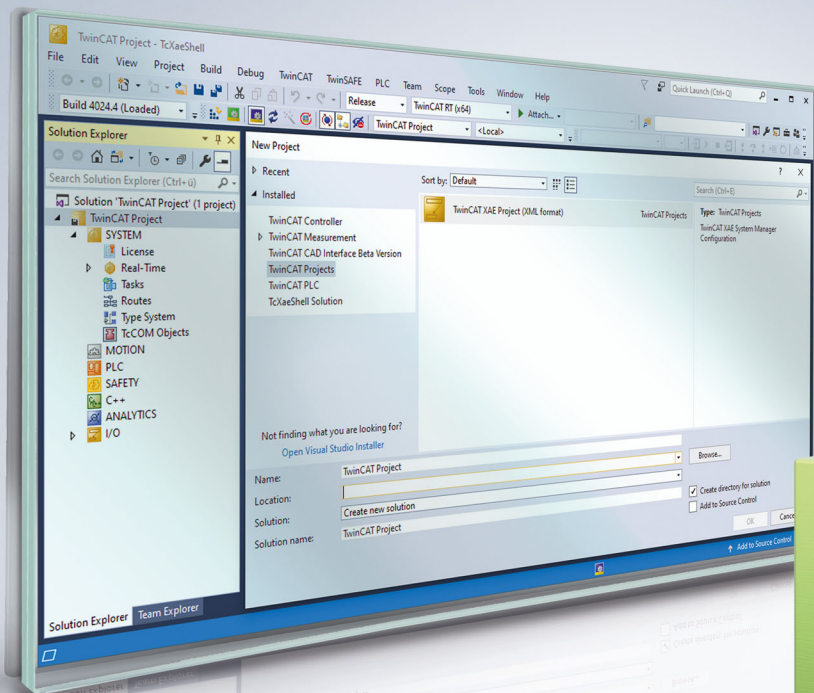**BECKHOFF** New Automation Technology

Manual | EN

TE1210

TwinCAT 3 | PLC Profiler

Table of contents

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1 Foreword

1.1 Notes on the documentation

This description is intended exclusively for trained specialists in control and automation technology who are familiar with the applicable national standards.
For installation and commissioning of the components, it is absolutely necessary to observe the documentation and the following notes and explanations.
The qualified personnel is obliged to always use the currently valid documentation.

The responsible staff must ensure that the application or use of the products described satisfies all 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 notice.
No claims to modify 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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EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702
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1.2 For your safety

Safety regulations

Read the following explanations for your safety.
Always observe and follow product-specific safety instructions, which you may find at the appropriate places in this document.

Exclusion of liability

All the components are supplied in particular hardware and software configurations which are 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 technology who are familiar with the applicable national standards.

Signal words

The signal words used in the documentation are classified below. In order to prevent injury and damage to persons and property, read and follow the safety and warning notices.

Personal injury warnings

⚠ DANGER
Hazard with high risk of death or serious injury.

⚠ WARNING
Hazard with medium risk of death or serious injury.

⚠ CAUTION
There is a low-risk hazard that could result in medium or minor injury.

Warning of damage to property or environment

NOTICE
The environment, equipment, or data may be damaged.

Information on handling the product

This information includes, for example:
recommendations for action, assistance or further information on the product.

1.3 Notes on information security

The products of Beckhoff Automation GmbH & Co. KG (Beckhoff), insofar as they can be accessed online, are equipped with security functions that support the secure operation of plants, systems, machines and networks. Despite the security functions, the creation, implementation and constant updating of a holistic security concept for the operation are necessary to protect the respective plant, system, machine and networks against cyber threats. The products sold by Beckhoff are only part of the overall security concept. The customer is responsible for preventing unauthorized access by third parties to its equipment, systems, machines and networks. The latter should be connected to the corporate network or the Internet only if appropriate protective measures have been set up.

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To stay informed about information security for Beckhoff products, subscribe to the RSS feed at https://www.beckhoff.com/secinfo.

2 Overview

The TwinCAT 3 PLC Profiler is an analysis tool that is used for performance evaluation and optimization of PLC programs within the TwinCAT 3 software environment. It enables the collection of detailed execution data from PLC code blocks, making it easier to identify runtime inefficiencies and potential areas for improvement. The Profiler is designed to provide comprehensive data on the execution time of PLC programs. This data is essential for finding and eliminating performance bottlenecks in automation systems. The profiler differs from other diagnostic and analysis tools by its specific focus on the TwinCAT 3 PLC development environment and its ability to provide detailed execution information of the PLC code. This in-depth analysis capability is especially useful for developers who need detailed insights into the execution times and behaviors of their PLC programs.

3 Installation

System Requirements

Technical data	Description
Operating system	Windows 10
Target platform	Windows, unsuitable for target systems based on Windows CE or TwinCAT/BSD
Minimum TwinCAT version	TwinCAT 3.1.4026.0

Requirements for Profiler measurements

To use the above features, the following requirements must be met.

- The TwinCAT 3 PLC Profiler is licensed on your system.
- A PLC project with an application consisting of various program and function blocks is open.
- The application is compiled error-free.
- A Profiler configuration has been created and selected.
- A connection to the control unit is established and the control unit is running.

Installation

The TE1210 | TwinCAT 3 PLC Profiler is already installed with the installation of the TwinCAT 3 PLC development environment component and has been included as a release version since TwinCAT Version 3.1 Build 4026.0. Therefore, only the additional TE1210 engineering component needs to be licensed.

Licensing

The TE1210 | TwinCAT 3 PLC Profiler engineering component must be licensed. See also the documentation on Licensing.

ℹ️ Please note that a 7-day trial license is not available for this product.

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4   Important notes

Observe the following instructions when using the Profiler.

NOTICE
Changed time behavior of the IEC program when using the Profiler functionalities
The Profiler measurements change the runtime behavior of the IEC program. The effects depend on the PLC program architecture and the Profiler configuration.

NOTICE
Watchdog exceptions when using the Profiler functionalities
The Profiler measurements change (slow down) the runtime behavior of the IEC program. Watchdog exceptions may occur.
• You should therefore only use the profiler functions in a secure test environment.

Change Profiler settings via download

Switching the profiling function on and off and changing the Profiler configuration will force a download. It is not possible to load these changes to the controller using Online Change.

Libraries

TwinCAT can only record calls to the application code of the current PLC project, the referenced libraries remain unnoticed!

• If you want to record calls from libraries, you can encapsulate these calls in actions in the application code.

• You can then record these actions.

5   Configuration

Creating the configuration in the TwinCAT 3 PLC Profiler is a crucial step that enables the measurement and analysis of PLC programs. The configuration window allows you to select the specific program blocks to be monitored during the profiling process. The user interface offers intuitive features such as the creation of blacklists and whitelists to precisely define which parts of the program should be included or excluded from the measurement.

You can use a drop-down menu to decide whether the POUs (Program Organization Units) to be measured should be configured on the basis of a blacklist or whitelist. The blacklist acts as an exclusion list, while the whitelist specifies exactly which elements are to be examined. The **Add button** allows you to add new program blocks to the configuration list. This list forms the core of the configuration and serves as the basis for profiling.

The **Instrumented Elements** information display provides information on how many elements are already configured for profiling. This provides a clear overview and makes it easier to manage sophisticated projects. You can also use this configuration interface to determine which functions and methods are highlighted to ensure that the critical parts of the code are monitored and analyzed.

Window Configuration [▶ 18]

6   Basics

Profiling is a process in software development and optimization and refers to the process of analyzing a software application to understand various aspects of its execution, such as the duration of function calls. The aim of profiling is to identify performance bottlenecks, inefficient code and unexpected behavior in order to improve the performance and efficiency of the application.

The TwinCAT 3 PLC Profiler uses the "instrumentation" measurement principle, where specific marks (entry and exit methods) are inserted into the code in order to measure the execution times of individual function blocks or code segments. One of the biggest advantages lies in the detailed insights that the process offers. It enables the accurate measurement of execution times and the frequency of calls to each individual function block within the program. This precision in measurement is essential to understand how the code behaves and where there may be potential for improvement.

Optimization also plays a key role. The insights gained not only allow you to identify performance bottlenecks, but also to address and eliminate them in a targeted manner. This leads to improved efficiency and performance of the application, which is particularly important in time-sensitive and resource-constrained environments. However, there are also important aspects to consider that can influence the results and their interpretation. On the one hand, the measurement marks that are placed in the code lead to an additional load on the system. This can affect the actual execution times and should be taken into account when analyzing the measurement results. On the other hand, this can lead to unwanted weighting: areas of the code that are provided with many measurement marks may appear over-represented in the analysis because the measurement methods themselves take time. This effect must be taken into account when analyzing the data to ensure an accurate interpretation of the code's performance.

In the further application of the TwinCAT 3 PLC Profiler, various challenges resulting from the complexity and dynamics of advanced PLC systems have to be taken into account. One such challenge is the inter-cycle variability of measured values caused by dynamic CPU clocking and other factors. Although measures such as using isolated cores or disabling power management mechanisms can reduce variability, it remains an issue that affects the interpretation of profiling results.

In addition, the implementation of the trace procedure, which measures the entire call tree in each cycle, can lead to an increase in real-time load, which can affect the performance of the system. Another issue is the increase in network utilization due to the transmission of measured values via ADS, especially with high information density. This increase in network traffic must be considered when planning profiling activities.

By taking a careful approach, developers can gain valuable insights into the performance of their applications and make targeted optimizations to improve the efficiency and reliability of their systems.

7   Quick start

The following chapter is intended to provide an easy introduction to using the TwinCAT 3 PLC Profiler.

✓ The starting point is a running project on a TwinCAT 3.1 Runtime of version 3.1.4026.0 or newer. Add the PLC Profiler to your PLC project via the context menu in the project tree.

1. Assign a name for the configuration and select whether to create it as a blacklist or a whitelist.

2. Then confirm with **Add**.

3. If you only create one configuration, it is automatically set to active. If there are several configurations, set the desired configuration via the context menu in the project tree.
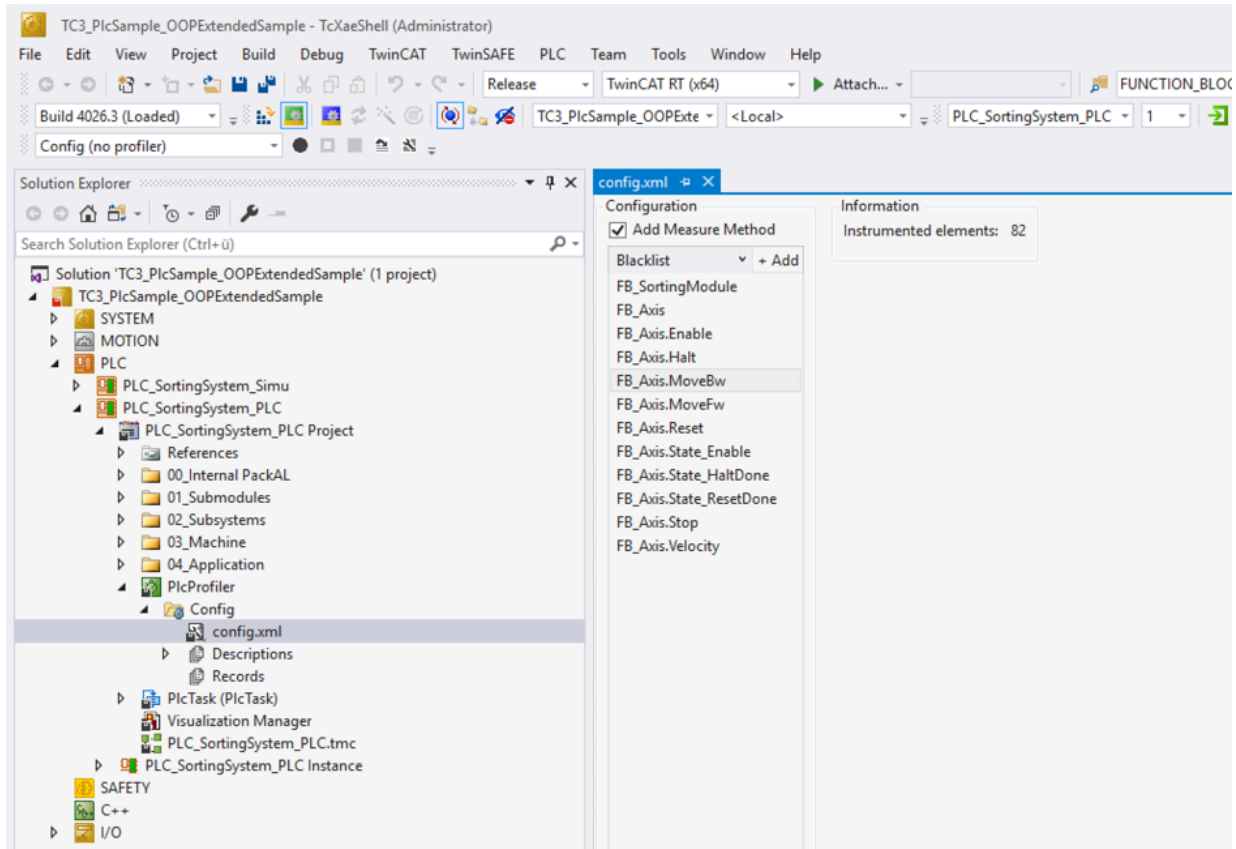
4. Compile the PLC project and carry out a download or enable the configuration.

5. Start the PLC.

6. Start a recording via the toolbar.
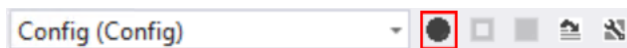
7. Profiler recording begins.

8. Stop the recording via the toolbar.

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9. Open the window **Records**.
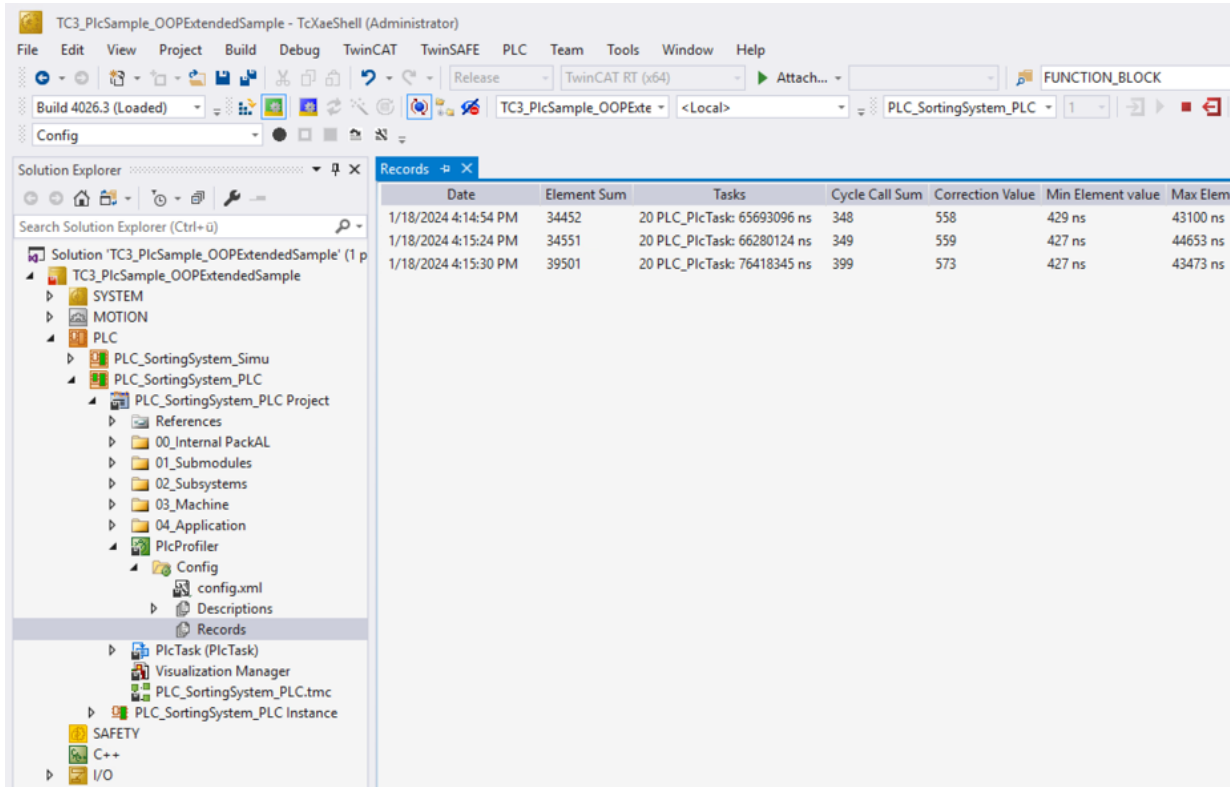
10. Open the report of your choice.

11. Right-click to open the context menu and click **Analyze**.
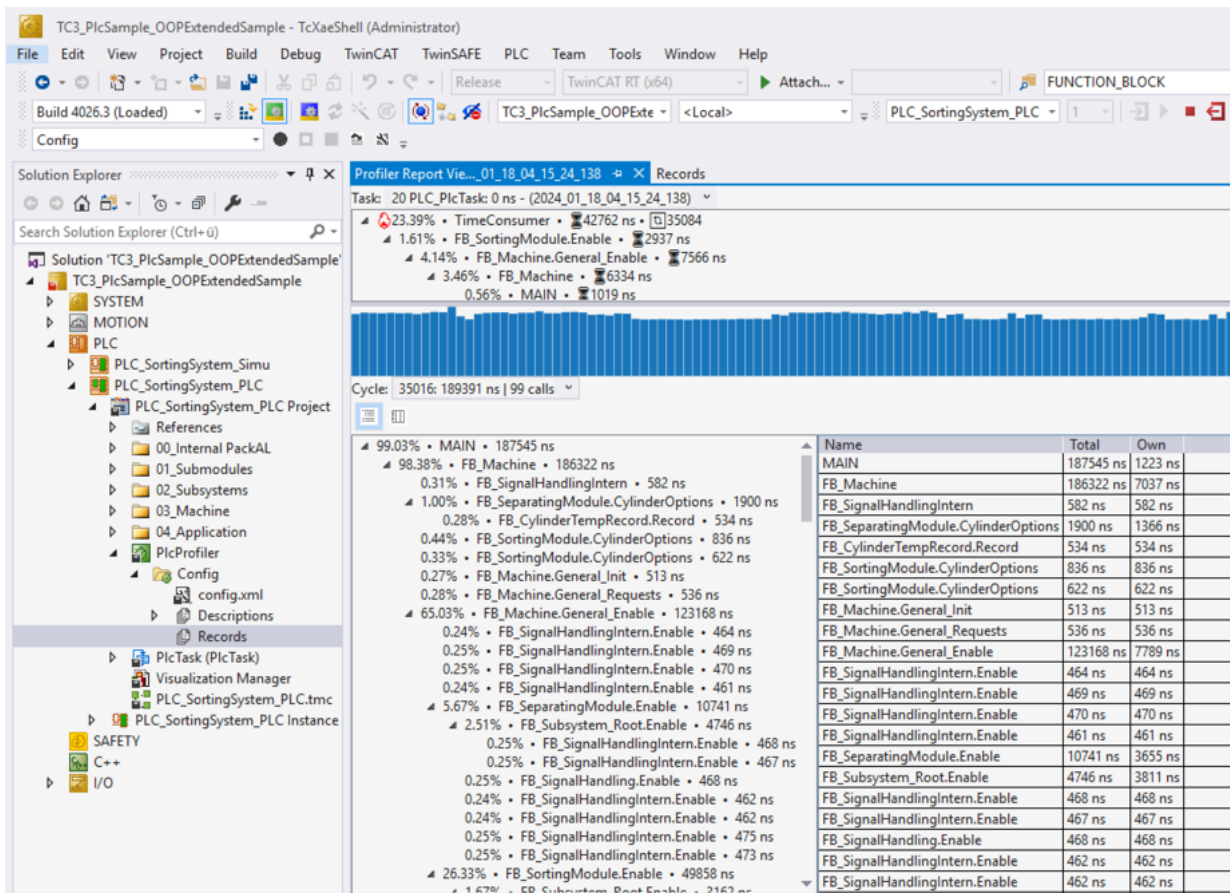
8   User interface

The user interface of the TwinCAT 3 PLC Profiler consists of the following components:

1	Toolbar
2	Report window
3	Recordings
4	Properties window
5	Configuration window

8.1   Toolbar – TwinCAT 3 PLC Profiler

The following commands are available in the PLC Profiler toolbar:

Config ▾	Currently selected measurement configuration
●	Start recording.
◻	Snapshot, save previous measured values in records, measurement continues.
◼	Stop recording.
⬆	Open the last record created.
⚒	Open the currently selected configuration.

8.2 Window Report
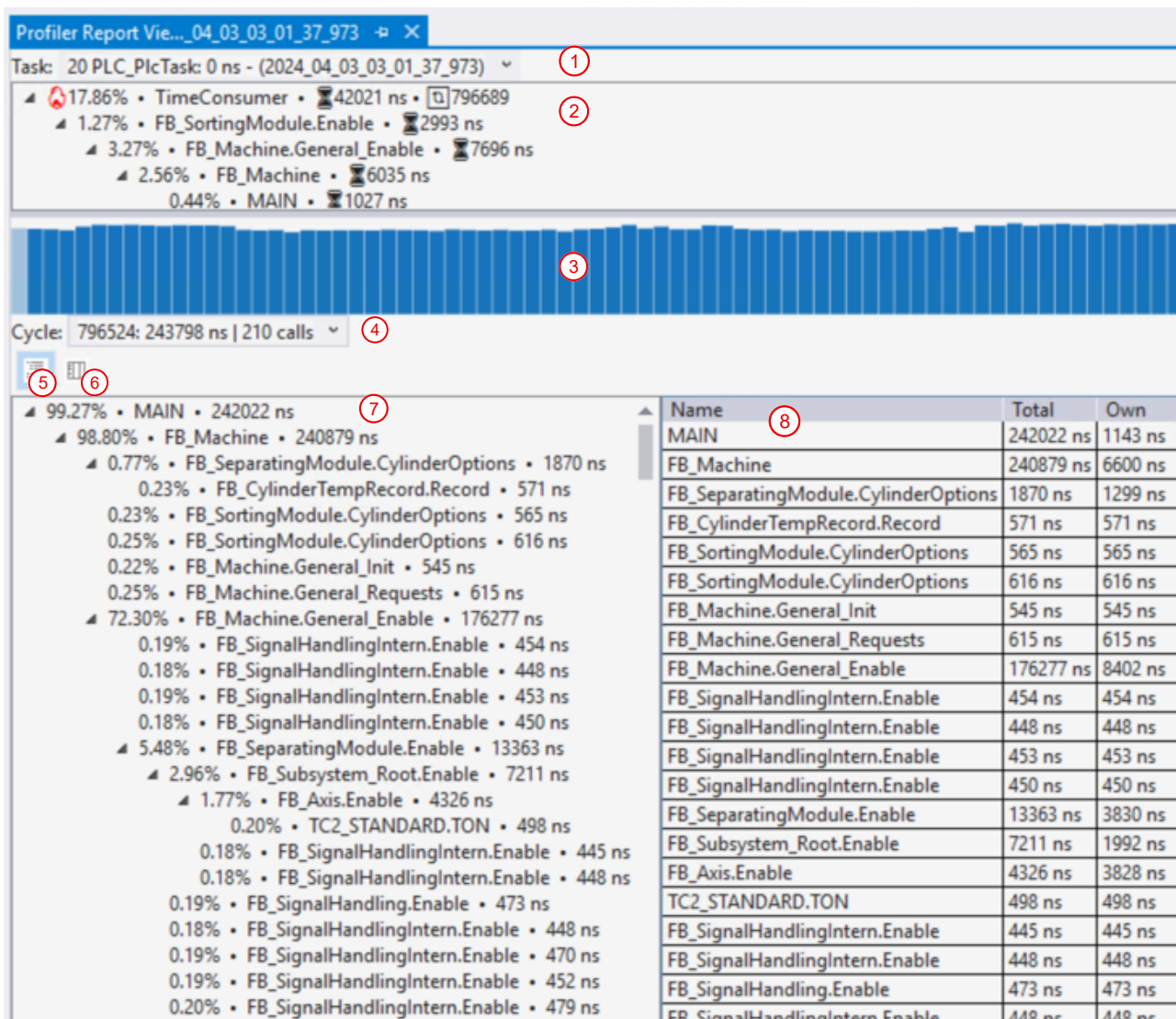
No.	Name	Property
1	Task selection	Drop-down menu for selecting the task
2	Hotpath analysis	Display of Hotpath analysis and cyclic deviation
3	Task execution time	Diagram with the task execution time over the various cycles
4	Cycle selection	Drop-down menu for selecting the cycle
5	Button Call Tree	Show/hide the Call Tree
6	Button Call Stack/Type-based list	Toggle between Call Stack/type-based list
7	Call Tree	Display of the Call Tree
8	Call Stack	Display of the Call Stack

8.3 Window Records

All previous Profiler recordings are listed in a table in the window Records.

The following information is listed in detail:

Column	Property
Date	Timestamp of the recording
Element Sum	Number of measured program calls over the entire measurement
Tasks	All tasks that were measured in the recording.
Cycle Call Sum	Number of measured program calls per cycle
Correction Value	Runtime determined for the Profiler measurement mark.
Min Element Value	Minimum call-up time of an element in the recording
Max Element Value	Maximum call-up time of an element in the recording
Call Depth	Maximum call depth during recording
File	Name of the file

Context menu

The following actions can be carried out in the context menu of the window Records.
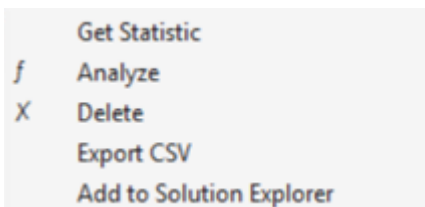
Action	Property
Get Statistic	
Analyze	Starts the analysis and opens the report.
Delete	Delete recording.
Export CSV	Export recording as CSV.
Add to Solution Explorer	Add recording to the Solution. The recording is added to the Solution as a separate file and is therefore included in Source Control and the archive.

8.4   Window Properties

The Properties window shows the properties of the currently active (selected) element of the project tree. The properties listed in the **Profiler** area always apply to all sub-elements of the tree.

## 8.4.1 Project node

The following settings are available on the project node of the TwinCAT 3 PLC Profiler. The properties listed in the **Profiler** area always apply to all sub-elements. These properties therefore apply to the entire PLC project at project level.
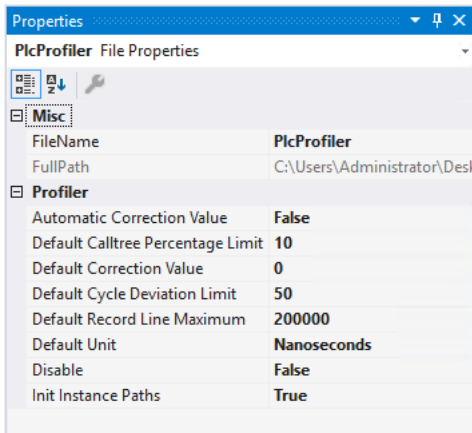
Property	Meaning
Profiler	
Automatic Correction Value	Turns on/off the function for the correction calculation of the runtime component of the Profiler measurement marks.
Default Calltree Percentage Limit	Threshold value for the Hoptpath analysis in percent. If the percentage of Own Time of an element exceeds the total execution time of a cycle, this element is displayed in the **Hotpath**.
Default Correction Value	Correction value for the correction calculation of the runtime component of the Profiler measurement marks in [ns]
Default Cycle Deviation Limit	Threshold value for the **Cyclic Deviation** evaluation in percent. If the percentage of Own Time of an element in the total execution time of a cycle exceeds this value, the element is displayed in the Hotpath.
Default Record Line Maximum	Maximum number of entries for the Record file. If this value is reached, a new file is automatically created.
Default Unit	The default time unit for opening a report (ms/µs/ns).
Disable	Disable the Profiler.
Init Instance Paths	Switch on instance path generation. The function is required to display the exact instance path of each call in the report. Generation can be disabled, as this prolongs the compile process.

8.5 Window Configuration

The measurement configuration of the Profiler can be adjusted in the window Configuration.
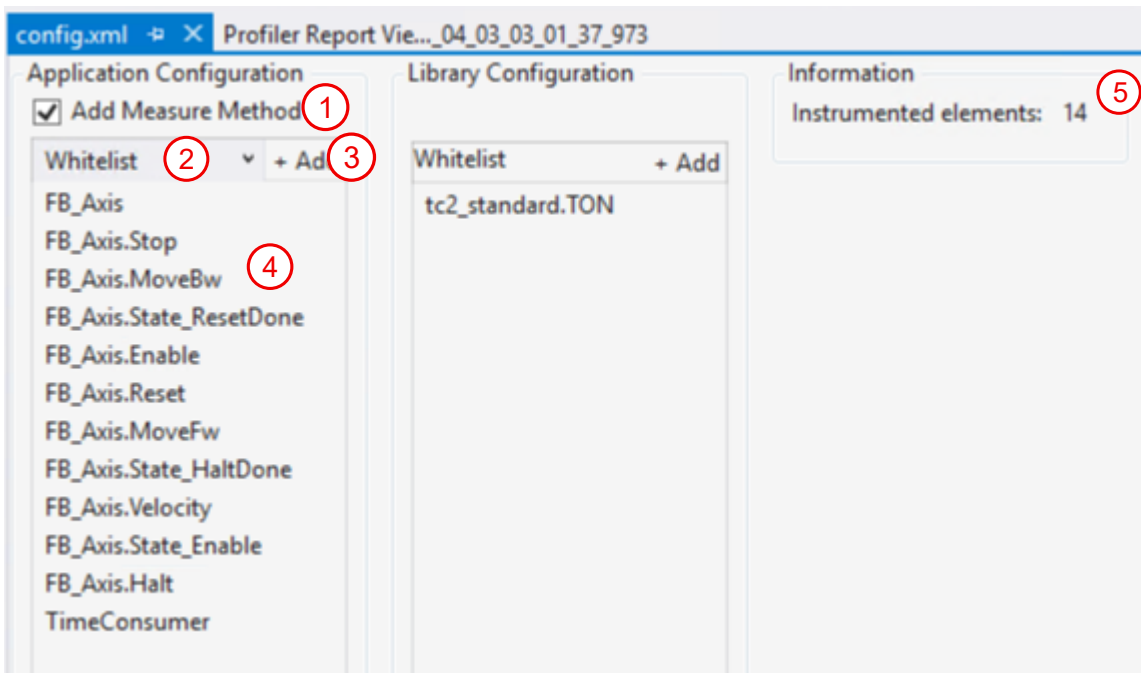
No.	Property	Meaning
1	Add Measure Method	Enables the function that includes a Profiler measurement mark. Can be used for the correction calculation.
2	Blacklist and whitelist	The drop-down menu is used to select whether the configuration of the POUs to be measured is created on the basis of a blacklist or whitelist.
3	Add Button	The button can be used to add program elements to the configuration list.
4	Configuration list	List that serves as the basis for the configuration. Library function blocks can be added to the configuration in a second whitelist.
5	Instrumented Elements	Number of program elements whose runtime is to be measured.

9   Support and Service

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The downloads are available in various formats.

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