A Bosch Company

NYCe 4000

Linear motion system
LMS Commissioning Tool User Manual

Commissioning
R911425756

Edition 02

Title: NYCe 4000
Linear motion system
LMS Commissioning Tool User Manual

Type of Documentation: Commissioning

Document Typecode: DOK-NY4000-LMS*COM*V54-CO02-EN-E

Internal File Reference: RS-50a930c17fbf82080a347e865955178f-2-en-US-6

Record of Revision

Edition	Release Date	Notes
DOK-NY4000-LMS*COM*V54-CO01-EN-E	08/2024	First edition 54V02
DOK-NY4000-LMS*COM*V54-CO02-EN-E	04/2025	2nd edition 54V04

Published by: Bosch Rexroth AG

P.O. Box 7170 ■ 5605 JD Eindhoven ■ The Netherlands

http://www.boschrexroth.com

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1 Introduction

1.1 What is in this manual

The "NYCe 4000 LMS Commissioning Tool Manual" provides information how you can commission a Linear Motion System (LMS) using the LMS Commissioning Tool. The manual describes the process steps of commissioning a single track which consists of 4 coils.

- chapter 2 "Commissioning overview" on page 3 describes the overall layout and the prerequisites.
- chapter 3 "Commissioning Tool description" on page 9 gives an overview of the functionality of the Commissioning Tool.
- chapter 4 "Commissioning of an LMS" on page 15 describes the commissioning process and all process steps (the workflow)

1.2 Intended audience

This manual is intended for users who have a certain level of background knowledge and understanding regarding the Linear Motion System and the commissioning of an LMS. It is highly recommended that the reader of this manual and the user of the LMS Commissioning Tool has prior experience commissioning an LMS track and/or has attended a course in commissioning of an LMS.

1.3 NYCe 4000 LMS system

This manual uses in all examples an LMS track with 4 coils, LMS sensors and one carrier positioned on the track. Besides the physical LMS track the following system hardware is required.

- NYCe 4000 LMS node
- Power supplies
- PC

The NYCe 4000 LMS node is a metal housing that contains the Motion Control Unit (MCU) and the drive module(s) or SERCOS III master module. The MCU is always installed in the leftmost slot of the system housing.

Depending on the required energy to drive the coils of the LMS you can use the NY4120/10 drive module for currents up to 10A nominal for a single coil, or the NY4150/10 SERCOS master module for connection to DriveLink drives. The NY4074 is the system housing for the NY4120/10 drive modules. The NY4079 and NY4089 is the system housing for the NY4150/10.

The position of a carrier on an LMS track is detected by LMS sensors. These LMS sensors are connected to the node.

See for more information the NYCe 4000 Hardware System Manual and NYCe 4000 Standard Housings & Accessories Manual.

1.4 NYCe 4000 tools

The NYCe 4000 LMS product includes several programs to define and configure an LMS track. With these programs, also called tools, you can set and test parameters which are required for the correct operation of an LMS track. Some tools are specifically for LMS configuration. Other tools are for setting general NYCe 4000 parameters. Example of an LMS-specific tool is

NYCeLmsCommissioning. Examples of NYCe 4000 general tools are NYCeConfigurator, NYCeTuner, and NYCeScope.

1.5 NYCe 4000 documentation

After you installed the NYCe 4000 LMS software on the PC you can find a folder "Rexroth" in the Start menu. Here you can find all NYCe 4000 documentation. The following documention is referenced in this manual.

Document tile	Description
NYCe 4000 LMS Tools Manual	This manual describes the software tools specific for LMS
NYCe 4000 LMS User Manual	This manual describes the NYCe 4000 LMS CM API
NYCe 4000 Tools Manual	This manual describes the software tools for NYCe 4000 in general
NYCe 4000 Standard Housings Manual	This manual describes the system housings and accessories
NYCe 4000 Hardware System Manual	This manual describes the NYCe 4000 modules

Tab. 1-1: Most relevant NYCe 4000 documentation for LMS commissioning

1.6 Used abbreviations in this manual

The following table gives a summary of abbreviations used in this manual.

Abbreviation	Description
API	Application Programming Interface
CM	Carrier Management
IEEE	Institute of Electrical and Electronics Engineers
LMS	Linear Motion System
MCU	Motion Control Unit
MUX	Multiplexer
NY4114	MCU with 3 IEEE 802.3 (ethernet) connections
NY4120/10	PWM Drive Module for LMS
NY4150/10	SERCOS III Master Module
NY4074	LMS System housing for MCU and two NY4120/10
NY4079	LMS System housing for MCU and one NY4150/10
pu	Position unit (user-defined dimension of position)
SERCOS III	Third generation SERCOS (Serial Real time Communication System) drive communication protocol based on the Ethernet physical hardware architecture
XML	Extensible Markup Language

Tab. 1-2: Summary of used abbreviations

2 Commissioning overview

2.1 Introduction

The process of commissioning is used to configure the LMS system to a fully operating system. Before you can start commissioning, all control hardware of the LMS must be correctly connected and ready for use. The LMS system can perform controlled motion profiles after the commissioning process is finished.

2.2 Commissioning workflow

The commissioning process consists of 5 separate sequential steps, also called the commissioning workflow. The workflow to commission an LMS track consist of the following activities.

- Parametrization
- Validation
- Configuration
- Teaching
- Tuning

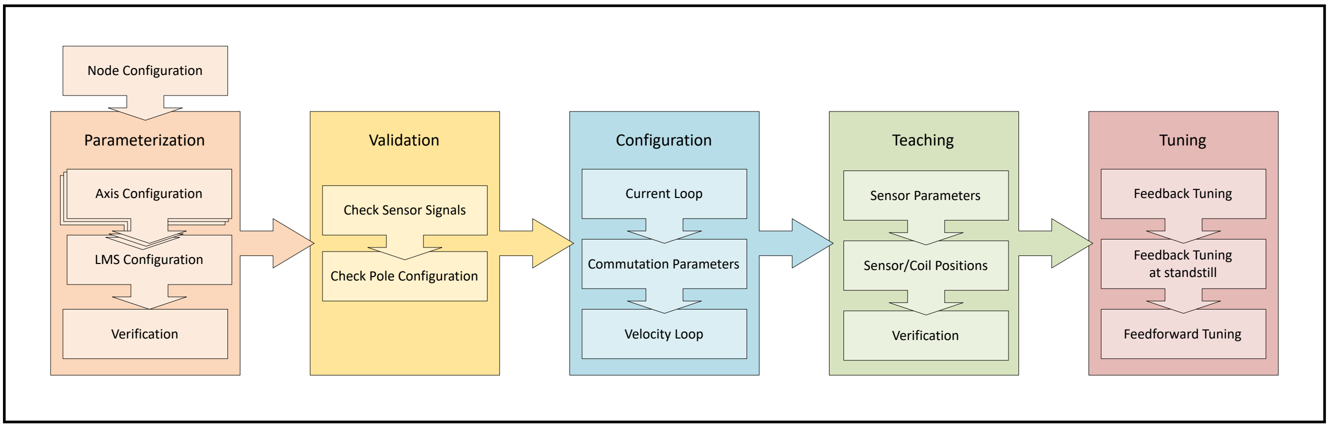

Fig. 2-1: Commissioning workflow activities

Parameterization

The parameterization activity involves the configuration of the node, axes and the LMS tracks. Configuration of the node defines parameters for the MCU and the drive module(s). Configuration of the axes defines the motor parameters, safe operation and error guard parameters, constraint parameters and error handling. LMS configuration defines the LMS layout, such as the number of tracks, number of coils, coil specific layout, and sensors. In this context an axis is a coil. See chapter 4.2 "Parameterization" on page 15.

Validation

The validation activity is a measurement and check of the sensor signals and the pole configuration at the track level. See chapter 4.3 "Validation" on page 21.

Configuration

The configuration activity defines the coil configuration. Configuration involves the definition of the commutation, setting current loop and velocity loop parameters. See chapter 4.4 "Configuration" on page 25.

Teaching

The teaching activity defines the sensor parameters, such as sin/cos offset, sin/cos amplitude, and phase offset, but also the position of the sensors and coils. See chapter 4.5 "Teaching" on page 32.

Tuning

Tuning involves modifications of the motion control parameters to get a smooth movement for high precision motion of a carrier. See chapter 4.6 "Tuning" on page 37.

Collision avoidance – track to track distance

The LMS Commissioning Tool can also be used to determine the distance between two tracks. The parameter `trackDistance` is a required parameter for the function `CmCollAvoidMoveBetweenTracks` to move a carrier from one track to another track with collision avoidance. Note that this distance can only be determined **after** a complete and successful commissioning of the involved tracks. See chapter 4.7 "Collision avoidance – track to track distance" on page 45.

The Commissioning Tool is designed to guide you step by step through this workflow.

2.3 XML files and parameter handling

The LMS Commissioning Tool creates XML files. These files contain all the data regarding the track and coils. Based on the parameters specified in these files, the system is controlled.

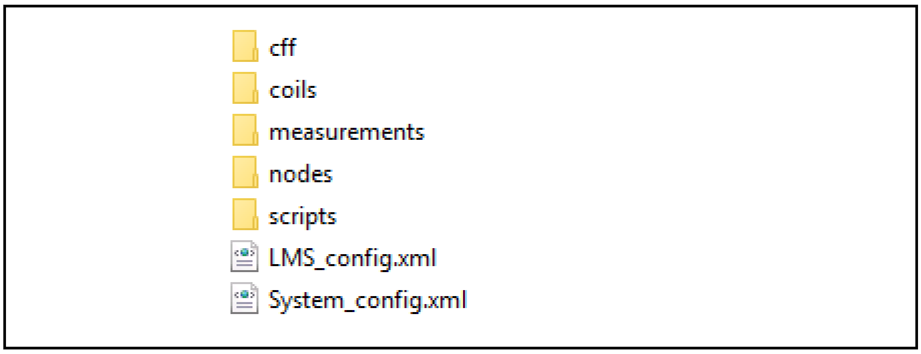

Fig. 2-2: XML folders and files created or used by the Commissioning Tool

XML files

Before you can use the Commissioning Tool, you must create the `System_config.xml` file with the NYCeConfigurator tool. This is described in chapter 2.4 "LMS setup" on page 5.

The Commissioning Tool creates the `LMS_config.xml` file which describes the layout of the LMS system. One XML file is created for all coils. The coil XML file contains all parameters of all coils. You can also create an XML file for each coil separately. It is advised to store the coil XML file(s) in a separate folder, as shown in fig. 2-2 "XML folders and files created or used by the Commissioning Tool" on page 4.

Parameter handling

The way parameters are handled by the Commissioning Tool is shown in fig. 2-3 "Parameter handling of the Commissioning Tool" on page 5. LMS-specific parameters and coil-specific parameters are handled differently. Entered parameters in the Commissioning Tool are written to shared memory on the PC when you select a different field. The coil-specific parameters are stored on the node only when the system is initialized.

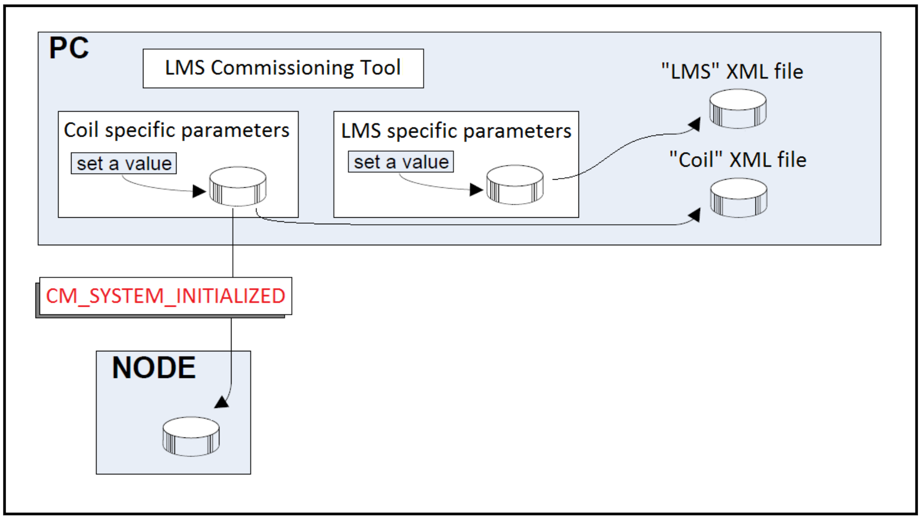

Fig. 2-3: Parameter handling of the Commissioning Tool

While the system is not initialized, the LMS-specific and coil-specific parameters are only held in local memory of the Commissioning Tool, they are not automatically saved to a file on the PC. If you close the Commissioning Tool without saving the parameters first, all changes you made to the parameters are lost. Parameters can be changed while the system is initialized.

2.4 LMS setup

You must configure the LMS before you can start the commissioning process. The system configuration is outside of the scope of the Commissioning Tool. The system configuration is performed with the NYCeConfigurator in the following steps.

- Verify network connection to the PC.

  Check the ethernet cable, and check the IP address of the MCU. The default IP address of the NY4114 MCU is 192.168.41.14. If you enter `http://192.168.41.14` (or the IP address that you assigned to the MCU) in the address field of a browser on the PC, the MCU web page must appear.
- Start NYCeConfigurator to check and set correct settings.
- Select the MCU entry in the left pane.

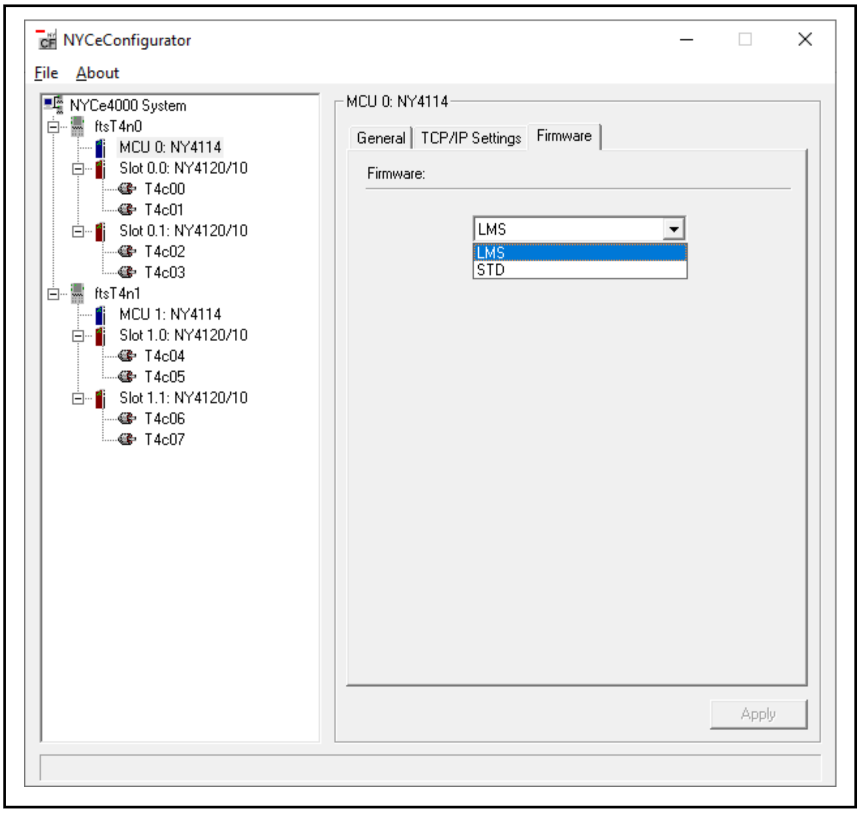

Fig. 2-4: NYCeConfigurator, MCU level, "Firmware" tab

On the "Firmware" tab you can see and change which type of firmware is stored in the persistent memory of the MCU. If you installed the LMS product software, you can choose between "STD" and "LMS". Make sure that the LMS firmware is selected. If you must change the firmware type from STD to LMS, a pop-up message appears, because you must reset the node to actually run the selected firmware.

- Do the following steps at the node level.

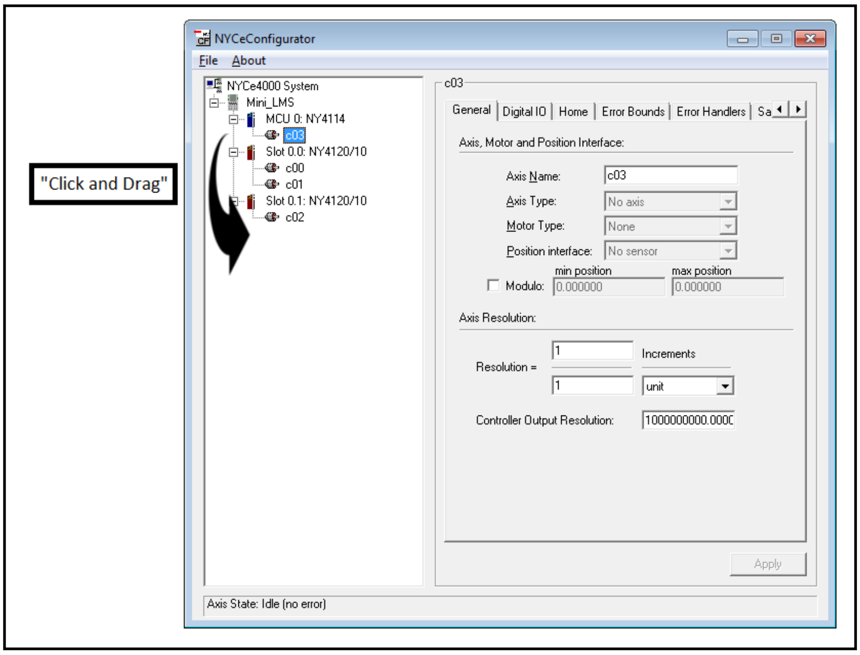

Fig. 2-5: NYCeConfigurator - node level settings

1. Enter an appropriate name for the node in the "Name" field.
2. Set the "Sample Frequency" to 2 kHz.
3. Select the correct setting for the "Service Input" and the "Stop Axes" input. The correct settings depend on the electrical connection of these inputs.

- Do the following steps at the slot level.
    1. On the "general" tab, enter the nominal drive voltage.
    2. On the "Inputs" tab, change the polarity of the "DigIn6" and "DigIn7" digital inputs to "Low".
- Do the following steps at the MCU level.
    1. Create the axes. The number of axes depends on the number of coils connected to the node.
    2. Select each axis and change the name of the axis to a meaningful identification.
    3. Click and drag the axes to the correct slot units.
- Do the following steps at the system level.
    1. Save the configuration to flash memory for each node.
    2. Save the configuration to a file on the PC.

You can close the NYCeConfigurator after these steps have been done.

3 Commissioning Tool description

3.1 Introduction

When you start the Commissioning Tool, the Commissioning Tool window appears, see fig. 3-1 "Commissioning Tool window" on page 9. The top bar in the window contains the Workflow tabs. Tool tabs are at the right side of the window. Each step of the workflow has its own color and each workflow step has subcategories. You use these workflow tabs with their subcategories from left to right during the initial commissioning of an LMS.

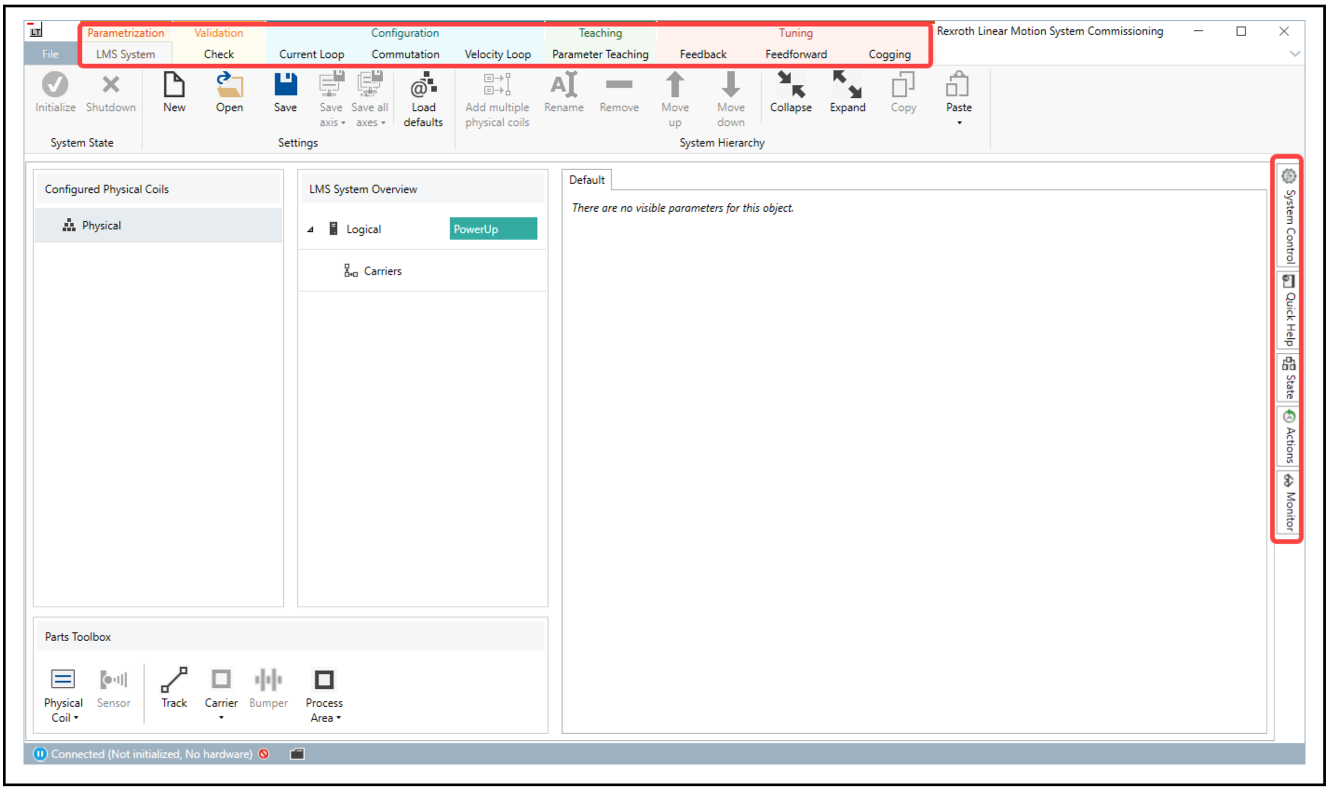

Fig. 3-1: Commissioning Tool window

This chapter describes the menu options and the various tabs of the Commissioning Tool.

3.2 File options

The "File" menu enables you to open and save files.

You can choose the following options on the tabs.

"Open" tab

- "New" – start with an empty configuration.
- "Open" – open an existing file.

"Save" tab

- "Save" – save the current opened file.
- "Save as" – save files in a new configuration file.
- "Save axes" – save all physical coil configurations in a single file.
- "Download" – initializes the axes from file, saves the axes configuration to flash memory, and executes a shutdown to set all axes in the idle state.

- "DriveLink motor parameters" – download and save DriveLink motor parameters.

3.3 System tab

On the System tab you manage the LMS System with the following options.

- "Shutdown" – shutdown LMS services and exit the application
- "Restore layout" – restore layout of dockingpanels to the default settings

Further, you can open external NYCe 4000 tools used during commissioning. Click "Setup" to start NYCeConfigurator. Click "Log" to start NYCeLogger.

You can also specify the following options.

- "Expert Mode" – configure advanced parameters
- "Diagnostic Mode" – display additional backend log entries and validations
- "File logging" – save debug log data to a file

3.4 Info tab

On the "Info" tab the NYCe 4000 version is displayed.

3.5 Tool tabs

3.5.1 Introduction

Tool tabs are at the right side of the Commissioning Tool window.

Fig. 3-2: Tool tabs

The following tool tabs are available.

- "Quick Help" – displays content-sensitive help information
- "State" – displays the object state diagram of the object that is selected
- "Actions" – shows a list of actions performed during commissioning
- "System Control" – provides basic software functions for track, carrier, bumper, and process area
- "Monitor" – monitor variables and their values

3.5.2 System Control tab

On the "System Control" tab you can execute basic software functionalities for track and carriers. To open the "System Control" tab select a logical system part (for example a track or a coil), and click on the "System Control" tab. All functions available in the "System Control" tab are explained in the NYCe 4000 LMS Software User Manual.

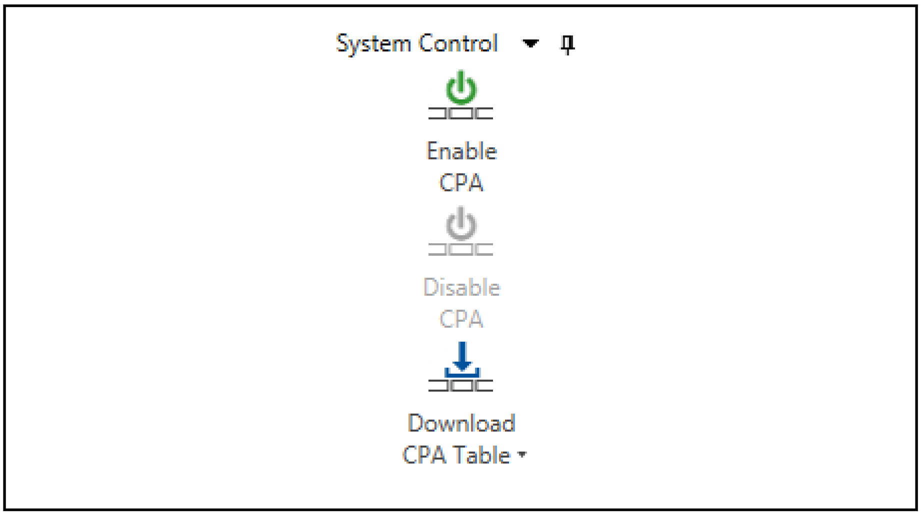

Fig. 3-3: System Control tab

3.5.3 Quick Help tab

The "Quick Help" tab shows a short summary of the commissioning process. A specific quick help summary is available for each step in the commissioning workflow. Note that the "Quick Help" only displays a summary of the commissioning steps. Use this manual for detailed descriptions.

3.5.4 State tab

The "State" tab displays a representation of the states of different components of the LMS. The states are displayed for the system and the tracks. If all necessary preconditions are met, you can go to an other state when you click on that state.

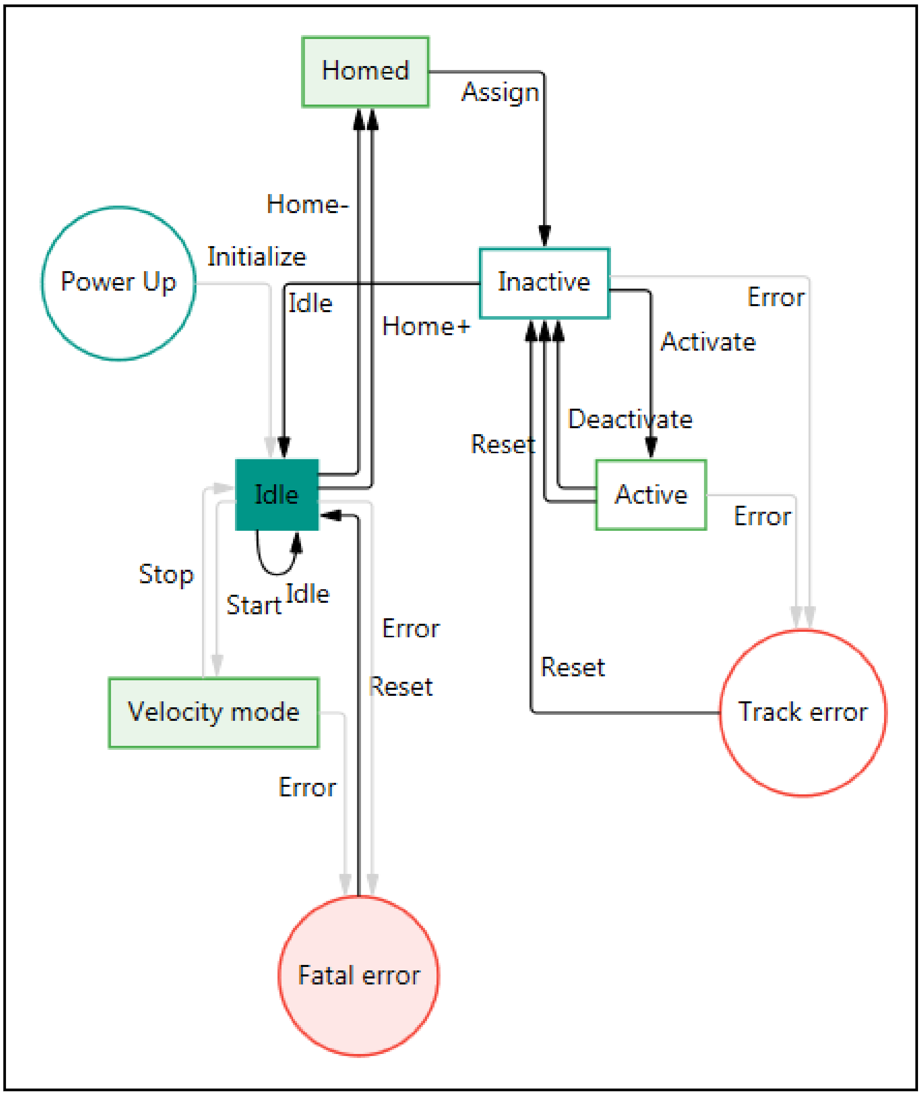

Fig. 3-4: State tab

3.5.5 Actions tab

The "Actions" tab gives an overview of the executed functions in the tool. The functions that you executed, with their results, are displayed. Successful results are displayed in green color, unsuccessful results are displayed in red color. Functions that are executed in the background are displayed in grey color.

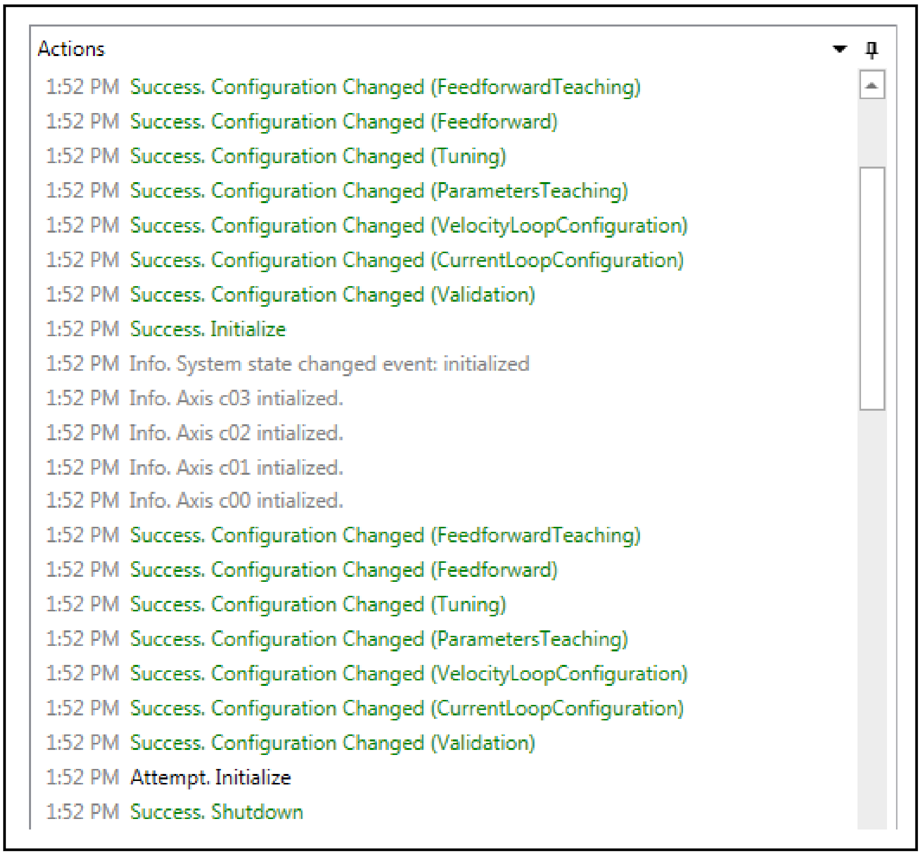

Fig. 3-5: Actions tab

3.5.6 Monitor tab

The "Monitor" tab displayes values of variables and parameters within the LMS. When you select track- or carrier-specific variables, you can monitor their values. When you click the "+" for a variable, the variable is pinned and its value remains monitored even when the object is no longer selected.

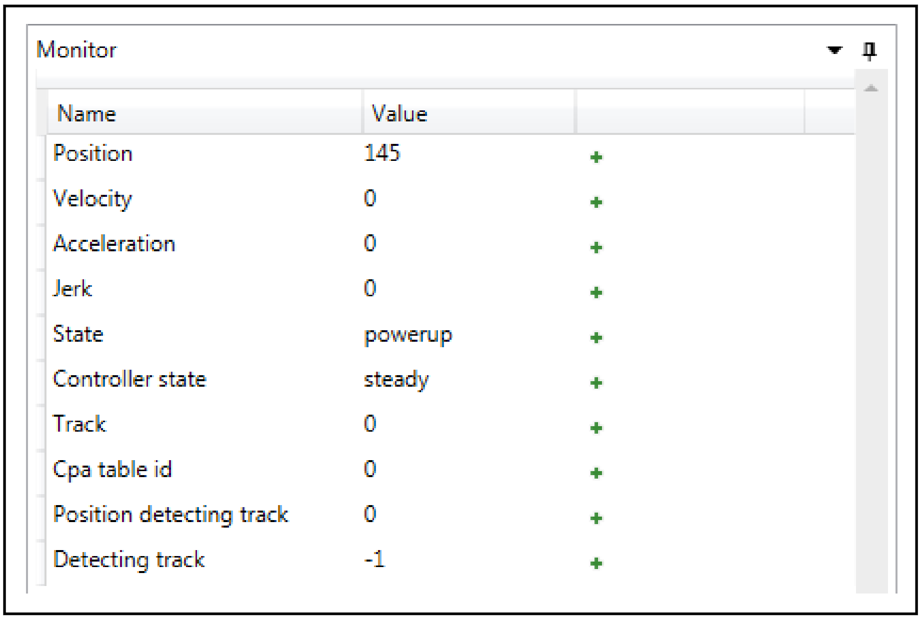

Fig. 3-6: Monitor tab

4 Commissioning of an LMS

4.1 Introduction

This chapter describes the process of commissioning an LMS. As described in chapter 2.2 "Commissioning workflow" on page 3, the commissioning process follows a strict workflow order. Each step of the commissioning workflow is described in the following chapters.

Start the NYCeLmsCommissioning tool to start the commissioning process of an LMS. The LMS Commissioning Tool startup window appears.

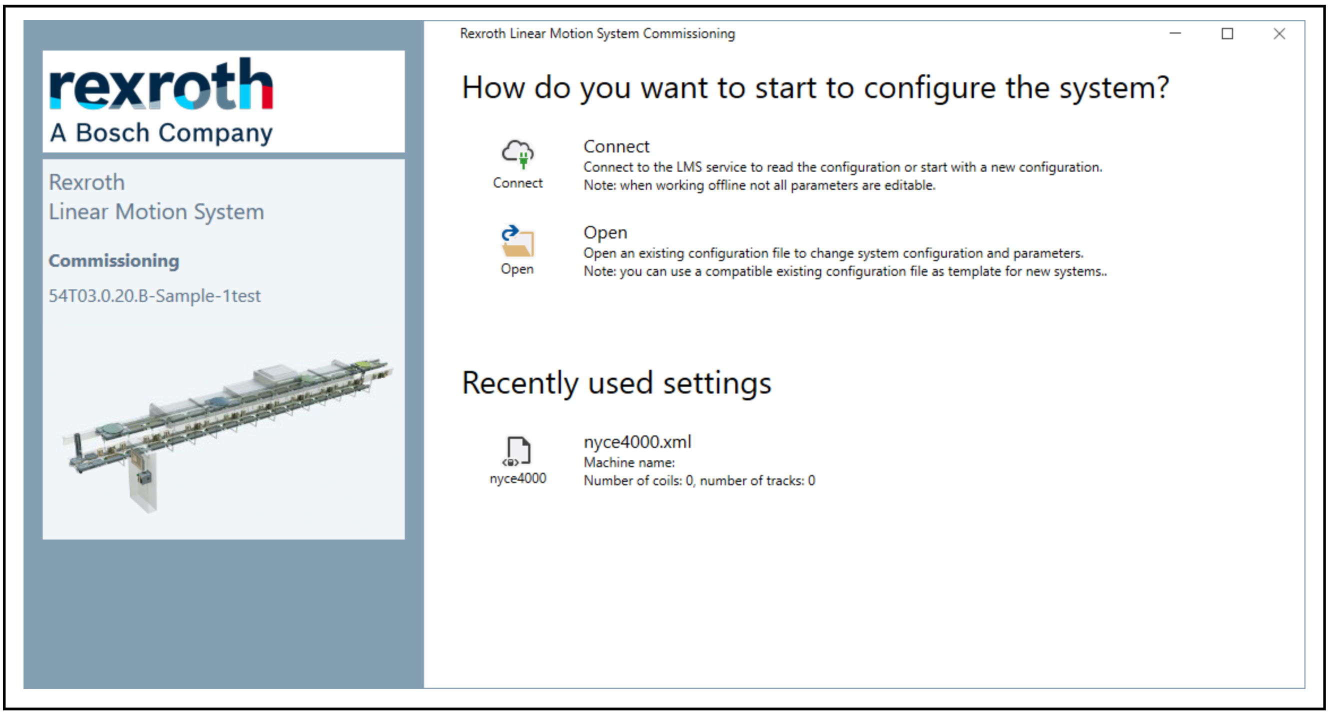

Fig. 4-1: LMS Commissioning Tool startup window

Select "Connect" to create a new LMS configuration file.

With the Commissioning Tool you can follow the workflow steps described the in following chapters to commission an LMS track.

4.2 Parameterization

The first step of the commissioning workflow is the parameterization. In this step the parameter files are created which contain the details of the LMS.

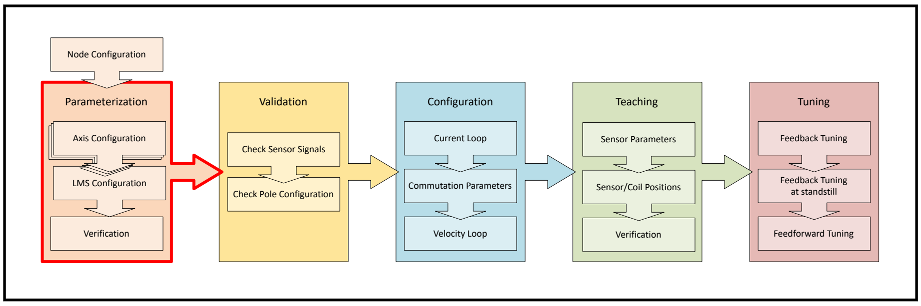

Fig. 4-2: Commissioning - parameterization

Before you can start filling in all required parameters, you must build the system configuration.

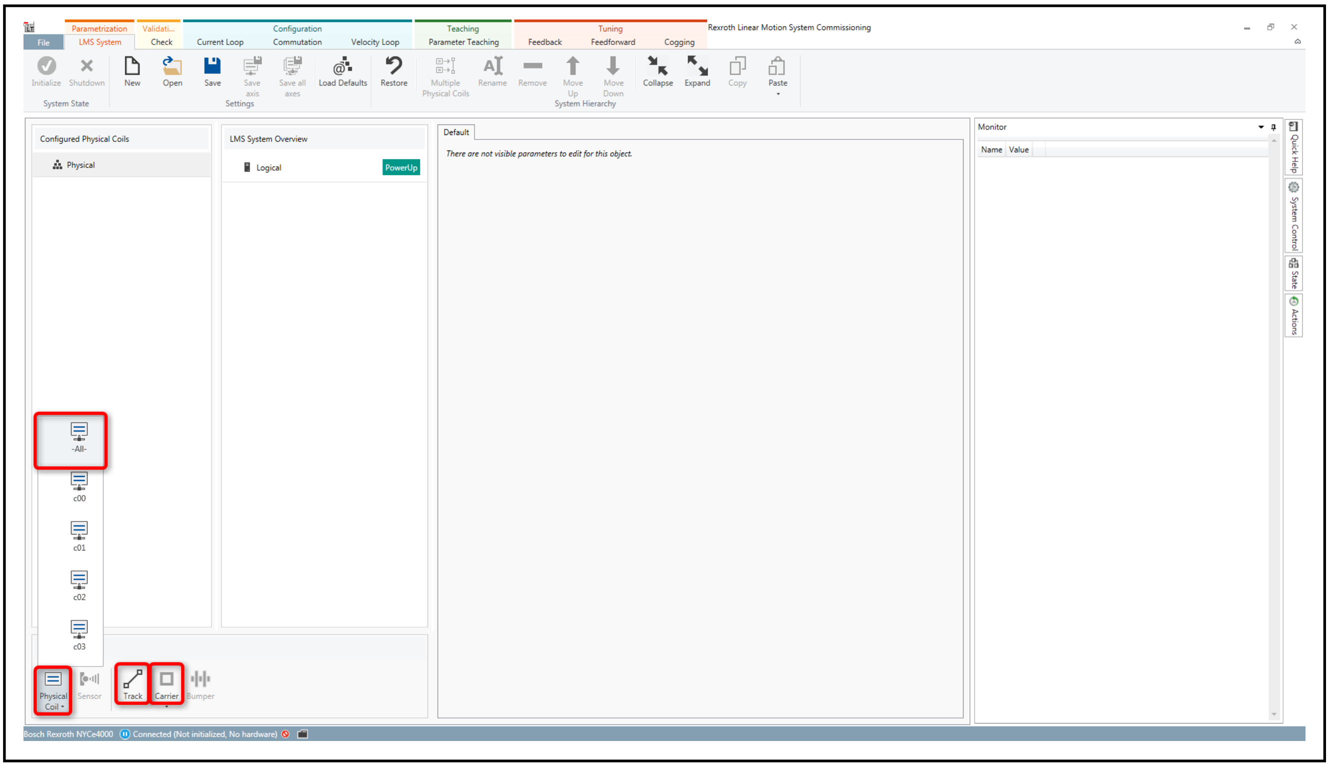

Fig. 4-3: Parameterization - start a new LMS configuration file

Do the following steps to build the system configuration.

1. Click "Physical coils". All coils in the LMS are displayed in the "Physical" coil tree view (left column).
   - Select the "All" coil icon to add all coils in the network to the configuration.
   - Select individual coils to add individual coils in the network to the configuration.
2. Click the "Track" button to add the required number of tracks. The tracks are displayed in the "Logical" tree view, the column right from the "Physical" tree view.
3. Drag the coils in the "Physical" coil tree view one by one to the correct track in the "Logical" tree view.
4. Select the tracks in the logical tree view one by one and click the "Carrier" button as many times as there are carriers physically present on the track.
5. Optionally, add sensor(s) to coils with a 3-sensor configuration.

Now that the tree view is complete, you can select the correct coil type for each coil, see fig. 4-4 "Parameterization - first steps" on page 17.

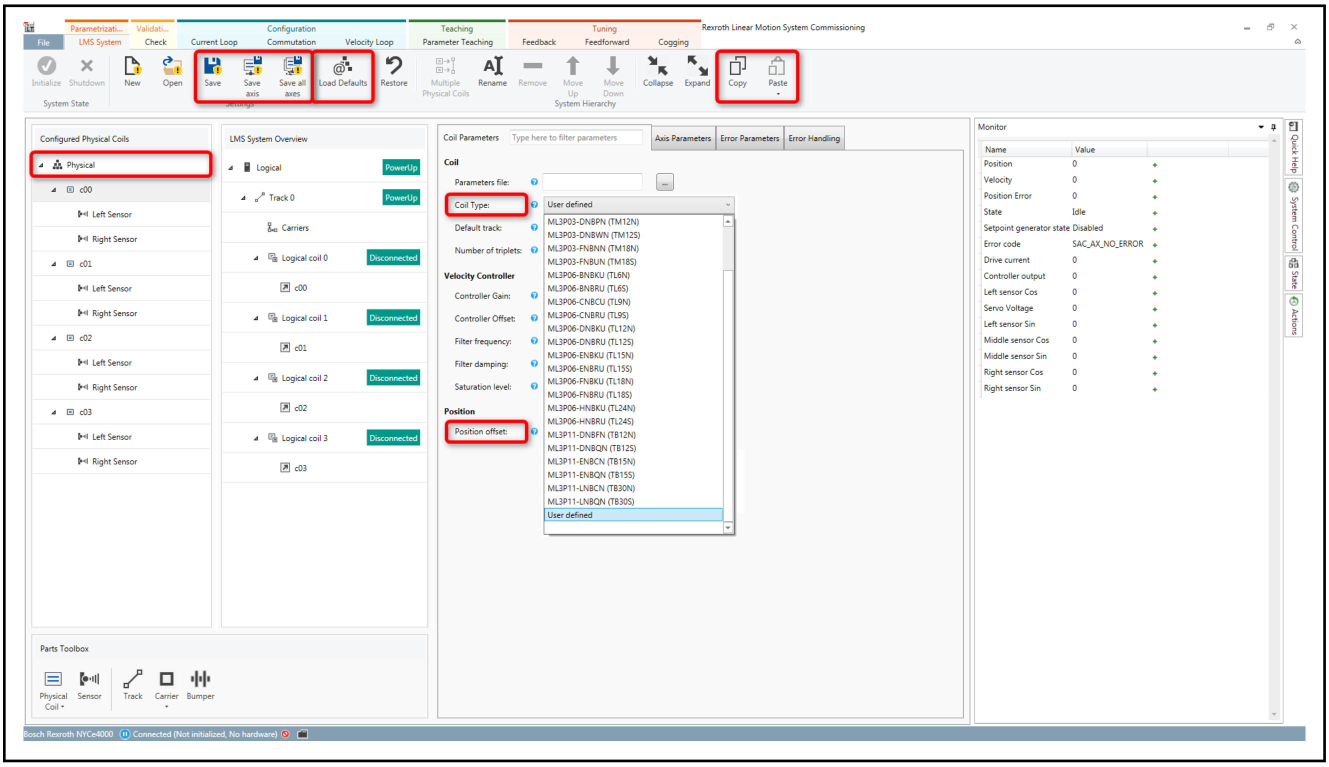

Fig. 4-4: Parameterization - first steps

Usually all coils in a track are of the same coil type and most often all coils in an LMS are of the same type. For convenience, you can use the copy and paste functions to copy the settings of one physical coil to other physical coils in the "Physical" coils tree view, in this case the coil type.

The defaults can be loaded after the correct coil type is selected for all coils in the "Physical" coils tree view.

1. Select "Physical" in the "Physical" coil tree view.
2. Click the "Load Defaults" button.

☞ If DriveLink drives are used, the first DriveLink drive in a node must have SERCOS address 1. Subsequent DriveLink drives in that node must have consecutive SERCOS addresses (that is, 2, 3, 4), otherwise "Load Defaults" will fail.

☞ You must select the sensor type used in the track **before** you click the "Load Defaults" button, because the default values depend on the sensor type.

All settings from NYCeConfigurator such as the default coil type specific settings and the default track to which the physical coil belongs are loaded.

After loading defaults you can continue the configuration at the physical coil level.

- "Coil parameters" tab
  – Specify values for "Position" parameters.

  - The parameters with the header "Velocity Controller" are determined during the Configuration step of the workflow, in the section "Velocity Loop". Keep the default values in this step of commissioning process.
- "Axis parameters" tab
  - Specify values for "Setpoint Generator" parameters.
  - Specify values for "Axis Error Bounds".

    If the axis is a coil axis connected to an DriveLink drive, you cannot select the error handler for `SAC_AX_ERR_NETWORK_ERROR`.
  - Specify values for "Quick Stop".

  Note that max acceleration is used to check the motion parameters, and are used for deceleration for quickstop and smooth stop.
- "Error parameters" tab
  - Specify values for "Motor Protection".
  - Specify values for "Position Error Window".

After setting these parameters to appropriate values you can save the coils to a file.

These settings can be copied to all objects with the copy/paste functions.

- To save the parameters of a single coil to a separate XML file, select the specific coil and click the "Save axis" button. If you click the button, the coil parameters are saved to flash memory. If you click the button text legend, you can choose from the drop-down menu whether you save the coil parameters to flash memory or to a file.
- To save the parameters of all coils to a single XML file, click the "Save all axes" button. If you click the button, all coil parameters are saved to flash memory. If you click the button text legend, you can choose from the drop-down menu whether you save all coil parameters to flash memory or to a file.

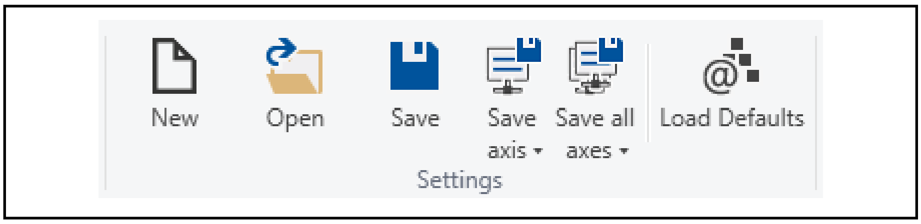

Fig. 4-5: Parameterization - save the coil file(s)

After saving parameters to flash memory, save the parameters also to a file (for backup purposes).

Start-up of the LMS application, regardless where the application executes, is significantly improved when the LMS configuration file and axis (coil) configuration file are stored in flash memory on the node.

After the coil file has been generated, you can select the coil file in the "Coil Parameters" tab, "Parameters File".

- On this tab you must enter an appropriate value in the "Position offset" field.

A coil file is needed to initialize the system. Parameters that are set in the tabs "Axis Parameters", "Error Parameters" and "Error Handling" are stored in the coil file.

In the "Physical" coils tree view, select the first sensor and select the correct "Mux Connector" and the correct "Slot ID" to which the Mux is connected. Select these settings correctly for each sensor.

You can leave the parameters in the header "Determinable" at their default values. These parameters are automatically determined in the Teaching step of the workflow.

In the "Logical" tree view, select the first track.

- Enter the homing mode and velocity.

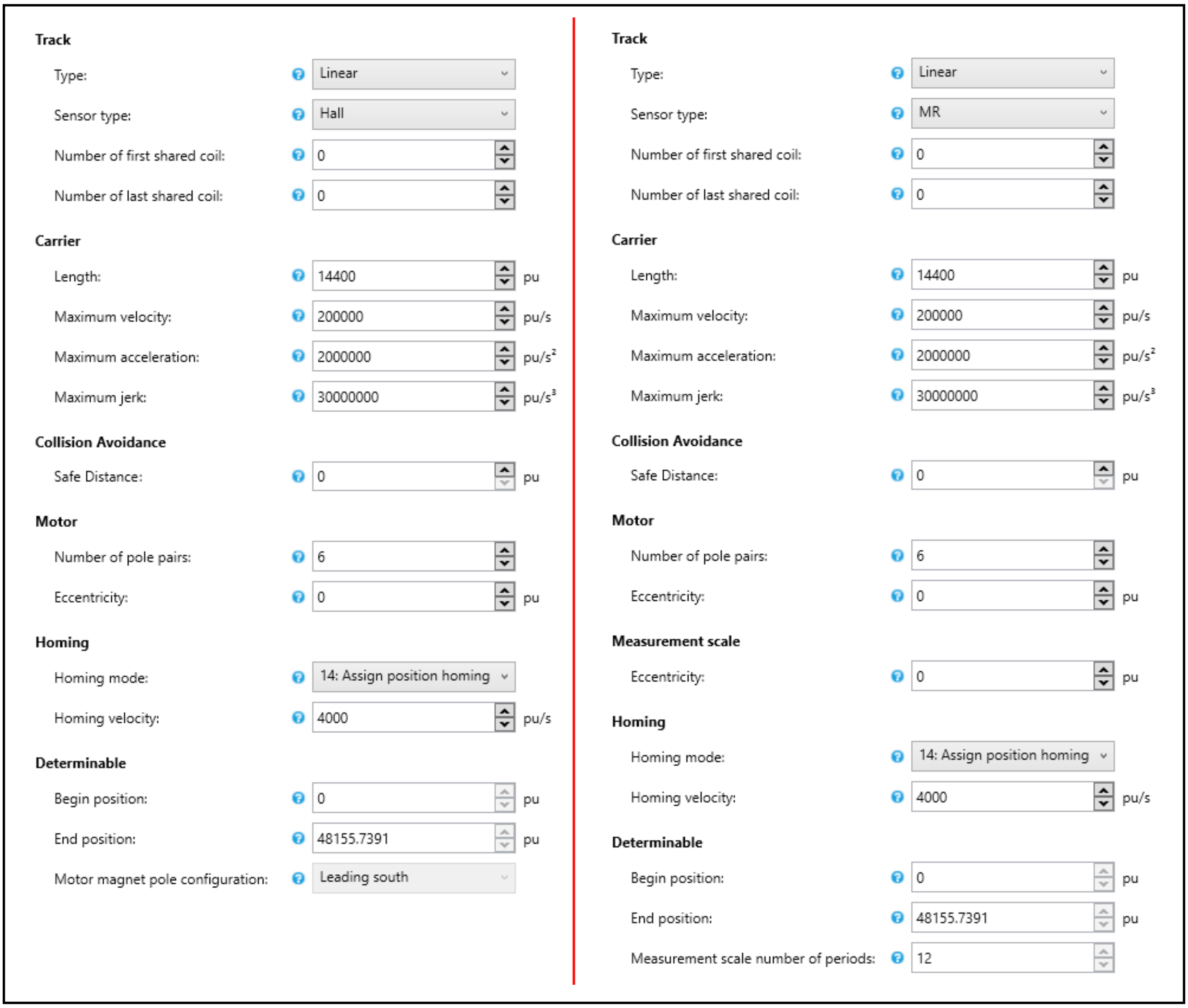

Fig. 4-6: Parameterization - set the track parameters

The track parameters depend on the selected type of LMS sensor. The screenshot at the left side shows the track parameters when the selected sensor type is a Hall sensor. The screenshot at the right side shows the track parameters when the selected sensor type is an MR sensor. Safe Distance is the minimum distance between 2 carriers for the collision avoidance functionality. The MR sensor based track has an additional parameter (Measurement scale eccentricity), and in the "Determinable" section the "Motor magnet pole configuration" parameter for a Hall sensor based track is "Measurement scale number of periods" for an MR sensor based track.

Enter the parameter values for each track in the system. The parameters in the "Carrier" section are carrier parameters that apply for all carriers.

The last step of the parameterization are the parameter settings that are specific for each carrier.

In the "Logical" tree view, select a carrier.

- Enter the carrier parameters.

  The "Measurement scale offset" parameter only applies when the track uses MR sensors.

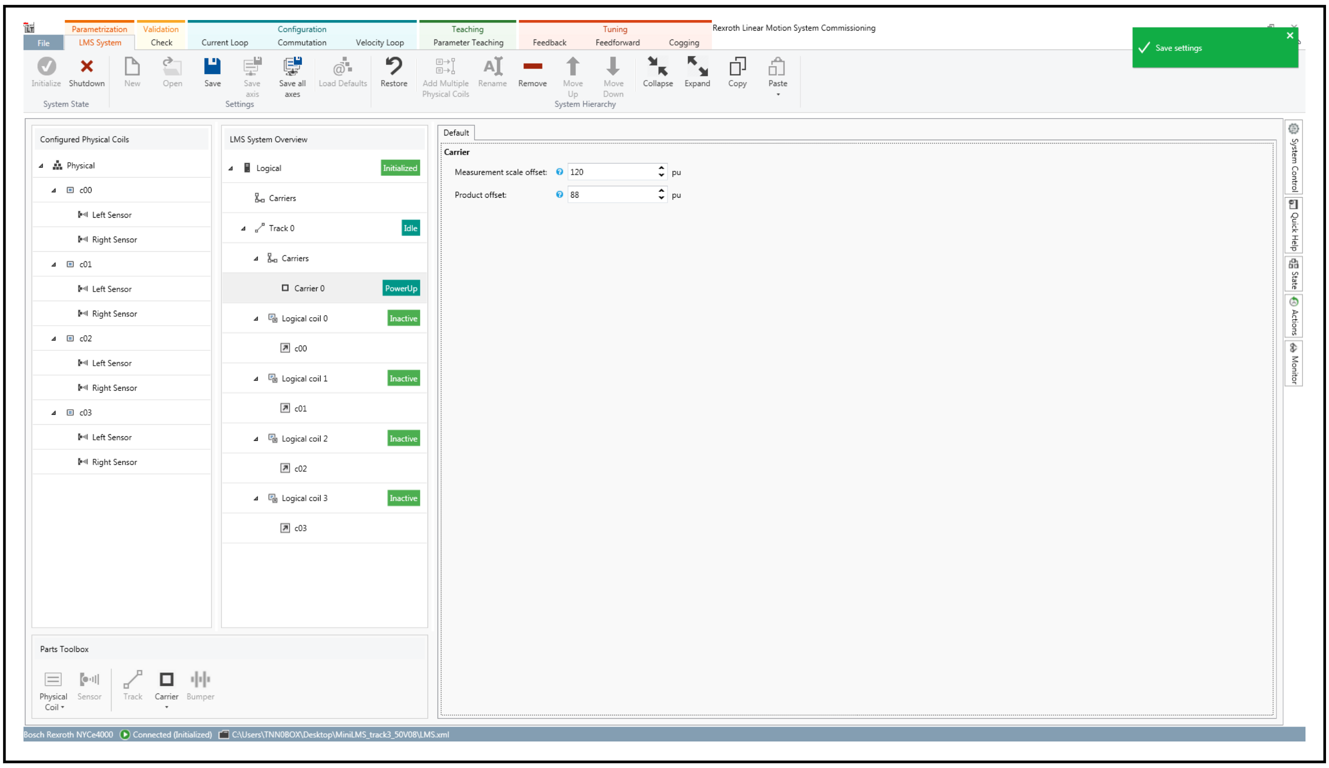

Fig. 4-7: Parameterization - set the carrier-specific parameters

Set the carrier-specific parameter(s) for all carriers in the system.

Now the parameterization step is finished.

- Click the "Save" button to save the LMS configuration file, see fig. 4-4 "Parameterization - first steps" on page 17.
- Initialize the system and check for errors.

4.3 Validation

The next step of the commissioning workflow is the validation. In this step the parameters which have been provided during the parameterization step are checked and validated.

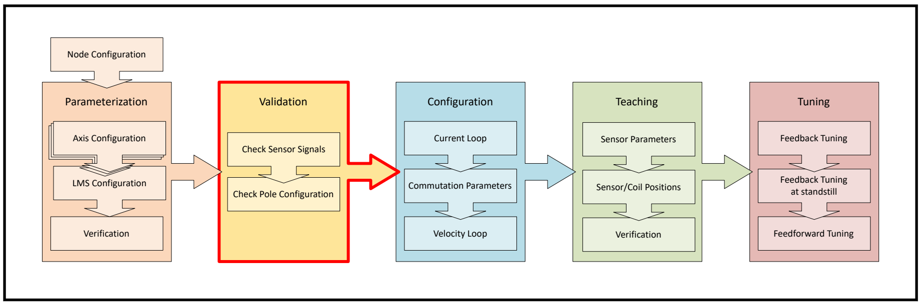

Fig. 4-8: Commissioning - validation

Do the following steps to execute the validation.

1. Click "Check" to open the "Validation" tab.
2. Move the carrier manually to the begin position of the track.
3. Select a "Track" in the tree view when the system is initialized.
4. Click the "Select all" button to select all sensors.

   Configure the oscilloscope, enter a number in the "Seconds per page" field to set the time frame of the trace.
5. Click the "Start" button of the oscilloscope to start measuring the sensor signals.
6. Move the carrier manually over the track to the end position of the track. The sensor signals are traced.
7. Click the "Stop" button to stop the oscilloscope after the trace is completed. See fig. 4-9 "Validation - sensor signals" on page 22 for the resulting time trace of the sensor signals.
   - You can select or deselect individual sensor signals with the checkbox in front of the sensor in the tree view.
   - Enter a different number in the "Seconds per page" field to change the time frame of the trace.

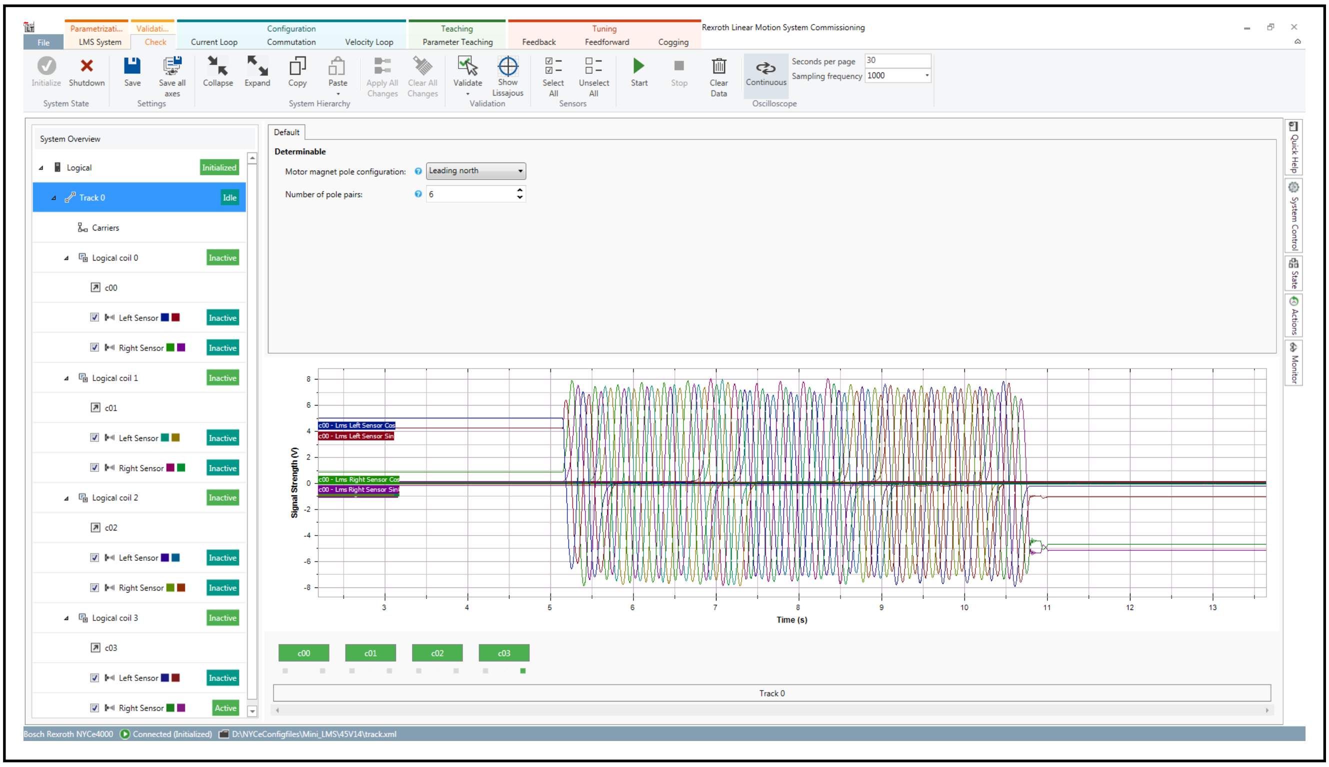

Fig. 4-9: Validation - sensor signals

After the trace is stopped you must check whether all sensors have a correct sine/cosine signals, no sensor connections are swapped, and following parameters are correct.

- Pole configuration (track level)
- Number of pole pairs (track level)
- Invert sine/cosine (sensor level)

The tool can execute an automatic validation to determine whether the signals and mentioned parameters are correct. To execute this automatic validation, click the "Validate" button and specify the movement direction of the carrier. If the carrier has been moved from the beginning of the track to the end of the track, the movement direction is positive.

After you clicked the "Validate" button, select the track to check whether the pole configuration and number of pole pairs are correct. If the pole configuration is incorrect, a red box is displayed with the text "Incorrect", see fig. 4-10 "Pole configuration validation" on page 23. If that is the case, change the pole configuration. At the right side of the field "Number of pole pairs" the determined number of pole pairs is displayed. If these numbers are not the same, click the green arrow button to apply the determined number of pole pairs.

The track state must be idle before you can change parameters.

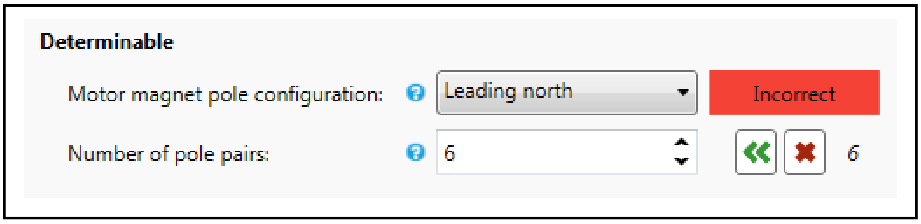

Fig. 4-10: Pole configuration validation

Select the sensors one by one. If a sensor has a red box with the text "Incorrect" next to the "Node connector", see fig. 4-11 "Sensor signal validation" on page 23, the tool was not able to validate the sensor signals. If this is the case, check the traced sine/cosine signals of that sensor and check whether the node connector is correctly entered.

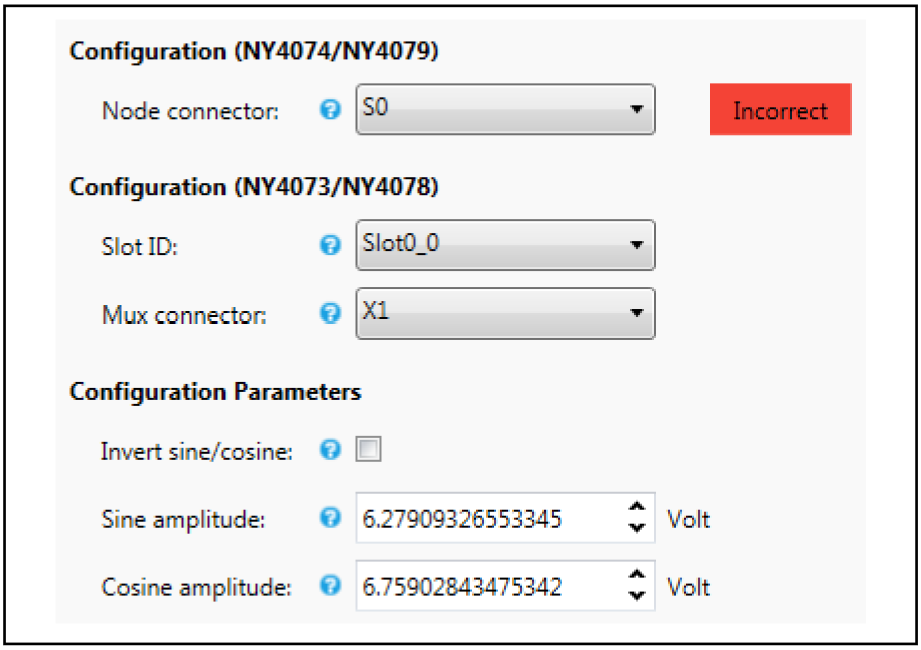

Fig. 4-11: Sensor signal validation

If the validation is done successfully, nothing is displayed at the right side of the node connector, see fig. 4-12 "Sensor sine and cosine signal" on page 24). In that case, the tool has determined an estimated value for the amplitude of the sine and cosine signal. These amplitudes must be between 3V and 10V. If the amplitude is lower than 3V, the distance between sensor and magnet plate is too large. If the amplitude is too high the sensor signal is clipped and the sensor must be moved further away from the magnet plate. Click the green arrow buttons to apply the estimated amplitude. Check the “Invert sine/cosine” whether a red box is displayed with the text "Incorrect". In that case, the checkbox must be checkmarked.

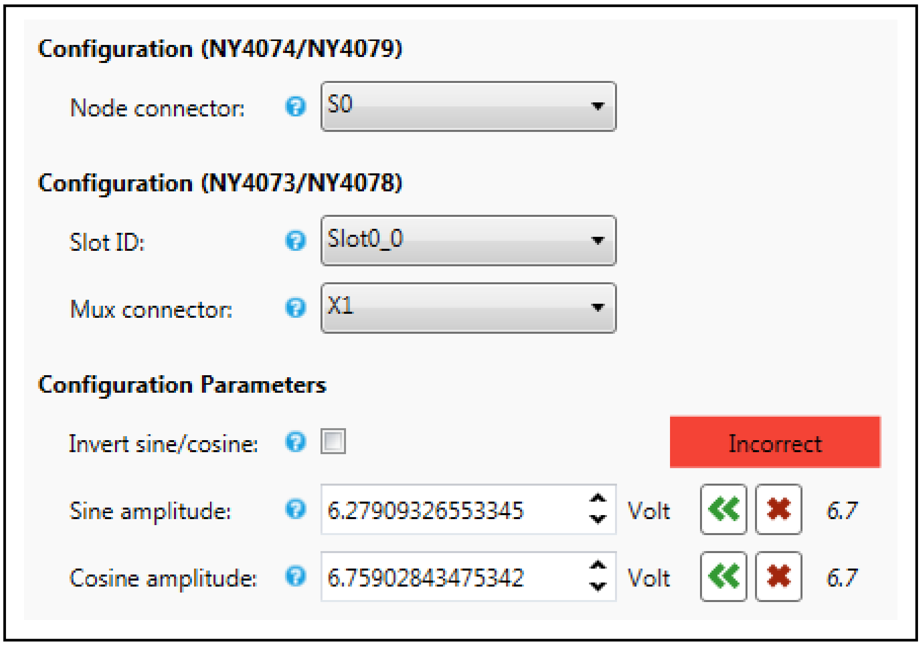

Fig. 4-12: Sensor sine and cosine signal

- If the sine signal is leading instead of the cosine signal, the "Invert sine/cosine" must be changed.
- If the order in which the sensor signals are displayed in the oscilloscope is not correct, the "Slot ID" or "Mux connector" setting must be changed.
- If the first period of a sensor goes "up", the "Motor magnet pole configuration" setting must be "Leading North". If the first period of a sensor goes "down", the "Motor magnet pole configuration" setting must be "Leading South".
- Check that the number of pole pairs specified during the parametrization is correct.

Optionally, you can display the Lissajous plot of a sensor. To display this plot, click "Show Lissajous". An additional plot window appears which displays a circle plot of the sine and cosine signals. The blue line indicates the traced sensor signals. The red circle indicates the minimum sensor signals. Observe whether

- the blue circle has a radius larger than the red circle, and
- the blue circle does not have an "oval" shape.

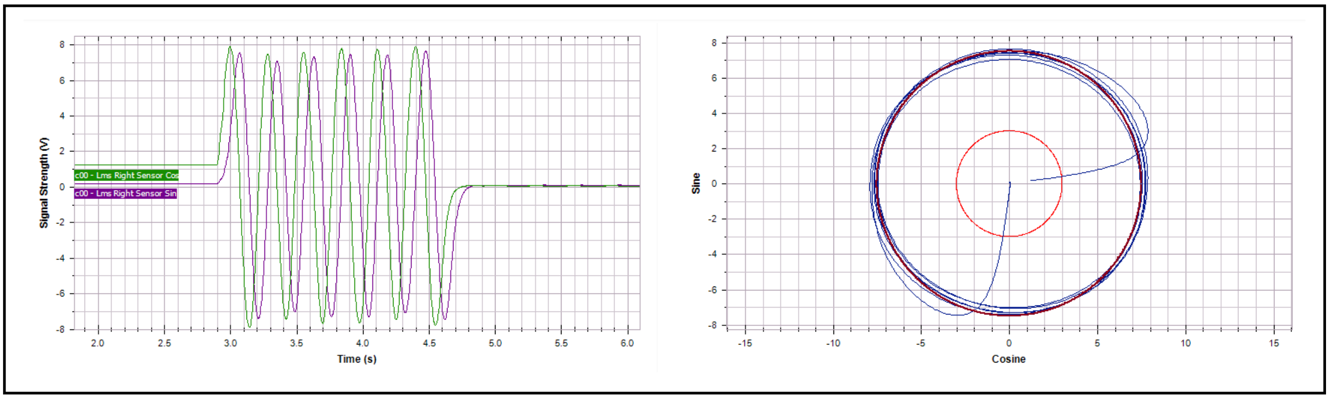

Fig. 4-13: Sensor signals and Lissajous plot

Make sure the track is back in the IDLE state after this step is finished. Move the carrier manually over the entire track. After the movement, the track should still be in the IDLE state and there should be no errors. If a coil or sensor generated an error, check this coil or sensor again.

4.4 Configuration

4.4.1 Introduction

The next step of the commissioning workflow is the configuration. In this step the electrical part of the LMS is configured and enables the active movement of a carrier in a controlled way.

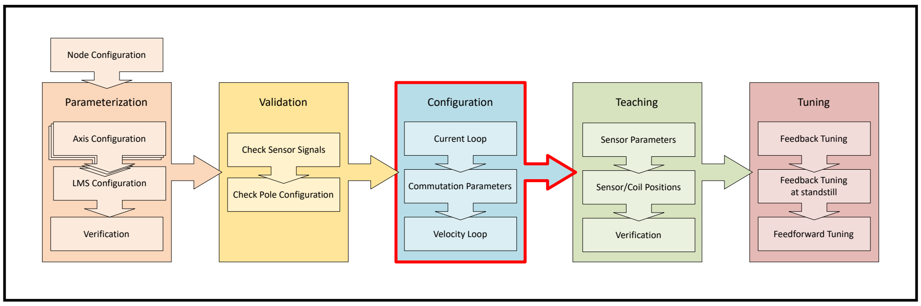

Fig. 4-14: Commissioning - configuration

The configuration step of the workflow consists of 3 sections.

- Current Loop
- Commutation
- Velocity Loop

4.4.2 Current loop

Click the "Current Loop" tab, see fig. 4-15 "Configuration - current loop" on page 26. You check in this section whether the current controller parameters are correct.

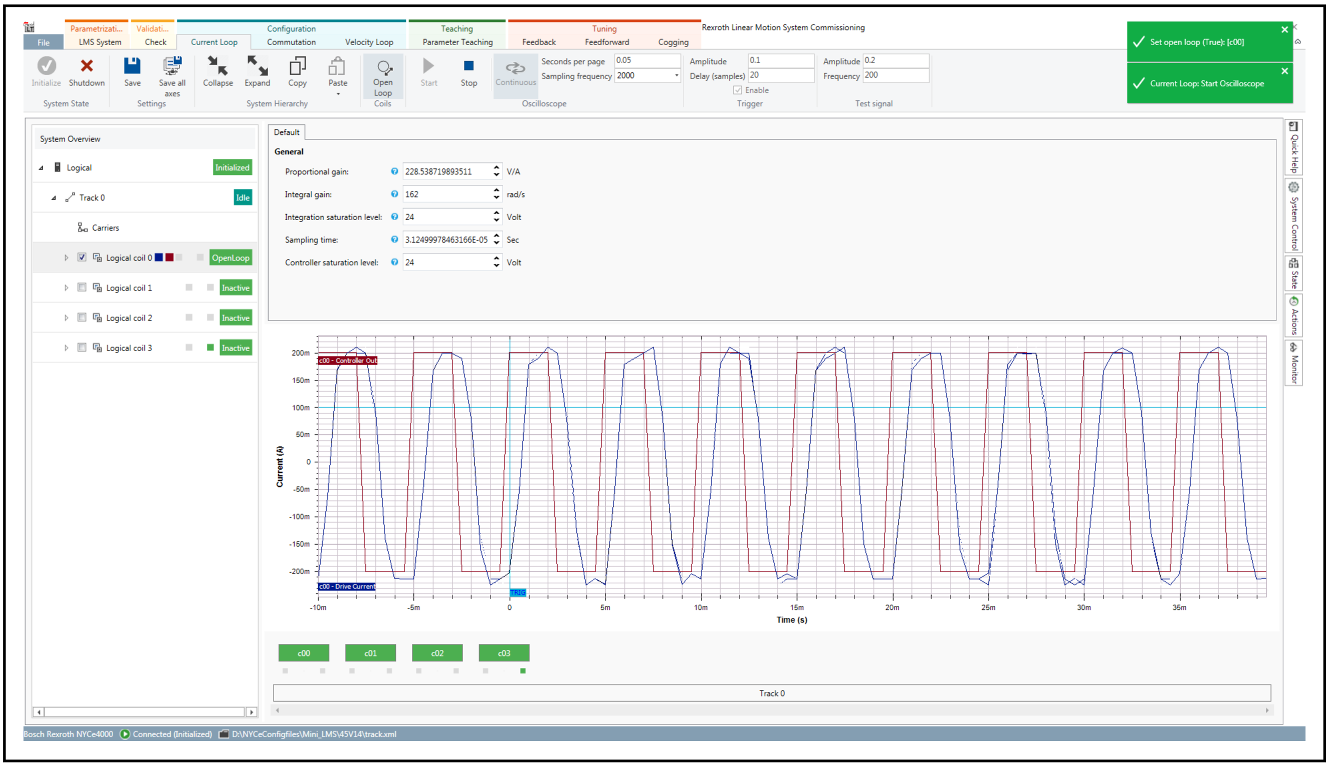

Fig. 4-15: Configuration - current loop

The current loop parameters are coil type-specific and are automatically defined after you clicked "Load Defaults" in the parameterization step.

Select a coil which has no carrier above it, and click the checkbox in front of the "Logical coil" in the tree view to select "Logical coil".

1. Click "Open Loop" and then click "Start" (see fig. 4-15 "Configuration - current loop" on page 26) to start the test signal and the time trace.

   The controller out signal and the drive current are displayed in real time in the oscilloscope plot. The drive current must follow the controller out signal as shown in the time trace.

   - If the drive current is too low or there is too much overshoot, you can, respectively, increase or decrease the "Proportional gain".
   - If the drive current ramps up too slow or there is overshoot after the ramp up, the integral gain can, respectively, be increased or decreased.
2. Click the "Stop" button when finished.
3. Copy the new parameters to all coils and save the configuration file, if you changed current loop parameters.

☞ You can change the oscilloscope, trigger and test parameters, if desired, with the parameters indicated by the upper right red square.

4.4.3 Commutation

The commutation angles must be determined for each coil. Commutation is divided into 2 sections.

1. Move Current Angle

In this section, you check, and change if necessary, the "Commutation direction".

2. Magnetic Alignment

   In this section, the commutation angle is determined for each sensor.

Move current angle

Do the following steps to check, and change if necessary, the commutation angle.

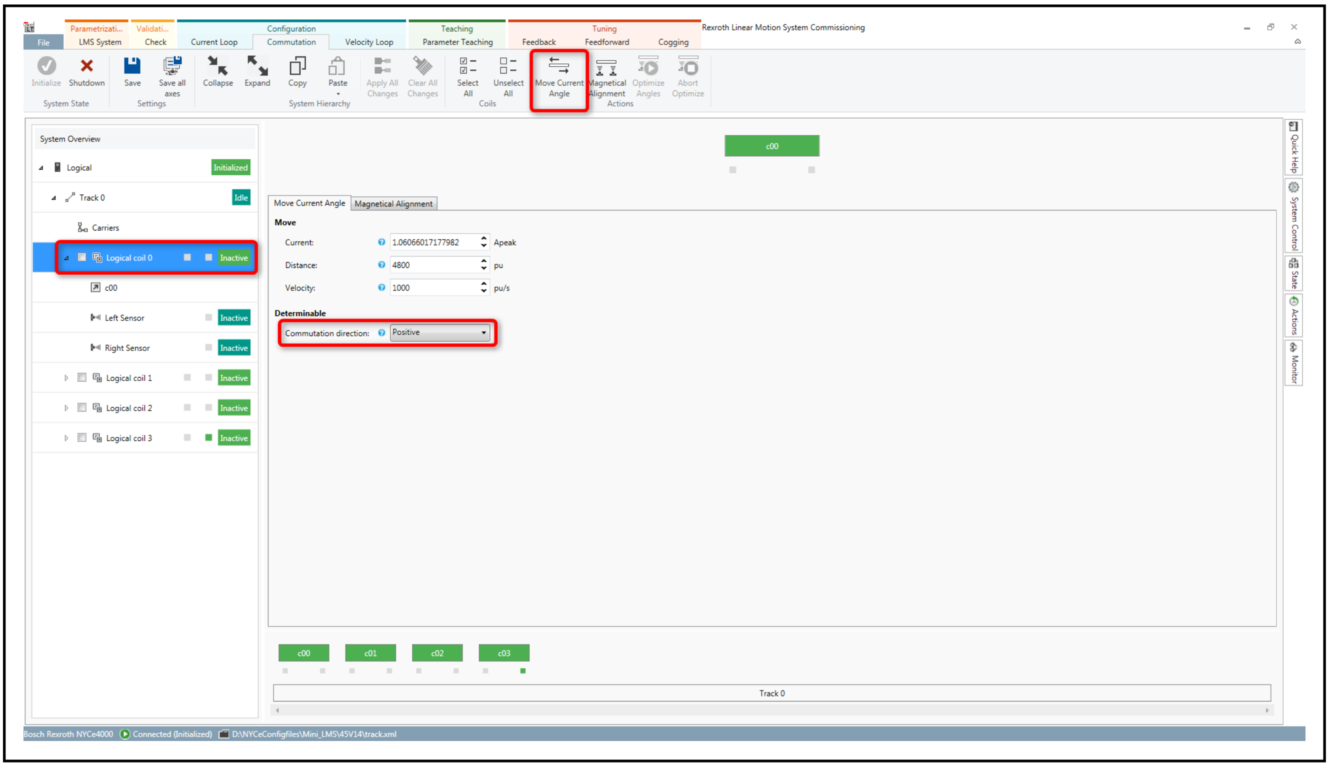

Fig. 4-16: Configuration - commutation, move current angle

1. Select the "Commutation" tab.
2. Select a logical coil.

   The parameters in the section "Move" have default values.

☞ The current setting must be the specified maximum nominal motor current divided by 2. Check that the current setting is not too high.

3. Position a carrier above the middle of the coil.
4. Click the "Move Current Angle" button and check whether the carrier moves above the selected coil.

☞ The carrier may move during this step.

In the "Determinable" section the "Commutation direction" is default set to "Positive".

- If the carrier movement is in positive direction over the track, the "Commutation direction" is indeed positive. In this case the commutation direction is correct and a green-colored message appears in the upper right corner, and "Correct" next to the direction.

- If the carrier movement is in negative direction over the track, the "Commutation direction" must be changed to "Negative". In that case the commutation direction is not correct and a red-colored error message appears in the upper right corner, and "Incorrect" next to the direction.

If orientation and electrical wiring is identical for all coils, you can click the "Copy" button and then click the "Paste to All" button to copy the commutation direction to all coils. However, for initial commissioning, it is advised to do a "Move Current Angle" above each coil to verify correct wiring.

Magnetic Alignment

Do the following steps to check the magnetic alignment.

1. Select the "Magnetic Alignment" tab.
2. Move a carrier manually over the first coil in the track and over the left sensor.

   The minimum overlap for both sensors and magnet plate is 24 mm, as shown in ①. If this minimum overlap is not possible at the same time, do the check twice. Once for the left sensor (see ②), and once for the right sensor (see ③).

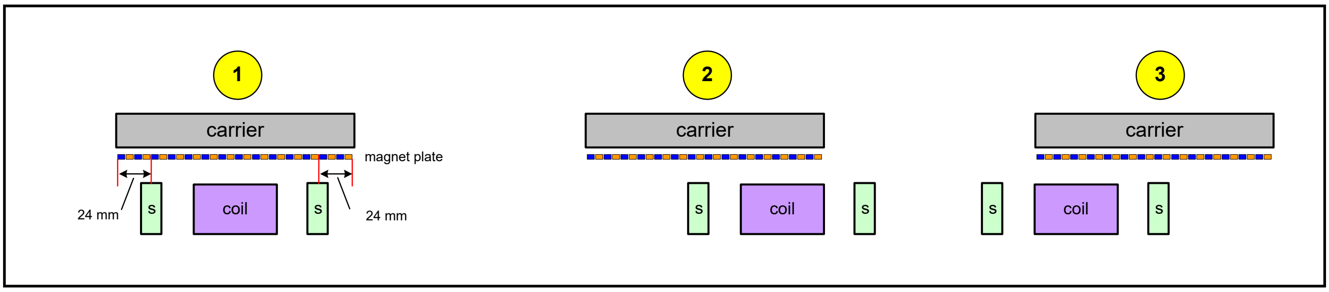

Fig. 4-17: Minimum overlap between sensor and magnet plate

3. Select this first logical coil in the tree view.

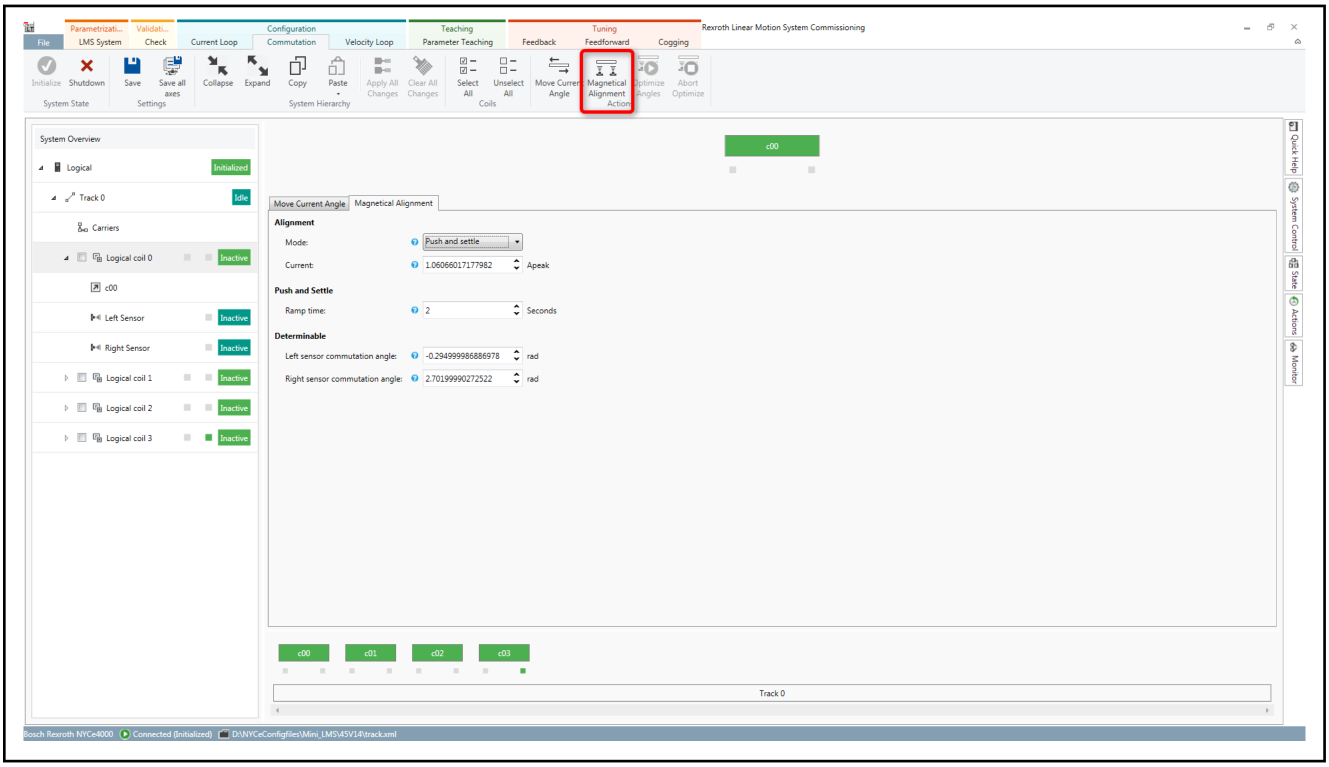

Fig. 4-18: Configuration - commutation, magnetic alignment

The parameters in this tab have default values.

☞ The current setting must be the specified maximum nominal motor current divided by 2. Check that the current setting is not too high.

4. Click the "Magnetical Alignment" button. The carrier aligns above the coil

☞ The carrier may move during this step.

5. When the carrier is only above the left sensor, the blue-colored message appears in the upper right corner when the alignment is finished. Select the sensor in the tree view and click the "Apply" button to apply the new commutation angle for this sensor.
6. Move the carrier manually above the next sensor and repeat steps 4 - 6 to determine the commutation angle for all sensors of the track.
7. Click the "Save" button to save the configuration file.

   If the distance of the coil to the sensor and the electrical wiring is identical, you can copy the commutation angle to all coils.

4.4.4 Velocity loop

Do the following steps to determine the velocity loop parameters.

1. Select the "Velocity Loop" tab.

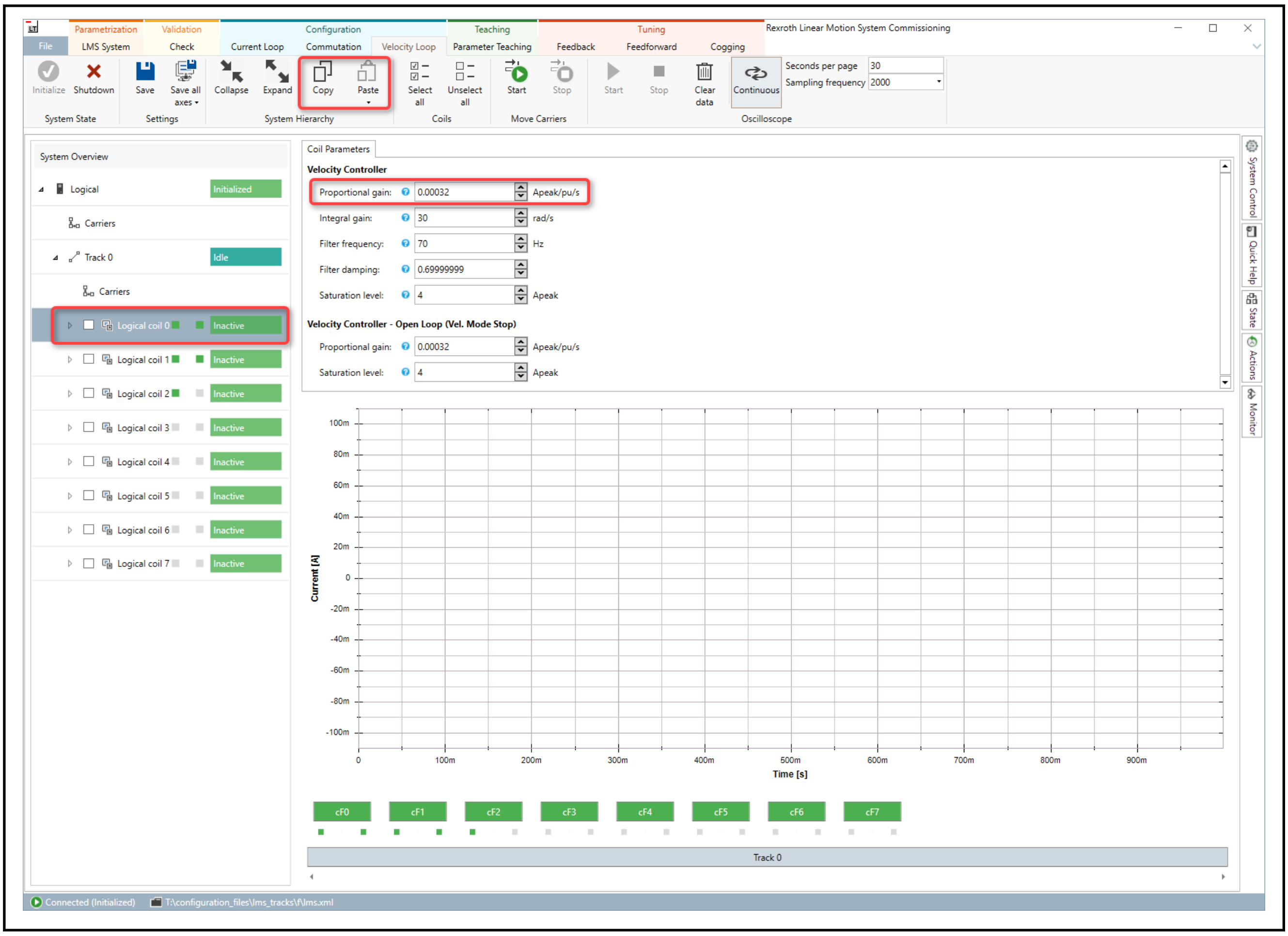

Fig. 4-19: Configuration - velocity loop

2. Select a "Logical coil" in the tree view.
3. Start with a low proportional gain value (0.0002).
4. Click the "Copy" button and then the "Paste to All" button to copy these controller settings to all coils.
5. Select the "Track" in the tree view.

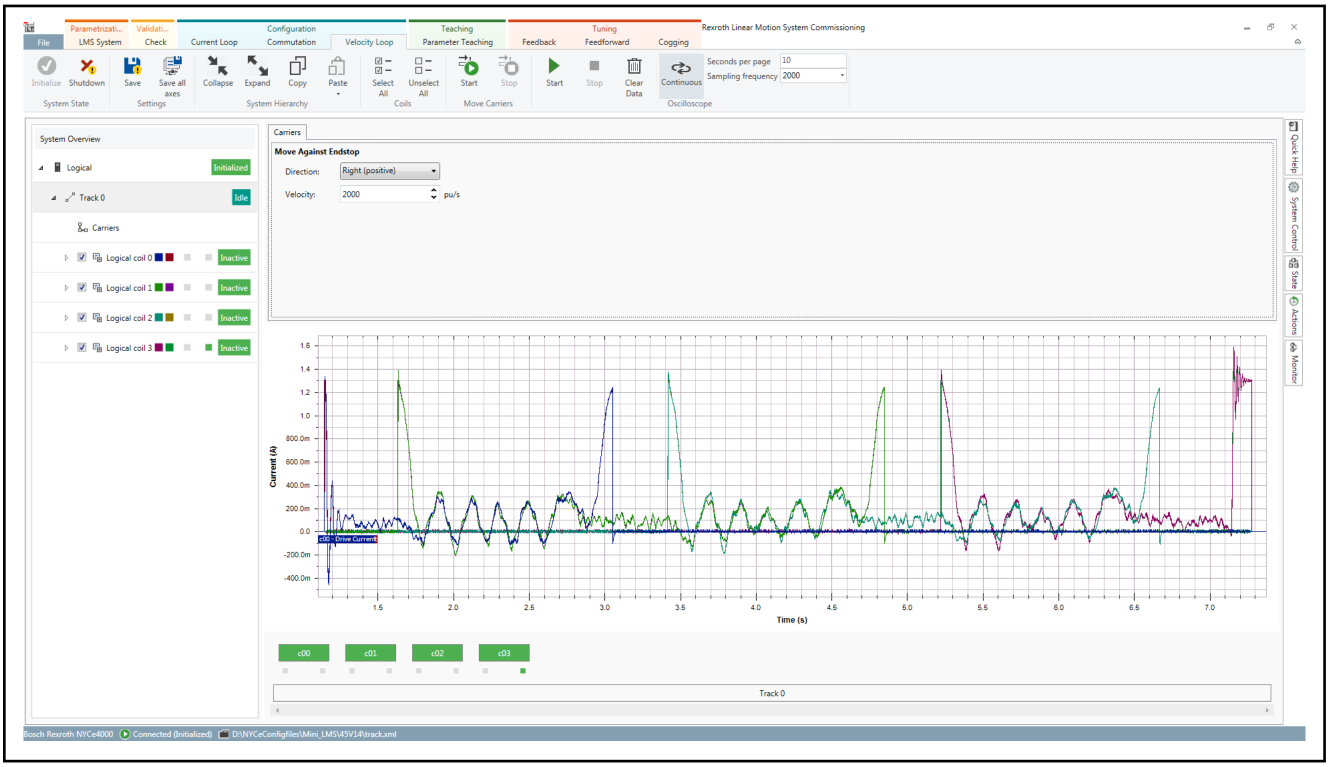

Fig. 4-20: Configuration - velocity loop, track level

6. Click the "Select All" button to select all coils for the time trace plot of the Drive current.
7. Move the carrier manually to the begin of the track.
8. Click the "Start trace" button to start the trace.
9. Click the "Start" button to move the carrier.

☞ The carrier moves automatically over the entire track during this step.

- If the carrier does not move, increase the controller gain value.
- If the carrier moves very shaky, decrease the controller gain.

  The carrier does not have to move smoothly.

Do the following steps if the carrier moved satisfactorily.

1. Review the drive current plot and define the average amplitude of the signal.
2. Enter the average amplitude value in the "Controller Offset" field.
3. Copy the setting to all coils ("Copy" / "Paste to All").
4. Execute a final check.

   First, move the carrier with 2000 pu/s and then with 5000 pu/s.

   - If the movements look smooth and the movement at 5000 pu/s is clearly faster than the movement at 2000 pu/s, the controller is correctly tuned.

- If the movement still looks shaky, increase the controller offset with a small value. If you see no difference in velocity between both movements, decrease the controller offset.

4.5 Teaching

The next step of the commissioning workflow is the teaching. During the teaching step of the commissioning process the sensor parameters, sensor positions and coil positions are automatically teached. You can also verify the obtained parameters and positions in the "Teaching" Step.

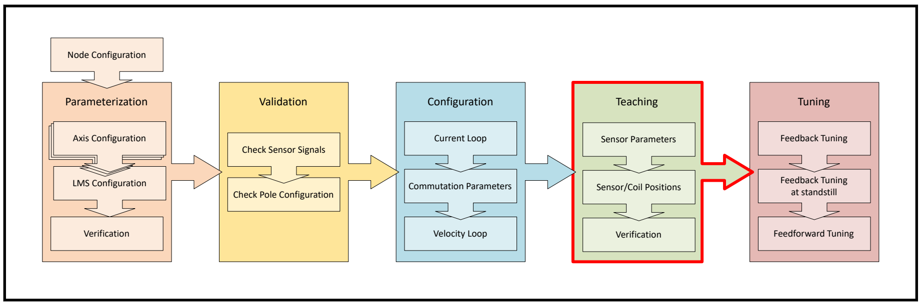

Fig. 4-21: Commissioning - teaching

Before you can start the parameter teaching, you must define the teaching configuration as shown in fig. 4-22 "Teaching configuration" on page 33.

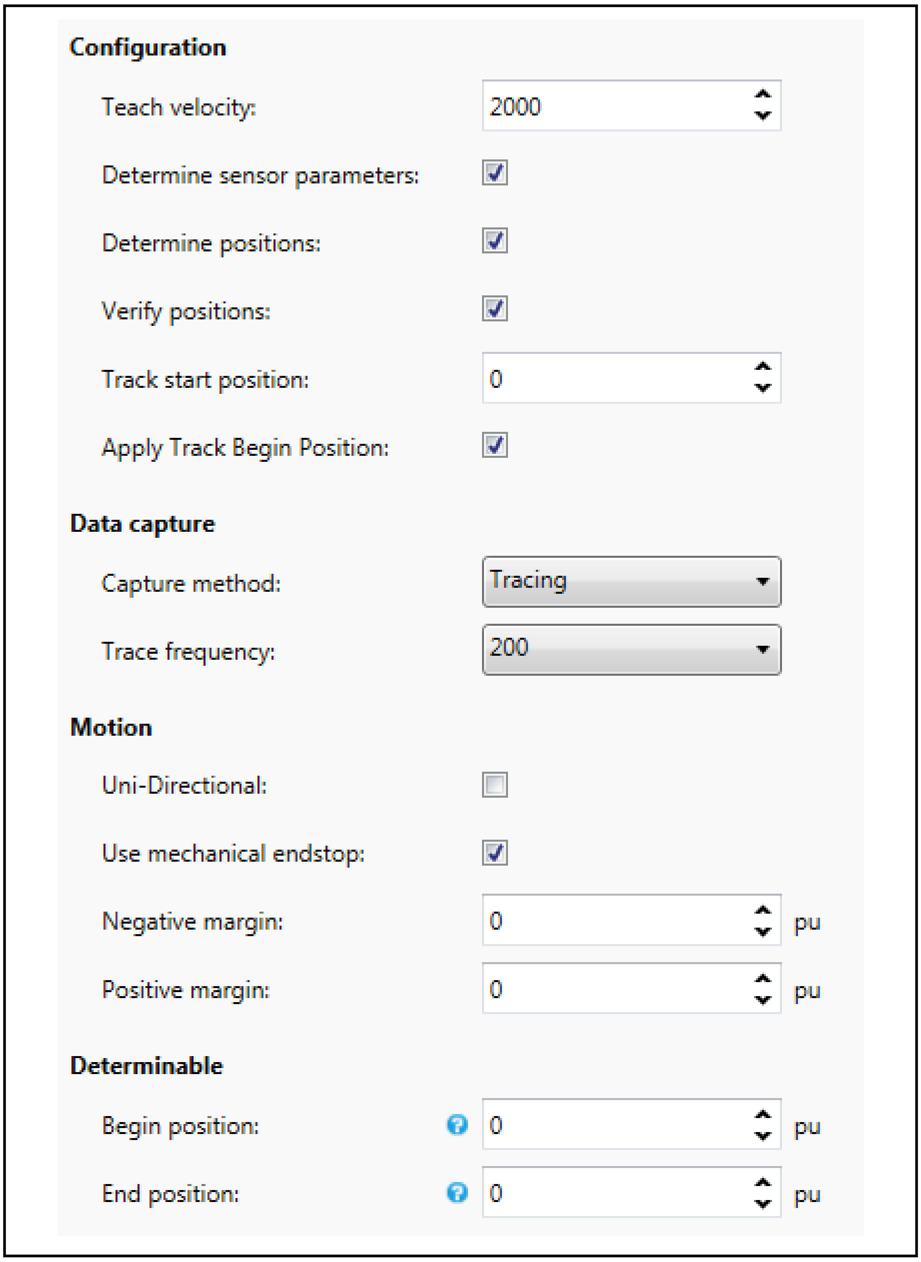

Fig. 4-22: Teaching configuration

- The advised teach velocity is 2000 (pu/s).
- You can simultaneously determine sensor parameters, determine positions and verify positions by putting or removing the checkmark in each checkbox.
- You can set the "Track start position" to a specific value, or leave it at the default value 0.
- Two options are available for the data capture method, "Tracing" and "Sampling", with a specific Trace frequency. The data capture method "Tracing" is advised and the "Trace frequency" set to 200 Hz.
- Default, the motion is bi-directional. If you put a checkmark in the "Uni-Directional" checkbox, the motion is uni-directional.

- If the track does not have mechanical endstops, you must specify values in the "Negative margin" and "Positive margin" fields.

1. Click the "Select All" button to determine parameters for all coils and sensors.
2. Click the "Start" button to start the parameter teaching.

☞ The carrier moves automatically.

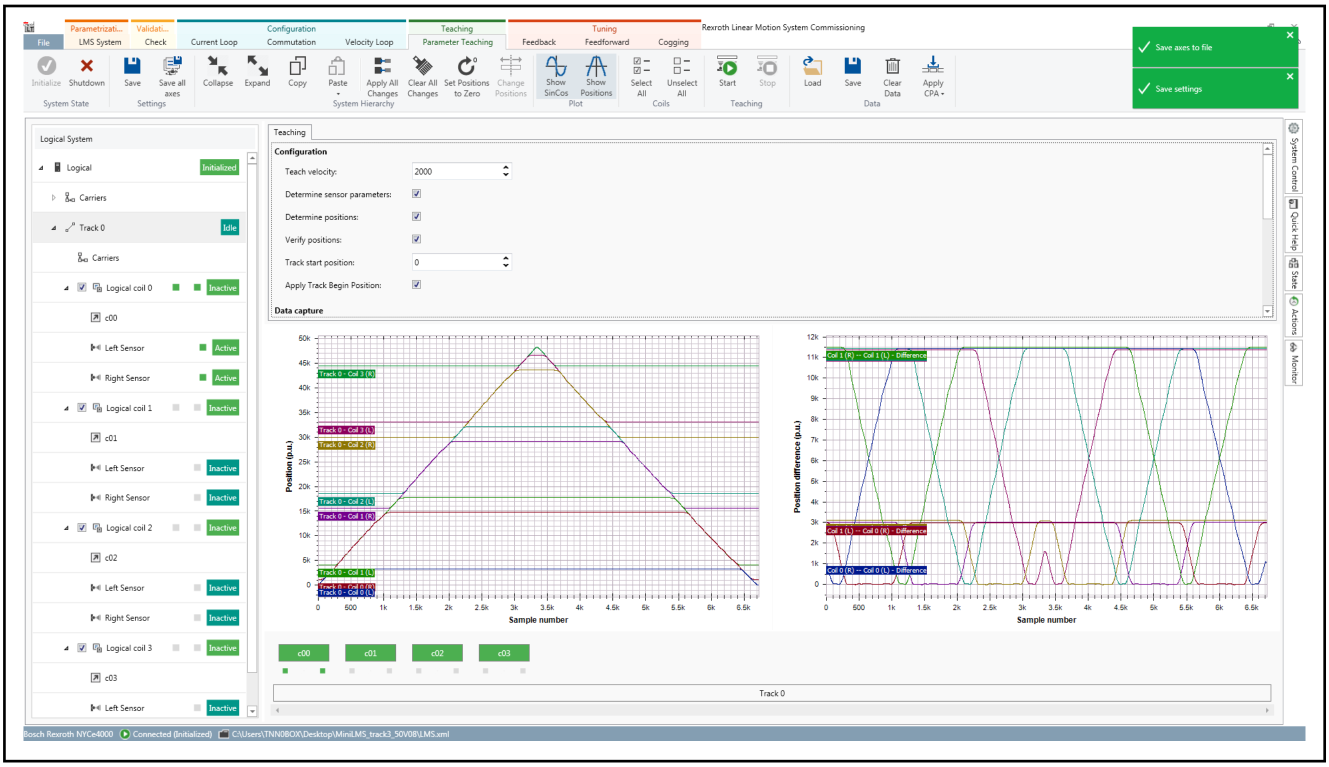

Fig. 4-23: Teaching parameters

Two plots are generated when you click the "Show Positions" button.

The left plot shows the position of the carrier as detected by each sensor. If the motion is bi-directional, the plot has a pyramid shape.

Zoom in around 0 on the Y axis of the position difference plot at the right side to verify that positions over sensors are correct.

- If the position difference between sensors is in the range +60 .. –60, the sensor have correct positions.

If the sensor parameters and positions are teached correctly, click the "Apply All Changes" button to set all sensor parameters while the track is selected.

☞ When a sensor is replaced, or its orientation is inverted, a re-teach of the sensors has to be done.

If a part of the track involving the first coil is re-taught and the checkbox "Apply Track Begin Position" is marked, the newly taught positions are not fitted on the positions of the remainder of the track. Instead, the priority is to put the defined value for the begin position at the start position of the teach measurement. This means that the location of the physical track begin position is very critical.

Note that when you select the track, the "Apply All Changes" button writes the parameters and positions for all coils. The "Apply All Changes" button saves information of the selected object and its subordinate "child" objects.

After the teaching of sensor parameters and positions has been completed, the teached positions can be improved by using a CPA table. CPA is the abbreviation of "Carrier Position Adjustment" and uses a correction table to improve accuracy on position measurement.

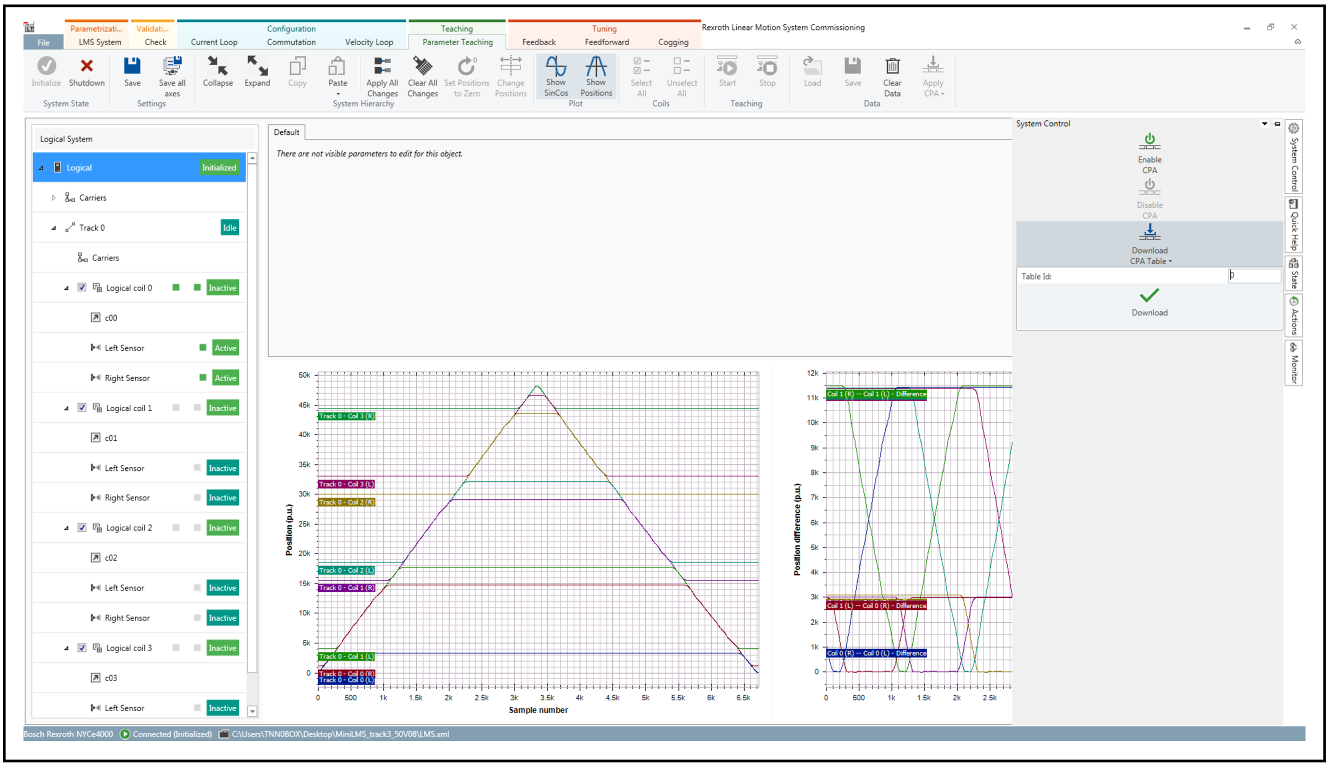

Fig. 4-24: Teaching - download a CPA table

Do the following steps to update the learned positions.

1. Select a logical track in the tree view.
2. Click on the "System Control" tab at the left side, and select "Download CPA Table".
3. After the CPA table is downloaded, you specify the correct CPA table ID and then click the "Apply CPA" button to apply the CPA adjusted positions which belong to the carrier used to teach the track.

Now that positions are defined, you can add so-called process areas on the track. A process area is an area on a track defined by a minimum and maximum position. The process area can be disabled or enabled. When a process area is enabled, the state of that process area is "empty" when no carrier is within the area, or "occupied" when a carrier is within the area. A carrier in an enabled process area can move freely within the process area, no collisions are possible with neighboring carriers. See NYCe 4000 LMS User Manual for more information.

Click the "Process Area" button in the Toolbox to add the definition of a process area.

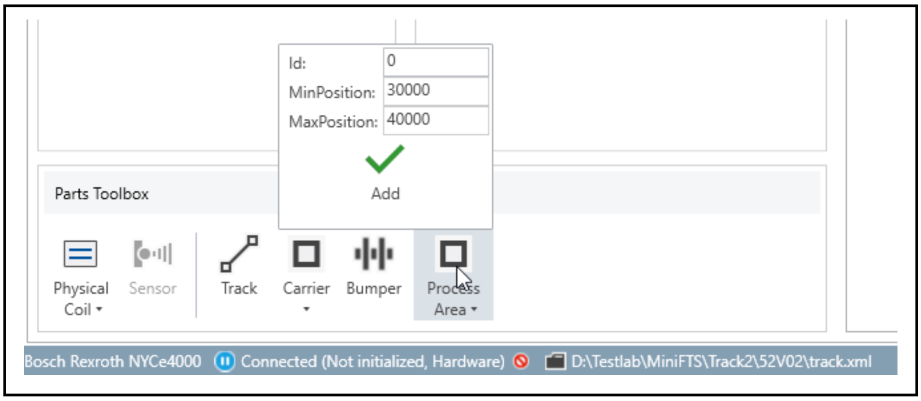

Fig. 4-25: Add a process area to the track

The process area is defined by a minimum position and maximum position on the track, and a unique identifier in the range of 0 .. 32767. This process area identifier must be system-wide unique. Click the "Add" button to add the new process area to the track.

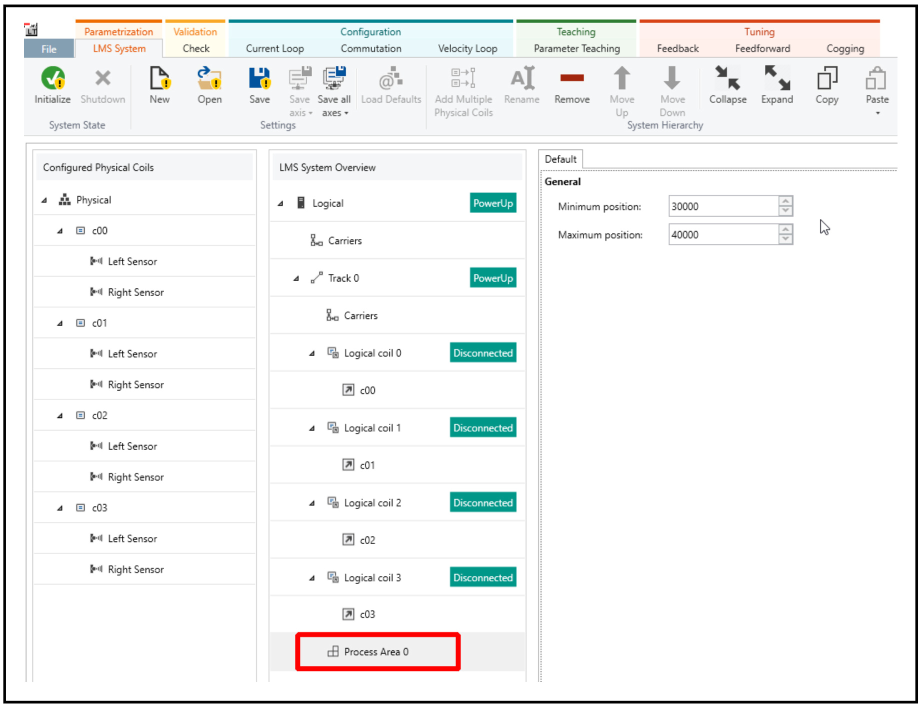

Fig. 4-26: Defined process area in LMS System Overview

The defined process areas of a track with their identifiers are shown in the LMS System Overview. When you select a process area definition, you can see the minimum and maximum positions of that process area. Note that you cannot change these values, the spinbox buttons are disabled. Delete the process area definition and add a new definition with the desired minimum and maximum positions.

4.6 Tuning

4.6.1 Introduction

The last step of the commissioning workflow is the tuning of the position controller. High-precision motion can be obtained after correctly tuning the LMS.

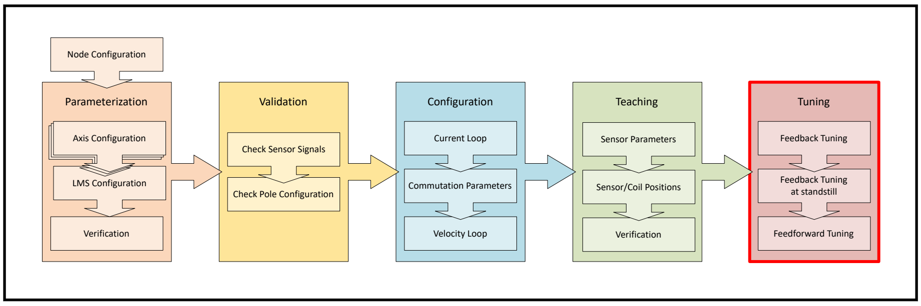

Fig. 4-27: Commissioning - tuning

4.6.2 Feedback

Preparations

Do the following steps before you can tune the feedback controller of the position loop.

1. Select the "Tune and Check" tab.
2. Do the following steps to set the track state to "Active".
   2.1 Select the track in the tree view.
   2.2 Click the "State" button'.
   The track state diagram appears.

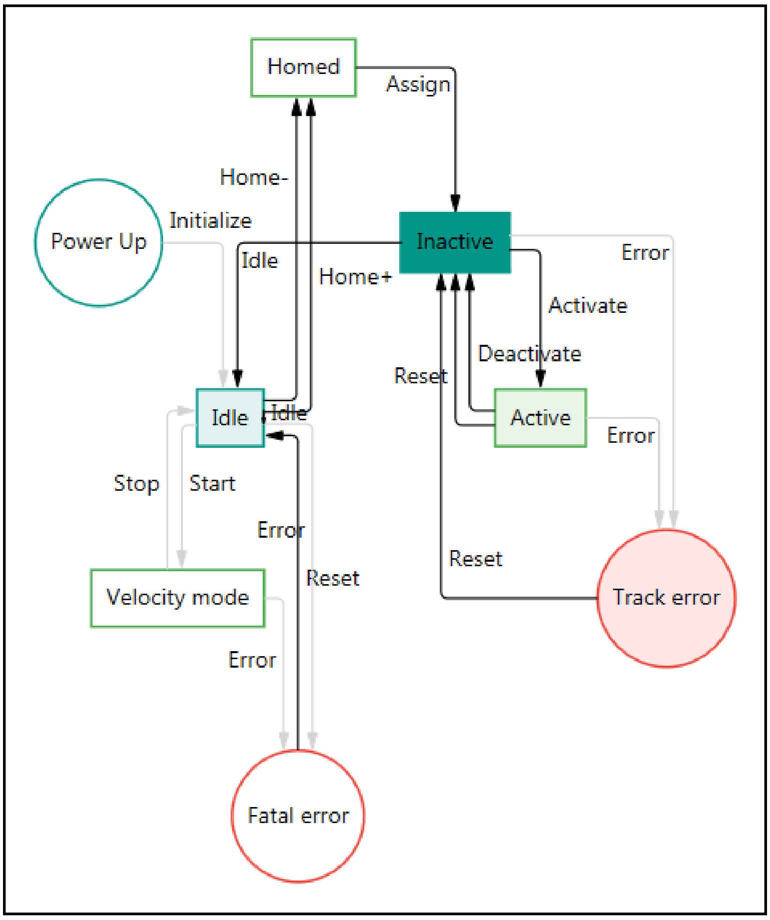

Fig. 4-28: Tuning - feedback, track state diagram

2.3 Click the "Homed" box to home the track.

2.4 Click the "Inactive" box to assign the carrier.

4.6.3 Automatic feedback tuning

This tool includes the option to use the automatic feedback tuner to generate a (robust) feedback controller. To use the autotuner, the track state must be set to inactive. Make sure that the carrier is located above a single coil and that the carrier can move freely ± 2000 pu on the track in both directions.

Do the following steps to execute the automatic feedback tuning.

1. Select the coil above which the carrier is located.
2. Click the "Start" button for Auto tuning.

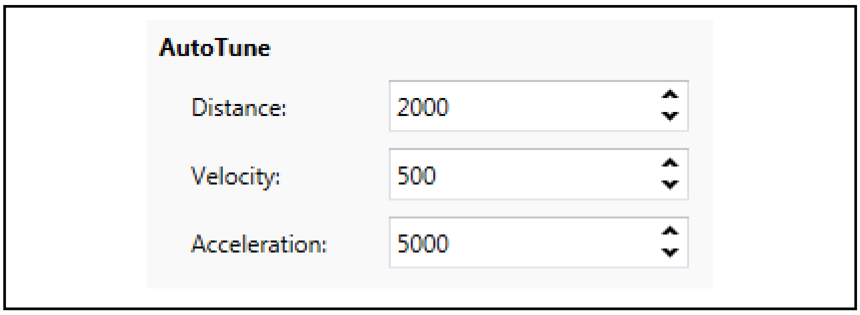

Fig. 4-29: Tuning - autotune parameters

During the autotuning process, the carrier first starts to move, as well as oscillate, which can be quite vigorous.

4.6.4 Manual feedback tuning

You must be able to move a carrier in the position loop to start tuning the feedback controller of the position loop. For that reason, a ‘weak’ (low bandwidth) but valid feedback controller is required. Do the following steps to create a valid feedback controller.

1. Select the logical coil in the tree view above which the carrier is positioned.
2. Select the "Feedback" tab.

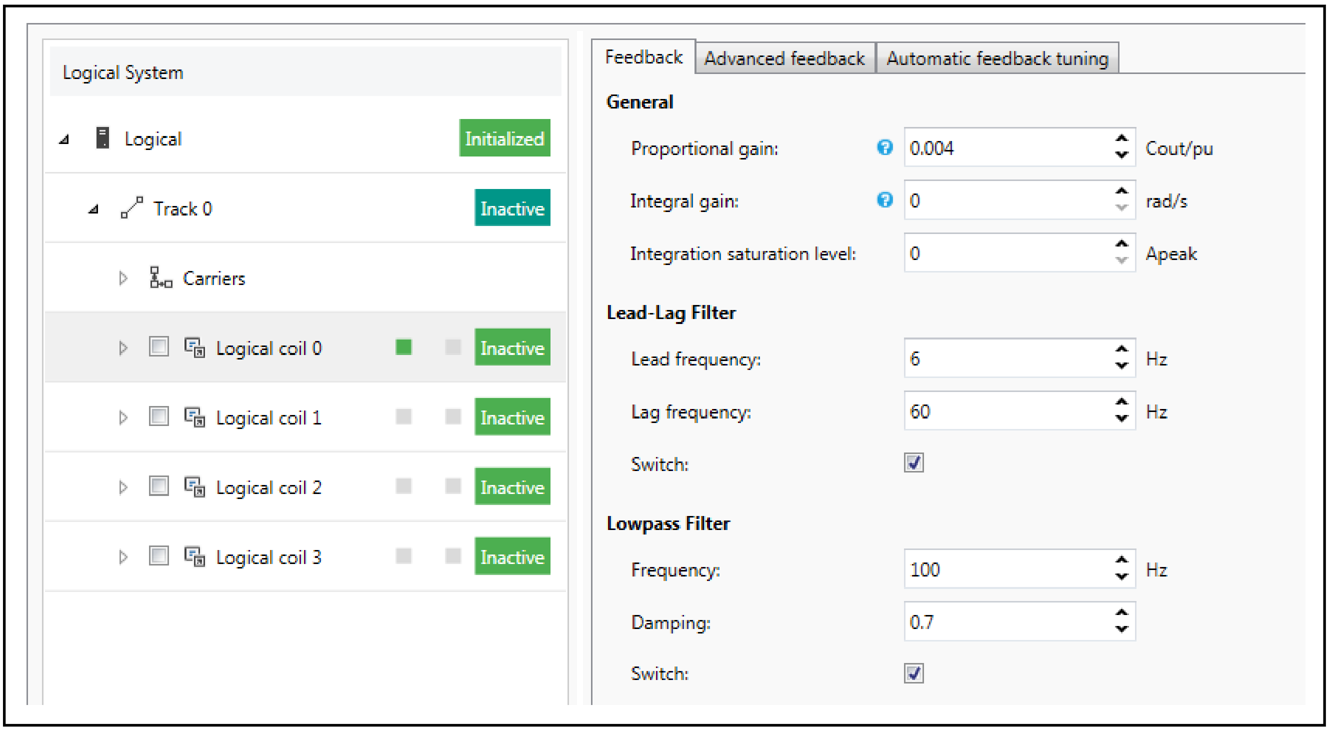

Fig. 4-30: Tuning - initial feedback controller

3. Specify a relatively low proportional gain and lead-lag filter and low-pass filter settings, see fig. 4-30 "Tuning - initial feedback controller" on page 39.
4. Select the logical coil in the tree view above which the carrier is located.
5. Click the "Monitor" button to check the coil position.

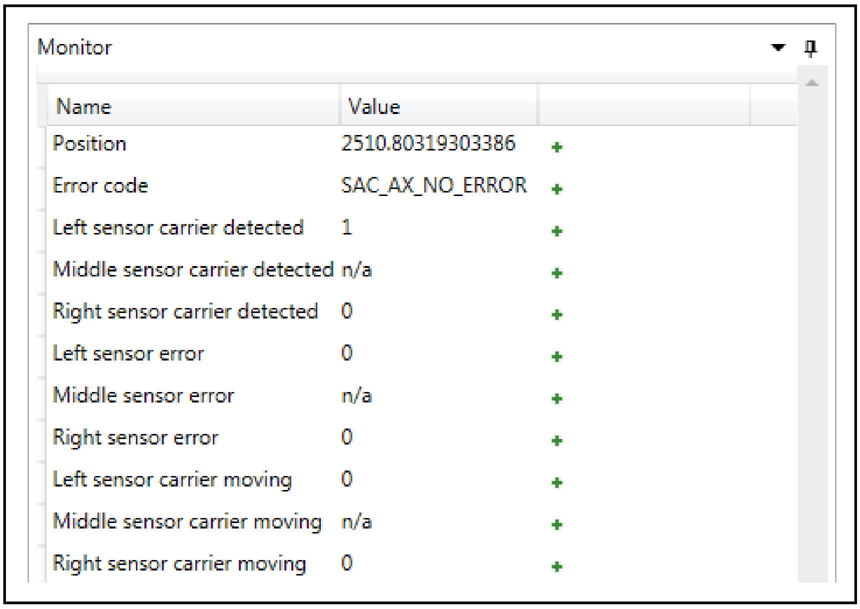

Fig. 4-31: Tuning - monitor

6. Select the carrier in the tree view.
7. Enter the begin and end position for the movement of the carrier above the coil.

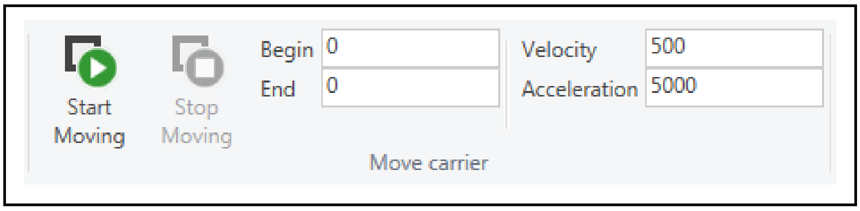

Fig. 4-32: Tuning - movement settings

8. Choose the begin position lower than the position checked with the monitor and the end position higher than that position.
9. Choose the movement range approximately 3000 pu.

   Choose the velocity relatively low (magnitude 2000 pu/s).

   Choose the acceleration 200000 pu/s^2.

   These movement settings are for moving the carrier slowly positive-negative in a loop, to prevent slip-stick effect during tuning of the feedback controller with random noise.
10. Click the "Start Moving" button to start the movement of the carrier.

☞ The carrier starts to move. The position loop is not yet tuned.

The carrier may move unexpectedly fast.

- If the carrier does not move, increase the proportional gain.
- If the carrier moves too fast or unstable, decrease the proportional gain.

You can start tuning the feedback controller if the carrier moves smoothly in both directions. Do the following steps to tune the feedback controller.

1. Select "Logical coil" in the tree view, above which the carrier is located.

2. Enter a good amplitude for the test signal.
3. Click the "Start Signal" button.

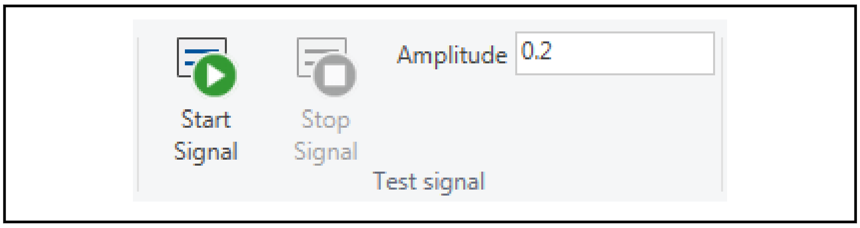

Fig. 4-33: Tuning - test signal

4. Click the "Start" button to start the oscilloscope.

Tune the feedback controller with classic manual loop shaping techniques, looking at the bode plot and Nyquist diagram, see fig. 4-34 "Tuning - tune the feedback controller" on page 41.

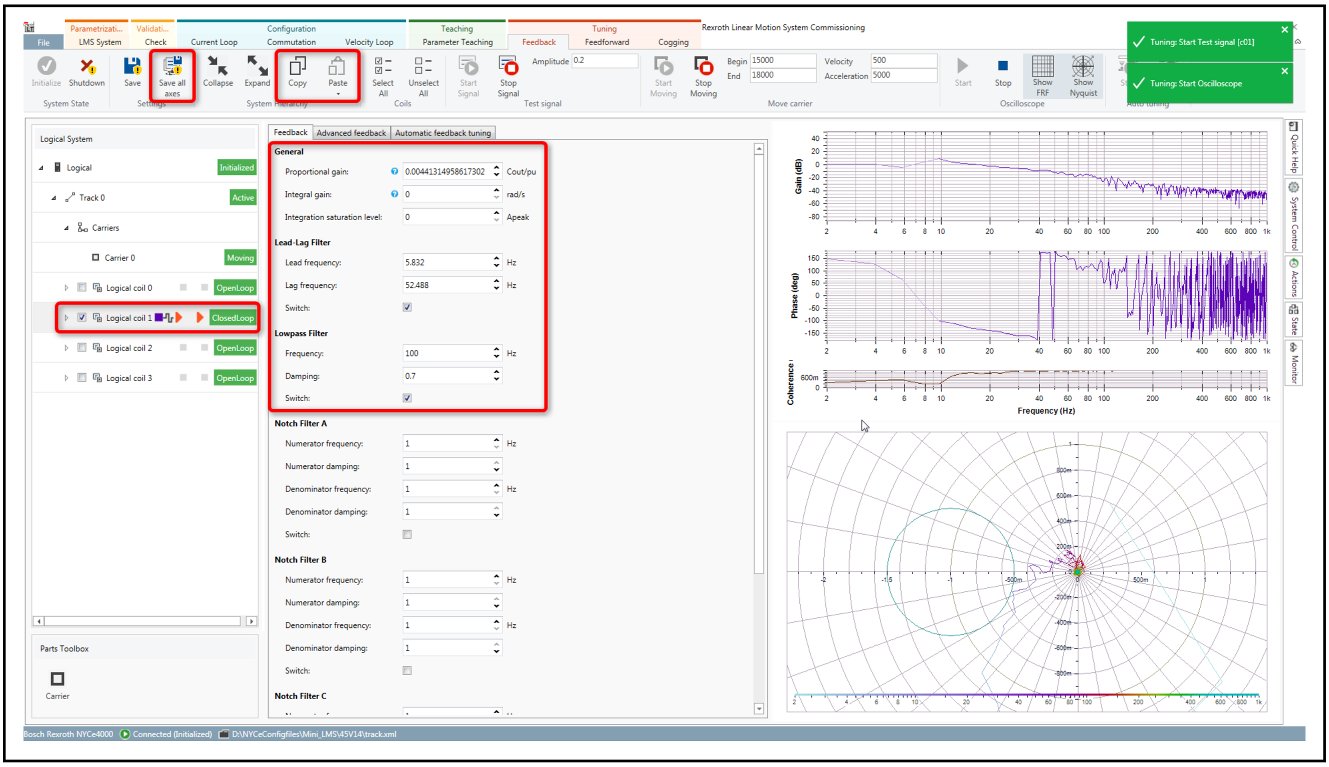

Fig. 4-34: Tuning - tune the feedback controller

Do not use an integrator. When the carrier moves above 2 coils, due to imperfections of the magnet plates, integrators cause the 2 coils to work against each other. This decreases the performance of the system.

The maximum bandwidth for LMS is typically between 15 Hz and 20 Hz. For LMS systems, the dynamics can typically differ a little over the length of the track. For that reason, it is recommended to tune the feedback controller relatively robust and stay well outside the -6dB circle in the Nyquist diagram.

When the feedback controller is well tuned for the selected coil, click the "Copy" button and then the "Paste to All" button to copy these controller parameters to all coils. Save the controller settings to the axis configuration file.

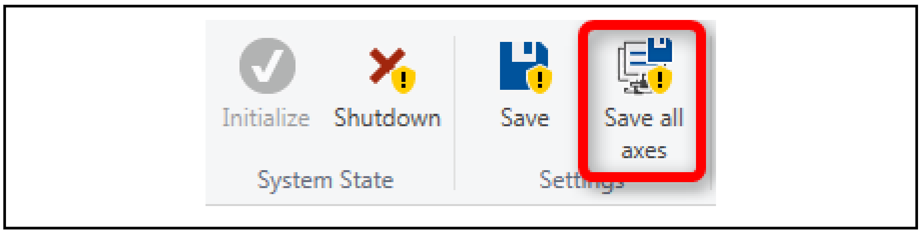

Fig. 4-35: Tuning - save axis configuration

4.6.5 Advanced feedback tuning

The parameters in the "Advanced feedback" tab are the "stand still" feedback controller parameters. When the carrier is positioned, an integrator is often preferred to eliminate the remaining position error (difference between setpoint position and position measured by the LMS).

Tune the feedback parameters of the coil above which the carrier is located with an integrator to find out which parameters to specify for the advanced feedback parameters.

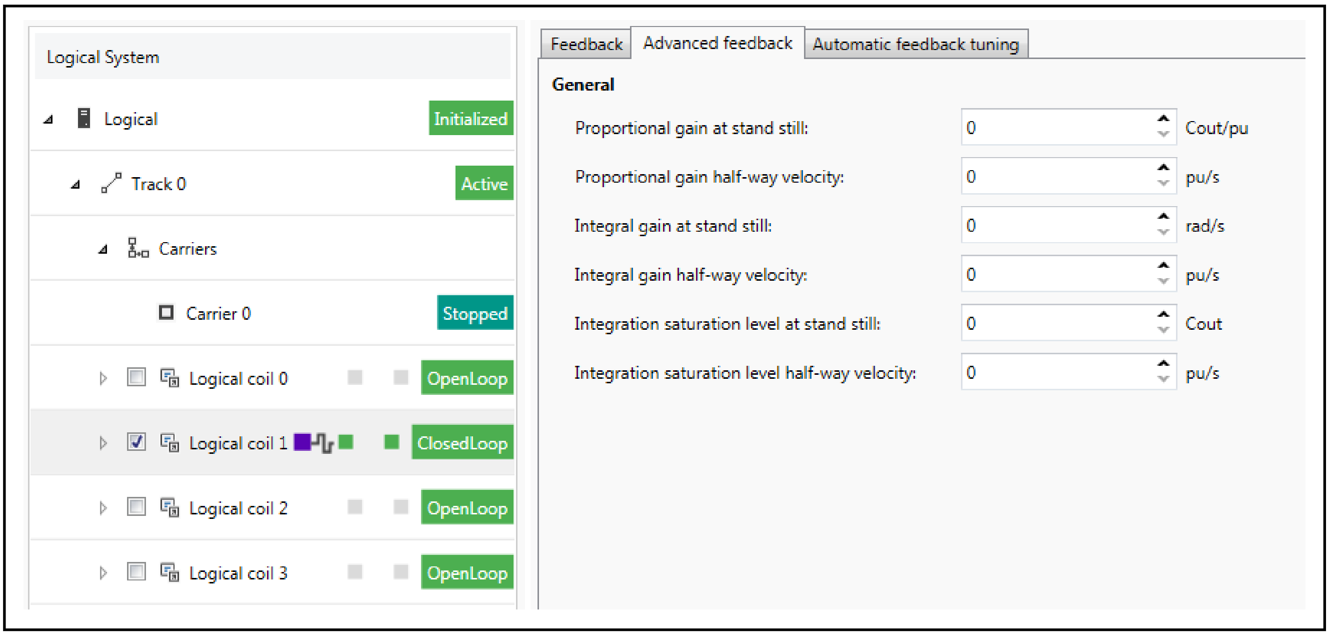

Fig. 4-36: Tuning - advanced feedback parameters

Only tune the parameters in the "General" section. After setting the integrator, the proportional gain may have to be decreased, because the integrator will increase the gain in the low frequency region (below the cut-off frequency of the integrator).

Write down the tuned parameters with integrator.

Select another logical coil in the tree view and click the "Copy" button and then the "Paste to All" button to undo the tuning with integrator.

Select the "Advanced feedback" tab and enter the values that you wrote down in the parameter fields, see fig. 4-36 "Tuning - advanced feedback parameters" on page 42, proportional gain in "P gain at stand still", integral gain in "I gain at stand still", and integrator saturation level in the section "Maximum Integrator Level" in "At stand still". A typical value for the half-way velocities is 100.

When finished with the advanced feedback tuning for the selected coil, click the "Copy" button and then the "Paste to All" button to copy these controller parameters to all coils and save the controller setting to the coil configuration file, see fig. 4-35 "Tuning - save axis configuration" on page 42.

4.6.6 Feedforward tuning

Besides the feedback controller, feedforwards can compensate static forces, coulomb frictions, viscous frictions and the acceleration forces (needed to accelerate the mass / inertia driven by the coils).

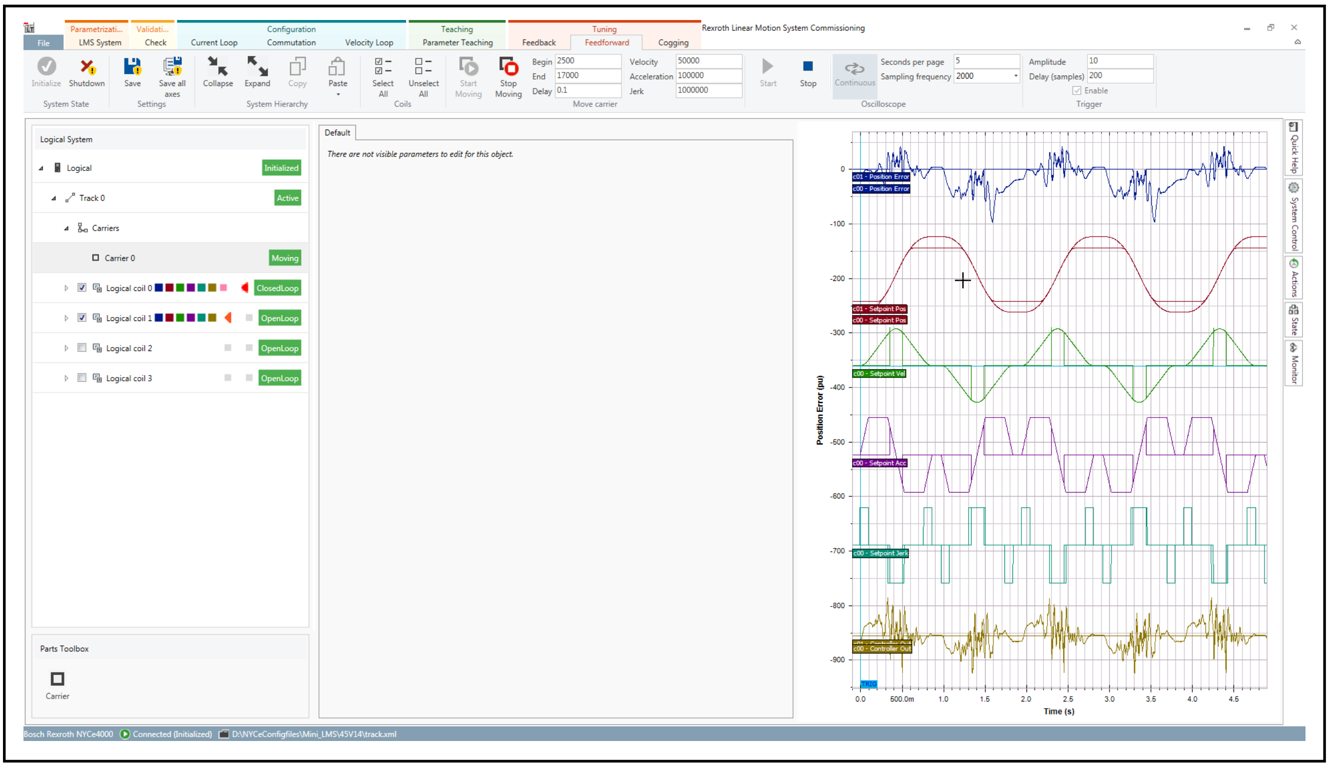

Fig. 4-37: Tuning - feedforward tuning

The following feedforward parameters can be set to minimize the position error in each part of the motion profile.

- Kfv – velocity feedforward gain of the position loop
- Kfa – acceleration feedforward gain of the position loop
- Kfj – jerk feedforward gain of the position loop
- Kfc – Coulomb friction feedforward gain of the position loop
- Kfst – static feedforward gain of the position loop

Each parameter can be tuned accordingly to each part of the motion profile. In the oscilloscope (from top to bottom) the position error, setpoint velocity, setpoint acceleration, setpoint jerk and controller out are displayed.

☞ Start the tuning of each feedforward parameter with "low" start value, in the order of 0.00001. The system may become unstable if too high values for the feedforward parameters are applied.

4.6.7 Cogging

Cogging is defined as the attraction between a magnet plate and the iron core in a coil. Due to this attraction, the carrier may experience a jerky motion while moving over a coil, especially if the air gap between the magnet plate and the coil is relatively small (< 1 mm).

You can create a feed forward table for each coil to compensate for this cogging effect. You can configure the step size, number of points, teach mode and saturation level. Subsequently you define the motion parameters.

☞ The teaching velocity must be approximately 500 pu/s (5 mm/s) to create a correctly working cogging table. This implies that the creation of cogging tables for a large application can take several hours.

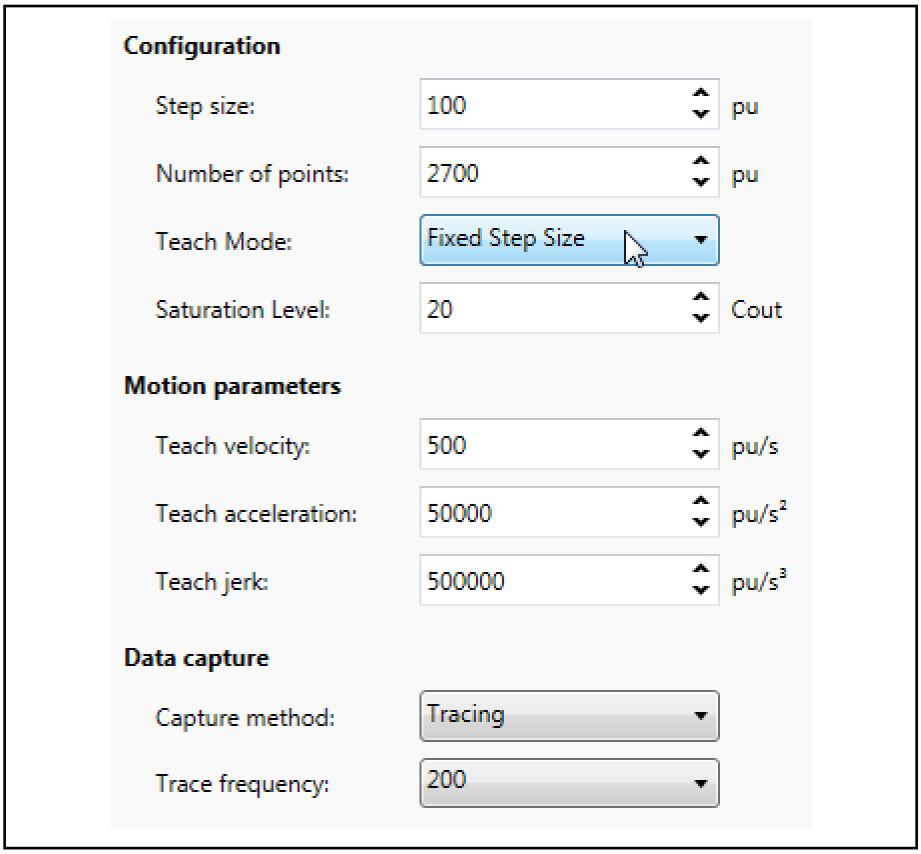

Fig. 4-38: Tuning - cogging configuration

The following plot is created, after you moved the carrier in both directions over coil.

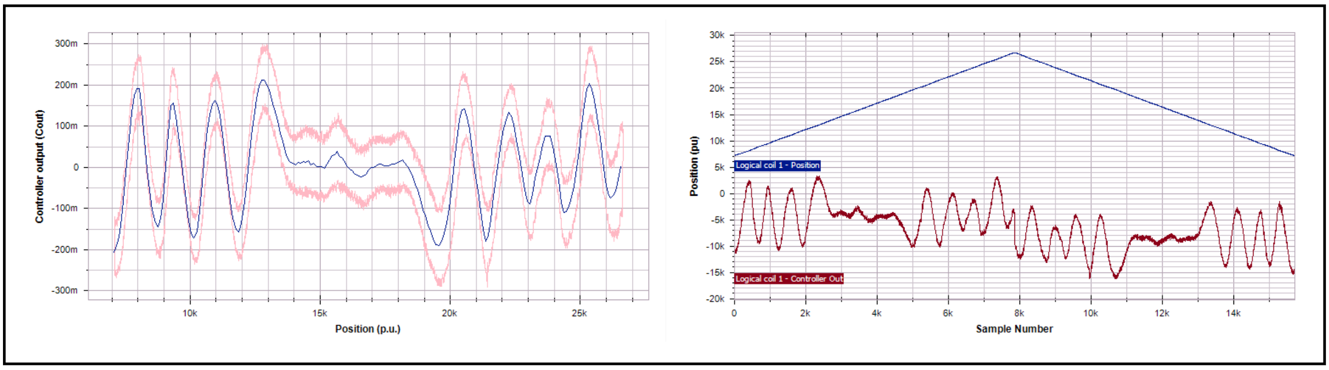

Fig. 4-39: Tuning - controller out when creating cogging

You can save the created cogging tables (when finished for the selected coils) to a file.

- If you select a single logical coil, you can save a single table for that coil.
- If you select the track, then each cogging file will be saved as `"NAME"_cXX.xml`. Afterwards, you must link each cogging file to the appropriate coil.

4.7 Collision avoidance – track to track distance

With the function `CmCollAvoidMoveBetweenTracks` you can move a carrier from one track to another track with collision avoidance. One of the parameters for this function is the distance between the two involved tracks. This required parameter `trackDistance` can be determined with the LMS Commissioning Tool.

☞ You can determine the distance between the two involved tracks only **after** both tracks have been completely and successfully commissioned.

You can find the "Track Distance" button on the tab "Parameter Teaching".

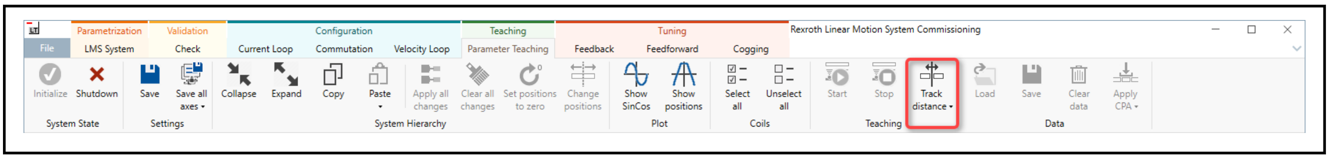

Fig. 4-40: Track Distance button

The following options appear when you click the "Track Distance" button.

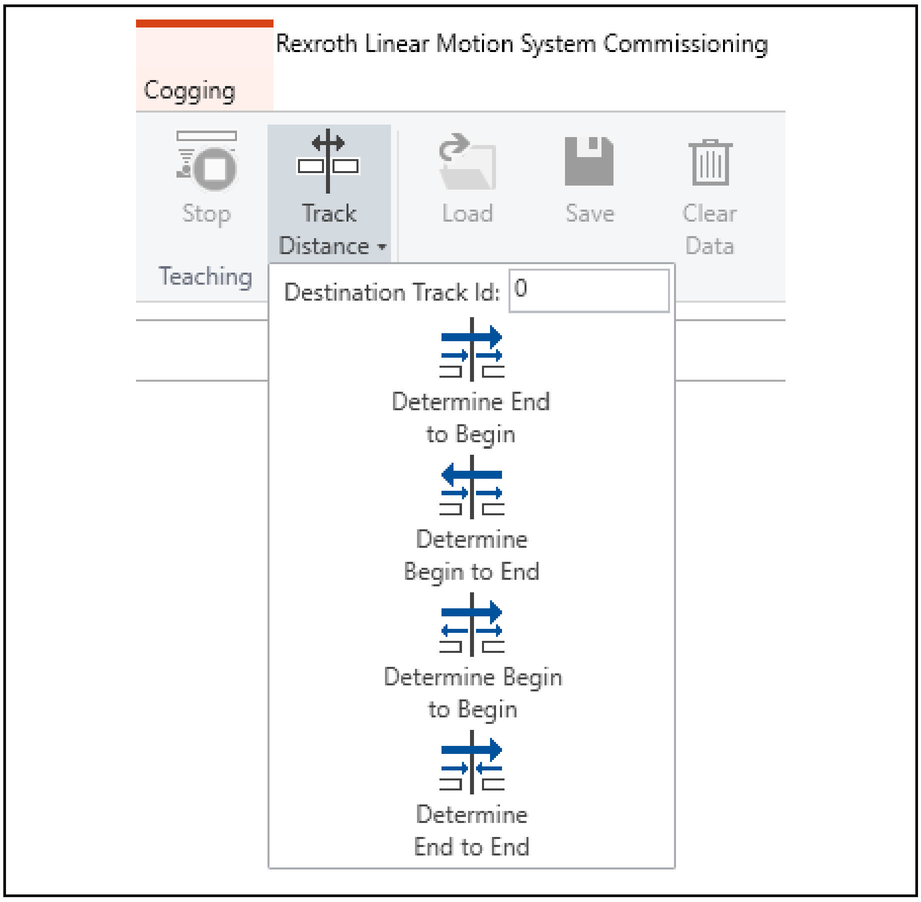

Fig. 4-41: Track distance options

The following conditions must be met before you can determine the distance between two tracks.

- Both involved tracks must have been commissioned successfully.
- Both involved tracks must be in the track state `CM_TRACK_ACTIVE`.

Do the following actions to determine the track distance.

1. Select a carrier which will be moved from its origin track to the destination track.
2. Specify the destination track.
3. Select one of the four track distance options.

The specified carrier makes a movement from its origin track to the destination track.

After the movement has finished you can read the measured distance between the two tracks on the "Teaching" tab at the bottom. This result is not saved, so you have to copy the measured value into the application software that uses the function `CmCollAvoidMoveBetweenTracks` as the value for the parameter `trackDistance`.

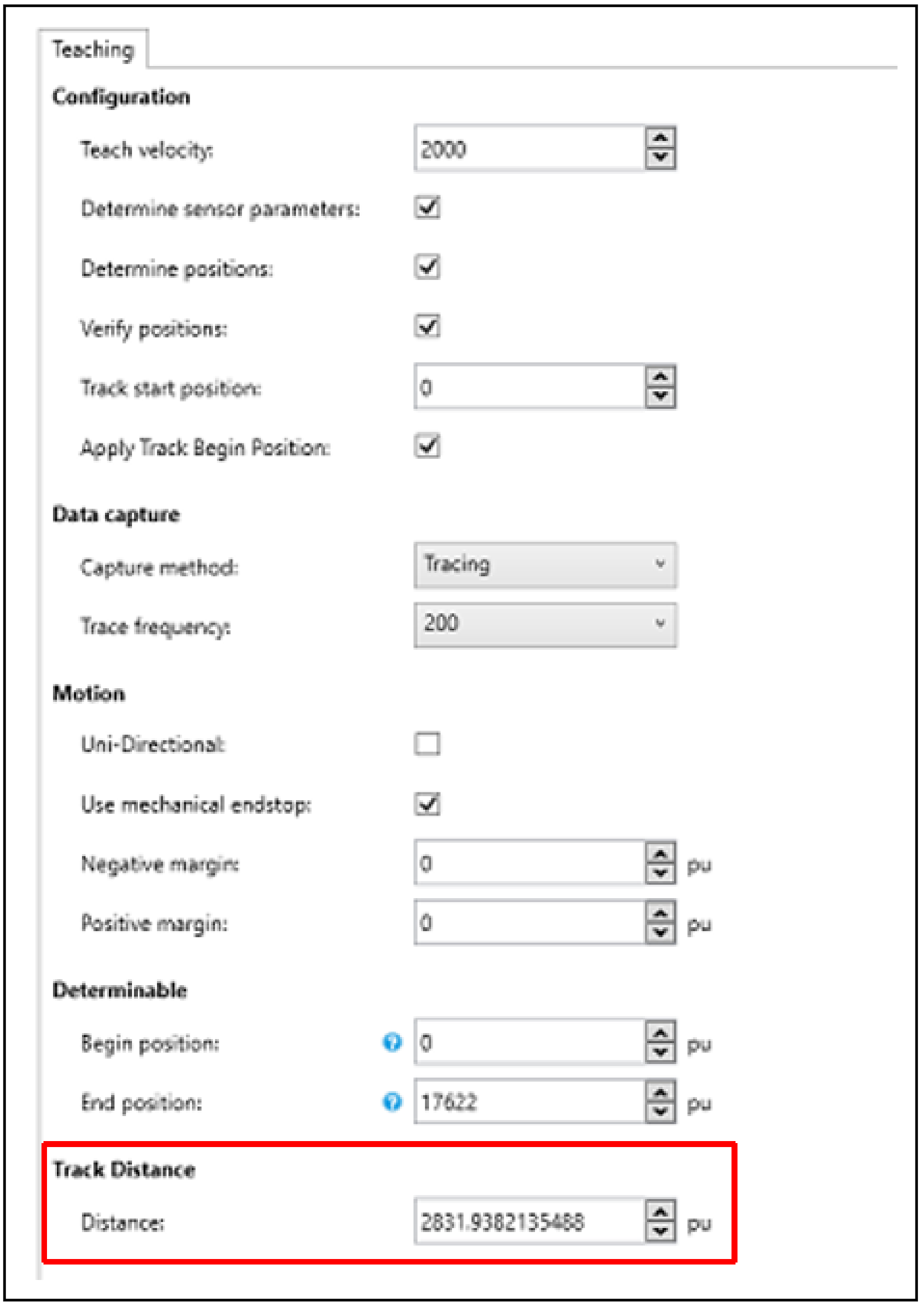

Fig. 4-42: Track Distance measurement result

Notes

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