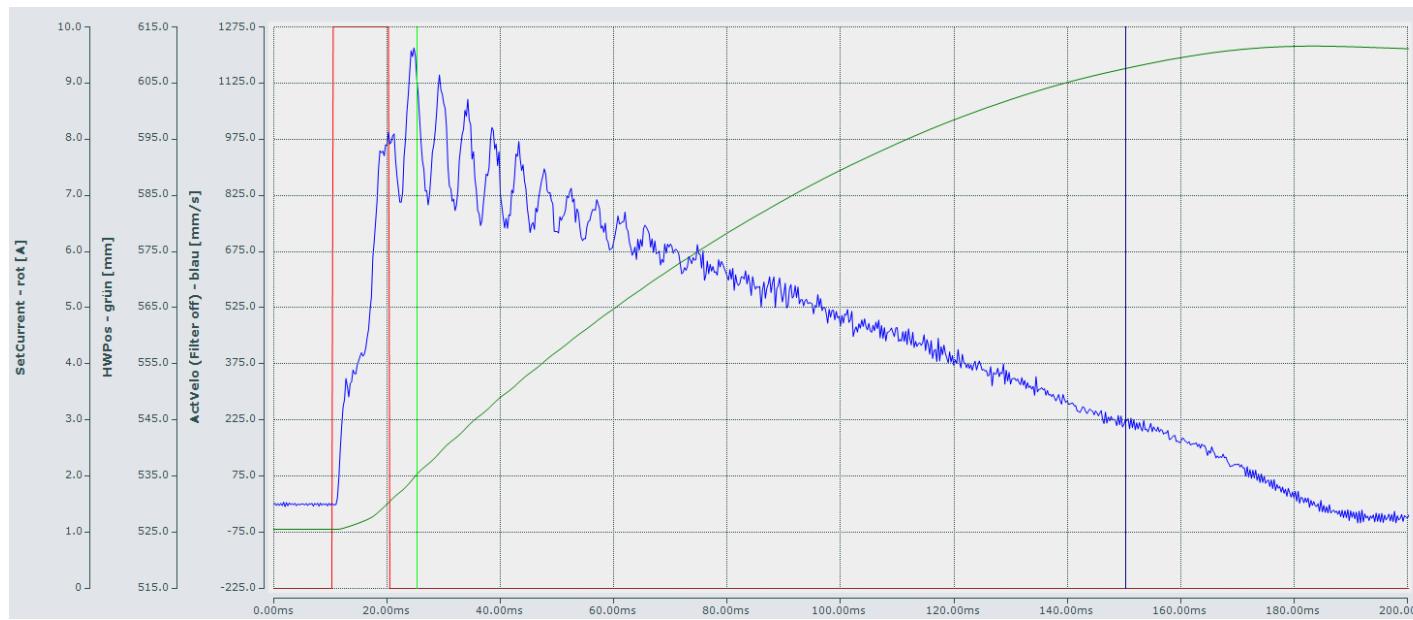
- The response of the system (Mover with tooling) will be measured and a Fast Fourier Transformation (FFT) is used to determine the frequency components
- The result could be visualized with the array bar chart functionality of TwinCAT 3 Scope Views (Version \geq 3.2.3136 starting with TwinCAT 3.1.4020.14)

| | |
|--|---|
|  | 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 | |



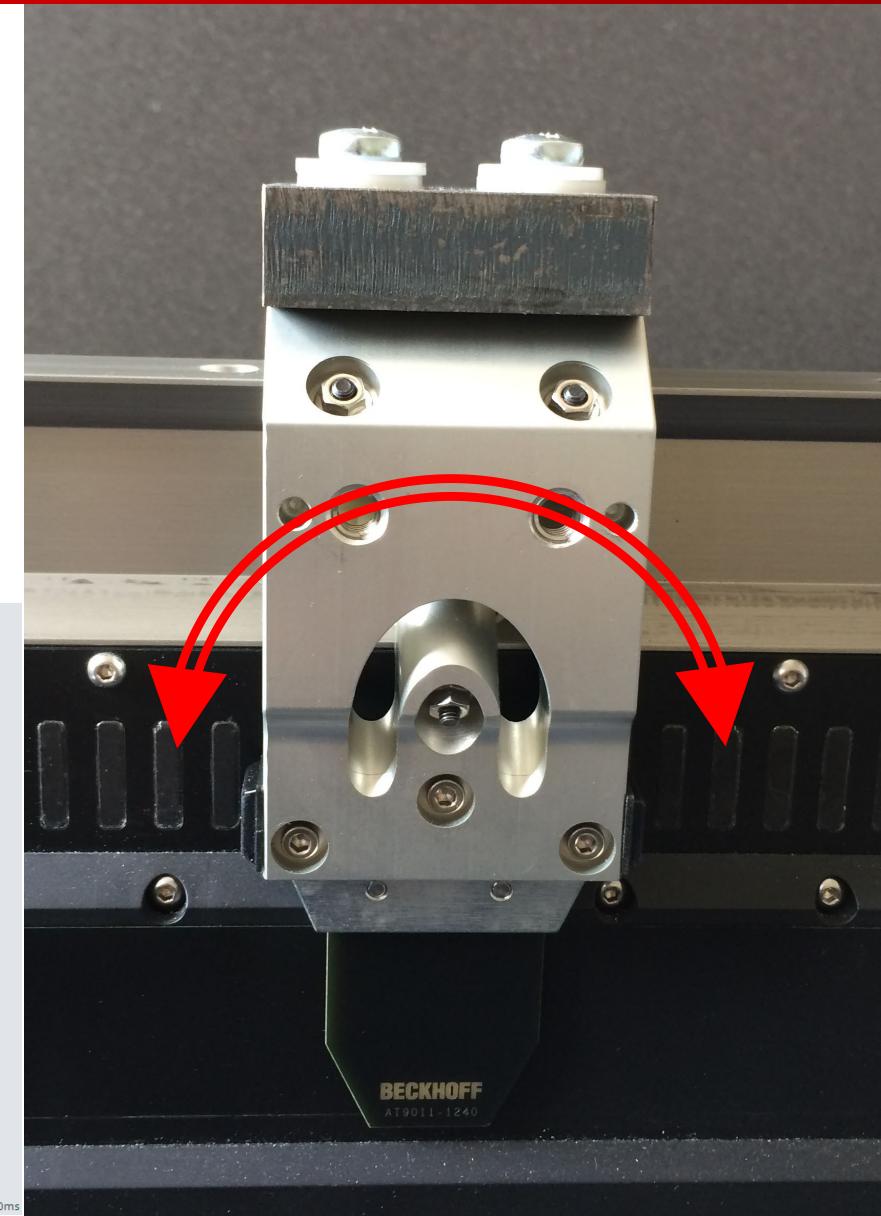
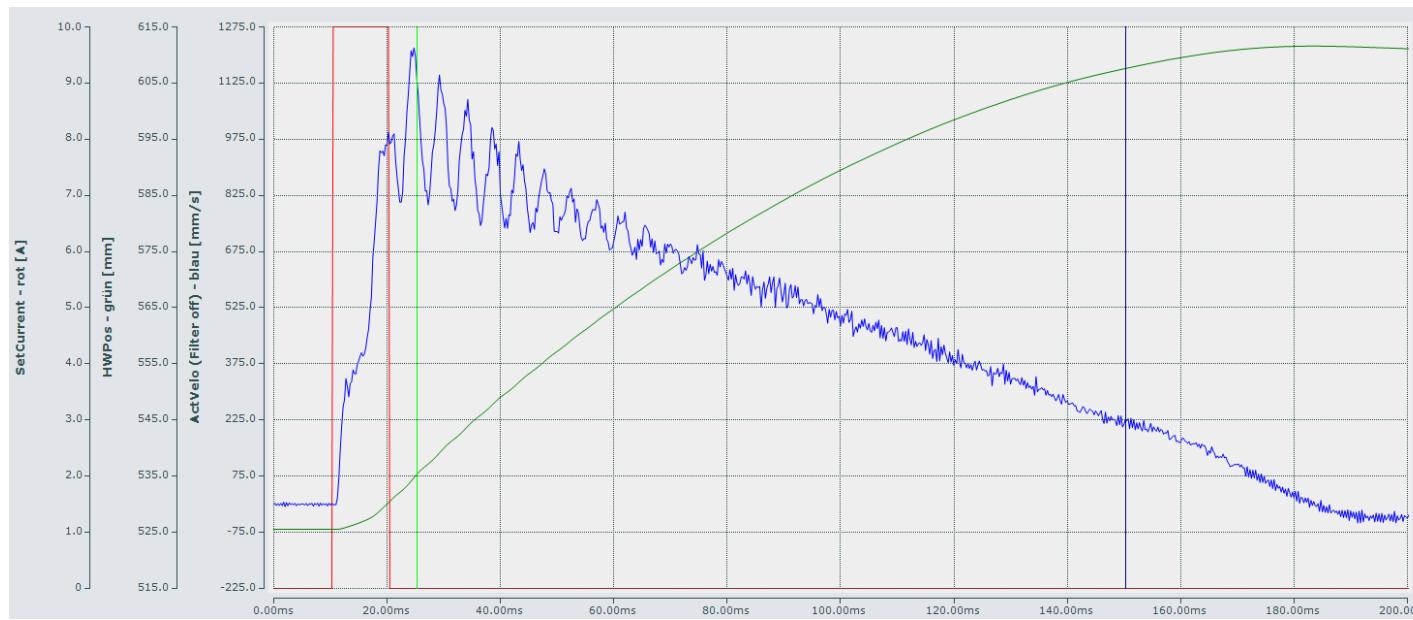
Determining Filter Settings using Tuning Assist

- 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.



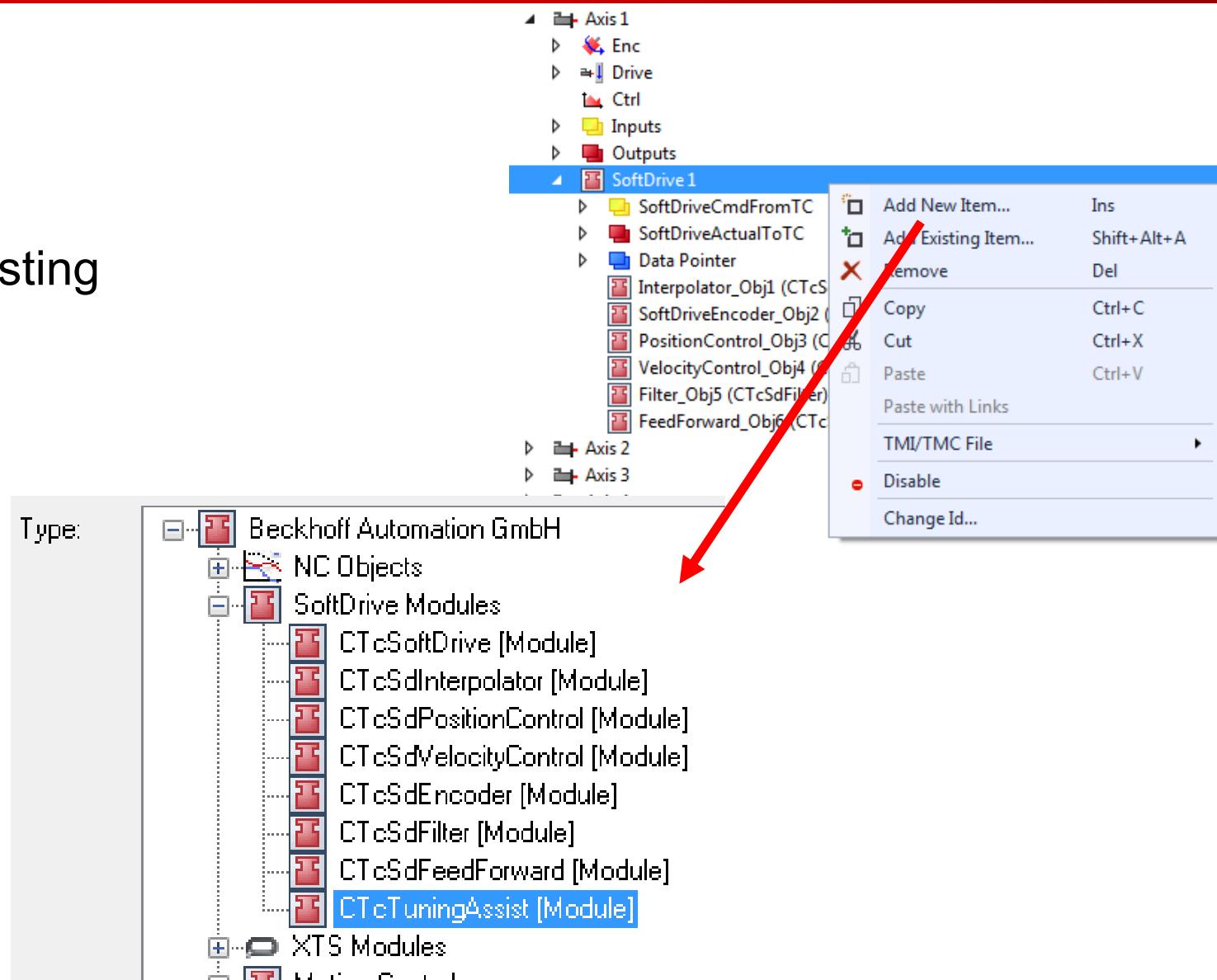
Determining Filter Settings using Tuning Assist

- 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.



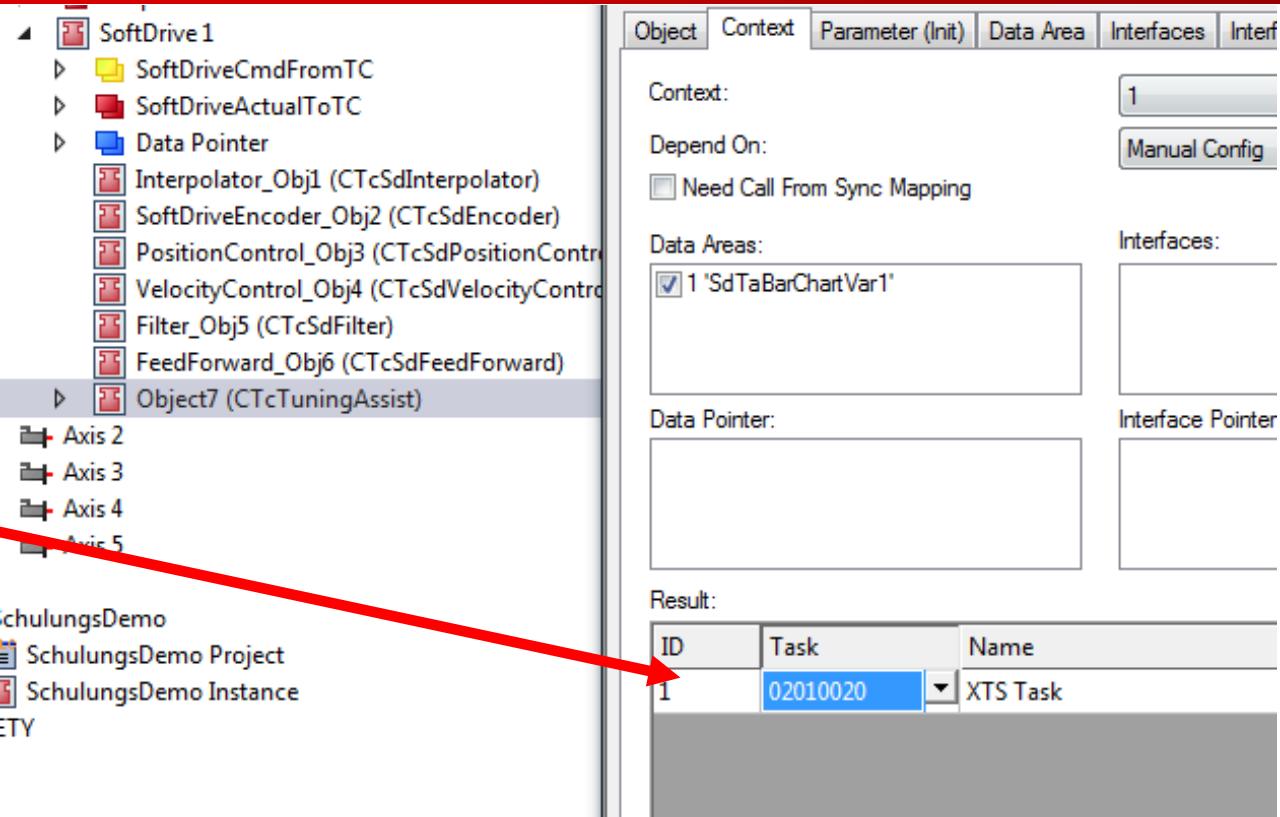
Determining Filter Settings using Tuning Assist

- Add a TuningAssist object to an existing TcSoftDrive



Determining Filter Settings using Tuning Assist

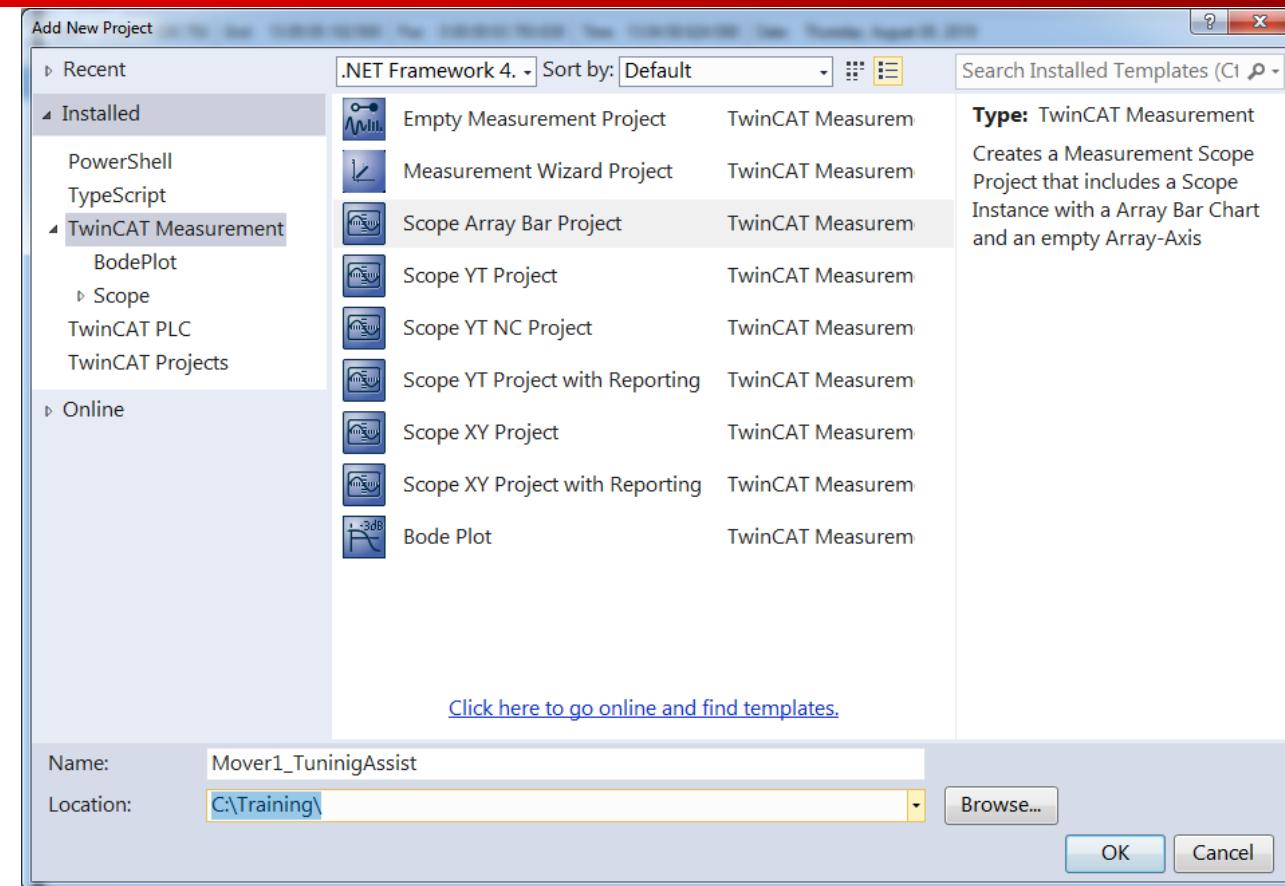
- Set the context task of the TuningAssist object to the same XTS task the TcSoftDrive is using
- Activate the configuration and restart TwinCAT



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

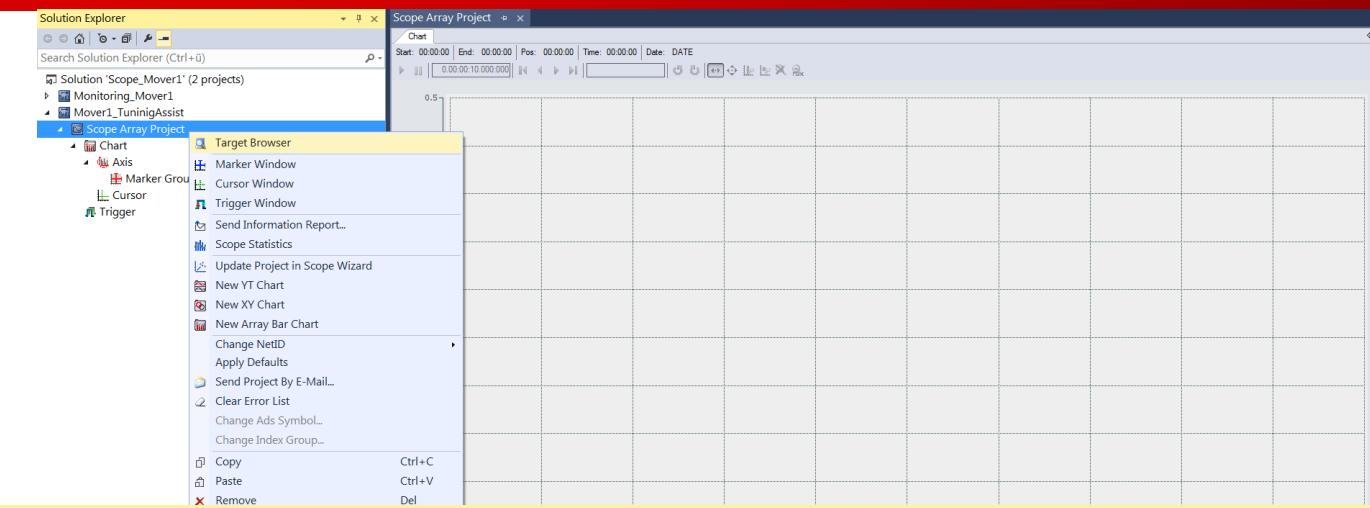
Determining Filter Settings using Tuning Assist

- 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



Target Browser

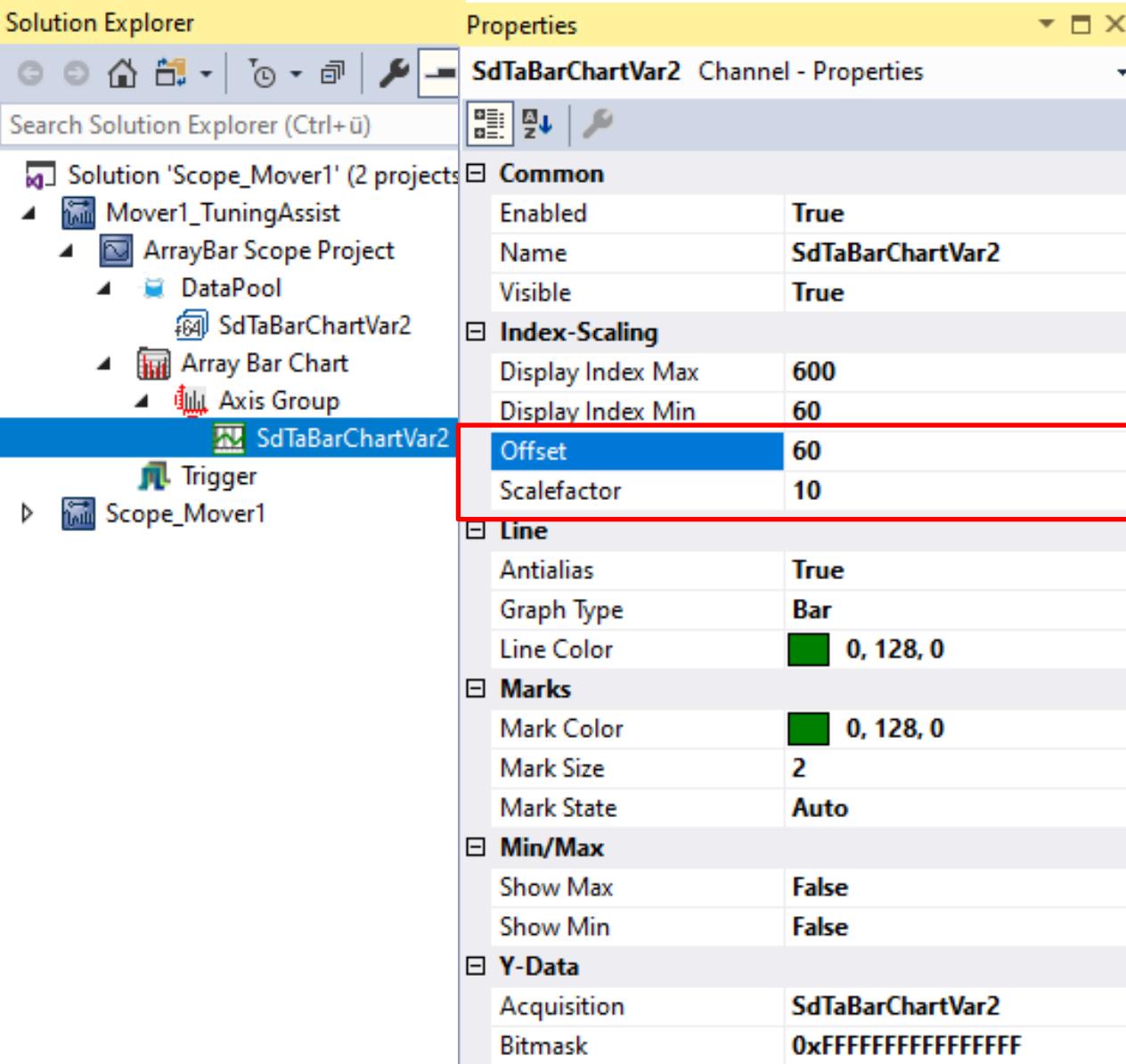
| Name | Type | Size | Category | Full-Nam | Comment | Subitem |
|-------------------------|----------|------|----------|------------------|--------------|---------|
| BECK-NB-1294 | | | | | | 1 |
| CP-22F110 | | | | | | 1 |
| 350: XTS Task 1 | | | | | | 1 |
| 351: PlcTask | | | | | | 1 |
| 352: VISUTASK | | | | | | 1 |
| 501: TCNC.NcTaskSaf | | | | | | 1 |
| 851: Port851 | | | | | | 1 |
| SdTaBarChartVar1 | | | | | | 1 |
| SdTaBarChartVar2 | ARRAY... | 440 | Struct | SdTaBarChartVar2 | FFT spectrum | 55 |

Add to Scope

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)

The screenshot shows the XTS Tuning Assistant interface. At the top, there's a navigation bar with tabs: General, Settings, Parameter, Dynamics, Online, Functions, Coupling, and Compensation. The 'Parameter' tab is currently selected. Below the tabs is a table with columns for Parameter, Offline Value, and Online Value. The table contains several entries, with the last two rows being highlighted in blue:

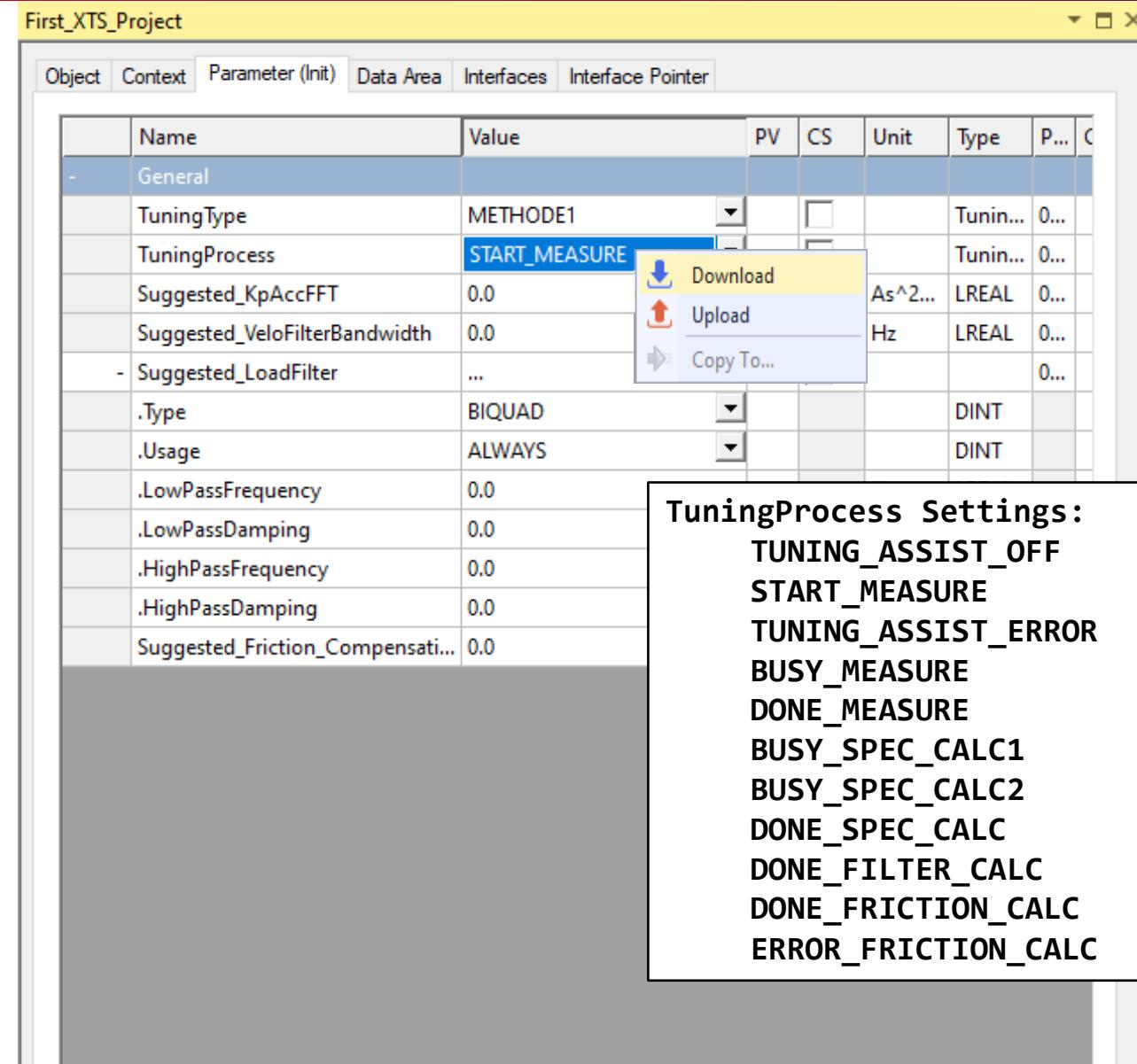
| | Parameter | Offline Value | Online Value |
|---|----------------------------------|---------------|--------------|
| + | Maximum Dynamics: | | |
| + | Default Dynamics: | | |
| + | Manual Motion and Homing: | | |
| + | Fast Axis Stop: | | |
| + | Limit Switches: | | |
| - | Monitoring: | | |
| |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

At the top right of the main window, there's a title bar labeled "First_XTS_Project". Above the main window, a sidebar titled "Axes" lists the project structure:

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

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 |

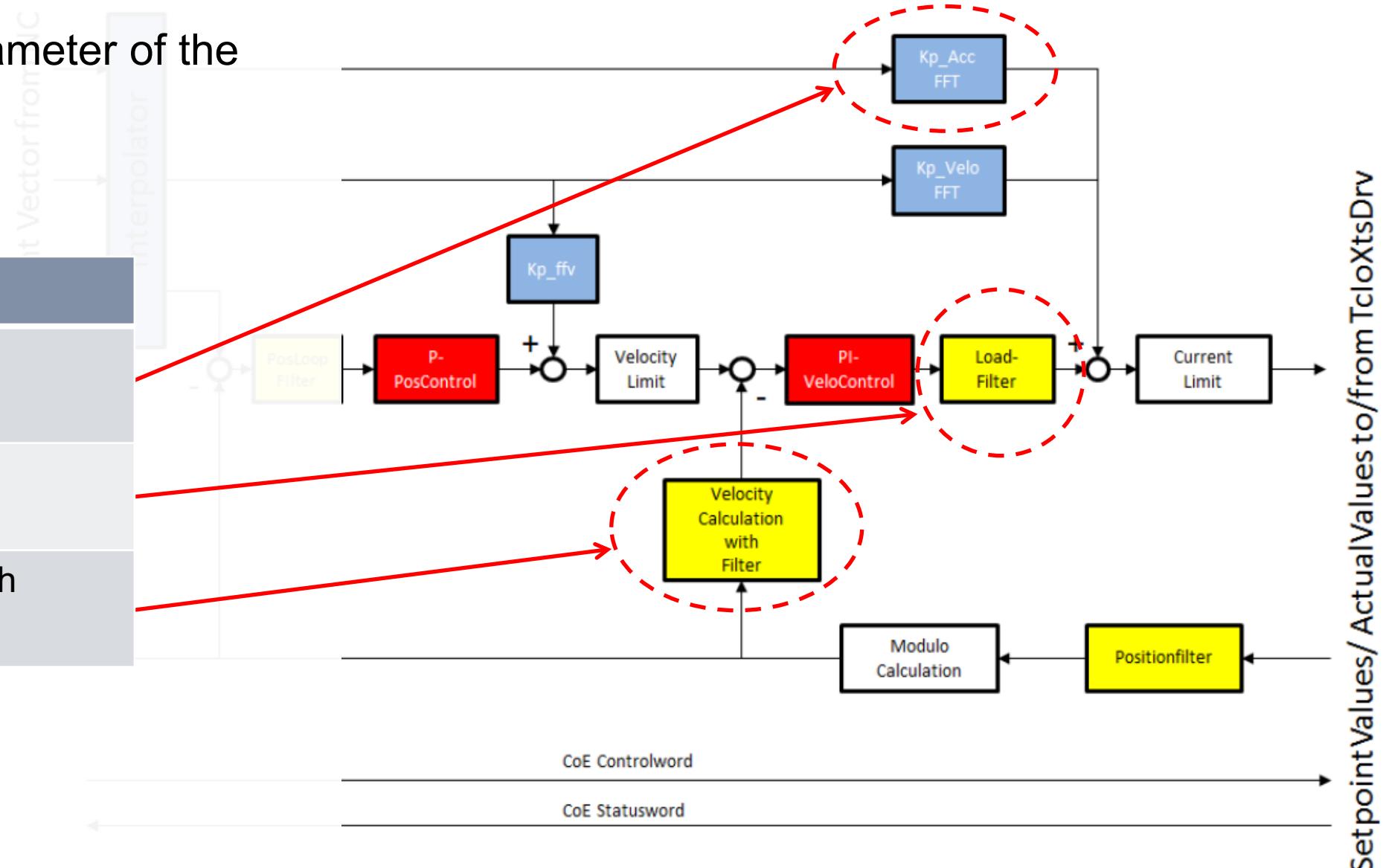
- The Suggested parameter of the Tuning Assist

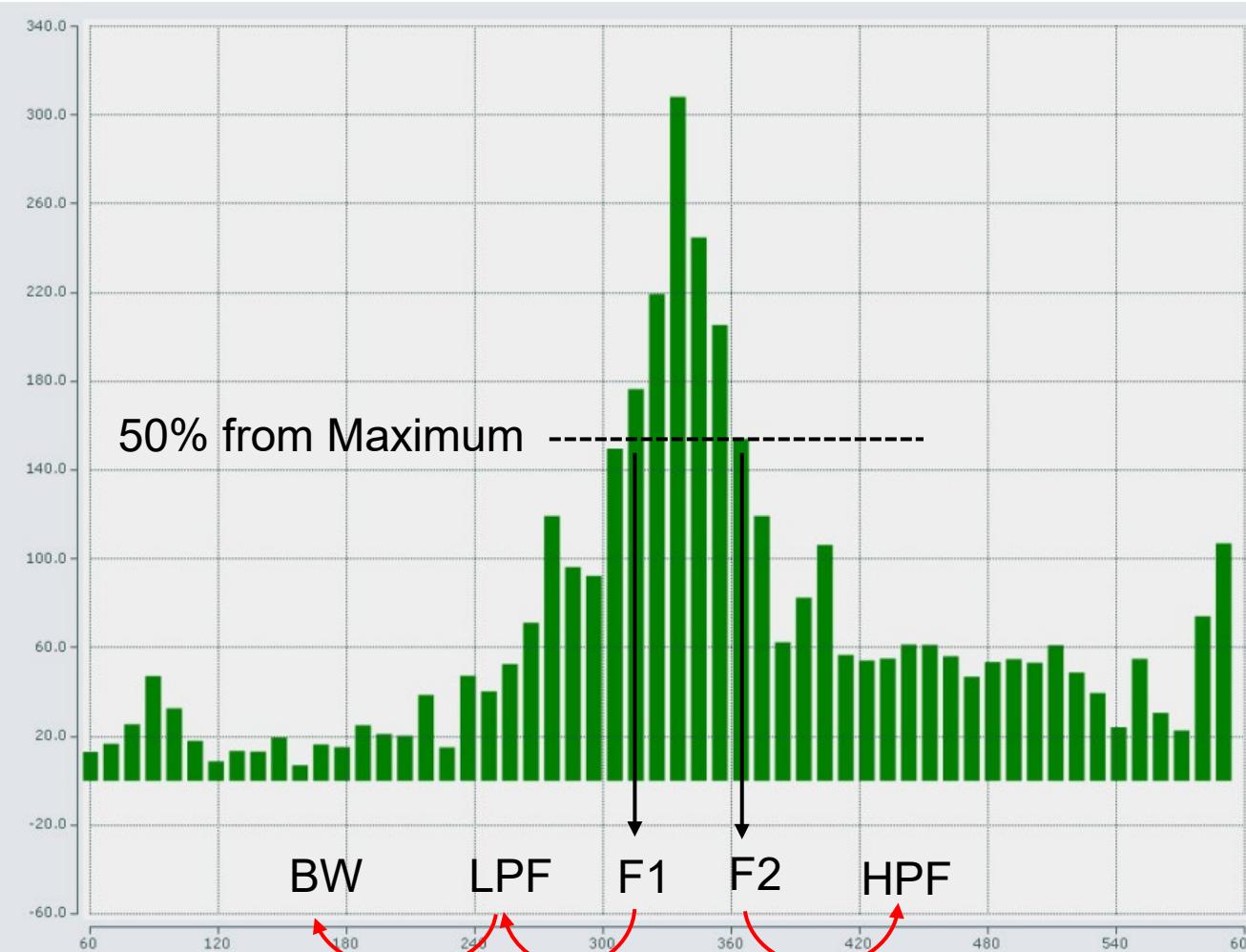
Parameter

Suggested_KpAccFFT

Suggested_LoadFilter

Suggested_VeloFilterBandwidth



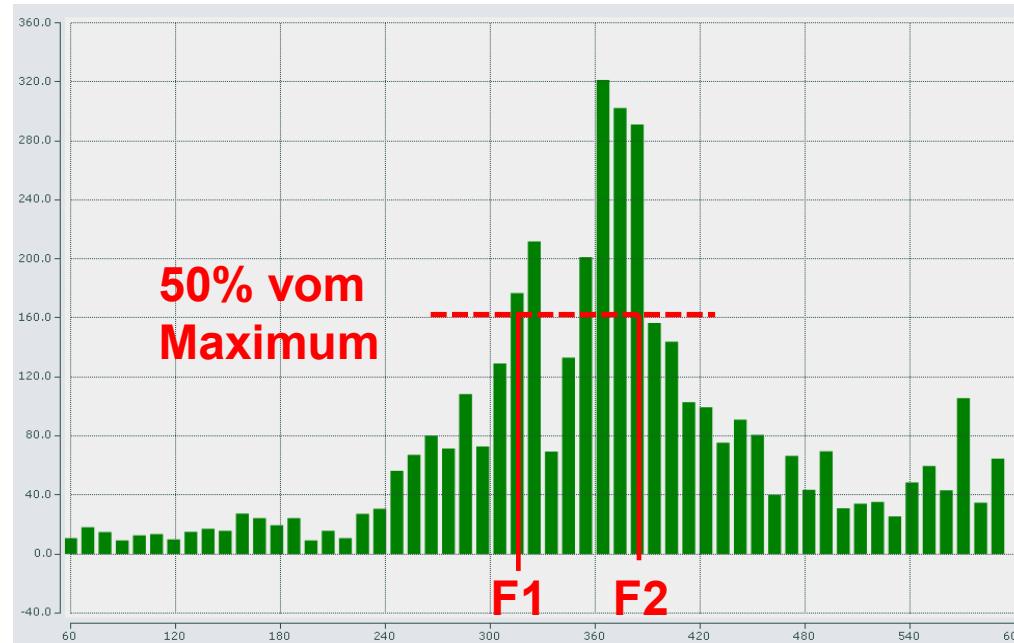


| Name | Value |
|-------------------------------|------------------|
| TraceLevelMax | tlAlways |
| TuningType | METHODE1 |
| TuningProcess | DONE_FILTER_CALC |
| Suggested_KpAccFFT | 1.6 |
| Suggested_VeloFilterBandwidth | 146.0 |
| Suggested_LoadFilter | ... |
| .Type | BIQUAD |
| .Usage | ALWAYS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

Result of calculation

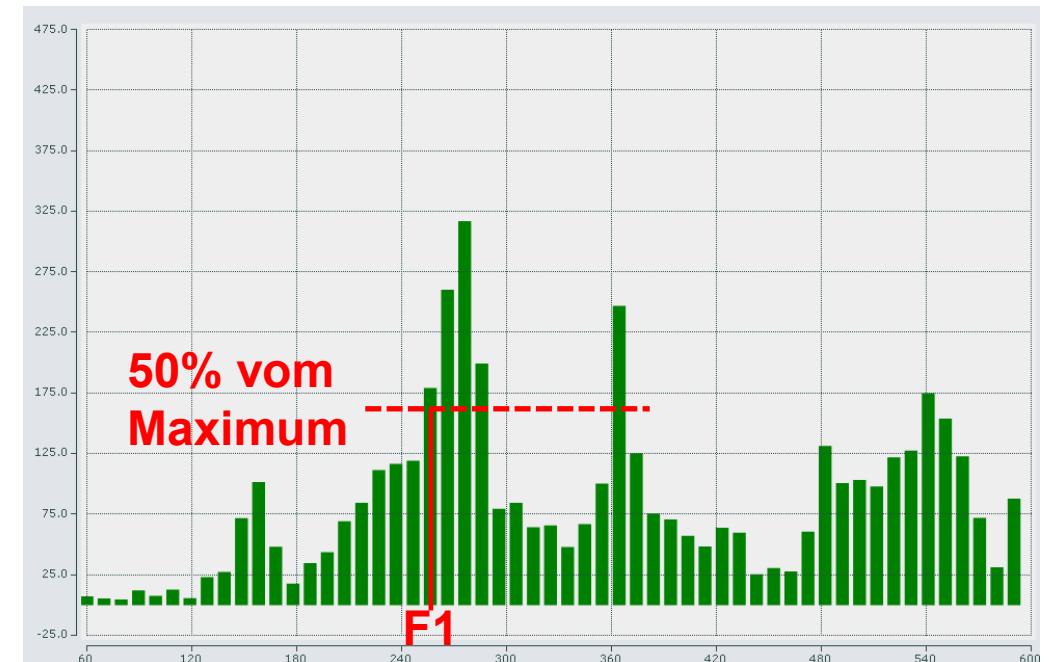
This graphic shows how the calculation for the filter suggestion is done with one FFT result

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



Example 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

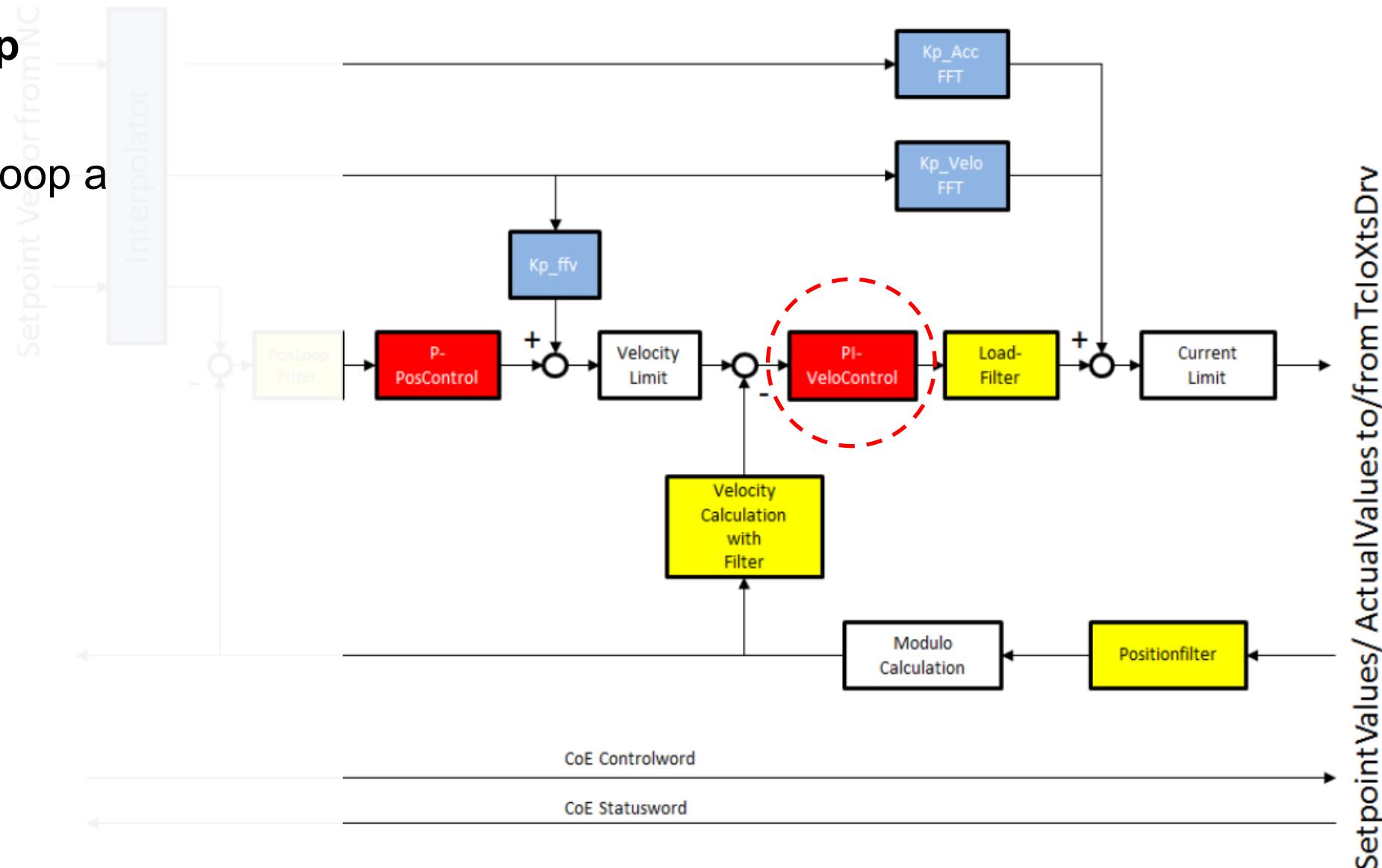
- Enable the NC axis first and set the following error monitoring in the corresponding NC axis to a high value e.g. 500mm (or disable it)
- Execute some more measurements e.g. three on the straight and three on the curve and maybe also with / without product on the mover
- Analyze the spectrum manually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

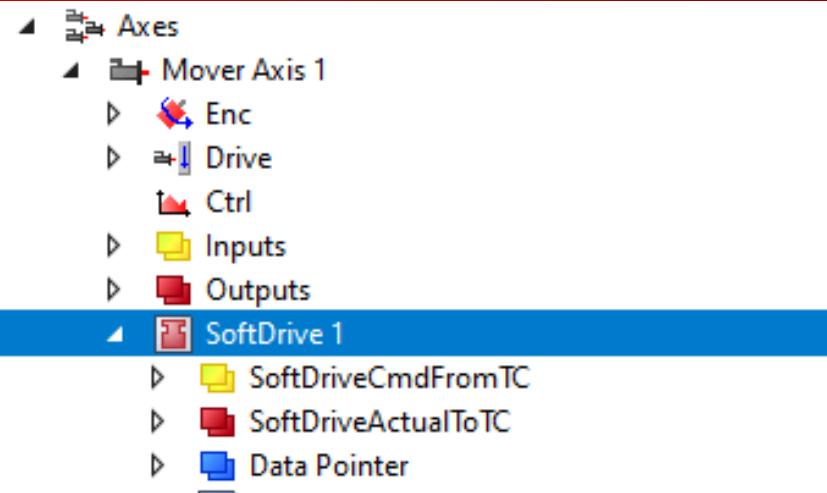
- For velocity control loop a “PI” – Loop is used.

- Setup Kp
- Setup Tn



Velocity Control Loop

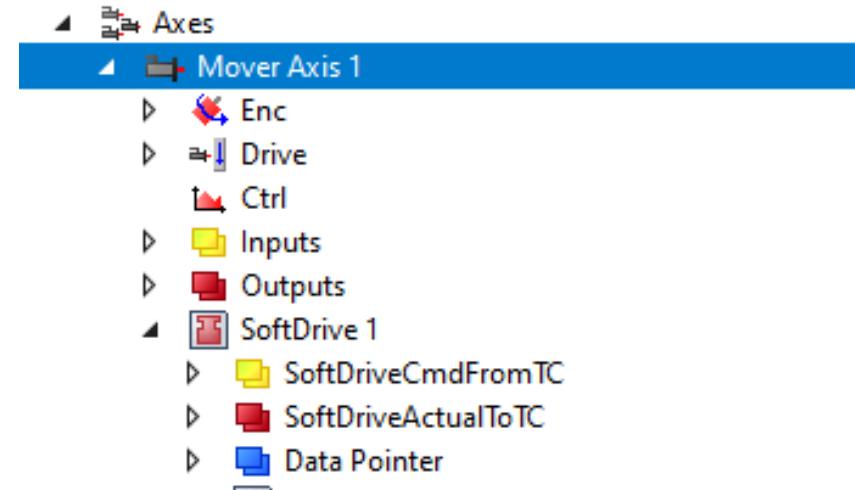
- Disable or remove the Tuning assist object (if not already done)
 - Set the SoftDrive “OperationMode” parameter in the main object to 9 (cyclic synchronous velocity mode)



| Data Area | | Interfaces | | Interface Pointer | | Data Pointer | | | |
|-----------|----------------------|------------------|--------------------------|-------------------|------|--------------------|----|-------|---|
| Object | Context | Parameter (Init) | | | | Parameter (Online) | | | |
| | Name | Value | | CS | Unit | Type | P | Co... | ^ |
| - | General | | | | | | | | |
| | AdsPort | 0x015e | <input type="checkbox"/> | | | W... | 0. | | |
| | HardwareModulo | 3000.0 | <input type="checkbox"/> | | | LR... | 0. | | |
| | OperationMode | 9 | <input type="checkbox"/> | | | UD... | 0. | | |
| | MaxCurrentOutput | 12.0 | <input type="checkbox"/> | | | LR... | 0. | | |
| | EmergencyRamp | 10000.0 | <input type="checkbox"/> | | | LR... | 0. | | |
| | EmergencyTimeOut | 0.5 | <input type="checkbox"/> | | | LR... | 0. | | |
| | StandstillSwitchTime | 0.1 | <input type="checkbox"/> | | | LR... | 0. | | |
| | StandstillSwitchTime | 0.1 | <input type="checkbox"/> | | | LR... | 0. | | |

Velocity Control Loop

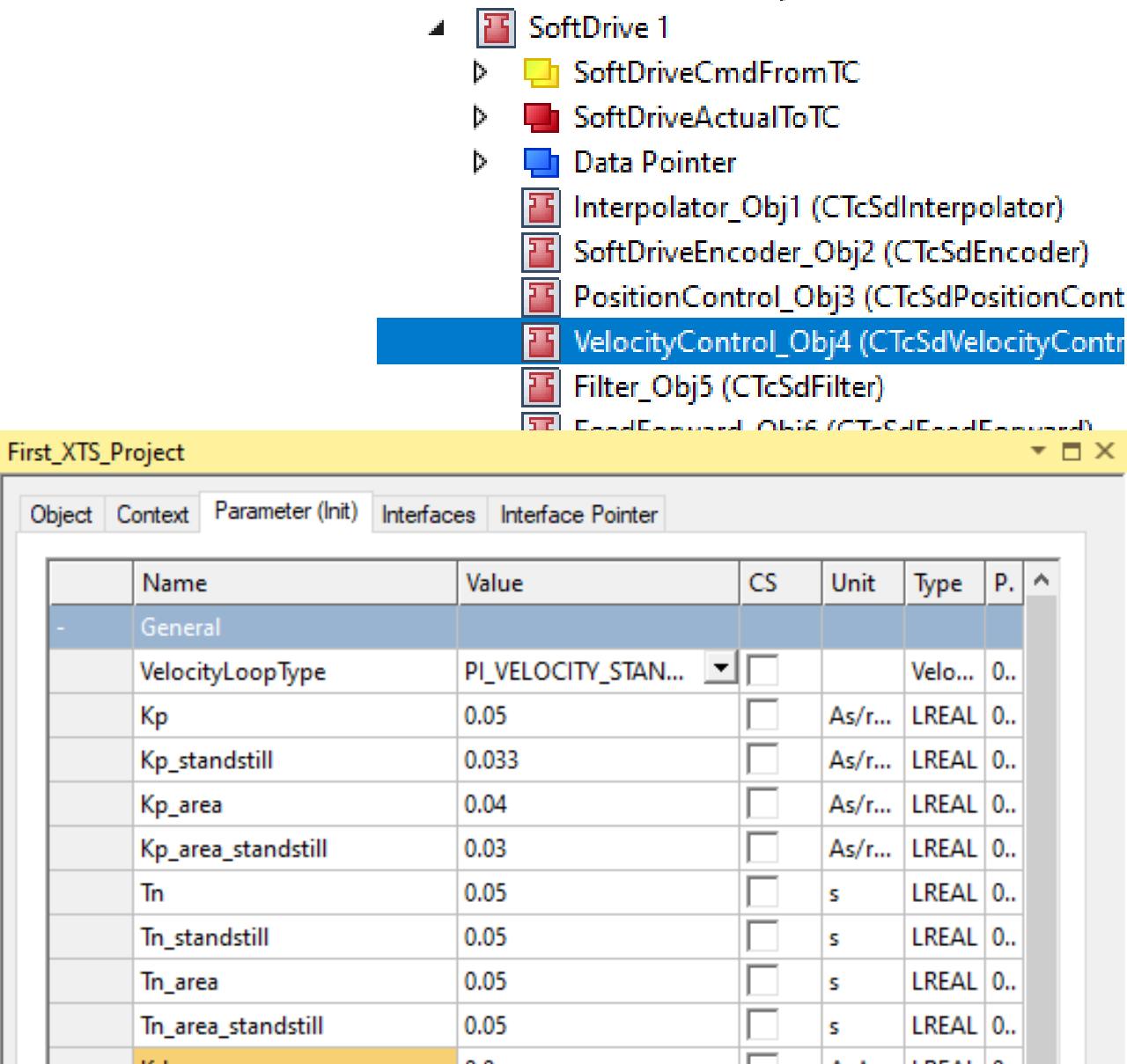
- Set the following error monitoring to a high value e.g. 500mm (or disable it)



| 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 |

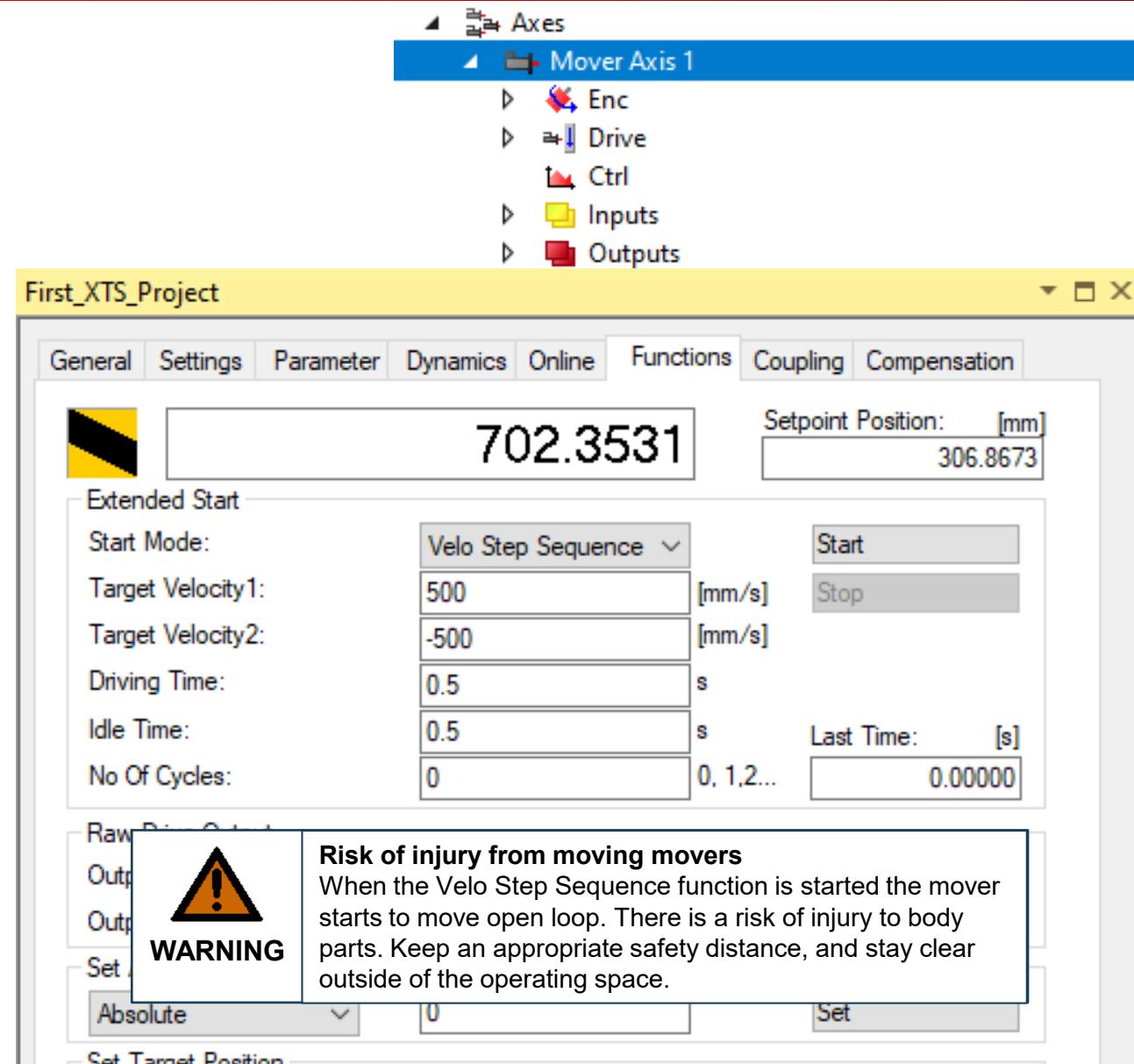
Velocity Control Loop

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



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)



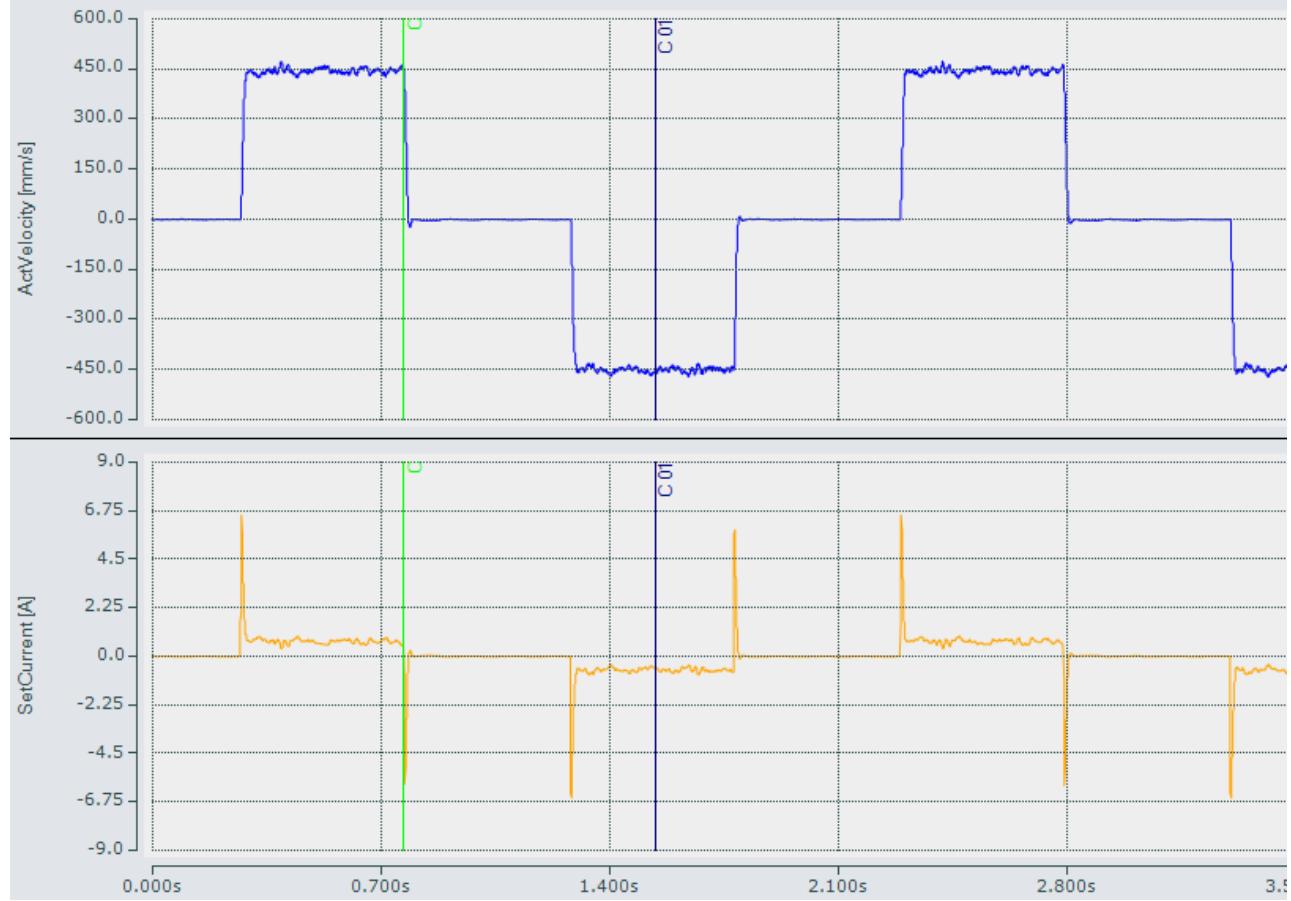
Velocity Control Loop

- 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)

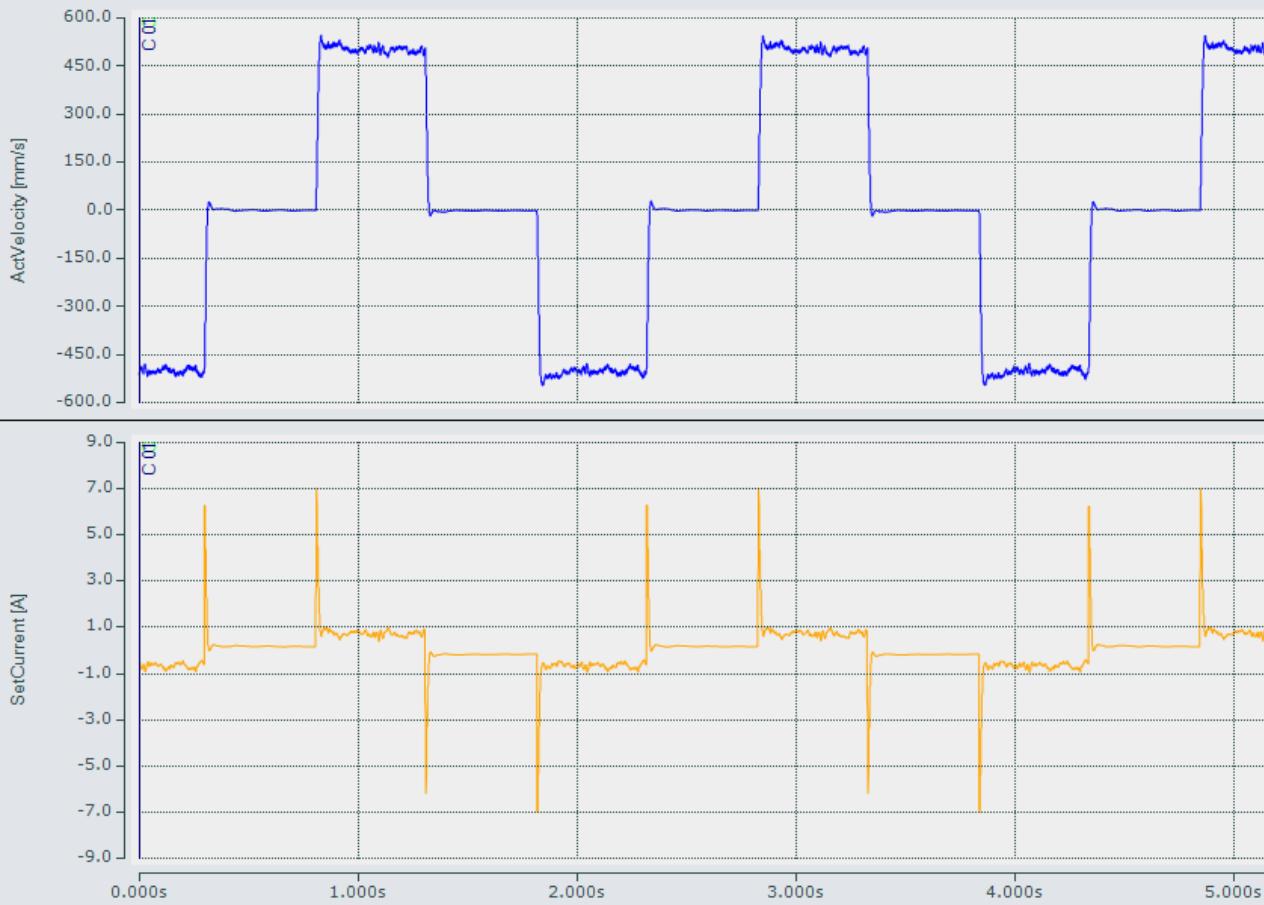
- Set Kp_standstill parameter to the same value or a bit less e.g. 75%



Set Kp to reach 90% of command velocity

Velocity Control Loop

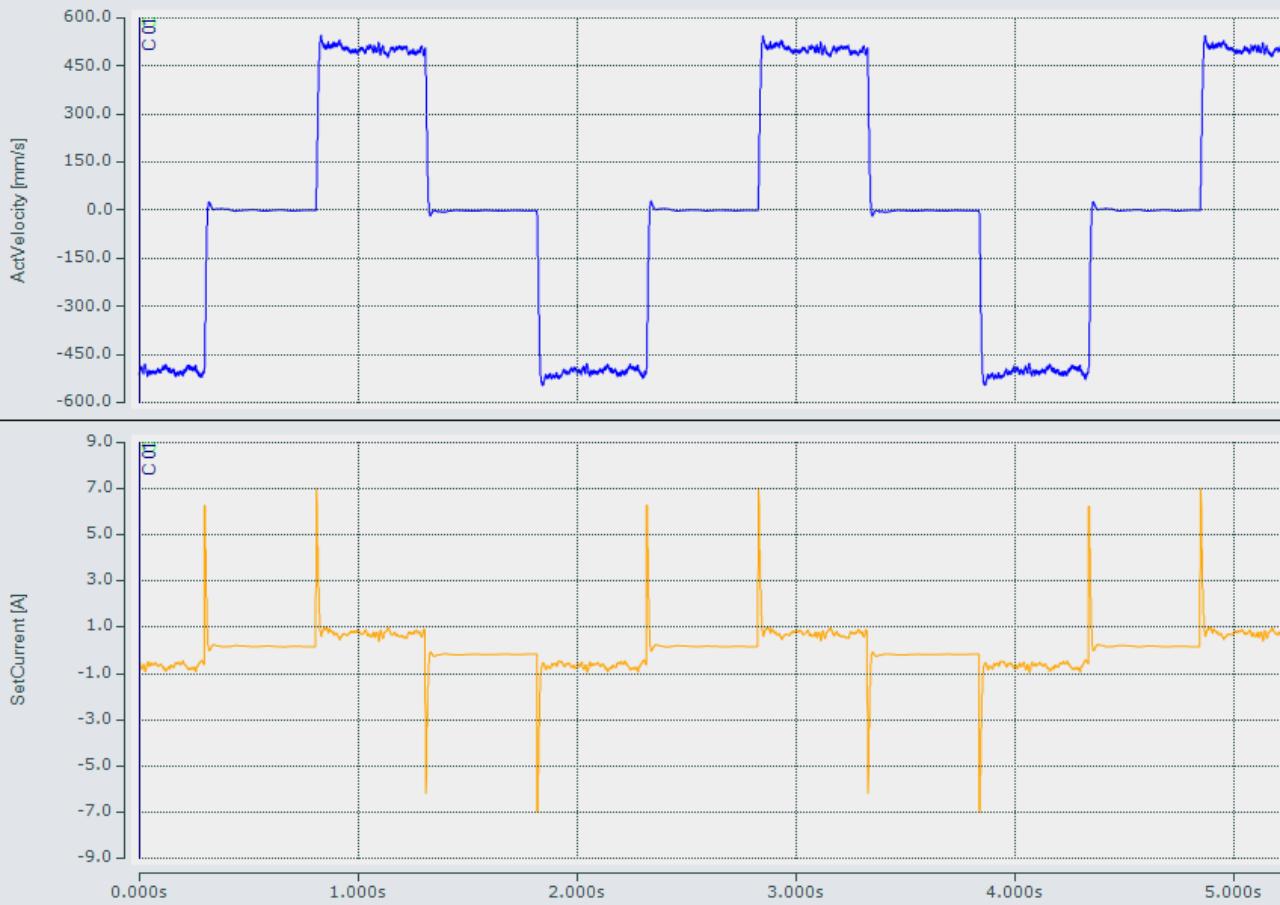
- Switch on Tn with a large time value
e.g. 0.2 s
and reduce this incrementally until the
actual velocity has a small overshoot
of
5 – 10% of the command
- Repeat procedure for the curve and
use area parameters in case of
differences in the straight and curve
sections
- Avoid saturating the current output



Set Tn to reach 5 -10 % overshoot

Velocity Control Loop

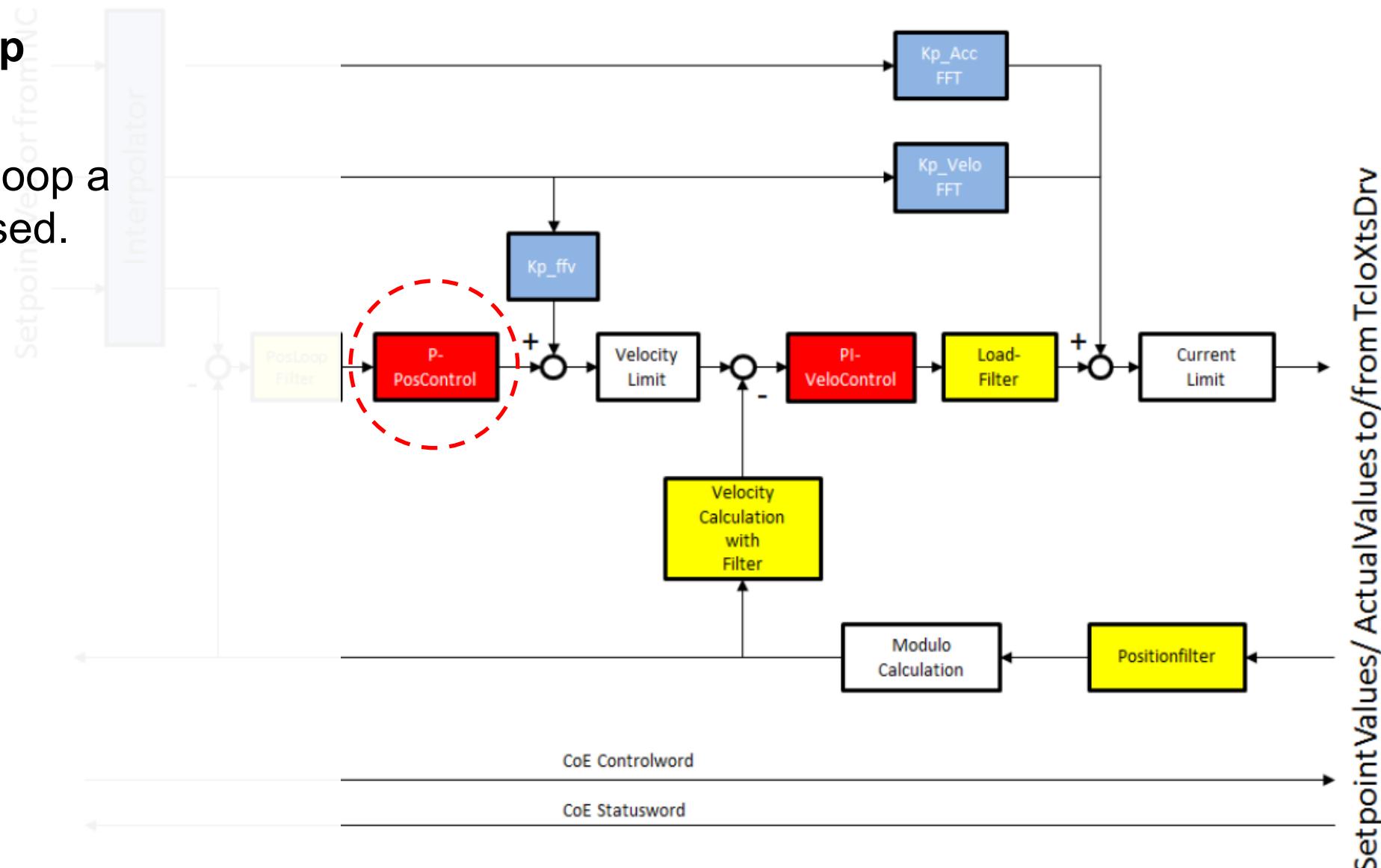
- Repeat procedure for the curve and use area parameters in case of differences in the straight and curve sections
- Avoid saturating the current output



Set Tn to reach 5 -10 % overshoot

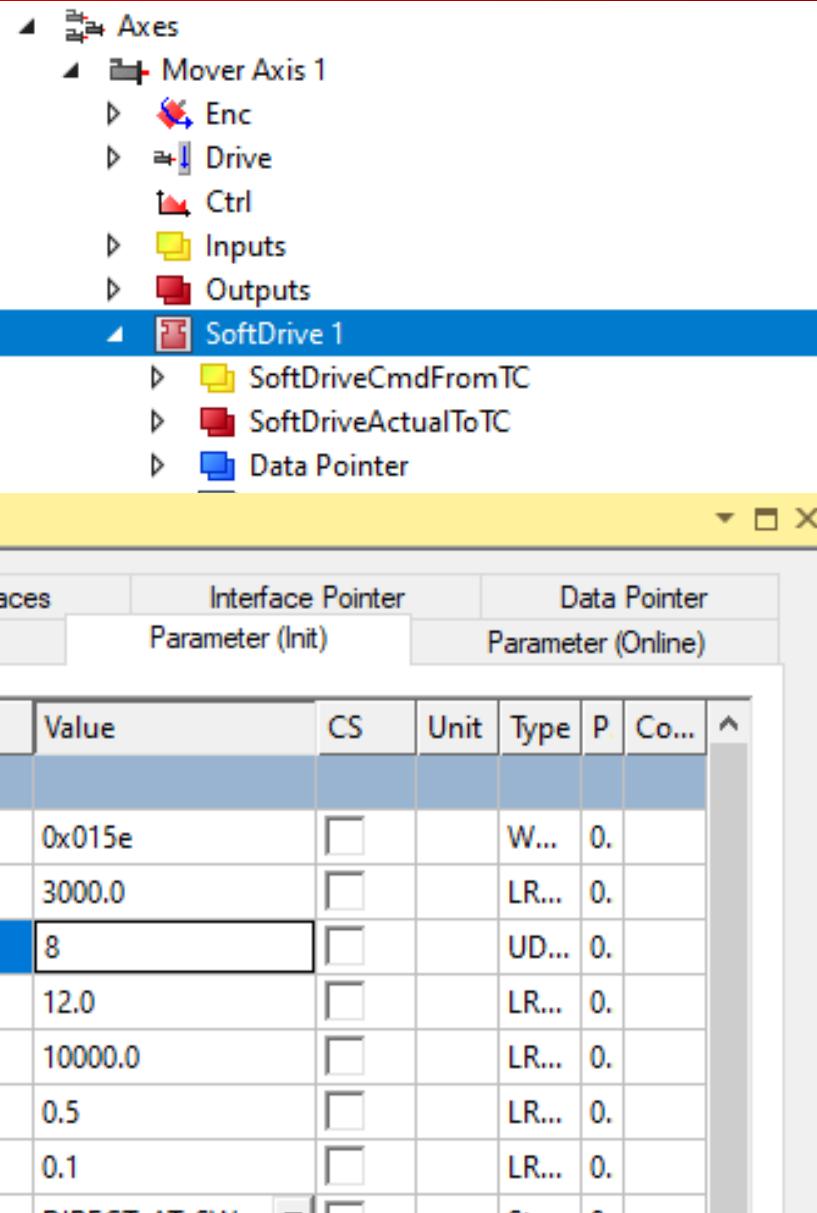
Position Control Loop

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



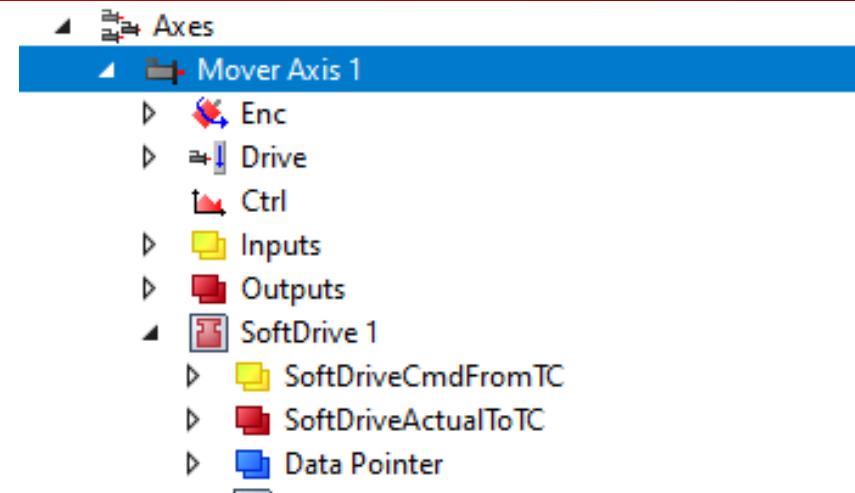
Position Control Loop

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



Position Control Loop

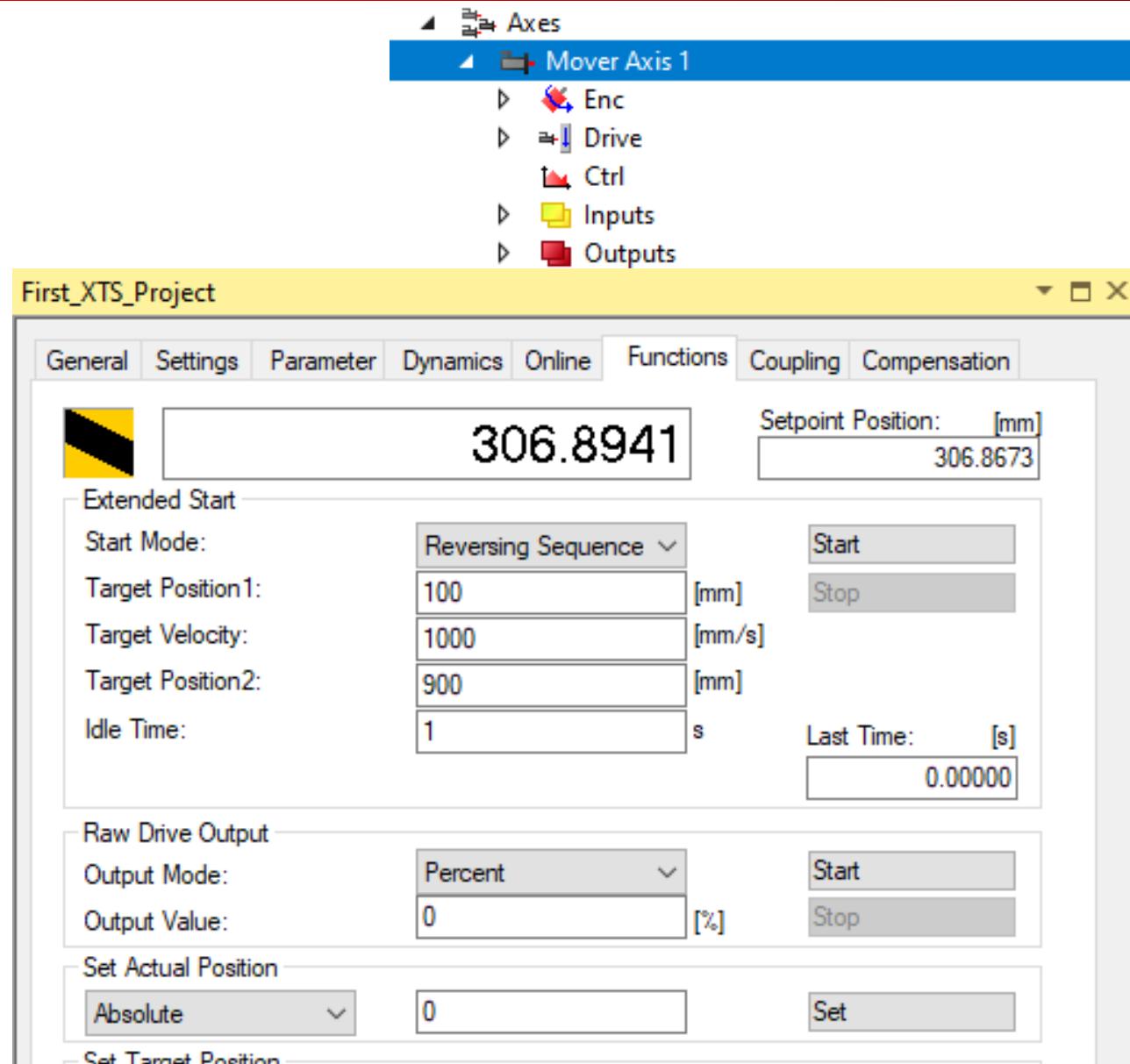
- Set the following error monitoring back to “normal” values



| | 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 |

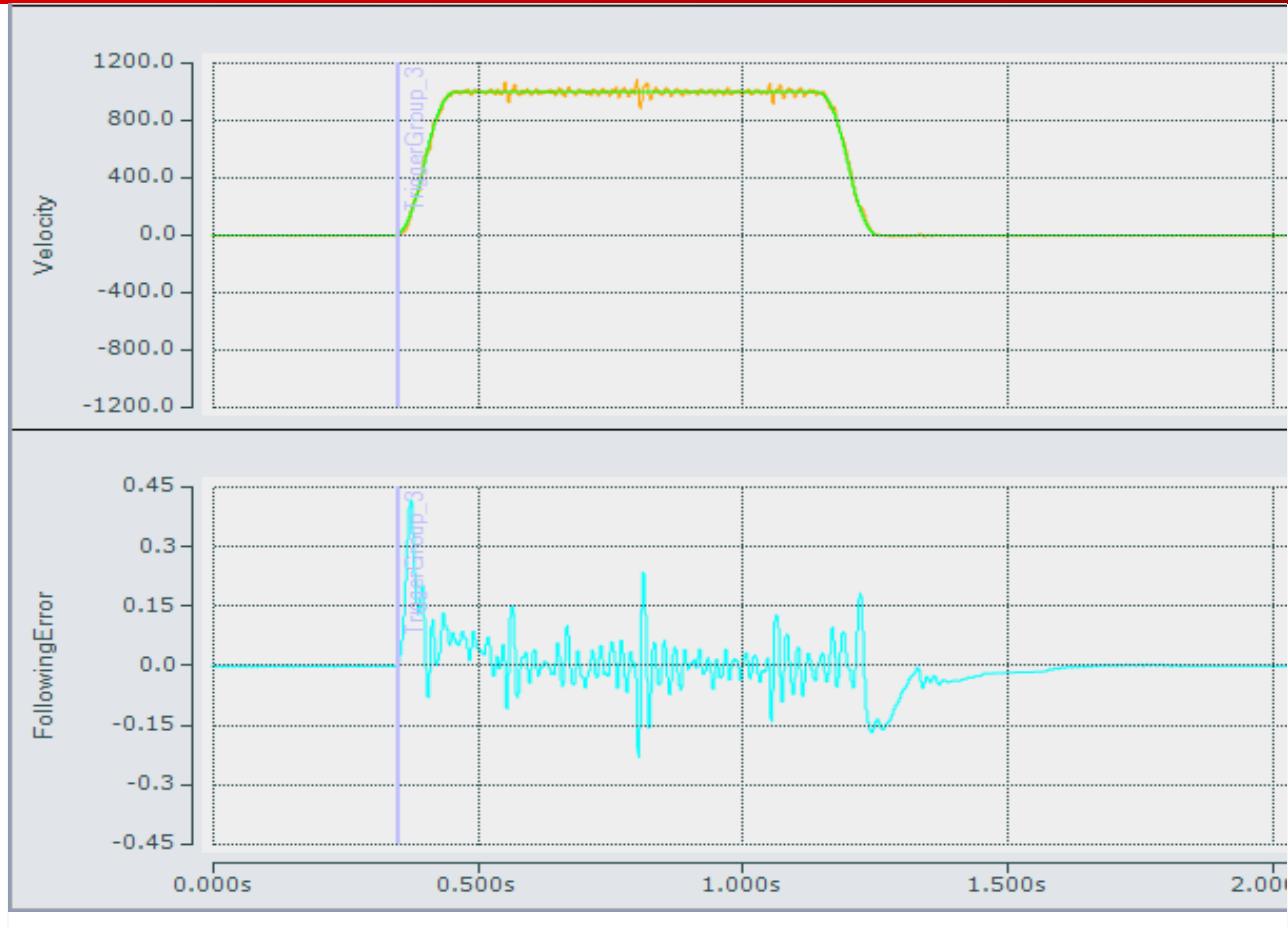
Position Control Loop

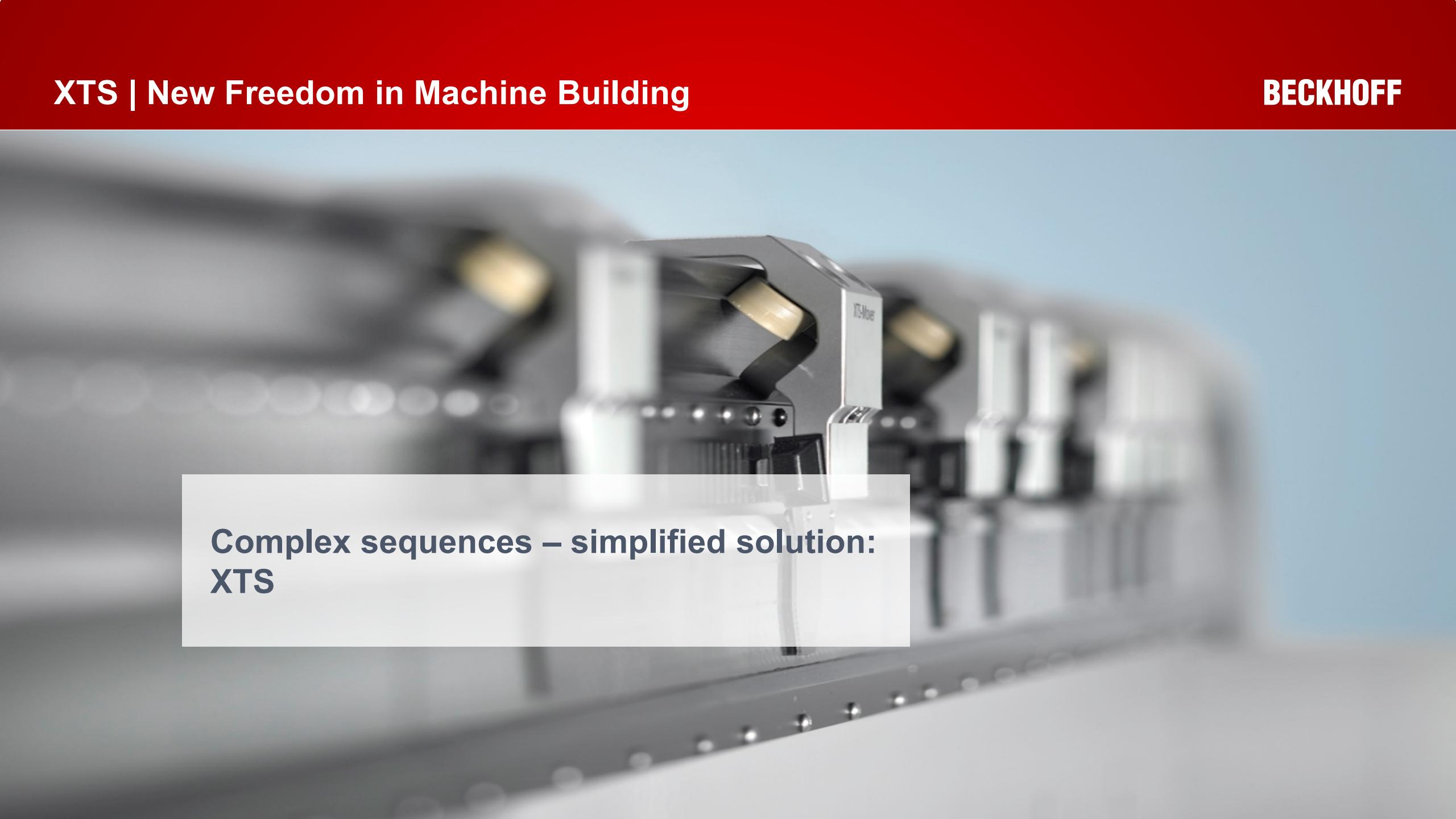
- Enable the NC axis and start the service mode “Reversing Sequence” with achievable (or necessary) values for velocity, acceleration and jerk
- Also scope the following error parameter of the SoftDrive



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

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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

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