Triamec TwinCat Ethercat

Quick Startup Guide

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1 Introduction

This user guide explains how to use Beckhoff TwinCAT NCI or CNC in conjunction with Triamec EtherCAT drives. EtherCAT drives from Triamec are marked with the letter “E” after the name, i.e., TSD80E, TSD85E, TSD130E, TSD350E, TS360E, TS710E.

The TriaLink series TS35x, TSP700, TSD80T etc. are not covered with this guide. See ([1]) on how to set up these drives with TwinCAT.

2 Configuring the drives

Before a drive can be used with TwinCAT, the drive has to be configured with the TAM System Explorer. See the Setup Guide[(2)] for how to setup the drive parameter, install new firmware and for how to save the parameters persistently on the drive.

Remarks:

- For configuration the drive has to be connected with the PC through a USB or Ethernet connection and the TAM System Explorer has to be installed on the connected PC. It is recommended to set “File > Preferences > Startup > Acquired Adapters” to “Triamec devices over USB” or “Triamec Devices over Ethernet” to accelerate booting. The EtherCAT control system PC does not require an installation of the TAM System Explorer if it is not intended to used for configuration or debugging of the drive.
- When using the TAM System Explorer to configure the drive, the drive must not follow the EtherCAT commands. Therefore set *Axes[].Commands.General.OverwriteControlSystem* to 1 or, when using the Axis Module, use the button “Attach” to set the *OverwriteControlSystem* command. Don't forget to reset the command when the configuration is done.
- Set *Parameters.PositionController.PositionUnit* for each axis for proper position scaling as discussed in chapter 6.1.
- To not loose the settings on a power-down of the dive save the configuration persistent on the drive as described in [(2)]. Later changes of the configuration need to be persisted again to not be lost after a power-down. Also save the configuration as a `*.TAMcfg` file on the PC.

1 SWTC_TwinCAT-UserGuide_EP***.pdf in Help > Documentation/Software.
2 SW_TSD-TSP360-TSP710-Setup-Guide_EP***.pdf in Help > Documentation/Software

3 Preparation of TwinCAT and DC

Copy the device description file (ESI) "*Triamec.xml*" to "*C:\TwinCAT\3.1\Config\Io\EtherCAT*". If TwinCAT was already open, choose "*Twincat/EtherCAT Devices/Reload Device Descriptions*".

Open a new Twincat Project and add an Ethercat Adapter.

- IO/Devices/Add new item
- Ethercat/Ethercat Master

If there is no EtherCAT driver installed yet, try the menu "*TwinCAT/Show Realtime Ethernet Compatible Devices*" in the TwinCAT environment. Make sure the LLDP Protocol is disabled ([3]).

Make sure the cycle time of Distributed Clock (DC) Sync is a multiple of 100µs. Choose for example

- System/RealTime/Settings/BaseTime 200µs
- For NCI: Choose MOTION/NC-Task1 SAF/Task/CycleTicks=2 400µs (must be n* 100µs)
- For CNC: Choose MOTION/CNC Task GEO/Task/Cycle Time=2 400µs (must be n* 100µs)

Consider the sync shift settings at EtherCAT/EtherCAT/AdvancedSettings/DistributedClock/ SyncShift-Time if the jitter on the host PC is large.

Set Drive/EtherCAT/AdvancedSettings/DistributedClock/"UseAsPotentialReferenceClock"

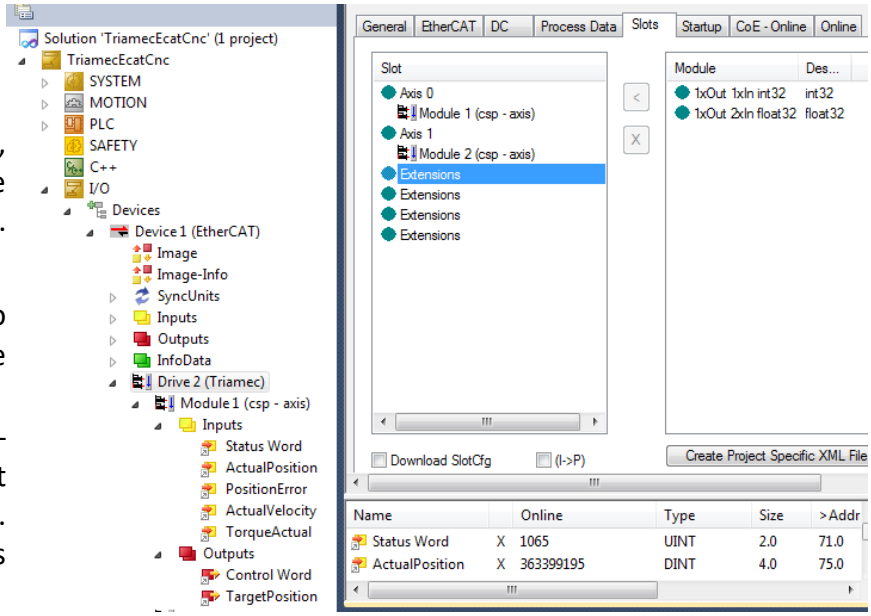
4 Drive setup in TwinCAT

On the EtherCAT master, choose "Add New Item" and choose "Triamec Motion AG/Drives/TriamecDualDrive". You will be asked, if new NCI-Axes should be added. Answer

- yes, if you intend to use NCI
- no, if you intend to use CNC

If you need additional cyclic data, open *Slots* in the Ethercat drive. Use the left arrow to add your choice. Choose to

- Change the axis from default to touchProbe, if you want to use the TwinCAT touchProbe feature.
- Open the first extension and select one choice from the right list for integer or float variables. Check AN104 on how to use this feature.



3 NetworkConnections/Properties/MicrosoftLLDPProtocolDriver is disabled.

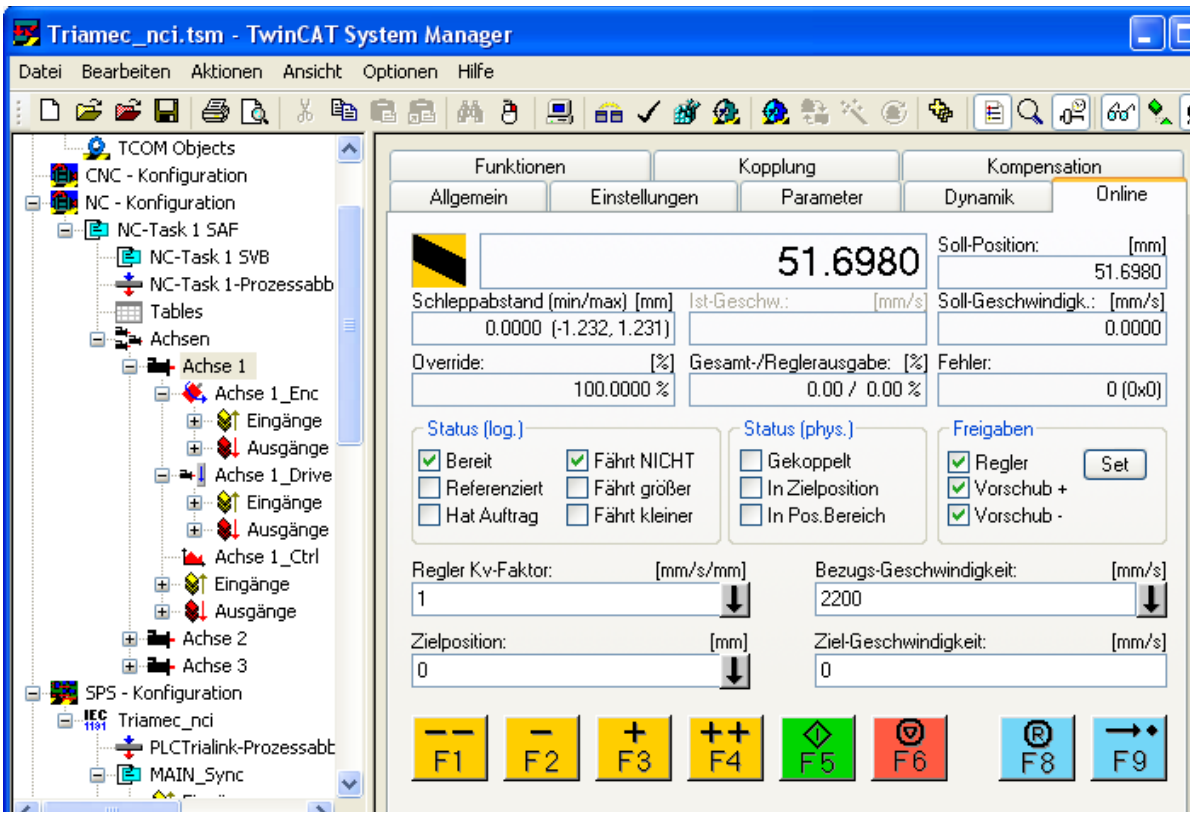
4.1 Using the NCI

If you answered “yes” in the “Add new item” dialog above, a new NCI axis was added for every axis in the drive and connections were made between the drive and the NCI. Consider

- NciAxis.Parameter.Dynamics: Set the dynamic Parameters
- NciAxis.Parameter.OtherSettings.CoupleSlaveToActualValuesIfNotEnabled TRUE

Choose *Twincat/ActivateConfiguration* to run Twincat.

Then the NCI interface should look like



First, enable is off (*Freigaben* are not selected). You can move the axis by hand and see the actual position reflect the correct position. If the actual position is gray, the axis state is not valid. Make sure the drive is in the EtherCAT operational state (see drive Online) and the drive is not in an error state (see cyclic signal “error” or the COE-online objects 0x6035 (axis 0) and 0x683F (axis 1).

Now enable the axis using *Freigaben* and *Regler*, *Vorschub+*, *Vorschub-*, *Override 100%*.

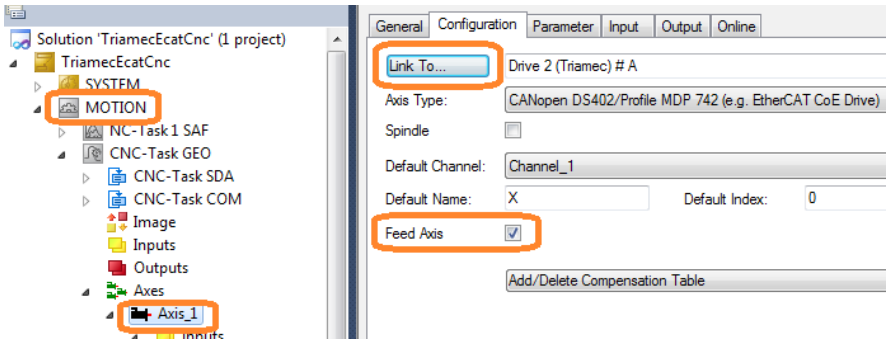
Press + and - to move the axis. The axis should move and the actual position should change accordingly.

4.2 Using the CNC

Attach the CNC using “Add new Item” on the *MOTION* node.

Attach an axis using “Add new item” on the *MOTION/CNC-Task GEO/Axes* node.

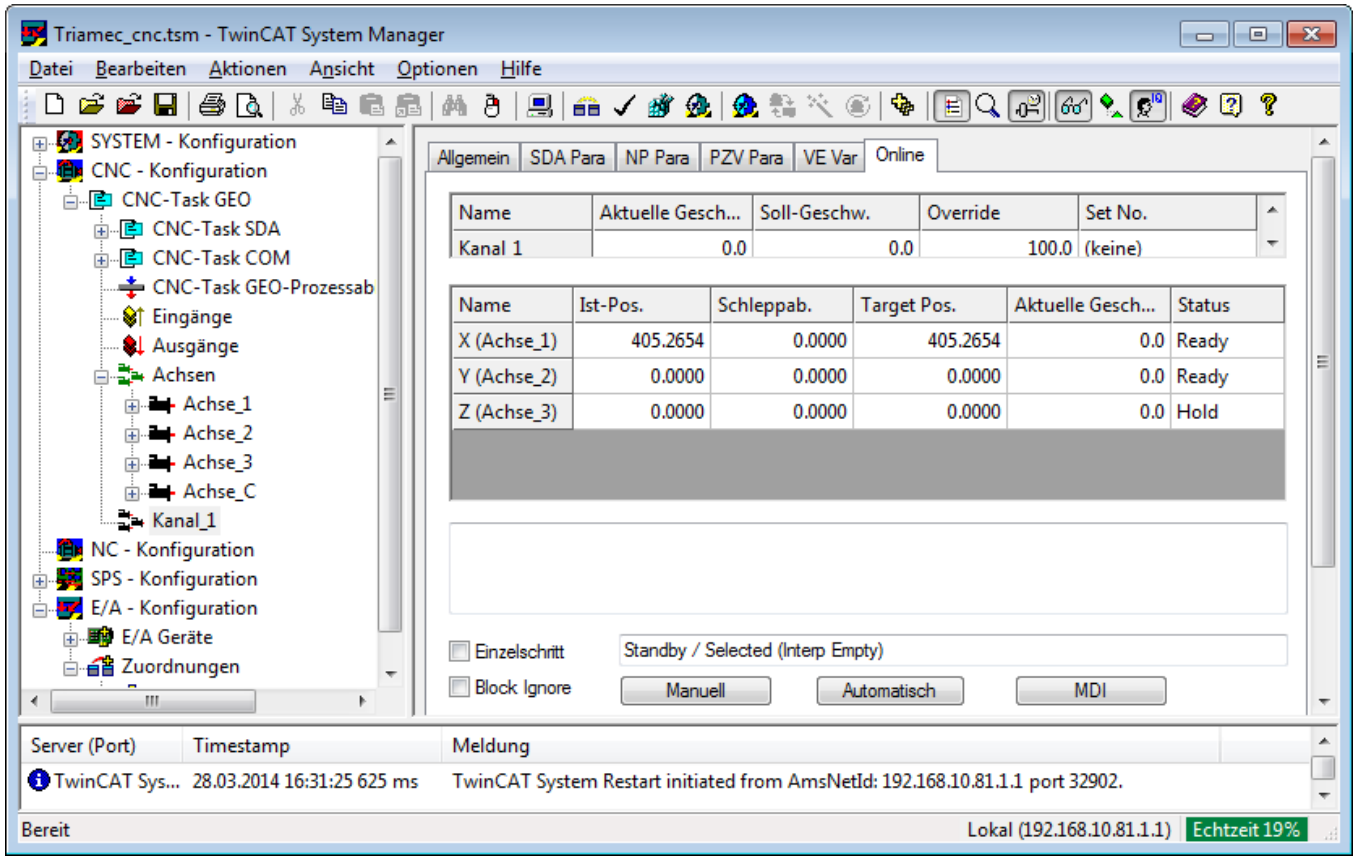
Select the Triamec Axis using “Link To” and make sure *FeedAxis* is selected.



Attach a ***channel*** (***Kanal***) using “Add new item” on the *MOTION/CNC-Task GEO* node.

Choose *Twincat/ActivateConfiguration* to run TwinCAT.

The axes will not be enabled yet. Each axis can be moved by hand and the ActualPosition should change correctly in the CNC window.



Enabling the axes requires an HLI command to the CNC. An example PLC program is available in the Sample code.

Open the CNC channel control window: *CNC-Task GEO/Kanal_1/Online*.

Switch to Operation mode “Manual”. Select the first axis. Press + and - to move the axis. The axis should move and the actual position should change accordingly. The position “DistanceToGo” should reach zero at standstill.

Configure

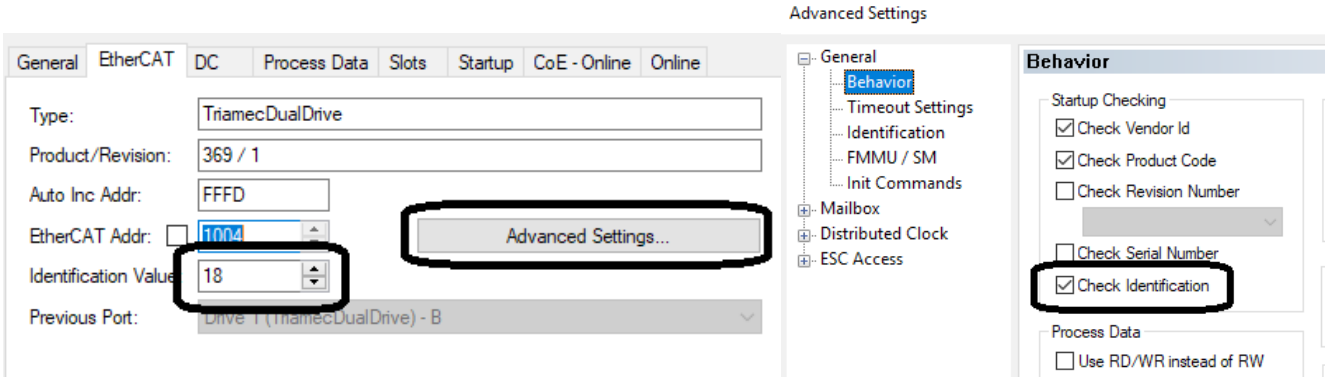
- the CNC channel in CNC-Konfiguration/CNC-Task GEO/Kanal_1 and
- the CNC axes in CNC-Konfiguration/CNC-Task GEO/Achsen/Achse_n/Parameter

as shown in the CNC-documentation.

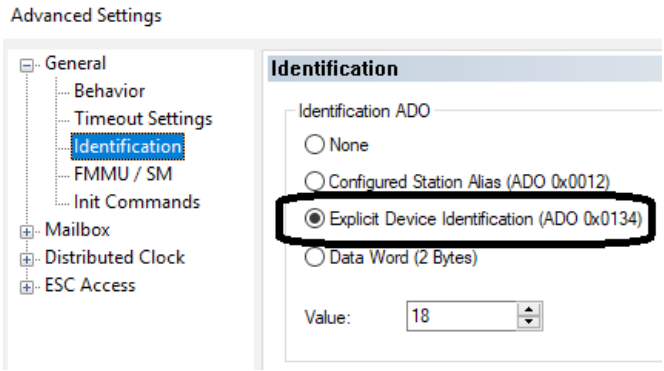
5 Identification

Triamec drives support the EtherCAT “Explicit Device Identification” method (FW>=4.4.0). This requires the ESI-File Triamec1.4.xml. Setup the address in the drive register ***General/Parameters/LinkAddress*** and make the parameter persistent (chapter 2).

Setup the address as “Identification Value” in the TwinCAT EtherCAT section of the drive (see figure below). If this value is not changeable, the ESI-File version might be smaller than 1.4. Then open the advanced Settings dialog and select General/Behavior/CheckIdentification.



Then specify “Explicit Device Identification” in the same dialog under General/Identification.



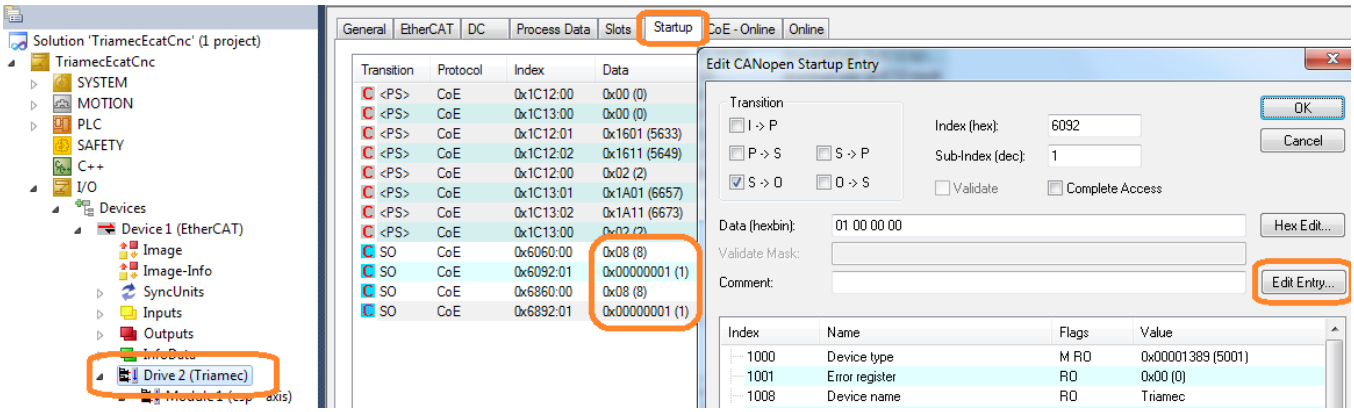
6 Positions

6.1 Choose position scaling

EtherCAT uses integer32 for positions whereas Triamec drives use the double format representing SI units (double ***meter*** or ***rad*** or similar). Therefore the drives need to convert the double to integer.

The standard scale factor of EtherCAT is 10'000 inc/***mm*** or 10'000 inc/***degree***. Since the conversion factor depends on the axis type (linear or rotative), the drives need to know their axis unit. Specify the axis unit using *Parameters.PositionController.PositionUnits* in the drive axis configuration.

To change the default scaling, use the startup parameter Feed (0x6092.01) for the first axis and 0x6892.01 for the second axis. Its units are inc/mm or inc/degree. It is part of the startup parameter list as shown below. The standard is 10'000. To get for example 1nm resolution, choose the value 1000'000. Be aware that this reduces the maximum possible position to 2^{31}*1nm = 2.1m.



This changes the scale at the interface. The TwinCAT path planner modules must also know this scaling factor:

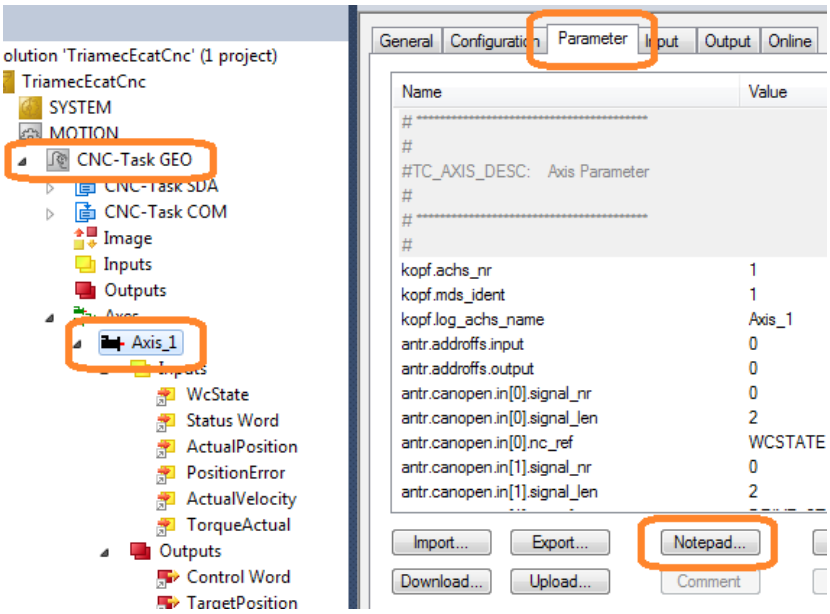
CNC

If a CNC is attached adapt the CNC axis parameter (see figure below)

getriebe[0].wegaufz 1 P-AXIS-00234 : Path resolution of the measuring system (num).

The unit of this parameter is 10'000 inc/mm or inc/degree. Its default is 1. Use this equation for the values of the drive and CNC parameters

0x6092.01 = wegaufz * 10'000



NCI

Another use case is NCI. Lets assume a finer resolution of 1nm.

- Set the scale of the EtherCAT positions to 1'000'000 using 0x6092.01 as shown above.
- Set NC/Achsen/Achse_N/Achse_N_Enc/Parameter/ScalingFactorNumerator to 1E-6.
  Select the row and use “Download, Save” to save the settings.
  Reload the solution to activate the changes

6.2 CSP mode

The standard mode of operation is CSP, where commanded positions are expected cyclically. There are three interpolation modes, specified with the drive register Axes[].Parameters.PathPlanner.StreamInterpolatorMode.

- Polynom3A A 3th order recursive polynom into the last three positions
- Polynom4A A 4th order polynom exactly fitting into the last five positions (legacy)
- BSpline3A A cubic B-Spline of the last three positions

Choose Polynom3A in standard situations with a smooth target path. Choose BSpline3A in situations with not physical target positions.

6.3 Modulo

If the Triamec parameters Axes[]/Parameters/PathPlanner/ModuloPositionMaximum and ..Minimum are unequal to 0.0, the axis runs in modulo mode. In CSP mode, it expects commanded positions within this range. The actual positions from the encoders will wrap as soon as the respective commanded positions wrap.

The commanded velocity is not considered directly for path generation in CSP mode. However, it is considered at higher speeds to decide, what modulo wrap should be taken (FW 4.5.0). If, for example, the NC-rate is 1ms and the target speed is larger than 30’000 turns/min, the drive will face more than half a

modulo per position update and it cannot resolve correct positions, if velocities are not provided. If the velocity is correctly provided, the drive will decide for the correct modulo wrap in this case. See CSV mode for the required velocity scaling.

Drive

Set the modulo ranges (if PositionUnits is on radian).

- Axis.Parameters.PathPlanner.ModuloPositionMaximum 2*pi
- Axis.Parameters.PathPlanner.ModuloPositionMinimum 0.0

CNC

If the axis is rotational with the CNC in units of 0.0001° and should get a 360° Modulo, set:

- kenngr.achs_typ 2 (ROTATOR) or 4 (SPINDLE)
- kenngr.achs_mode 0x4 (Modulo) +
- getriebe[i].moduloo 3600'000
- getriebe[i].modulou 0
- antr.drive_encoder_range 3600000. [4]
- if antr.mode_act_pos or antr.mode_cmd_pos are defined, set these parameters to 2.

For details on CNC axis, spindle, and channel settings see the Beckhoff or CNC documentation.

NCI

See Beckhoff documentation on using Modulo Moves. Set NCI/Axis/Enc/Parameters

- ScalingFactorNumerator = 0.0001
- ScalingFactorDenominator = 1.0
- Modulo Factor = 360
- EncderMask = 0x36EE80 (3600000)
- EncderSubMask = 0x36EE80 (3600000)
- ReferenceSystem = Absolute(modulo)
- See Beckhoff documentation on using Modul

and in NC/Axis/Drive/Parameters

- OutputScalingFactor (Velocity) to 429.5 = (2^32) / (10^7)

and set Axis/Settings/Unit=Degree and activate Axis/Settings/modulo.

6.4 CSV mode

The standard mode of operation is CSP Mode (8), where cyclic positions are commanded at the interface. With FW Release 4.5.0 CSV mode (9) is supported too, where cyclic velocities are commanded.

The resolution of the velocities are scaled by the same factor as for CSP mode: If for a rotational axis

- the feed object 0x6092.01 is 10000 inc/degree,

4 This value has to be scaled with getriebe[..].wegaufz/getriebe[..].wegaufn.

- a position of 10000 inc will correspond to ***1 degree*** and
- a velocity of 10000 inc will correspond to ***1 degree/s***

The drive side interpolation uses cubic B-splines in the target velocity and integrates these to a 4th order polynom in the position. To facilitate switching back from CSV mode to CSP mode, the signal General/ Signals/EtherCAT/targetPositionError is provided, which is the deviation between expected position and commanded position.

6.5 Referencing (Homing)

With FW Release 0.8.9 (FW2086), we support three modes.

Absolute encoders return the correct position without a reference move. See AN107 for setup. With Twincat-CNC pathplanner, make sure to set the *kenngr.set_refpos_mode* to “OFFSET” and *kenngr.set_refpos_offset* to 0 to avoid any difference between CNC and drive positions.

Drive controlled homing is described in AN107. See TwinCAT sample code for using this mode.

Reference moves controlled by TwinCAT are used to determine the position difference between drive position and TwinCAT position. This is then taken into account by adding an offset between the interface data and the display data. The drive positions are not referenced in this case.

7 Control and Status Word

Supported modes of operation modes for firmware 4.5.0 are PP(1), PV(3), HM(6), CSP(8), CSV(9). The EtherCAT control word depends on the mode of operation.

Bit	***Register***	
0	SwitchOn	
1	EnableVoltage	
2	QuickStop	
3	EnableOperation	For modes of operation CSP, CSV
PP [4] PV [4] HM [4]	NewSetpoint newSetpoint start homing	
PP [5] CSP [5..6]	ChangeSetImmediately OutputCycleCounter	
PP [6]	relativeTargetValue	
7	FaultReset	
PP [8] PV [8] HM [8] CSP [8] CSV [8]	halt halt halt no function no function	
PP [9]	changeOnSetPoint	

The EtherCAT status word

Bit	***Register***	
0 1 2	ReadyToSwitchOn SwitchedOn OperationEnabled	
3	fault	
5	quick stop	1 = quick stop is not active
6	switchOnDisabled	
7	warning	
8	follow me	manufacturer specific
[10] PP+PV [10] HM [10] CSP [10] CSV	TargetReached / velocityIsZero TargetReached / velocityIsZero ToggleStatus Toggle status	if halt=0 / 1 if halt=0 / 1 not implemented not implemented
[11]	internal limit is active	
[12] PP+PV [12] HM [12] CSP [12] CSV	SetPointAcknowledge Homing done DriveFollowsTheCommandValue DriveFollowsTheCommandValue	previous setpoint still in process [12] Kap 6.2 of ETG6010_V1i1i0 [12] Kap 6.2 of ETG6010_V1i1i0
[13] PP+PV [13] HM [13] CSP	FollowingError Homing error ExtendedToggle	
[15]	referenceDone	manufacturer specific

A typical start sequence for the mode of operation 8=CSP is

status	control	
0x121	0 2	ReadyToSwitchOn EnableVoltage
0x121	 3	ReadyToSwitchOn EnableVoltage+SwitchOn
0x127	 0xB	Enabled EnableOperation
0x1027		CoupledMotion

Please note the following behaviour of Target position versus actual position in this sequence: As long as bit 0x100=followMe is set, the drive actual position does not follow the target position. Instead, the control system is expected to track the actual position by setting target=actual.

During the enabling phase, the actual position may be changing due to the axis phasing procedure until the drive sets bits 1+2 (state=0x127) to indicate, it is enabled. Now the control system sets the command bit 0x8 as it wants to control the target position itself. At the same moment, it should stop tracking the actual position. Now the drive sets bit 0x1000 and resets bit 0x100 to indicate, it is ready to follow the target positions. If the control system continues to track the actual position at this stage, this

will cause a chasing behaviour.

8 Registers

Triamec EtherCAT drives support two register ranges. Both ranges are accessed the same way as shown in Application note AN109. The first set is published to TwinCAT by the COE-Information method. As a consequence, these are shown in the TwinCAT tab “COE-Online”. These are listed in the table below. A second range is not shown directly. This large set of registers is usually accessed using the TAM System Explorer when tuning the axis-motor-drive system. Nevertheless, these registers can be accessed from TwinCAT using the same function blocks. Finding there addresses is described in AN109. A sample of accessing a drive register is shown in the NCI TwinCAT sample project. A description of how to setup cyclic telegrams is explained in AN104.

8.1 Published COE Registers

For axis specific registers use the axis index a={0, 1} in the Index field. For PDO extensions use the extension index k={0, ..3}. (FW Release 0.8.8)

Index	***Register***	
0x1001	errorRegister	returns 0x8001 on any error. See 0x603F on per-axis-errors.
0x1008	devicename	for example TSD80E
0x1009	hardwareversion	String major.minor
0x100A	softwareversion	String major.minor.bugfix {-beta means firmware is in beta state}
0x1018	identity	02: productCode 03: HardwareRev ([0..7]=minor, [8..15]=major) 04: SerialNumber
0x1600 + a*0x10 0x1601 + a*0x10 0x1604 + a*0x10	RxPDO mappings for AxisPath	
0x1622 + k*0x10 0x1623 + k*0x10	RxPDO extensions	See AN104
0x1A00 + a*0x10 0x1A01 + a*0x10 0x1A04 + a*0x10	TxPDO mappings for AxisPath	
0x1A22 + k*0x10 0x1A23 + k*0x10	TxPDO extensions	See AN104
0x6040 + a*0x800 0x6041 + a*0x800	The EtherCAT control word The EtherCAT status word	
0x603F + a*0x800	The axis error.	See table below.
0x6064 + a*0x800	Position actual	
0x606C + a*0x800	Velocity Actual	
0x607A + a*0x800	Target Position	
0x6092 + a*0x800	FeedConstant	01:Feed, see chapter 6.1

0x60FF + a*0x800	Target Velocity	

A typical content of the TxPdoAssign arrays for two axes and two extensions would be:
RxPdoAssign: 0x1C12 = {4, {0x1601, 0x1611, 0x1623, 0x1633}}
TxPdoAssign: 0x1C13 = {4, {0x1A01, 0x1A11, 0x1A23, 0x1A33}}

Error codes

The axis error 0x603F is also transmitted cyclically. See table below for the error codes. Besides of this integer representation of an error, it is also possible to see a string representation using the TwinCAT Event-Logger-Method. An event file and sample code to show the messages is provided in the sample code TwinCAT project. The TwinCAT event bar executable is at ([5]).

error	***Short form***	***Description***
0	*None*	No error
1	*PositionErrorLimit*	The position error limit of the position controller is exceeded.
5	*EncoderSubresolutionError*	The sub-resolution of the encoder is ambiguous. Possible cause: faulty wiring.
6	*EnablingNoMotorAxis*	Enabling of an Axis with no motor configuration is not possible.
7	*EncoderError*	Encoder works not as expected. (no or too low signal from encoder)
8	*EncoderShort*	The encoder supply is shorted.
9	*DigOutputShort*	A digital output is shorted.
10	*MotorI2t*	The I2t limit of the motor is exceeded.
11	*PowerBridgeI2tLimit*	The I2t limit of the power bridge is exceeded.
12	*MotorPeakCurrentLimit*	The peak current limit of the motor is exceeded.
13	*PowerBridgePeakCurrentLimit*	The peak current limit of the power bridge is exceeded.
14	*EncoderConfigurationError*	Two encoders of different type point to the same hardware.
15	*OptionModuleFailure*	An encoder points to an option module which is not present or a present option module did not boot.
16	*EncoderDatabusError*	Digital Encoder data bus not connected, or communication failed.
17	*EncoderNotSupported*	This encoder type is not supported.
18	*NoDigitalEncoderPersistency*	The encoder does not contain persistency data. Get the reference and use AN107 to save.
19	*PhaseShort*	*A short (phase-to-phase or phase-to-earth) was detected in PWM during bridge power-up.*
20	*SynchronizationLost*	*The stream interpolaton synchronization is lost.*
21	*GantryTrackingError*	*The distance between the two gantry axes was larger than the GantryDeviationLimit*
22	*Commutation600HzLimit*	The 600Hz commutation frequency limit of this product was reached
23	*UnspecifiedPositionUnit*	The position unit is not specified or not known
24	*MotorTemperatureLimit*	The motor temperature is out of specification

5 C:\TwinCAT\3.1\Components\TcEventLogger\TcEventBar.exe.

25	*AxisParameterError*	A parameter of this axis is unknown
26	*AxisCommandError*	A command of this axis is unknown
66	*ComputingTime*	The limit of the computing time is exceeded.
69	*BridgeVoltageOutOfRange*	The power bridge voltage is out of range.
70	*BridgeOverCurrentLimit*	The limit of the power bridge current is exceeded.
71	*TemperatureLimit*	The limit of a temperatue is exceeded.
72	*VoltageOutOfRange*	At least one operating voltage is out ouf range.
73	*ExternalError*	The external error is triggered by the user.
74	*NoValidTamaCodeAvailable*	Running Tama without valid Tama code error.
75	*InvalidPersistentParameters*	Persistent parameters are not compatible with running firmware.
76	*TamaOutOfMemory*	While executing a Tama program, the program memory became full during heap allocation. Memory is typically allocated on the heap when creating new instances of reference types, including arrays.
77	*TamaDivisionByZero*	While executing a Tama program, an attempt was made to divide by zero.
78	*TamaNullReference*	While executing a Tama program, an object property was requested, but there was a null reference.
79	*TamaIndexOutOfRange*	While executing a Tama program, an array element index was outside the range of the array.
80	*TamaCorruptedState*	While executing a Tama program, Tama program state was corrupted. This value is returned when an unknown operation code is encountered.
81	*MonitorIsNotRunning*	Hardware monitor on the device is not running.
84	*SafeTorqueOffActiveWarning*	SafeTorqueOff (STO) is active.
85	*SafeTorqueOffInconsistent*	SafeTorqueOff (STO) safe mode due to inconsistent channels detected (only one contact is closed).
86	*SafeTorqueOffStartupTestFailure*	SafeTorqueOff (STO) safe mode due to a Startup test failure.
87	*SafeTorqueOffPulseTestFailure*	SafeTorqueOff (STO) safe mode due to a Pulse-Test failure.
88	*SafeTorqueOffTemperatureLimit*	SafeTorqueOff (STO) safe mode due to Temperature limit on Logic Monitor.
91	*PowerLinesNotOk*	Power lines are not OK. Not all power lines available or line disturbance.
92	*CommandError*	A Command was not successful
93	*ParameterError*	Found an unknown or inconsistent Parameter

8.2 Trouble Shooter

On the TwinCAT side, check

- C:\TwinCAT\3.1\Config\Io\EtherCAT\Triamec*.xml
- TwinCAT/EtherCAT Devices/Reload Device Descriptions
- Under IO/Devices/EtherCAT/Drive check "Slots", "Startup", and NC-A etc

For general information relevant for the EtherCAT link, see

- General/Signals/EtherCAT/LinkPll/State (should be DcMaster or DcSlave)
- Axes[0]/Parameters/PositionController/PositionUnit should be specified
- Axes[0]/Commands/PathPlanner/StreamRate
- Axes[0]/Signals/General/EtherCAT/

If EtherCAT does not control an axis as expected, check the following

- The EtherCAT state of the drive must be OP (Operational).
- The Triamec command register **Axes[].Commands.General.OverwriteControlSystem** must be zero, which is its default value. A value 1 is used to control the drive using the TAM System Explorer and disables EtherCAT command requests.
- The drive parameter **General.Parameters.Standalone** must be False. The value True allows using the drive without a Link and disables EtherCAT command requests and EtherCAT synchronization. Also, it suppresses the error LinkNotReady.
- Make sure, **Axes[0]/Parameters/PositionController/MasterPositionSource** points to the correct encoder and **Axes[0]/Parameters/PositionController/PositionUnit** is correctly set.
- Check the following drive signals visible at the EtherCAT interface and in the TAM System Explorer register:
  Axes[]/Signals/General/EtherCAT/ErrorCombined
  Axes[]/Signals/General/StateMerged
  Axes[]/Signals/General/EtherCAT/ControlWord.

8.3 Non standard

The hardware revision register 0x1018:03 reserves 8 bits for the minor revision. The CAN standard specifies 16 bits (EN 50325).

The register Torque (0x6077) is in absolute Units of mA. CAN does not specify the Unit, but specifies that the value should be relative to NominalTorque.

Dokument Revision

Version	Date	Editor	Comment
001	16.11.16	mvx	First Release
002	2017-06-16	mvx	Release with Homing
003	2017-11-20	mvx	Reference to AN109, add status and control word content

Version	Date	Editor	Comment
004	2018-11-06	dg	Chapter Modulo enhanced.
005	2019-02-12	mvx	Explicit Device Identification
006	2019-04-18	mvx	Velocity modes of operation
007	2019-09-23	dg	Synchronized with TSD User Guide EP001