Instruction Manual
Beckhoff CNC with XENAX® Xvi for EtherCAT® and TwinCAT® 3

Edition 20. September 2024

XENAX® Ethernet servo controller with EtherCAT® Busmodul

Functional Safety, TÜV certified
Force processes with „Force Limitation“, „Force Monitoring“ and „Force Control“

Beckhoff TwinCAT, the open PC software solution for PLC with NC and CNC Kernels for realtime interpolation of the XENAX® Xvi servo controller with EtherCAT technology.

General

This instruction manual describes the integration of the XENAX® servo controller with EtherCAT bus modules in a Beckhoff system with TwinCAT® Version 3 for CNC.

This manual describes only the use of the XENAX® with the internal library of TwinCAT® 3. The internal library must be taken for CNC Configurations and is recommended for experienced users.

Furthermore, the parametrization of LINAX®, ELAX® and ROTAX® motors is shown in this document.

XENAX® can be simply and quickly operated with the intuitive graphical user interface WebMotion®.

We will gladly answer any questions you may have or provide you with additional information.

Alois Jenny
Jenny Science AG

JENNY SCIENCE

moving precisely, within tight space

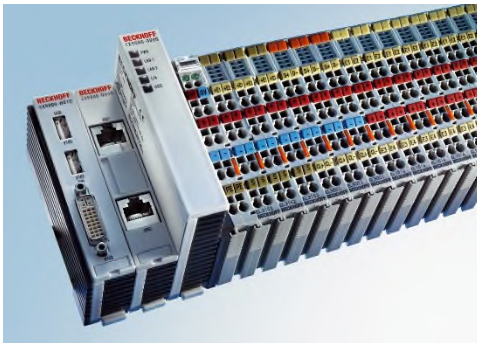
Contents

1 Development Environment

1.1 Beckhoff

1.1.1 Programmable Logic Controller

Beckhoff control technology is scalable – from Industrial PCs to PLCs – and can be accurately adapted to your application. The automation software integrates real-time control with PLC, NC and CNC functions.



1.1.2 TwinCAT® Version 3

In order to program Beckhoff PLCs the development software for automation TwinCAT® 3 is required.
TwinCAT® 3 uses the Visual Studio Framework and all explanations in this instruction manual are based on it.

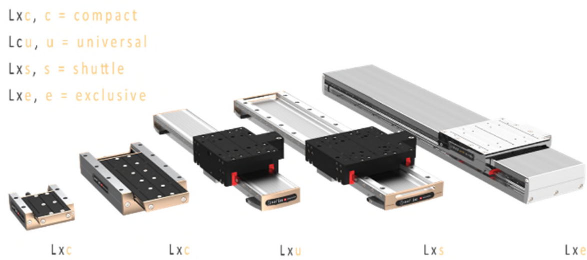
1.2 Jenny Science

1.2.1 XENAX® servo controller

XENAX® servo controller for Jenny Science Axis with integrated EtherCAT® bus module. The bus module is optional but it is required for this application. One XENAX® can control one axis. The XENAX® servo controller recognises all Jenny Science motors and configures the parameters correctly.

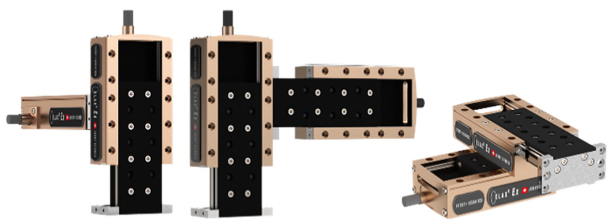
1.2.2 LINAX® Linear motors

The LINAX® linear motor axes are highly modular and can be flexibly combined amongst each other. Four different series are available.
Lxc = compact
Lxu = universal
Lxs = shuttle
Lxe = exclusive



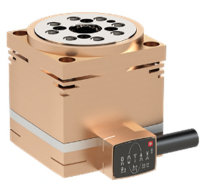
1.2.3 ELAX® Linear motor slides

Specifically designed for handling and Pick and Place tasks with strokes from 30mm up to 150mm. The configuration is extremely modular and there is only one cable to the XENAX® servo controller.



1.2.4 ROTAX® Rotary motor axes

Specifically designed for fast and precise assembly and handling tasks. It can be equipped with standard gripping tools which enables a 360° rotation and has a hollow shaft feedthrough for vacuum or compressed air.
Rxvp = vacuum pressure
Rxhq = high torque

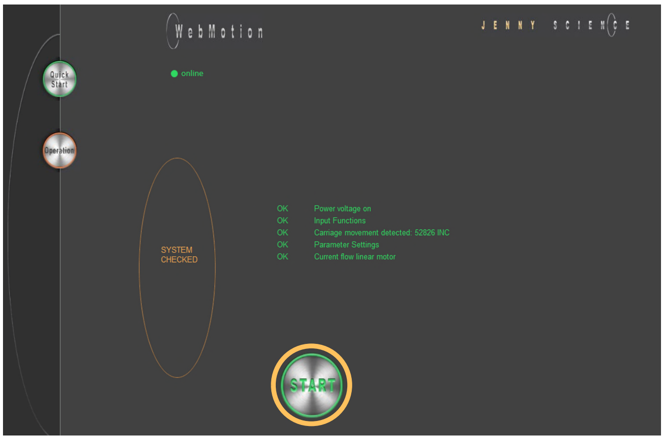


Rxhq

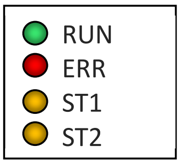
Rxvp

1.2.5 WebMotion

This is the graphical user interface from Jenny Science. It is stored in the embedded Web server of the XENAX® servo controller.
WebMotion® is launched with a web browser by entering the corresponding TCP/IP address of XENAX®.
LINAX® linear motor axes, ELAX® linear motor slides or ROTAX® rotary motor axes are automatically recognized. The corresponding controller parameters are saved and loaded automatically. With the Quick Start button, the linear motors can operate immediately. No user manual is needed.
Before the XENAX® controller can be used with the Beckhoff PLC via EtherCAT®, a set-up must be made via WebMotion®. This includes the set-up of a payload, soft limits, etc.
For further information on the set-up of a linear motor axis please refer to the instruction manual or the tutorial video that can be found on www.jennyscience.com.



1.3 Status LED's of EtherCAT bus module



LED Status	RUN	ERR	ST1 (Jenny Science specific)	ST2 (Jenny Science specific)
<OFF>	Initialisation state or no power	Bus module operable	-	Bus module ready
<ON>	Operational state	State bus off	No application in the flash	-
<BLINK>	Pre-operational state	Internal Eeprom blank	-	Protocol download in progress

1.4 Additional Material

The following data is needed for a successful operation of the XENAX® servo controller with a EtherCAT bus module:

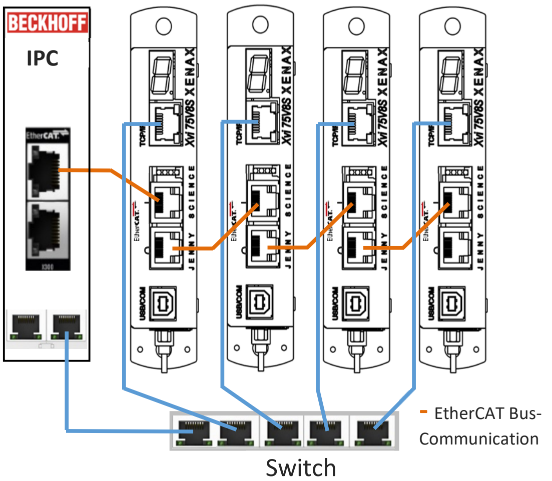
Filename	Description
Xenax_EtherCAT_Xvi_.xml	Jenny Science ESI-File/XML device description for TwinCAT. The ESI-file can be downloaded on our website www.jennyscience.com „XENAX® Servo controller“ and „Firmware Bus Module“
CANopen Ethernet Manual.pdf	Manual describes the CANopen communication profile CiA DS301 as well as the device profile CiA DS402 including all available parameters.

1.5 Software Requirements

Software	Version
TwinCAT® 3 Automation Software	3.1.4024.0 or later
XENAX Firmware	V8.00 or later
EtherCAT Bus-Module	V2.70 or later

1.6 Cabeling

The EtherCAT bus is connected with the XENAX® servo controller (IN/OUT).
For easy commissioning and maintenance, a TCP/IP connection to each servo controller is recommended for access to the WebMotion®.



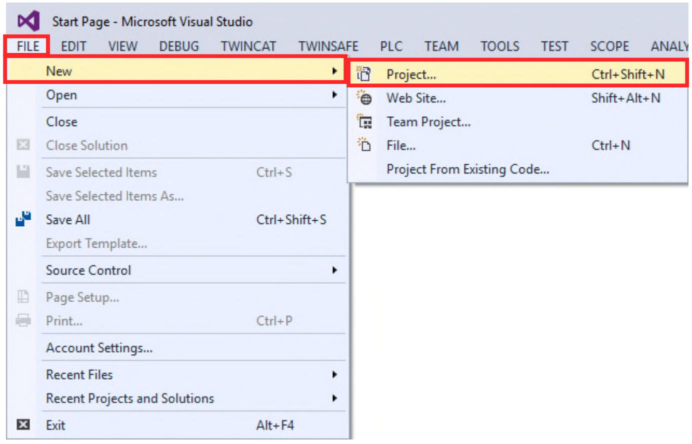
2 TwinCAT® CNC Configuration

This chapter describes the configuration of a Beckhoff TwinCAT® with CNC Kernel to communicate with the XENAX® Xvi servo controllers via EtherCAT.

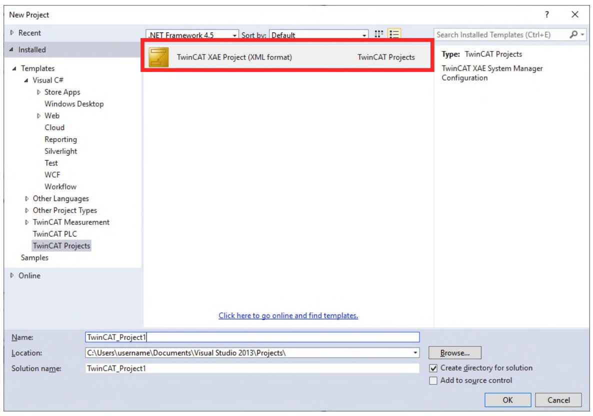
HINT:
For correctly setting up the CNC Kernel additional libraries and the Beckhoff HMI are required.
The CNC Kernel was developed by ISG Industrielle Steuerungstechnik GmbH and a detailed documentation can be downloaded at:
www.isg-stuttgart.de

2.1 Create Project

File→New→Project…

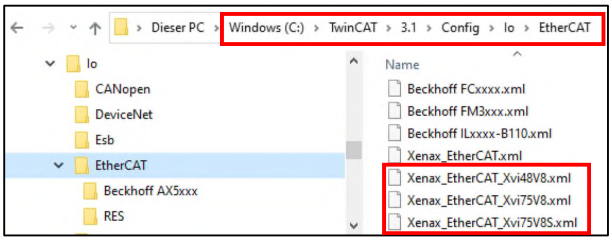


Create a new TwinCAT XAE Project.

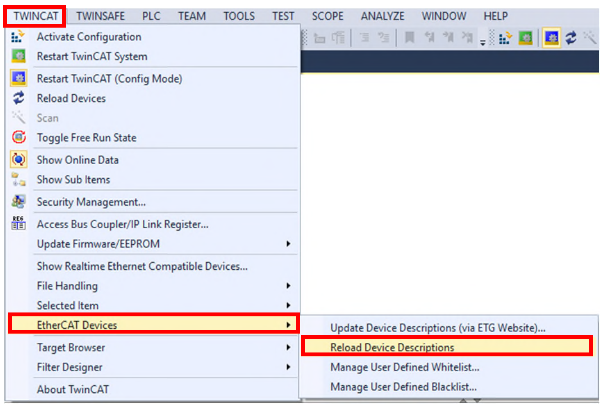


2.2 ESI XML Installation

The EtherCAT Slave Information XML for the XENAX should always be completely unpacked into the ESI-directory of the EtherCAT Master. In TwinCAT 3 these files are located in **\TwinCAT\3.1\Config\Io\EtherCAT**. This ESI file can be downloaded from www.jennyscience.com under “XENAX Servocontroller->Firmware Bus Module->EtherCAT”.

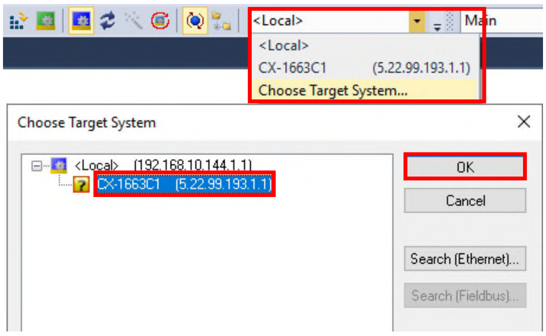


Load ESI file into TwinCAT. “TwinCAT→EtherCAT Devices→Reload Device Descriptions”.

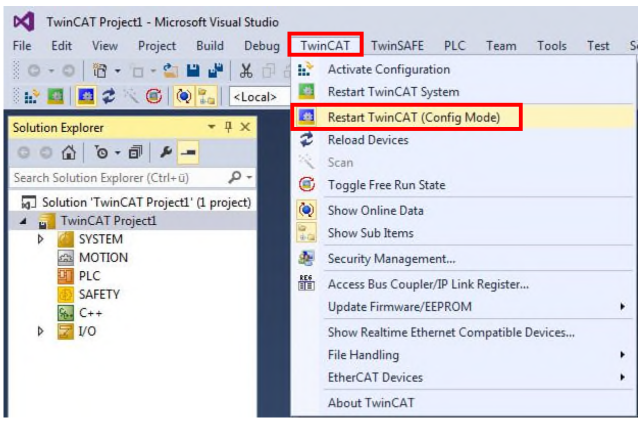


2.3 Choose Target System

Choose the target system to connect to a Beckhoff PLC selecting “Choose Target System…”.

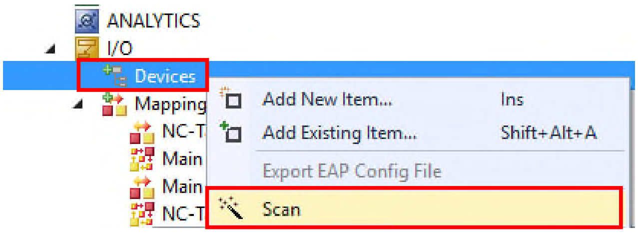


Set the system into the Configuration Mode.

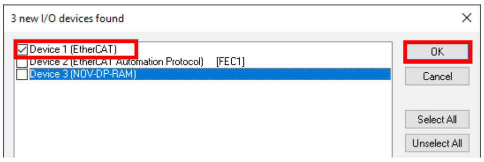


2.4 Scan for Devices

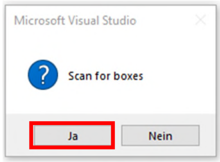
Right click on "Devices" and select "Scan".



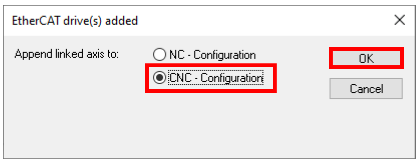
Select desired network interface card.



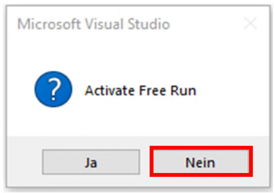
When "Scan for boxes" appears
→ Press YES (Ja).



Select "CNC – Configuration" and Press "OK".



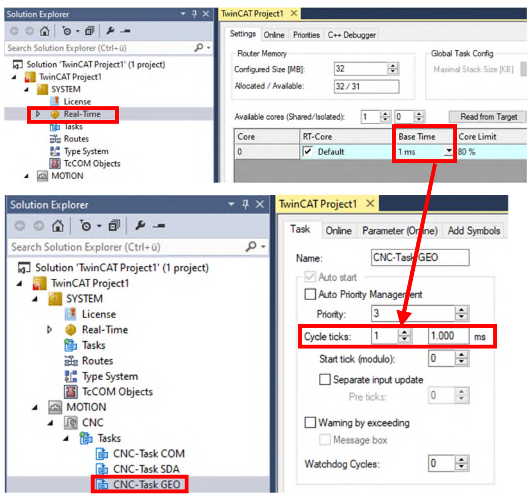
When "Activate Free Run" appears
→ Press NO (Nein).



2.5 Set Cycle Time

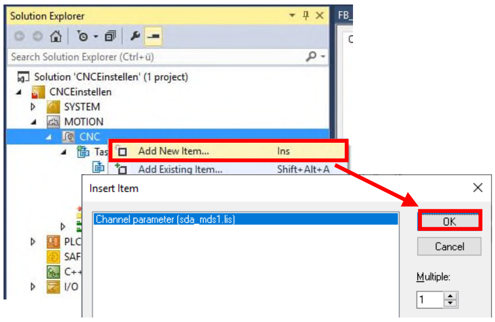
In "SYSTEM→Real-Time" (Tab Settings) set the base time of the CPU.

The cycle tick on the bus can be entered in "MOTION→CNC-Task 1 GEO". This time can only be greater than or equal to the base time. This is the objects transmission cycle in the "Cyclic Synchronous Position Mode".
Possible values are from 200us to 2ms.
Typical is 1ms.
Only multiple of 100us are allowed.

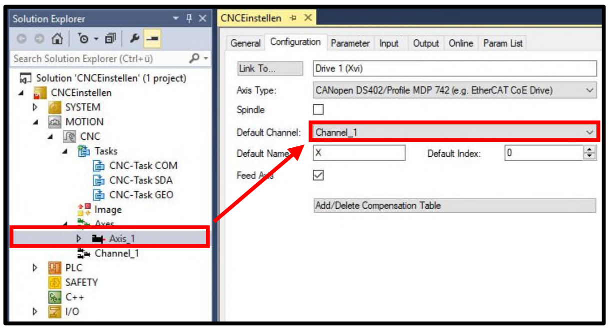


2.6 Add CNC Channel

Right click on “MOTION→CNC” and “Add New Item…”, then select “Channel parameter” and press “OK”.



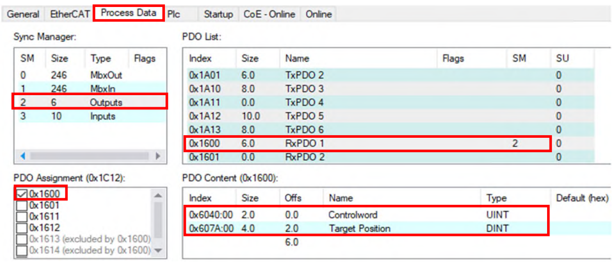
In “MOTION→CNC→Axis_1” in Register Configuration in “Default Channel” window select “Channel_1”.



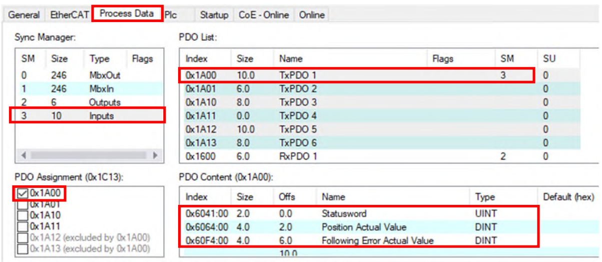
2.7 PDO-Mapping

2.7.1 Required PDO Configuration

Enable output PDO 0x1600



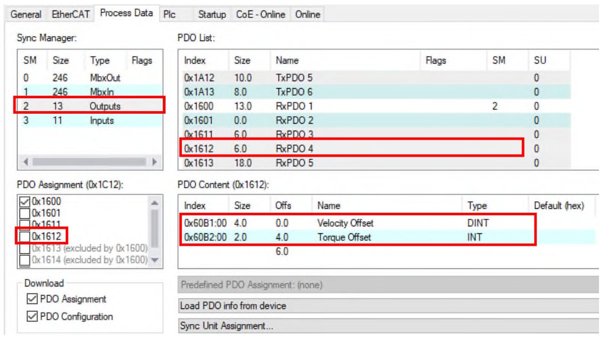
Enable input PDO 0x1A00



2.7.2 Optional PDO Velocity & Torque Offset

The Velocity Offset and Torque Offset transmit the corresponding target velocity and acceleration, along with the target position, to the XENAX®. This leads to smoother motion and reduces deviations from the target position.

To optimize the following error, particularly when navigating spline trajectories with high dynamics (accelerations >1g), it is essential to map these two objects correctly and adjust the feedforward control in parameter 2.9 Axis Parameters accordingly.

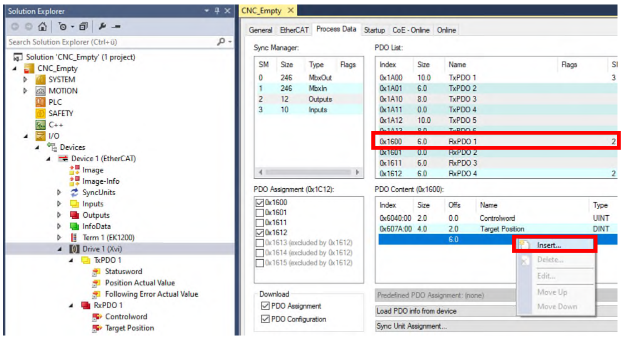


NOTE:

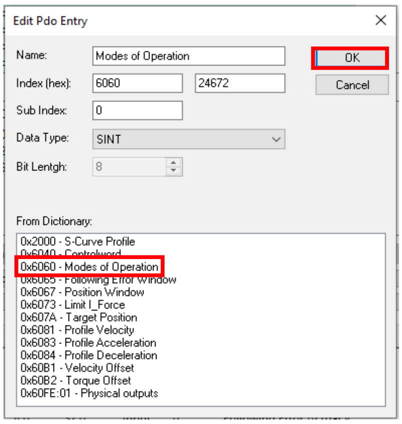
This links (Velocity and torque Offset) often gets lost when another PDO is added or removed. An unliked Velocity or Torque Offset PDO increases the deviation and results in a noisy rougher motion.

2.7.3 Add PDO "Modes of Operation"

Select the Output PDO 0x1600 and right click On PDO Content list and click to "Input".

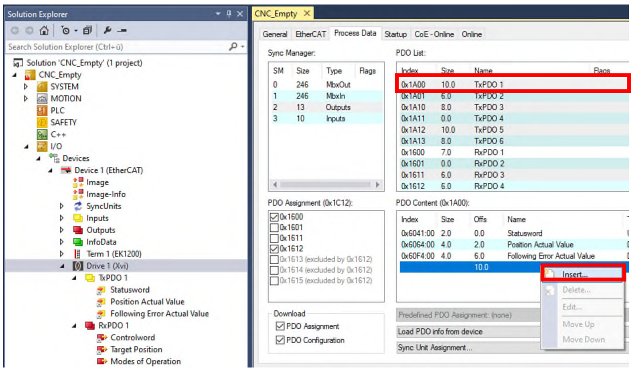


Select "0x6060 – Mode of Operation" and click to "OK".

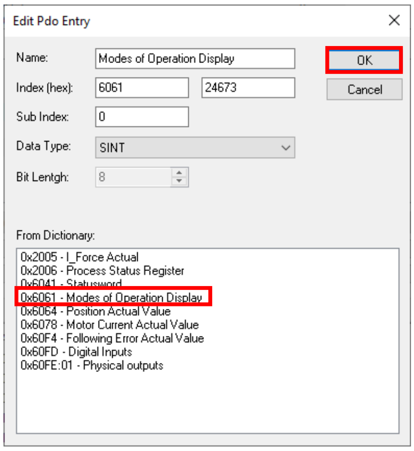


2.7.4 Add PDO “Modes of Operation Display”

Select the Output PDO 0x1A00 and Right click On PDO Content list and click to “Input”.

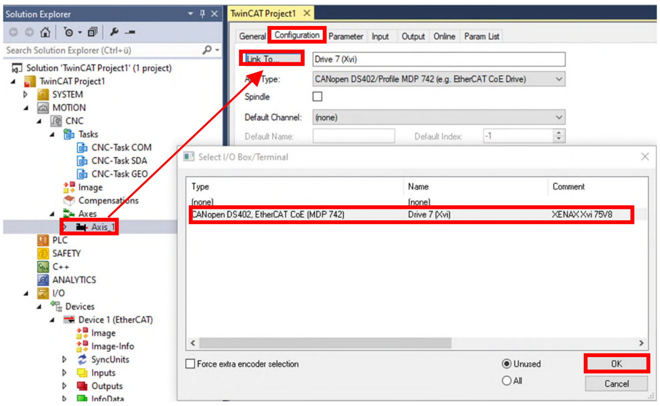


Select “0x6061 – Mode of Operation Display” and click to “OK”.



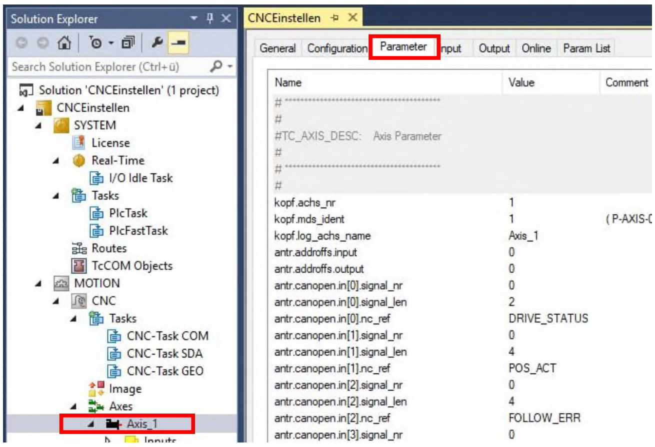
2.7.5 Link the added PDO’s

In “MOTION→CNC→Axis_1→Configuration” click to “Link To…”, select the desired I/O Box and click to “OK” to refresh and the manually added PDO’s will be automatically linked.

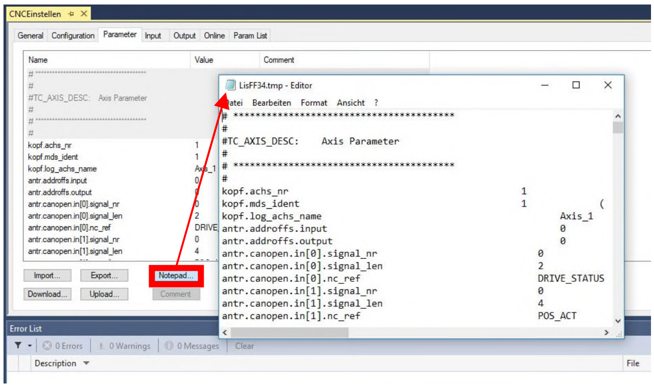


2.8 Axis Parameter Configuration

CNC-Axis parameter configuration:
Click on “MOTION→CNC→Axes→Axis_1” and select the “Parameter” register.



Open the parameter list:
In “Parameter” register click on “Notepad…”. The parameters can be directly modified, added, deleted and saved.



Edit or add the parameters listed in the following table according to the corresponding motor:

JENNY SCIENCE

moving precisely, within tight space

2.9 Axis Parameters

Edit or add the parameters listed in the following table according to the corresponding motor:

To do	Parameter Name	Parameter-ID	Parameter Description	LINAX®/ELAX® 1um	LINAX® 100nm	ROTAX® Rxvp (64'000Inc/rev)	ROTAX® Rxhq (120'000Inc/rev)	ROTAX® Rxhq (648'000Inc/rev)	ROTAX® Rxhq (2'592'000Inc/rev)
Edit	kenngr.swe_pos	P-AXIS-00178	Positive software limit switch	Stroke in 0.1um + 20'000		3'600'000	3'600'000	3'600'000	3'600'000
Edit	kenngr.swe_neg	P-AXIS-00177	Negative software limit switch	(Stroke in 0.1um + 20'000)*-1		-3'600'000	-3'600'000	-3'600'000	-3'600'000
Add	kenngr.swe_check	P-AXIS-00705	Switching software limit monitoring off (0) / on (1)	Not needed (Do not add)		0	0	0	0
Edit	kenngr.achs_mode	P-AXIS-00015	Operating mode; 1=linear , 4=modulo	0x1	0x1	0x1	0x1	0x1	0x1
Edit	kenngr.achs_typ	P-AXIS-00018	Axis type; 1=linear axis, 2=rotatary axis, 4=spindle/single axis	1	1	2	2	2	2
CNC controlled referencing									
Edit	kenngr.set_refpos_mode	P-AXIS-00278	Homing mode	OFFSET	OFFSET	OFFSET	ABSOLUT	ABSOLUT	ABSOLUT
Edit	kenngr.set_refpos_offset	P-AXIS-00279	Offset to the homing position	0	0	0	0	0	0
Edit	kenngr.homing_type	P-AXIS-00299	Homing type; CNC_CONTROLLED / DRIVE_CONTROLLED	DRIVE_CONTROL	DRIVE_CONTROL	DRIVE_CONTROL	CNC_CONTROL	CNC_CONTROL	CNC_CONTROL
Edit	kenngr.abs_pos_gueltig	P-AXIS-00014	Identification code for absolute path measurement system	0	0	0	1	1	1
Add	kenngr.vendor_id	P-AXIS-00535	Select manufacturer-specific procedures for drive controllers	100	100	100	100	100	100
Add	kenngr.device_id	P-AXIS-00536	Select device-specific procedures for drive controllers	8	8	8	8	8	8
Parameter non-linear velocity profile									
Edit	getriebe[n].slope_profil.a_beschl	P-AXIS-00001	Acceleration at machining feed G1,G2,G3	Application-specific					
Edit	getriebe[n].slope_profil.a_brems	P-AXIS-00002	Deceleration at machining feed G1,G2,G3	Application-specific					
Edit	getriebe[n].slope_profil.a_grenz	P-AXIS-00004	Acceleration at rapid movement G0	Application-specific					
Add	getriebe[n].slope_type	P-AXIS-00270	Effective acceleration profile; 0=step-shaped, 1=trapezoidal	1	1	1	1	1	1
Parameter linear velocity profile									
Edit	getriebe[n].lslope_profil.a_stufe_1	P-AXIS-00011	Acc./ dec. of step 1 at machining feed G1,G2,G3	Application-specific					
Edit	getriebe[n].lslope_profil.a_stufe_2	P-AXIS-00012	Acc./ dec. of step 2 at machining feed G1,G2,G3	Application-specific					
Edit	getriebe[n].lslope_profil.vb_stufe_1_2	P-AXIS-00221	Changeover speed between step 1 and 2 at G1,G2,G3	Application-specific					
Edit	getriebe[n].lslope_profil.a_grenz_stufe_1	P-AXIS-00005	Acc./ dec. of step 1 at machining feed G0	Application-specific					
Edit	getriebe[n].lslope_profil.a_grenz_stufe_2	P-AXIS-00006	Acc./ dec. of step 2 at machining feed G0	Application-specific					
Edit	getriebe[n].lslope_profil.vb_grenz_1_2	P-AXIS-00211	Changeover speed between ramp 1 and 2 at G0	Application-specific					
Permitted axis dynamics									
Edit	getriebe[n].dynamik.vb_max	P-AXIS-00212	Maximum permissible axis velocity	Application-specific					
Edit	getriebe[n].dynamik.a_max	P-AXIS-00008	Maximum permissible axis acceleration	Application-specific					
Edit	getriebe[n].dynamik.a_emergency	P-AXIS-00003	Deceleration for an emergency stop	Application-specific					
Permitted axis velocities									
Edit	getriebe[n].wegaufn	P-AXIS-00233	Path resolution of the measuring system (denominator)	10	1	3'600'000	3'600'000	3'600'000	3'600'000
Edit	getriebe[n].wegaufz	P-AXIS-00234	Path resolution of the measuring system (numerator)	1	1	64'000	120'000	648'000	2'592'000
Position lag monitoring									
Add	getriebe[n].load	P-AXIS-00391	Weighting of acceleration feed forward	0.000001	0.00001	0.000001	0.000001	0.000001	0.000001
Compensations and monitoring									
Edit	lr_hw[n].vz_stellgr	P-AXIS-00231	Sign reversal of command value	0	0	0	0	0	0
Edit	lr_hw[n].vz_istw	P-AXIS-00230	Sign reversal of actual value	0	0	0	0	0	0

JENNY SCIENCE

moving precisely, within tight space

To do	Parameter Name	Parameter-ID	Parameter Description	LINAX®/ELAX® 1um	LINAX® 100nm	ROTAX® Rxvp (64'000Inc/rev)	ROTAX® Rxhq (120'000Inc/rev)	ROTAX® Rxhq (648'000Inc/rev)	ROTAX® Rxhq (2592000Inc/rev)
Feedforward control (optional)									
Let	vorsteuer.vs_v_faktor	P-AXIS-00228	Weighting factor for feedforward control (enumerator)	1	1	1	1	1	1
Let	vorsteuer.vs_v_nenner	P-AXIS-00229	Weighting factor for feedforward control (denumerator)	1	1	1	1	1	1
Let	vorsteuer.vs_a_faktor	P-AXIS-00225	[us] Equivalent time constant feedforward control acc. (enum.)	1	1	1	1	1	1
Edit	vorsteuer.vs_a_nenner	P-AXIS-00226	Equivalent time constant feedforward control acc (denum.)	1	1	1	1	1	1
Let	vorsteuer.vs_max_Sprung	P-AXIS-00227	Max. permis. Jump in the down-gradation of feed forward	1	1	1	1	1	1
Let	vorsteuer.delay_time	P-AXIS-00055	[Cycle] Time shift between command actual values	1	1	1	1	1	1
Edit	vorsteuer.vorsteuerung	P-AXIS-00223	Bit-coded feed forward mode	0x303	0x303	0x303	0x303	0x303	0x303
Edit	vorsteuer.default_active	P-AXIS-00255	Permanent enabling of the feed forward	1	1	1	1	1	1
Let	vorsteuer.shift_time	P-AXIS-00165	[Cycles] Time shift command value - feedforward values	3	3	3	3	3	3
# ---									
Add	antr.acc_reference_value	P-AXIS-00392	Weighting of acceleration feed forward	3.1415	3.1415	17.6709	9.4245	1.74527	0.43632
Let	antr.abs_pos_offset	P-AXIS-00403	[0.1um] or [10-4°] Offset between drive- & CNC position	0	0	0	0	0	0
Let	antr.ignore_unknown_telegram_elements	P-AXIS-00358	Ignore unknown entries in drive telegram	0	0	0	0	0	0
Let	antr.use_drive_following_error	P-AXIS-00466	Drive based position lag calculation	0	0	0	0	0	0
Let	antr.probing_input_nbr	P-AXIS-00430	Number of probing input	0	0	0	0	0	0
Let	antr.encoder_bit_range	P-AXIS-00355	Number of bits for evaluation of encoder overflow	0	0	0	0	0	0
Let	antr.mode_cmd_pos	P-AXIS-00123	Normalization of command position	0	0	0	0	0	0
Let	antr.mode_act_pos	P-AXIS-00122	Normalization of actual position	0	0	0	0	0	0
Edit	antr.v_reso_num	P-AXIS-00206	Velocity scaling factor	1	10	64'000	120'000	648'000	2'592'000
Edit	antr.v_reso_denom	P-AXIS-00205	Velocity scaling factor	1	1	360'000	360'000	360'000	360'000
Add	antr.v_time_base	P-AXIS-00207	time base for velocity output, (1= per second)	1	1	1	1	1	1
Let	antr.operation_mode	P-AXIS-00320	Operation mode of an axis	DRIVE_DEFAULT	DRIVE_DEFAULT	DRIVE_DEFAULT	DRIVE_DEFAULT	DRIVE_DEFAULT	DRIVE_DEFAULT

2.10 Jerk Value Conversion

The jerk value for the CNC kernel is given in time units as acceleration ramp time.

The formula for the conversion from the jerk in inc/s to the acceleration ramp time in ms is the following:

$$j[\mathrm{ms}] = \frac{a[\mathrm{inc/s}\ ]}{j[\mathrm{inc/s^2}]} \cdot 1'000$$

The same formula for the acceleration ramp time in µs is the following:

$$j[\mathrm{\mu s}] = \frac{a[\mathrm{inc/s}]}{j[\mathrm{inc/s^2}]} \cdot 1'000'000$$

2.11 Demo Project

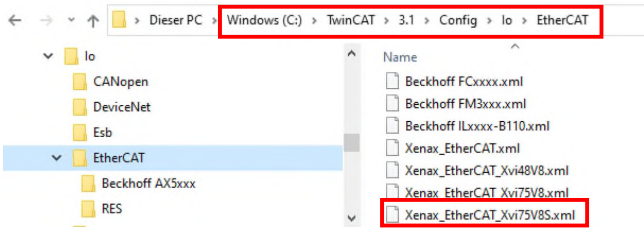
We cannot provide demo programs for CNC projects. Please contact us for the commissioning of your CNC project with Jenny Science axes.

3 Replacing Xvi 75V8 by Xvi 75V8S

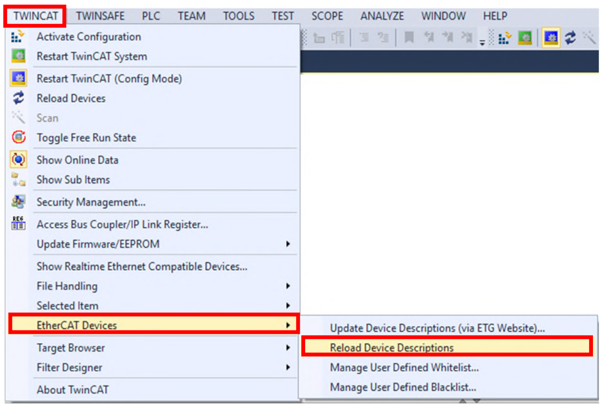
To replace a XENAX® Xvi 75V8 with an Xvi 75V8S in an existing project, the following steps must be done.

3.1 ESI XML Installation

The EtherCAT Slave Information XML for the XENAX Xvi 75V8S should always be completely unpacked into the ESI-directory of the EtherCAT master. In TwinCAT 3 these files are located in **\TwinCAT\3.1\Config\Io\EtherCAT**. This ESI file can be downloaded from www.jennyscience.com under "XENAX Servocontroller->Firmware Bus Module->EtherCAT".

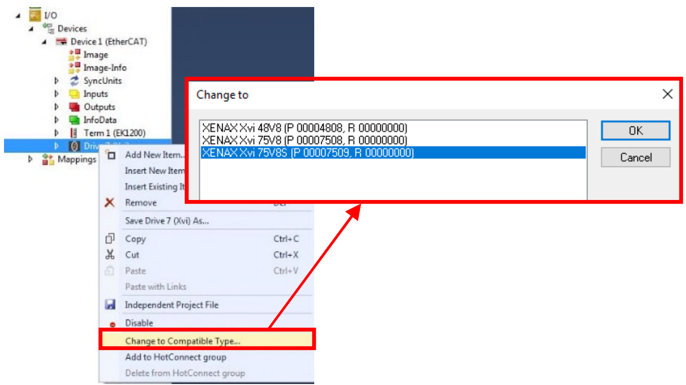


Load ESI file into TwinCAT. „TwinCAT→EtherCAT Devices→Reload Device Descriptions"



3.2 Change Type

Change the type of the selected XENAX® controller („*Change to Compatible Type...*"), then choose the right entry and press OK.



moving precisely, **within tight space**

Notes

Jenny Science AG grants no guarantee on, or will be held responsible for, any incidents resulting from false information.

Information in this instruction manual might be subject to changes.

Jenny Science AG
Sandblatte 11
CH-6026 Rain

Tel +41 (0) 41 255 25 25

www.jennyscience.ch
info@jennyscience.ch