Dokumentation

AX5000 Tuning - Guide

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BECKHOFF

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1 Foreword

1.1 Notes on the documentation

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning the components.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.
We reserve the right to revise and change the documentation at any time and without prior announcement.
No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

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1.2 Documentation issue status

Version	Comment
1.0	First Edition
0.1	internal Version

2 Safety

2.1 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

Description of symbols

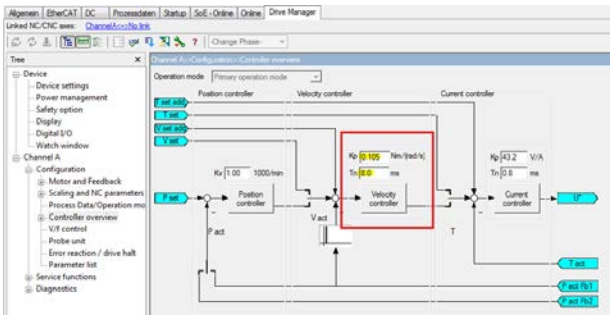
In this documentation the following symbols are used with an accompanying safety instruction or note. The safety instructions must be read carefully and followed without fail!

 **DANGER**	**Serious risk of injury!** Failure to follow the safety instructions associated with this symbol directly endangers the life and health of persons.
 **WARNING**	**Risk of injury!** Failure to follow the safety instructions associated with this symbol endangers the life and health of persons.
 **CAUTION**	**Personal injuries!** Failure to follow the safety instructions associated with this symbol can lead to injuries to persons.
 **Attention**	**Damage to the environment or devices** Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.
 **Note**	**Tip or pointer** This symbol indicates information that contributes to better understanding.

3 Tuning Velocity Controller (Ziegler&Nichols)

3.1 General Information

The main velocity controller parameters are the proportional gain Kp (S-0-0100) and the integral action time Tn (S-0-0101).



On selection of the motor default values are set, which enable the motor to be operated safely without load.

During commissioning the two parameters should be adjusted in order to find a good compromise between drive responsiveness (controller bandwidth) and noise generation.

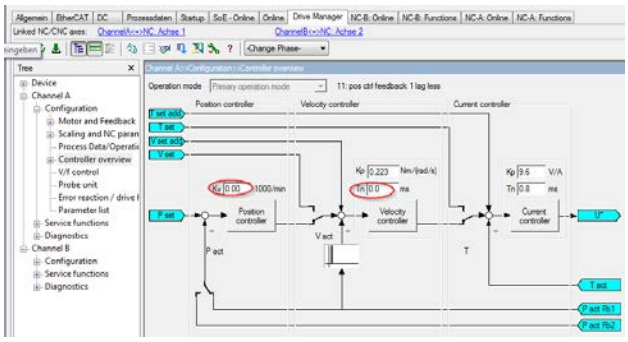
The method described below initially determines the stability limit of the control loop. The value determined for the gain is then multiplied with a field-proven factor, based on the rules of Ziegler and Nichols, in order to obtain a stable control loop.

If the bandwidth of the control loop turns out to be inadequate for the application, other methods should be used. A description of these methods would be beyond the scope of this documentation.

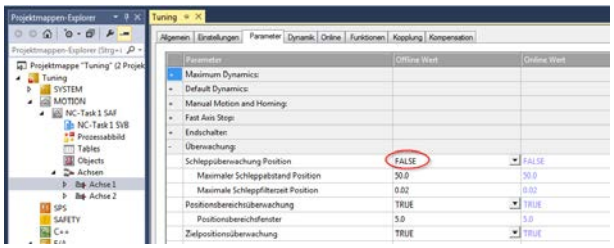
Attention	**Nature and source of the danger** This does not apply to vertical axes that are subjected to a continuous force, since it would cause the axis to drop. In order to minimize the influence of the integral controller, Tn should be set to a large value, e.g. 100 ms. Be sure to test carefully!

3.2 Preparation

For the tuning process the axis must be able to move in both directions, without reaching the mechanical end stops. For example, it should be pushed manually to the center of the travel path.



In most cases the AX5000 operates in mode "11: Position control feedback 1". In order to eliminate the influence of the position controller, Kv should be 0 for the tuning process in the position controller. In addition, Tn is set to 0 in the velocity controller.

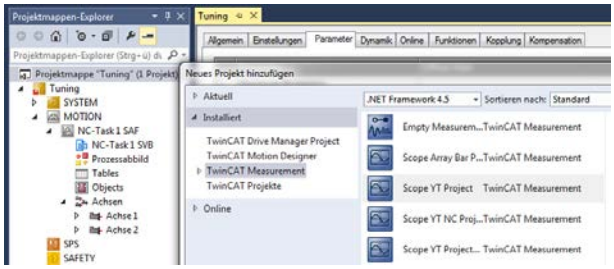


Following-error monitoring should be disabled for the NC axis or set to a large value so that it is not triggered in the following tests.

3.3 Determining the stability limit for Kp

To determine the stability limit, while the axis is active, Kp is increased in the velocity controller in small steps until the axis starts to oscillate. Depending on the axis type and the environment in which the axis is operated, it may be sufficient to determine the stability limit based on the noise generation. When Kp reaches a critical value, many axes start "squeaking" audibly. In noisy environments and for axes for which oscillation must be avoided, the TwinCAT "Scope View" oscilloscope should be used. The next chapter describes the setup. If the oscilloscope is not used, you can skip the next chapter and continue reading at "Starting the test movement [▶ 9]".

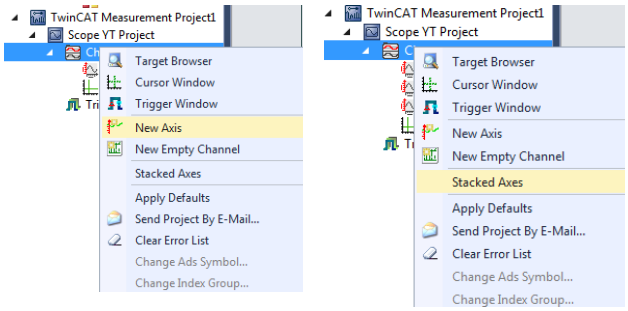
3.4 Setting up TwinCAT Scope View



Use the function:

- File → Add → New project

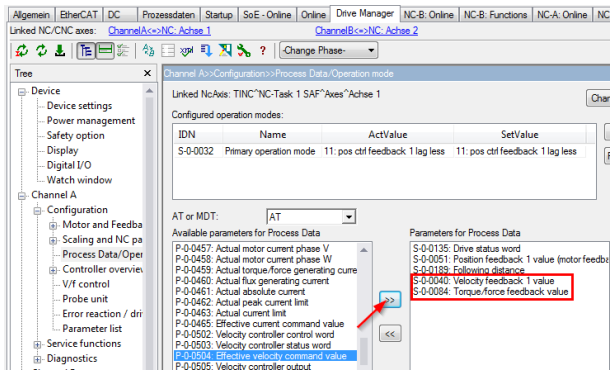
to add a "*TwinCAT Measurement*" project of type "*Scope YT NC Project*".



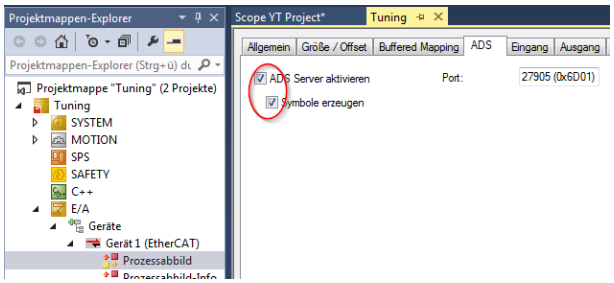
Right-click on the chart to add two axes, so that a total of three axes are available.

Notice!

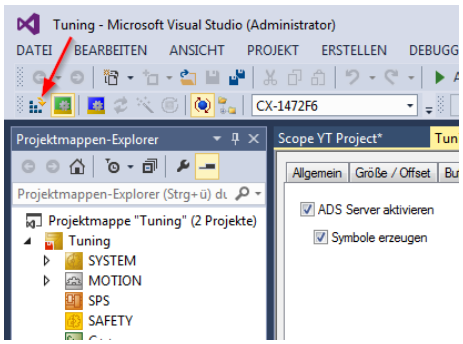
If you have a sufficiently large monitor, right-click on the chart again and select "Stacked Axes" for a better overview.



The axes are then shown one below the other. Add the "Torque feedback value" (S-0-0084), the velocity command value and the actual velocity value (P-0-0504 and S-0-0040) to the AX5000 process data.



In the process image of the EtherCAT master activate the ADS server and the symbol generation facility.



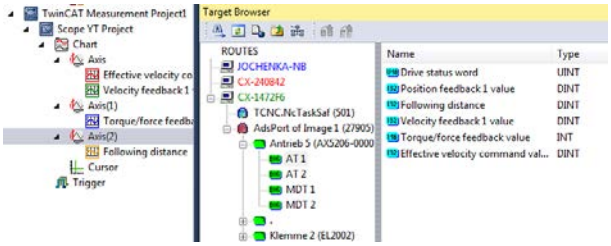
Now reactivate the configuration.

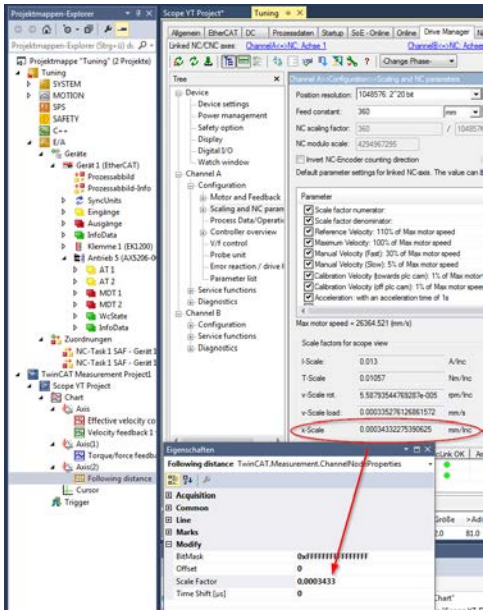
Right-click on an axis in the oscilloscope and open the target browser.

Select:

- the controller,
- the ADS port,
- the drive and the channel.

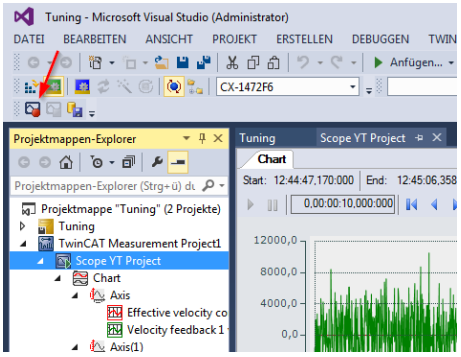
Use "*drag and drop*" to assign the signals to the oscilloscope axes, as shown (picture below).





The signal scaling is not important for determining the stability limit. To establish the relationship with the drive axis it may be useful to enter the scaling factors in the property window of the axis. The values can be taken from the "*Scaling and NC Parameters*" window in the TC DriveManager.

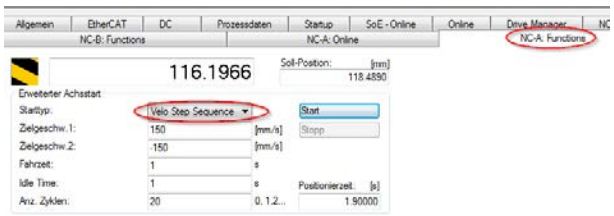
If you start the recording now, the oscilloscope should not issue an error message.



Nature and source of the danger!

If a German keyboard is used, the decimal symbol must be comma!

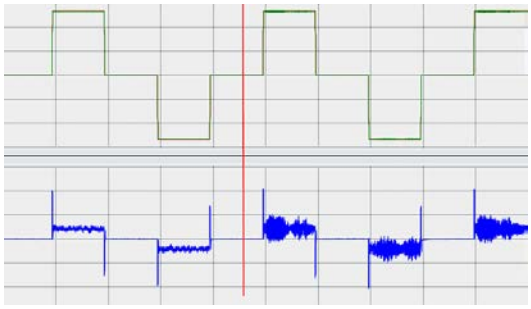
3.5 Starting the test movement



From "*NC Functions*" select the function "*Velo Step Sequence*". To make the axis reverse, you have to specify two velocities with different sign. Enter 1 second as "*Idle time*", for example, and a number of cycles.

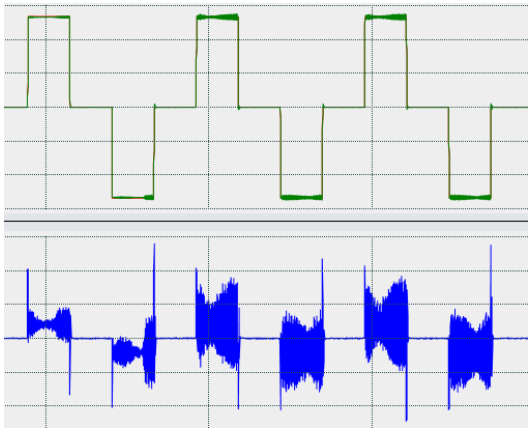
Attention	**Nature and source of the danger** Since the position controller and the integral component of the velocity controller are not active, the axis may drift into another positioning range during reversing.

3.6 Evaluating the oscilloscope pattern



While the axis reverses, observe the behavior with the oscilloscope. The following oscilloscope pattern shows the velocity command value and actual velocity value in the upper diagram and the current or torque ("*torque feedback value*") in the lower diagram.

The red line is based on an increased value for Kp. The next motion shows that an oscillation occurs, which continues for the whole motion.



Depending on the mechanical system, the value that was reached can be regarded as Kp_{crit}, or Kp can be increased further, until the oscillation also shows up in the velocity value. It will then also be more audible.

In the sample application with a ball screw, the oscillation in the current signal starts at Kp = 0.22. Only a soft "squeaking" can be heard, which is inaudible in a noisy environment.

At Kp = 0.25 the oscillation also shows up in the speed signal.

3.7 Reducing Kp

Based on the rules of Ziegler and Nichols, the correct value for Kp should be determined using the following formula.

$Kp = 0.45 \times Kp_{crit}$

In the example,

- Kp = 0.45 x 0.22 = 0.10 or
- Kp = 0.45 x 0.25 = 0.11

is the correct value.

3.8 Determining Tn

Tn determines the integral action time of the integral controller. The smaller Tn, the larger the gain of the Integral controllers. The correct value for Tn is mainly dependent on the type of coupling between motor and load. Many applications run satisfactorily with the default value Tn = 8 ms. At the Rigid coupling and if the tracking error appears to be too large, Tn can e.g. up to 5 ms.

Attention	**Value ranges from Tn!** Do not reduce Tn any further without using the TC ScopeView to ensure that the current or speed actual value does not start to oscillate! Values ≤ 5 ms are not required in most applications. With elastic coupling between engine and load or even with long straps it may be useful for Tn Values> 10 ms. Swinging of the axis is thereby prevented.

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