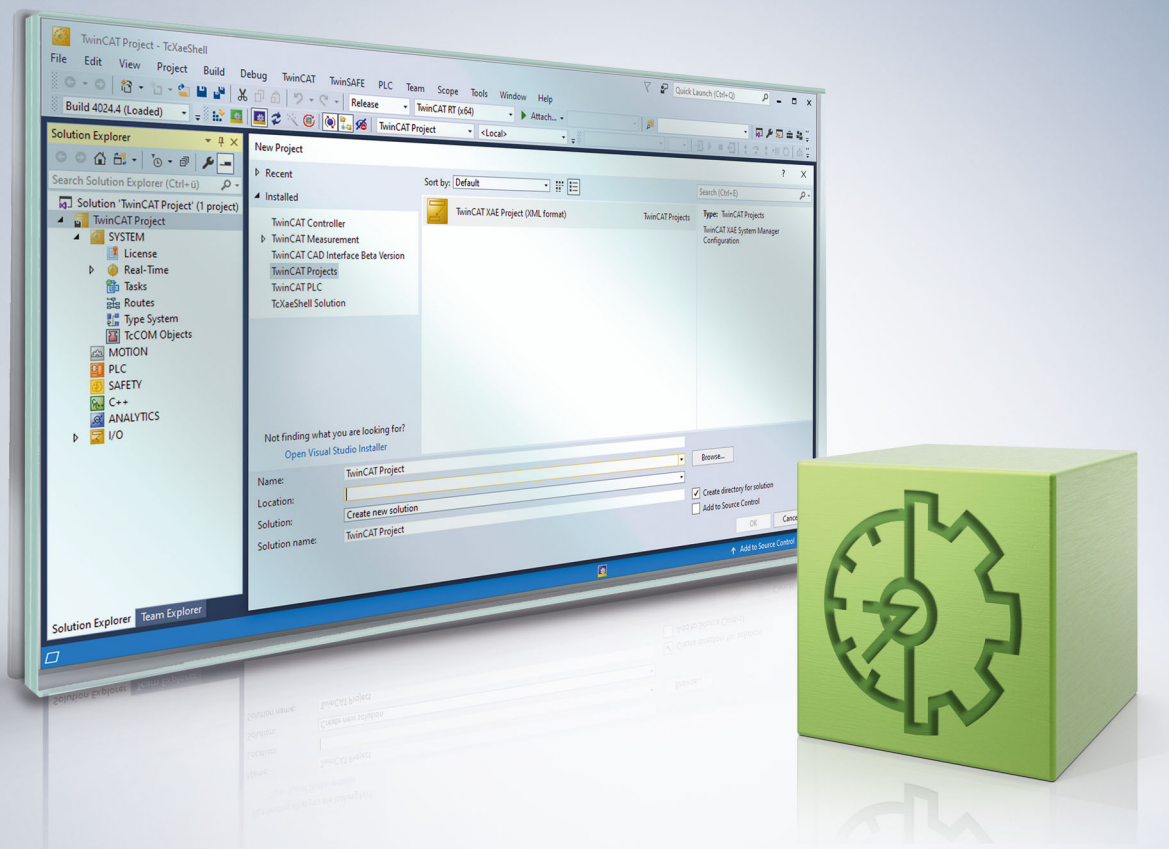
BECKHOFF New Automation Technology

Manual | EN

TE1010

TwinCAT 3 | Realtime Monitor



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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 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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Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents:
EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702
with corresponding applications or registrations in various other countries.

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1.2 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.

NOTICE

Damage to the environment or devices

Failure to follow the instructions associated with this symbol can lead to damage to the environment or equipment.

Tip or pointer

This symbol indicates information that contributes to better understanding.

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 Real-time Monitor enables precise diagnostics and optimization of the runtime behavior of tasks in the TwinCAT 3 runtime. It offers a graphical representation of the temporal processing of real-time tasks and their modules across all cores. In addition, user-defined processes and their dependencies can be represented graphically through appropriate instrumentation of the control software.

The Real-time Monitor makes the time behavior of the control software on a target system completely transparent and enables comprehensive time analysis. It thus supports both fault diagnosis and time optimization of the configuration, especially on multi-core systems.

Installation

A separate installer is used for the installation. The license is activated as usual under TwinCAT 3.

Requirements

The Real-time Monitor can only be used for diagnosis of TwinCAT 3.1 runtimes from TwinCAT 3.1 version 4024.0 or higher.

It is suitable for Windows 10-based target systems, but not for target systems based on Windows CE.

Licensing

The TwinCAT 3 Real-time Monitor (TE1010) is an Engineering product. Licensing is therefore carried out exclusively on the Engineering system.

There is no 7-day trial license available for this product.

3 Basic principles

The following chapter describes the basic principles that should be read before using the TwinCAT 3 Real-time Monitor.

3.1 TwinCAT 3 Real-Time

According to the DIN 44300 standard, real-time, or rather real-time operation, is defined as follows:
"Real-time operation is an operating mode of a computing system in which programs for processing data are continuously operational in such a way that the processing results are available within a specified period of time."
In other words, the output values of an application program (calculated based on the inner state and input values) are made available within a defined and guaranteed time. This defined time is also referred to as cycle time.

The application program itself can consist of several program blocks, which in turn call other programs or function blocks etc. (see also IEC 61131-3 standard). The program blocks can be assigned to real-time tasks, which in turn call them with a cycle time to be defined and a defined priority.

TwinCAT 3 Real-Time is a real-time extension that can be used in the current TwinCAT 3.1 version in Microsoft Windows operating systems from Windows 7 or later. TwinCAT 3 Real-Time supports the following features in order to meet the requirements described for the control of industrial processes:

- Real-time capable scheduling
- Parallel execution of processes
- Direct hardware access

In addition, TwinCAT 3 Real-Time also offers multi-core support to meet the ever-increasing demands for high-performance and flexible/expandable control platforms. The available cores can either be used exclusively for TwinCAT or shared with Windows. In the following sections, the cores are therefore referred to as "isolated" or "shared.

Real-time capable scheduling

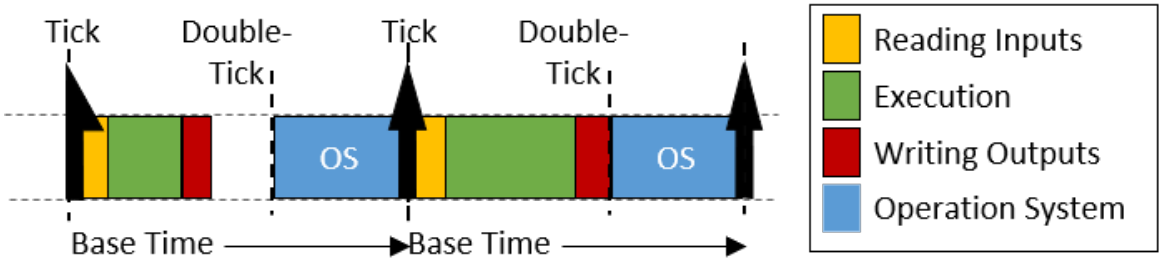
TwinCAT 3 Real-Time works with the double-tick method. This means that both switching to real-time mode and switching back is triggered by an interrupt. The interrupt when switching to the real-time mode also starts the scheduling at the same time. After an adjustable period of time, at the latest after 90% of the set cycle time, TwinCAT switches back to "shared" cores in non-real-time mode, so that the guest operating system has sufficient computing time available to comply with the response times required for hardware functions etc. The isolated cores are an exception.

Scheduling refers to the (system) process that determines the processing order and the processing time of the individual tasks, based on the defined cycle time and the defined priority. Strict adherence to the processing time ensures that the real-time compliance described above is guaranteed.

Triggered by a synchronous basic tick on all real-time kernels, the scheduling for each real-time kernel is calculated independently in TwinCAT 3 Real-Time. This guarantees that real-time tasks running on different cores do not interfere with each other unless this has been explicitly programmed in the user program by using interlocks.

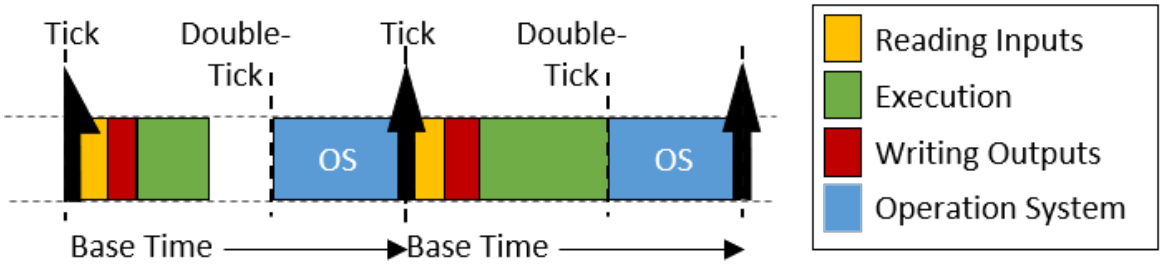
Scheduling in which the priority of a task is derived from its cycle time is also known as rate-monotonic scheduling. The TwinCAT 3 Real-Time automatically activates the "Automatic Priority Management" option. Since this is not always the best solution for every application, the priorities can be adjusted manually.

Exemplary representation of the call of a PLC task



The figure shows the call of a PLC task. After the real-time tick has occurred, the PLC task is called by the scheduler. This makes the current input values available to the PLC application (input update), followed by processing of the application program (cycle update). Finally the results are written to the outputs (output update). Once this has been completed, the device switches to non-real-time mode (double-tick). As shown in the figure, the execution time of the user program may vary depending on which code is executed based on the internal state of the program. Thus the time when the outputs are written also varies. Depending on which task a bus system is driven, this can cause the sending of the bus telegrams to vary to the same extent.

Sample call of a task with "I/O at task start“



By using the "I/O at task start" option, the processing order within a task can be changed so that after reading the inputs, the outputs (of the previous cycle) are written directly before the application program is executed. Although the outputs are not written until the next cycle, this setting has the advantage that the time at which the outputs are written to the process/bus is exactly the same in each cycle.

Preemptive multitasking

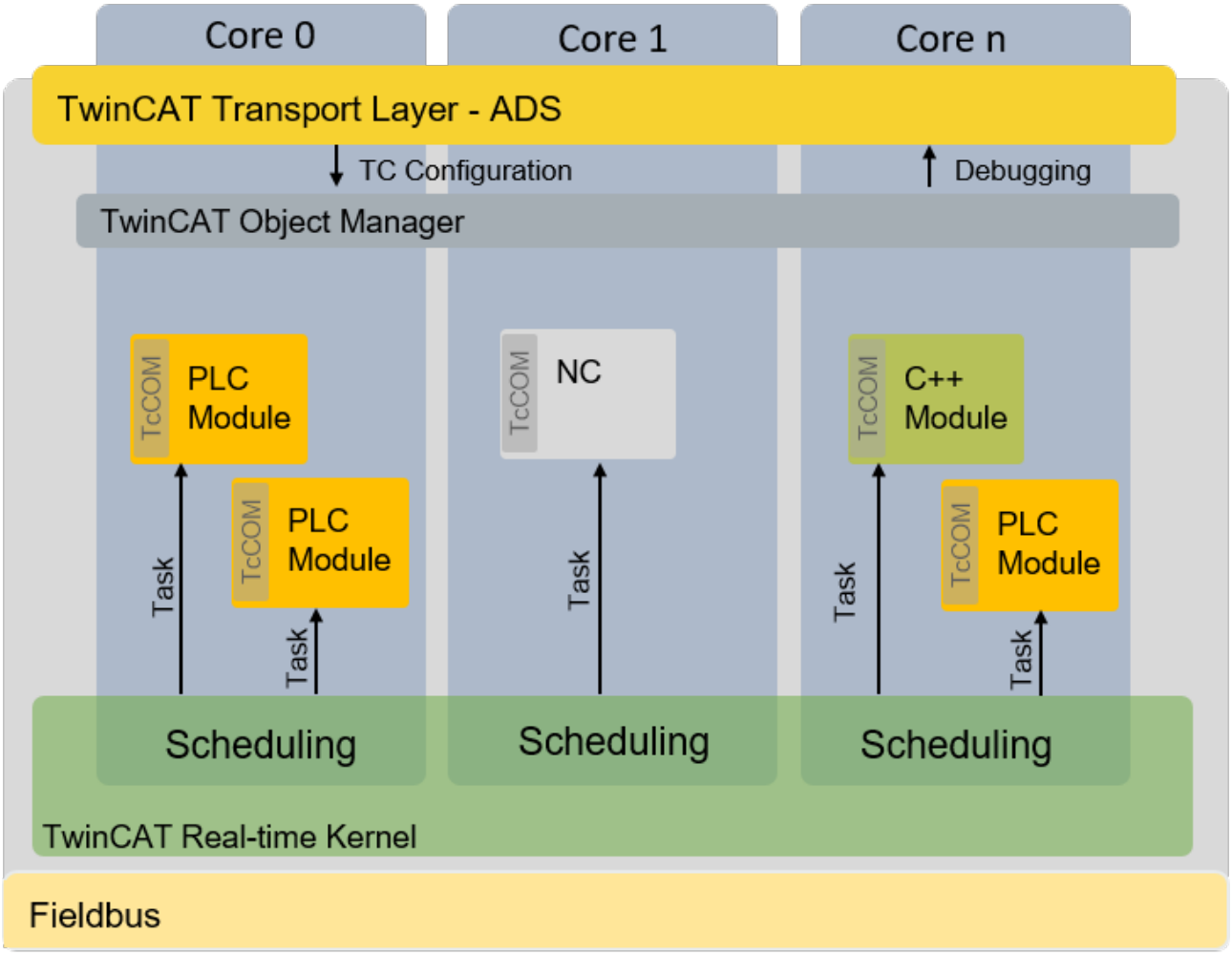
Preemptive multitasking means that the current state of a process (the CPU and floating-point registers) is saved in the event of an interrupt (e.g. by higher-priority processes), and the current process is paused. If this happens, the scheduler determines the (new) process to be executed, based on the task priorities. Once the process to be interrupted is complete, the process context is restored and the "old" process continues.

Direct hardware access

In order to achieve deterministic (reproducible) real-time behavior, TwinCAT 3 Real-Time requires direct hardware access. For this to be possible, TwinCAT 3 Real-Time must be executed in Windows kernel mode. This makes it possible, among other things, for TwinCAT Real-Time to access the network ports directly and send and receive real-time Ethernet telegrams (e.g. EtherCAT).

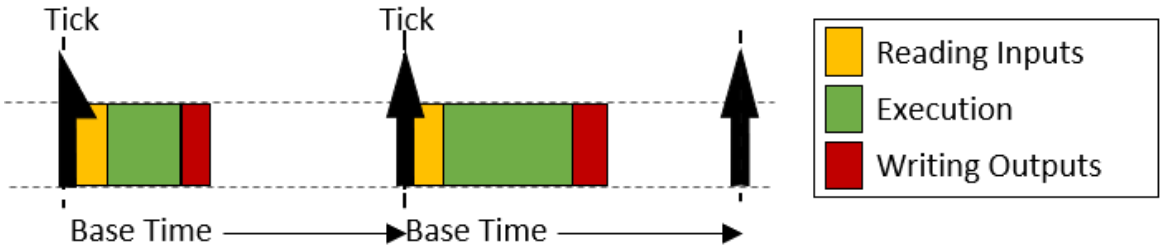
Schematic representation of the TwinCAT 3 runtime environment

The following figure illustrates the structure of the TwinCAT 3.1 runtime environment in relation to scheduling. The TwinCAT 3 runtime environment enables user modules to be executed in real-time. An essential part of the TwinCAT 3 runtime environment therefore is the real-time driver, which is executed on the cores that are activated for TwinCAT and handles the scheduling there. The latter takes place independently on the individual cores.



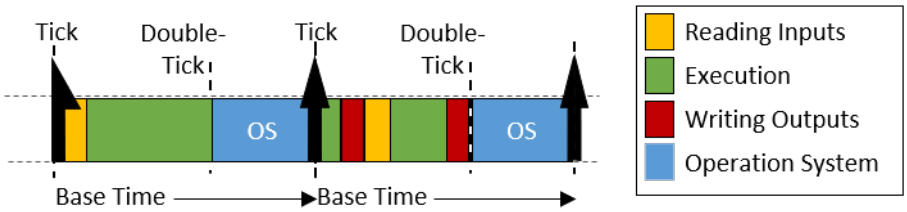
Isolated cores

As described under TwinCAT 3 Real-Time [▶ 9], TwinCAT uses a double-tick procedure to switch back to non-real-time mode at a specified point in time. When switching between real-time mode and non-real-time mode, the preceding process state is restored, as described under TwinCAT 3 Real-Time [▶ 10]. The restoration takes some time, depending on how intensively the real-time and non-real-time programs use the memory and in particular the cache. In order to eliminate these temporal effects, TwinCAT 3.1 Real-Time allows cores to be isolated from the guest operating system. This eliminates the need to switch back, resulting in more computing time for the real-time user program and better real-time quality (less jitter) by avoiding the time effects associated with restoring the "old" process state.

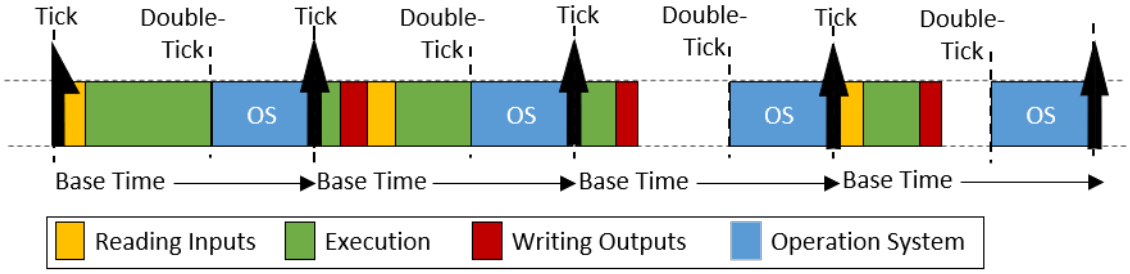


Behavior when the cycle time is exceeded

If the defined cycle time of a task is exceeded, processing of the "old" cycle continues in the next cycle. In addition, the task exceed counter is incremented. Once processing of the old / previous cycle is complete, the system immediately tries to start processing the tasks of the current cycle. If this is completed within the current cycle, further processing is carried out as shown above.



If the second cycle that follows directly is also exceeded (in this case it is irrelevant whether the system is still processing the first cycle or whether the second cycle has commenced), the current processing task is completed, and processing of the next task does not commence until the next possible scheduled cycle start. This means that several cycles may be lost. The exceed counter is incremented accordingly.

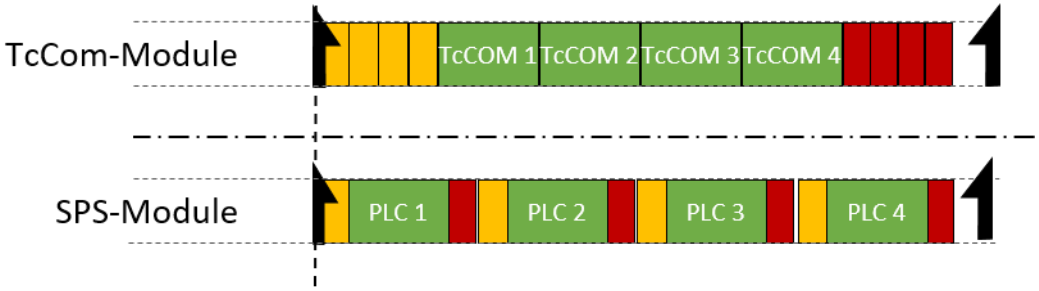


Differences in execution between PLC and "TcCom" runtime modules

Processing of a TwinCAT task, in relation to the execution of runtime modules, is based on the following sequence:

1. Copying of the inputs to the process images of the runtime modules called by the task.
2. Executing the modules according to the sort order (in ascending order).
3. Output update, which makes the outputs available accordingly. If this task drives an EtherCAT fieldbus, the frame is provided and sent during the output process image.
4. Post-cycle update: This is used, among other things, to trigger a cycle update when the "I/O at task start" option is active.

If runtime modules are added to a task, they "log on" to the respective calls of the task. The only exceptions are PLC runtime modules. For reasons of compatibility with TwinCAT 2, the PLC runtime modules directly update the inputs and outputs. The difference between the two behaviors is shown in the following figure:



Four runtime modules can be seen in each case. Standard TwinCAT 3 runtime modules log on to the corresponding method calls of the task. This means that all input updates (yellow) and output updates (red) are triggered by the task and take place one after the other directly at the start or end of task processing. If two of these modules communicate with each other via a mapping, they do not receive the current values until the next cycle.

The PLC runtime modules independently perform an input and output update. If two PLC runtimes communicate with each other, the runtime module that is executed second directly receives the current values from the first runtime module. Thus, there is no cycle offset in the communication direction from first runtime module to second runtime module, but there such an offset does exist in the other direction.

3.2 Display in the Real-time Monitor

In simple terms, the TwinCAT 3 Real-time Monitor enables the display of grouped events. In order to avoid confusion with the messages or alarms stored in the TwinCAT EventLogger, the data handled by the TwinCAT 3 Real-time Monitor are referred to as (time) markers.

These markers can be used to represent the temporal behavior of tasks or user processes. For this purpose, the markers are assigned an ID, a marker type, a context and a timestamp. In addition, if required a user-defined date formatted as UINT can be provided, in order to include additional information in the display in the real-time monitor (e.g. error number, state of a state machine etc.).

Marker ID:

The marker ID is used to identify the displayed task / process. In other words, all markers relating to the same task/process should use the same marker ID.

Marker type:

The TwinCAT 3 Real-time Monitor enables the display of events or processes / operations over time. For the representation of processes / operations, these are marked as a sequence. A sequence can be divided into one or more intervals. Markers can be typed to define the start or end of sequences or intervals. In addition, they can also show events within an application over time. A distinction is therefore made between the following types of markers:

1. Marker:
   The marker can be used to log an event, e.g. the time of an alarm or the change of a state etc.
2. Sequence start:
   A sequence start indicates the time when a task / process is allowed to start (higher-priority tasks / processes may result in a delay).
3. Interval start:
   An interval start specifies the time when a task / process actually starts. Due to interruptions etc., a sequence may contain several interval starts.
4. Interval stop:
   An interval stop specifies the time when a task / process is no longer executed. This can happen, for example, due to interruptions caused by higher-priority tasks or unfulfilled dependencies.
5. Sequence stop:
   A sequence stop indicates the point in time at which a task may no longer run or a process is terminated.

Context:

A context describes a summary of markers or marker groups.

For the system tasks, all tasks that are processed on a core are combined into one context (e.g. core 0). Such a (real-time) context thus maps the scheduling within a real-time kernel. For these real-time contexts, only one of the tasks assigned to a context is active at any one time. This restriction does not apply to user-specific marker groups.

When using simple markers (by using FB_Mark), the user-specific marker groups are automatically grouped according to their application ports. For example, all markers stored from within a PLC project with port 851 are assigned to a context with context ID 851 (hexadecimal 0x353).

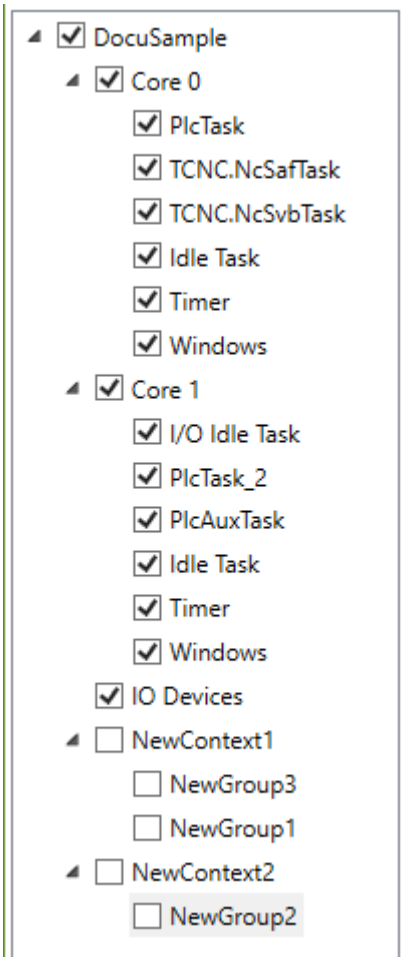
When using more complex markers (based on the function block FB_RTMon_LogMarkBase [▶ 37]), contexts (i.e. correlations) can be defined independently. This could be, for example, a grouping by process type or by machine modules (functional units).

Display in the tree view:

As described above, all markers that describe the same task / process use the same marker ID. These markers are combined into a marker group and are assigned an entry in the tree view of the TwinCAT 3 Real-time Monitor.

An entry with the corresponding task name is automatically created in the tree for the system tasks.

For user-related marker groups that describe processes, for example, this must be done manually. For each detected user-specific marker group an entry **NewGroup** automatically appears in the tree, which can be identified by the marker ID (corresponds to the group ID in the Properties window of the group). This group can be renamed as required (see Context node [▶ 31]).



As described under Display in the Real-time Monitor [▶ 13], the individual marker groups are combined into contexts. This happens automatically for the system tasks and when simple markers are used. When using extended markers, the context ID that is transferred in the application code is used for this purpose.

The names of marker IDs (group IDs) and contexts can be exported for later reuse and subsequently re-imported.

In the chart display, a marker group (i.e. all markers of a task / process) is shown within one row. For more information see Display in the Real-time Monitor [▶ 14].

Chart display:

Symbols in the chart display:

	Sequence start
	Sequence stop
	Indicates an interval start or stop.
	Marker

Example display:

The following diagram shows an example of a possible temporal behavior of a task. At time (1), the task receives "permission" to run based on the set cycle time. The start may be delayed until time (2) due to missing dependencies or due to higher priority tasks that are still active. At time (3) a marker was transferred. This can be a "system event" marker or a user-defined marker. Detailed information is provided by a tooltip associated with the marker. The marker itself has no influence on the temporal behavior of the task / process. At time (4) the task is interrupted (once again for example due to an interlock or a higher-priority task). At time (5) the task continues to run. At time (6) the task is finished.

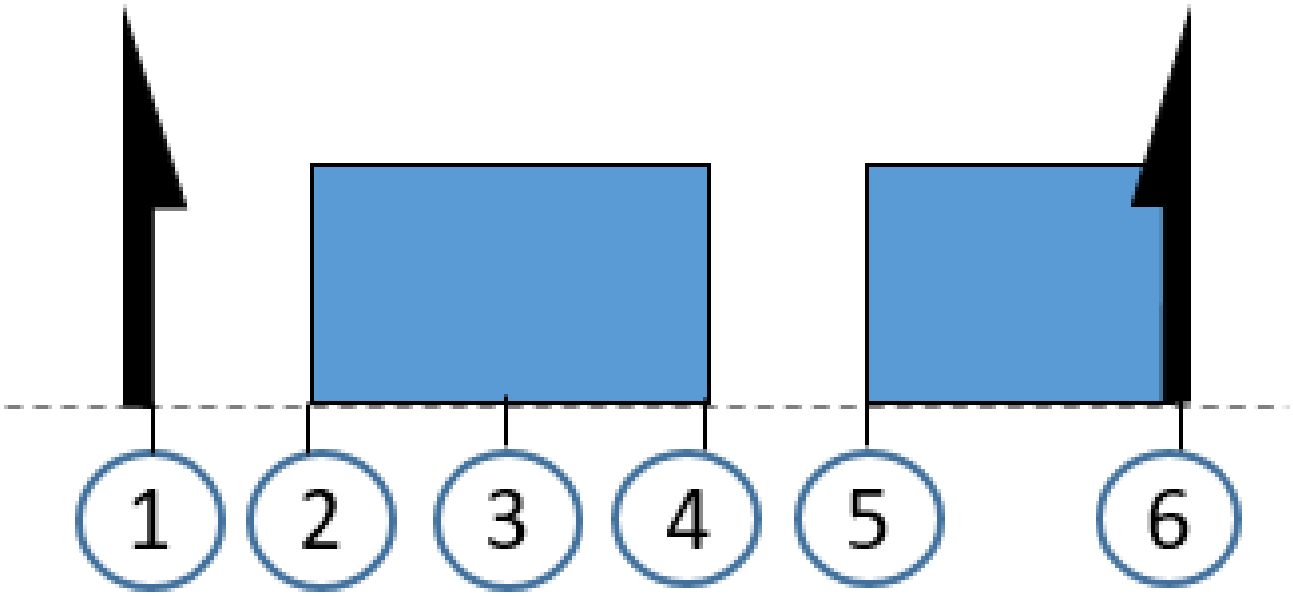
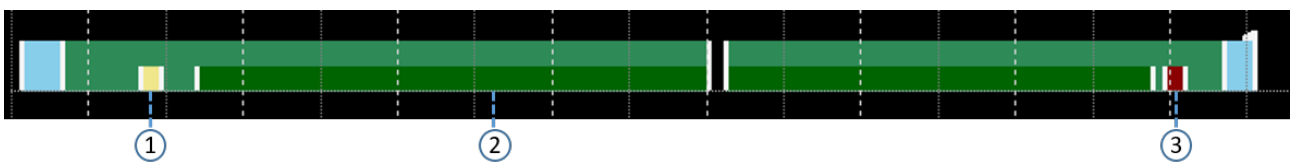


Illustration of the processing of a PLC runtime module:

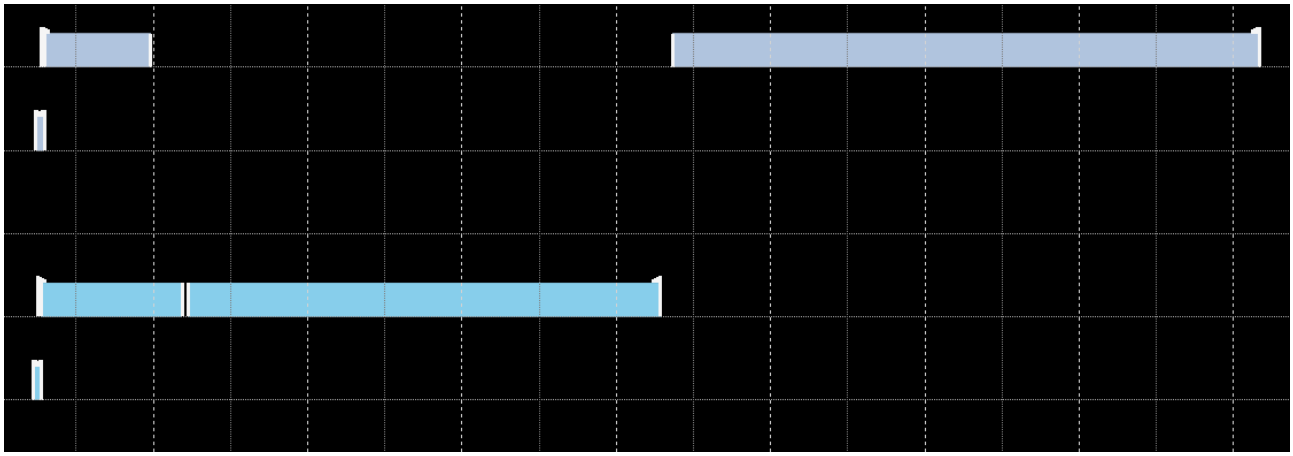
As described in section TwinCAT 3 Real-Time [▶ 12], each PLC runtime module calls the update of the inputs and outputs itself. The complete processing of the PLC takes place in the cyclic update of the task calling it. For this reason, if detailed logging is activated, processing of the PLC is mapped in the cyclic update of a task. The following figure illustrates this by means of an example. Time (1) shows the execution of the input update of the PLC runtime module. Cyclic processing of the PLC code takes place in area (2), which is interrupted by another task in the example shown here. Once processing is completed, the output update of the PLC runtime module takes place at time (3). In the example shown here, the task itself does not perform an input or output update.



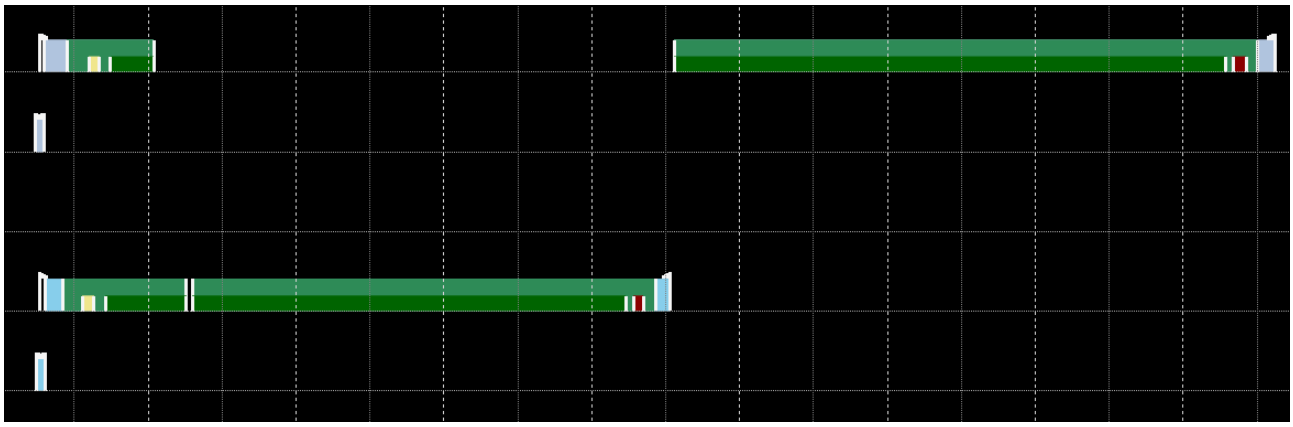
Detailed logging:

The option "detailedLogging" (see Project node [▶ 30] or Context node [▶ 31]) offers a detailed representation of the execution of real-time tasks (also within a task). The following two figures illustrate the difference.

Standard logging enabled:



DetailedLogging enabled:



Representation of the task references:

The option **Show Task Reference** (see Marker group element [▶ 32]) enables the assignment of user processes to the tasks on which they are executed to be made visible in the TwinCAT 3 Real-time Monitor. This is represented by dashed lines. The following figure shows the assignment of the user process shown in orange to a PLC task.

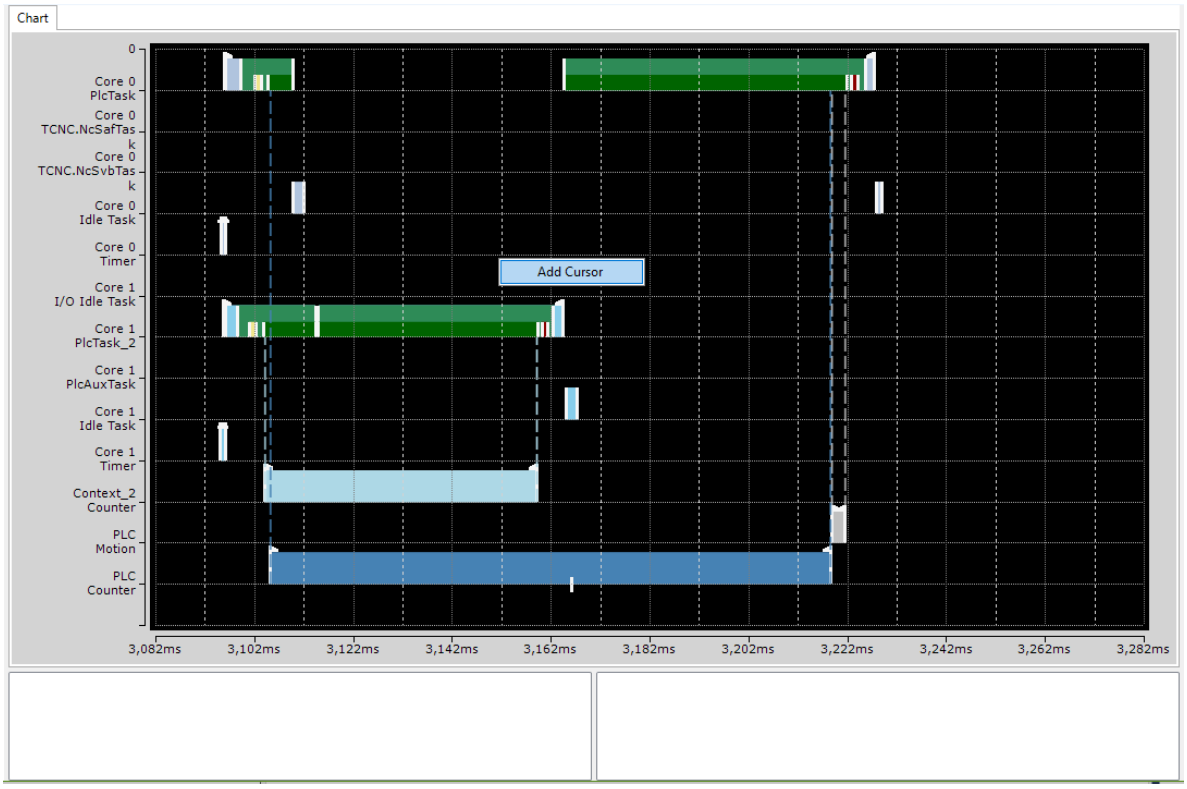
3.3 Use of cursors

In order to measure times or to display all (system) events that occur at a particular time, cursors can be used in the TwinCAT 3 Real-time Monitor.

Adding cursors

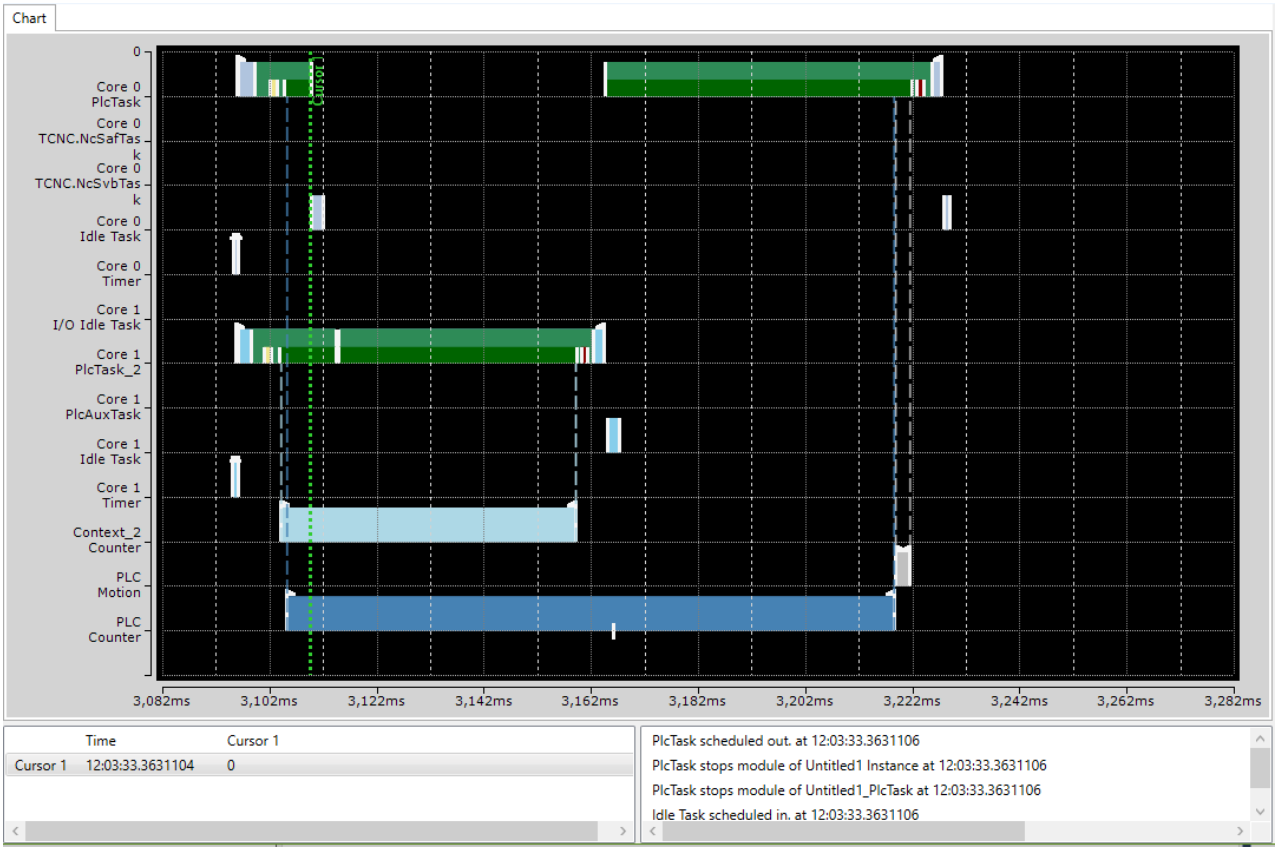
To add a cursor, proceed as follows:

1. Right-click within the display area of the chart.
   ⇨ A context menu opens, which contains the command **Add Cursor** as well as a command to delete all existing cursors.



2. Click **Add Cursor.**

⇨ A new cursor is created in the center of the chart.

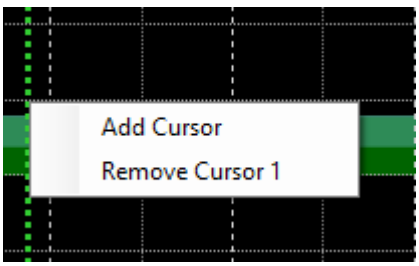


Deleting cursors

There are two ways to delete a cursor:

Inside the chart

1. Right-click within the display area of the chart
   ⇨ A context menu opens which contains a command to delete all existing cursors.



2. Use the **Remove Cursor** command of the cursor you want to delete.

⇨ The cursor is deleted.

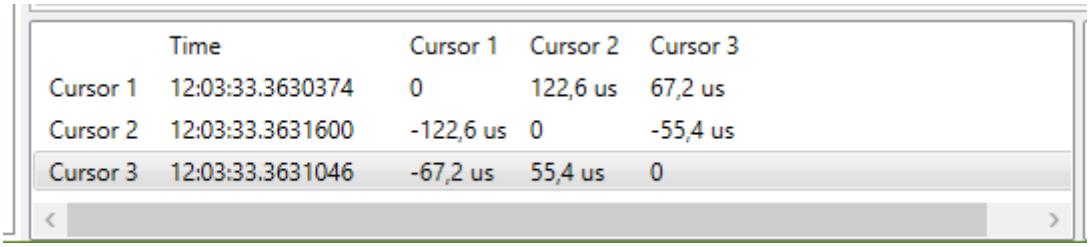
Inside the cursor window

1. Right-click the cursor you want to delete.
   ⇨ A context menu opens with a command to remove the cursor.
2. Use the command **Remove Cursor** to delete this cursor.

⇨ The cursor is deleted.

Navigating using the cursors

All cursors that were created are displayed in the cursor window.

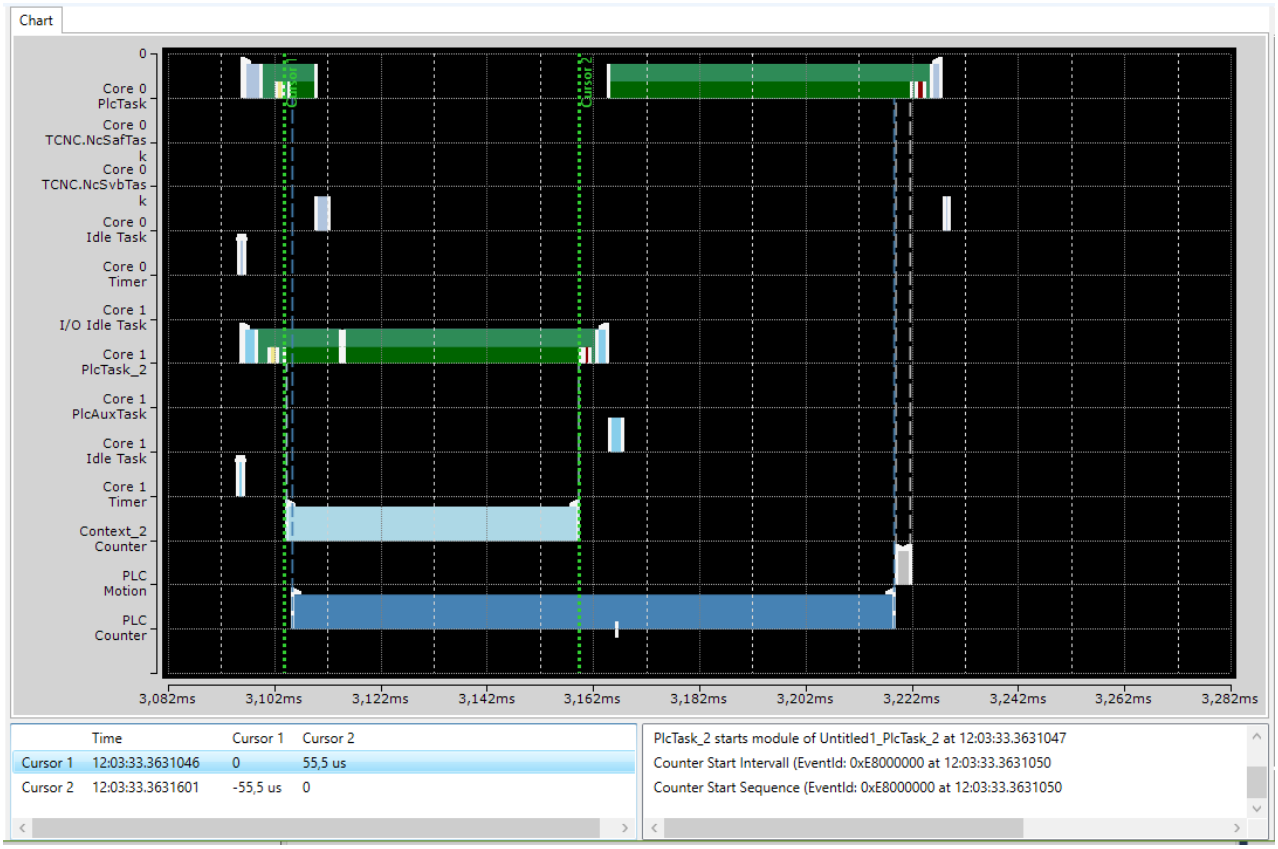


	Time	Cursor 1	Cursor 2	Cursor 3
Cursor 1	12:03:33.3630374	0	122,6 us	67,2 us
Cursor 2	12:03:33.3631600	-122,6 us	0	-55,4 us
Cursor 3	12:03:33.3631046	-67,2 us	55,4 us	0

Double-clicking a cursor causes the display within the chart to jump to the exact position where the cursor is positioned. The cursor is centered in the display area.

Measuring times

The cursors can be used to precisely determine the execution times of processes or the time of occurrence of a user event. To do this, move one cursor to a relevant time within the display. The cursor automatically "latches" to events and displays the events occurring at that time for the active cursor in the cursor window. In the following figure, this is the application event **Counter Start Interval** for cursor 1.



To measure the duration of the process "Context_2_Counter", proceed as follows:

1. Create a cursor for the process start or use an existing cursor.
2. Move the cursor to the sequence / interval start marker of the process "Context_2_Counter" so that this event is displayed in the Event window (see figure above).
3. Proceed accordingly with another cursor and move it to the sequence / interval stop marker of the process "Context_2_Counter“.
   ⇨ The differences between all existing cursors are now displayed in tabular form in the cursor window.
4. Read the value for the cursor you are using directly from the table. For the example shown here, the execution time is 55.5 µs.

Cursor properties

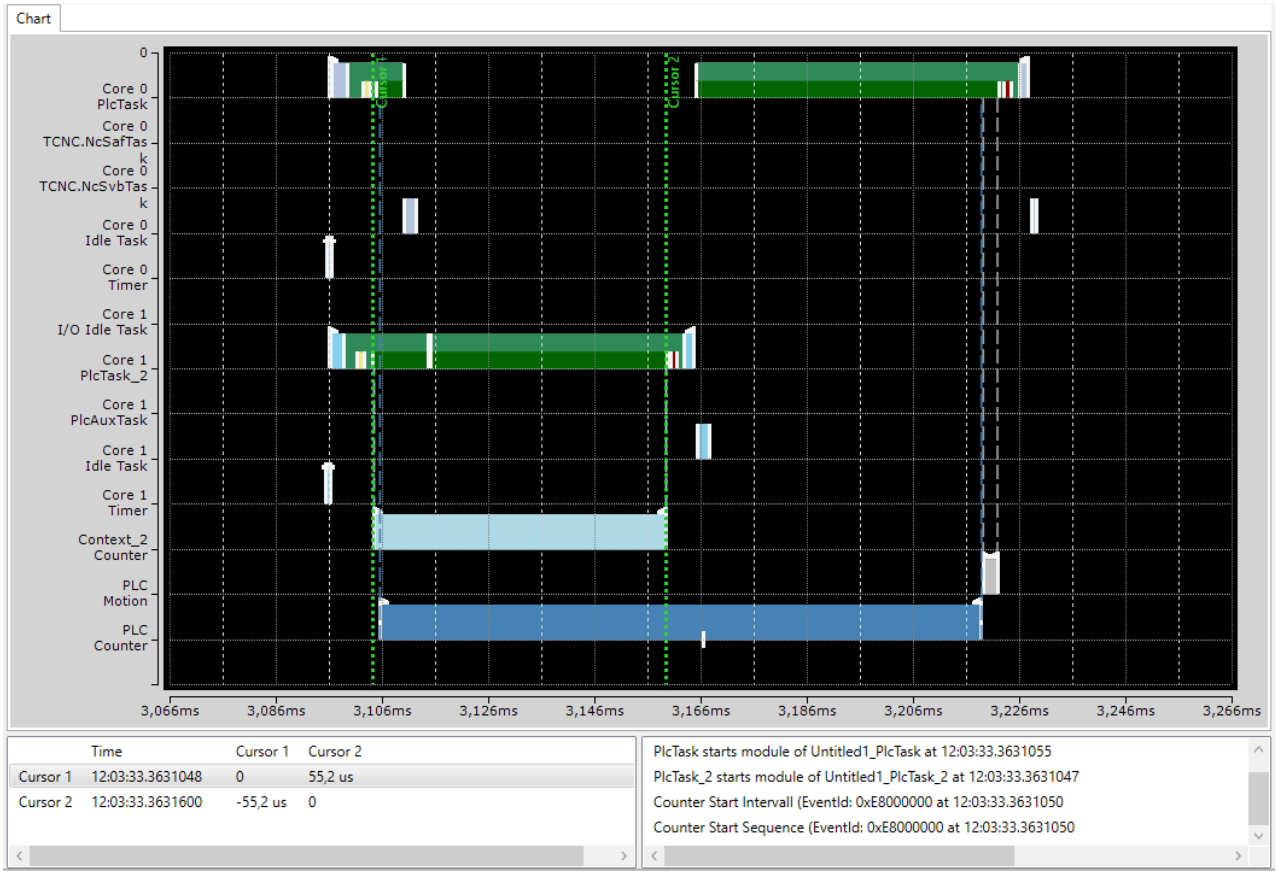
The following properties are available for cursors.

Property	Meaning
Cursor info	
Color	Allows you to change the color of the active cursor.
Text	Shows the text displayed at the cursor.
Information	
TriggerCursor	Activates the property TriggerCursor, which causes a cursor in trigger mode to remain at the same position in the chart window, rather than being latched to a point in time (which would cause it to disappears from the display area).

Event window

The Event window shows all events taking place at this time for the active cursor. In the following figure, these are the following events for cursor 1:

- The PlcTask starts processing of the runtime module Untitled1.
- PlcTask_2 also starts processing of the runtime module Untitled2.
- The Counter application process starts both the sequence and the interval.



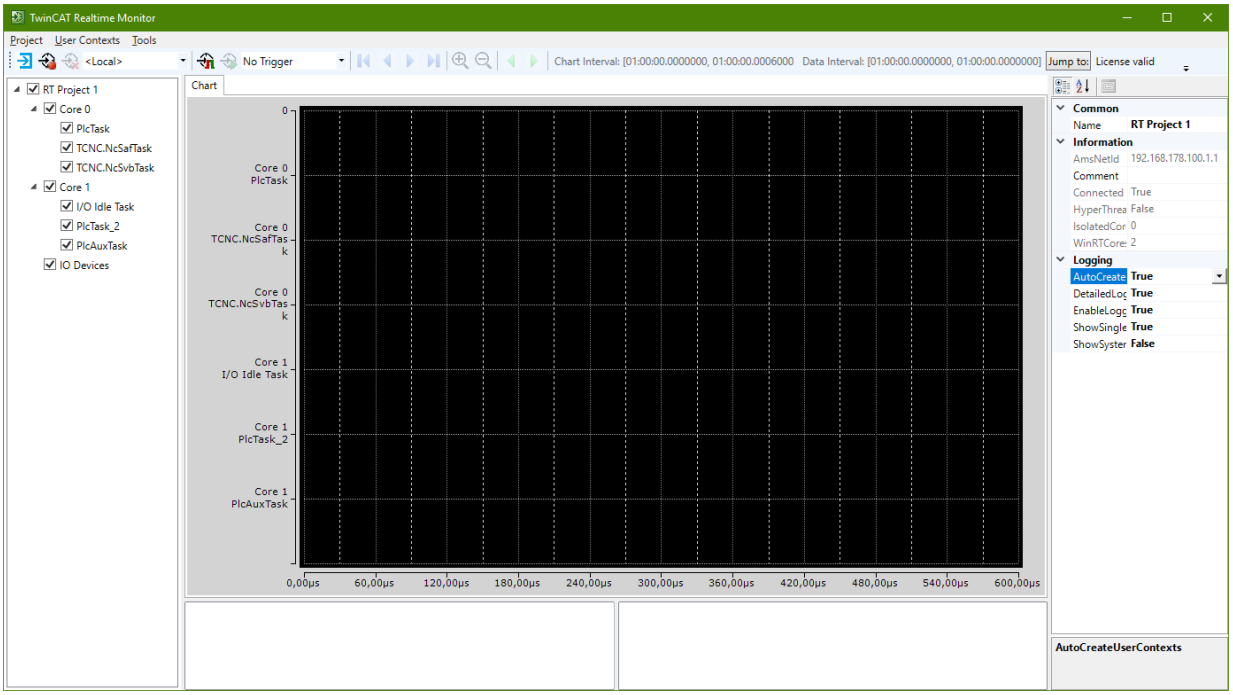
4 Quick start

The following chapter is intended to provide an introduction to using the TwinCAT 3 Real-time Monitor.

✓ The starting point is a project running on a TwinCAT 3.1 runtime version 3.1.4024.0 or later.

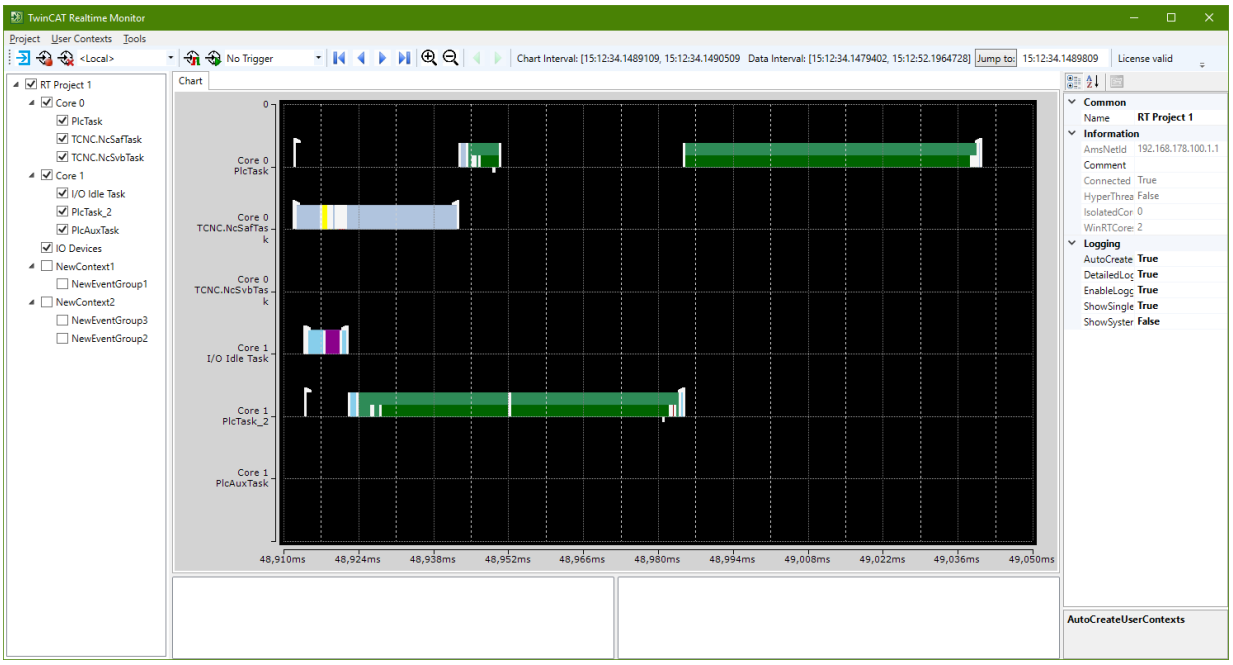
1. Open the Real-time Monitor.
2. Create a new project.
   To do this, use the **New Project** option in the **Project** menu of the TwinCAT 3 Real-time Monitor. The project name can be changed via the project properties (see Project node [▶ 30]).
3. Now select the target system that you want to analyze. This is done via the toolbar of the TwinCAT 3 Real-time Monitor.
4. A prompt appears asking whether you want to load the configuration from the target system. Confirm with "Yes“

   ⇨ The active configuration of the target system has been loaded and the contexts are displayed hierarchically as a tree.
5. Select the tasks that you want displayed in the TwinCAT Real-time Monitor



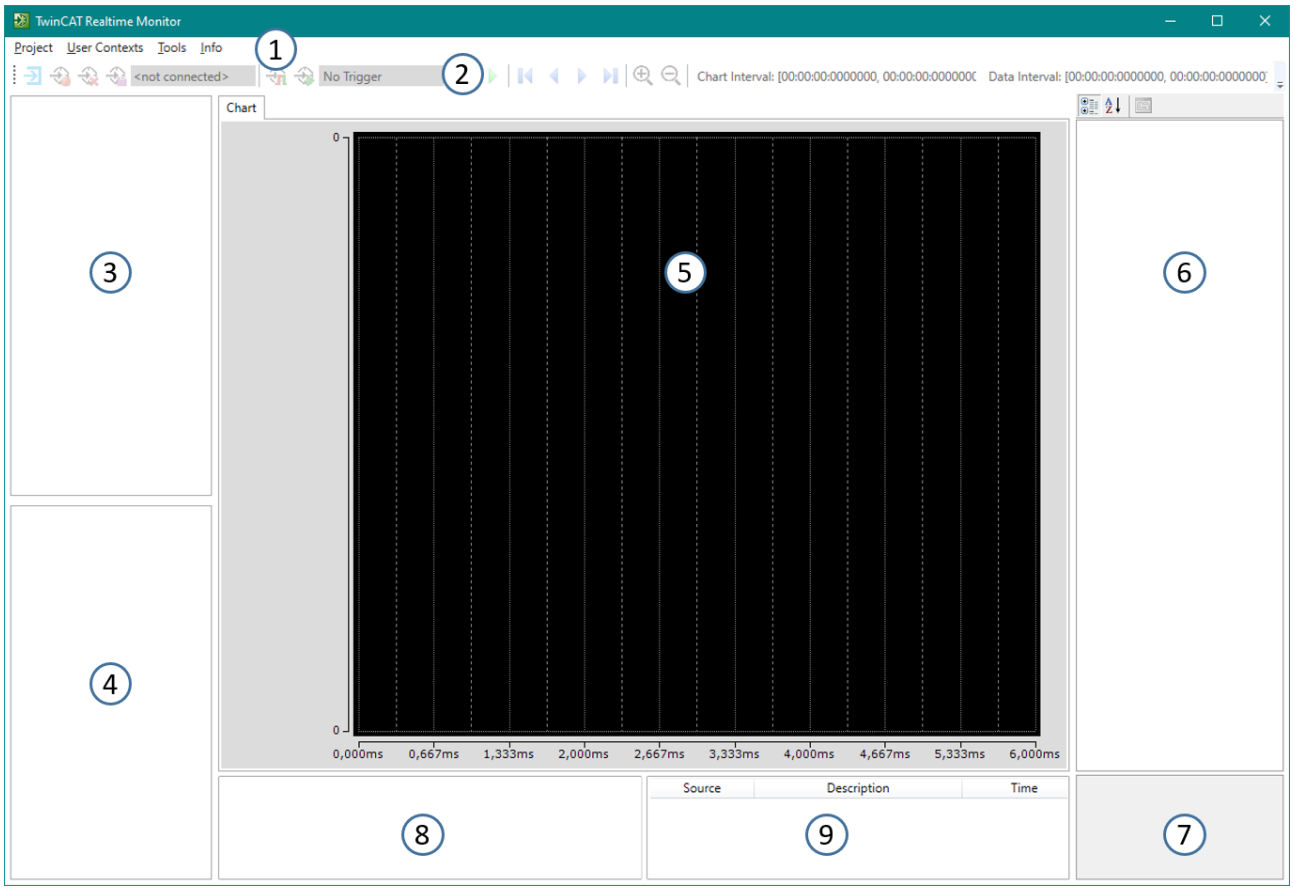
6. Select the project in the tree view and set the **Detailed Logging** option in the Properties window to "True" (see also Marker group element [▶ 32]).
7. If you also want to automatically read the user contexts that may have been set in an application program, set the **AutoCreateUserContexts** option to "True" as well.
8. Click the **Start Log** button in the toolbar of the TwinCAT 3 Real-time Monitor.

⇨ Recording of the real-time behavior begins.



5 Reference, user interface

The user interface of the TwinCAT 3 Realtime Monitor consists of the following components:



1	Menu bar
2	Toolbar
3	Project tree
4	Recordings
5	Display window
6	Properties window
7	Description display of the selected property
8	Cursor window
9	Event window

Project tree: the various time contexts are displayed in the project tree of the TwinCAT 3 Realtime Monitor.

5.1 Menu bar

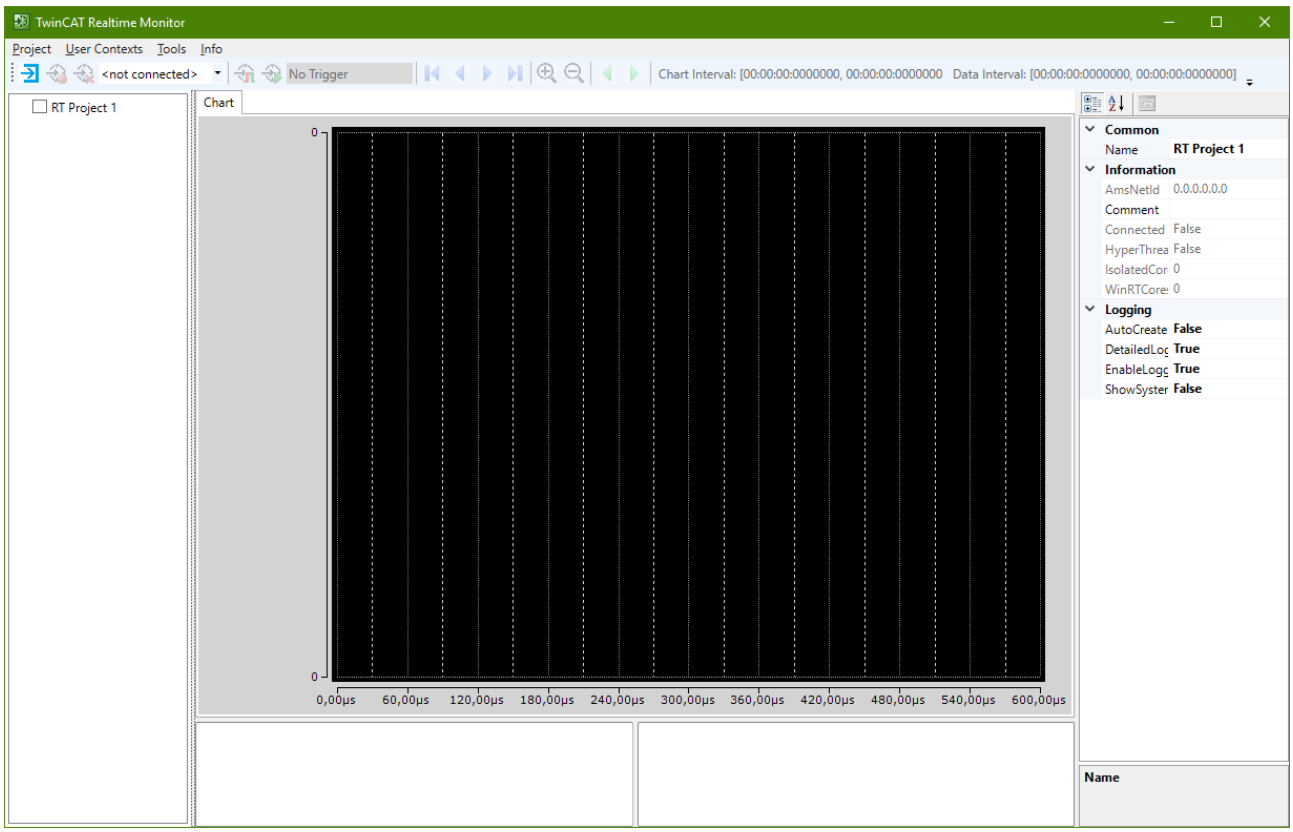
5.1.1 Project

New Project

Function: this command creates a new TwinCAT 3 Realtime Monitor project.

Call: menu **Project** > **New Project**

After a new project has been created, the TwinCAT 3 Realtime Monitor appears as follows:



Open Project

Function: this command opens an existing TwinCAT 3 Realtime Monitor project.

Call: menu **Project** > **Open Project**

Save Project

Function: this command saves an existing TwinCAT 3 Realtime Monitor project.

Call: menu **Project** > **Save Project**

Save Project as

Function: the command saves an existing TwinCAT 3 Realtime Monitor project under a name to be defined.

Call: menu **Project** > **Save Project as**

Save Project to archive

Function: the command saves an existing TwinCAT 3 Realtime Monitor project including the recordings contained therein to a zip file.

Call: menu **Project** > **Save Project to archive**

Close Project

Function: this command closes an existing TwinCAT 3 Realtime Monitor project.

Call: menu **Project** > **Close Project**

Import Recording

Function: the command imports recordings and inserts the recording at the end of the recording list.

Call: menu **Project** > **Import Recordings**

5.1.2 User contexts

Import User Contexts

Function: this command imports existing user contexts into a TwinCAT 3 Realtime Monitor project. If the project contains previously (automatically) found contexts with the same event groups and event IDs, the user is asked whether these should be replaced by the saved names and settings.

Call: menu **User Contexts** > **Import User Contexts**

Export User Contexts

Function: this command exports existing user contexts from an open TwinCAT 3 Realtime Monitor project.

Call: menu **User Contexts** > **Export User Contexts**

Scan User Contexts

Function: this command scans for existing user contexts and inserts them into a TwinCAT 3 Realtime Monitor project.

Call: menu **User Contexts** > **Scan User Contexts**

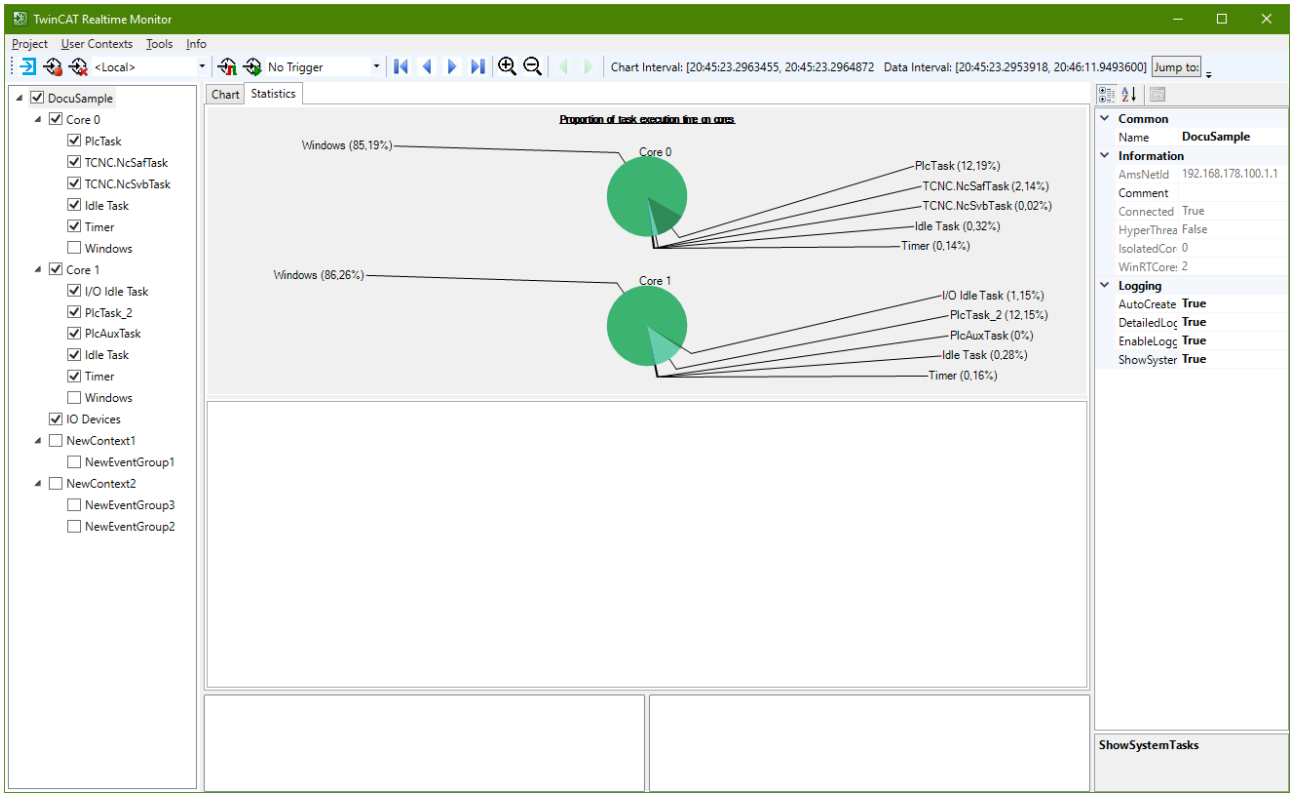
5.1.3 Tools

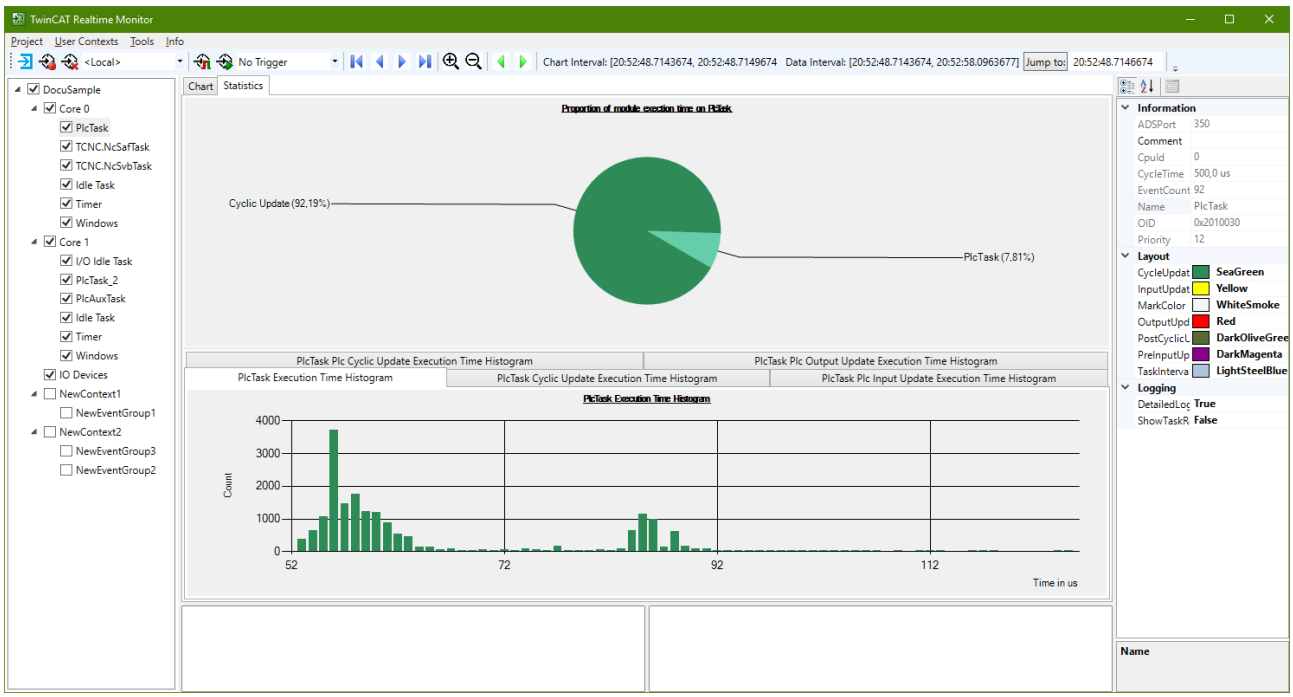
Create Statistics

Function: the command evaluates the markers recorded with the TwinCAT 3 Realtime Monitor and generates a statistic. This is displayed in the **Statistics** tab.

Call: menu **Tools** > **create Statistics**

Examples of generated statistics:





Export Statistics

Function: the command exports the selected statistics to a CSV file.

Call: menu **Tools** > **Export Statistics**

Set Trigger Prelude

Function: the command determines the prelude of a trigger. The values 1 s, 10 s, 30 s and 1 min are available. From version 1.2 of the Realtime Monitor, you can find this setting under the properties of the Realtime Monitor project node (see Project node [▶ 30]).

Call: menu **Tools** > **Set Trigger Prelude**

5.1.4 Info

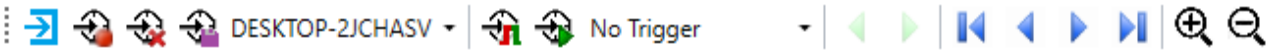
Real-time Monitor

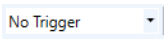
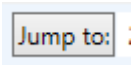
Function: The command opens a dialog window showing the version number of the installed TwinCAT 3 Real-time Monitor version.

Call: Menu **Info** > **Real-time Monitor**

5.2 Toolbar - Real-time Monitor toolbar

The TwinCAT 3 Realtime Monitor toolbar provides the following commands.



	Loading the project configuration from the set target system
	Start recording
	Stop recording
	Deleting the displayed data and deleting the recorded data
	Saving the recorded data within the project
	Choose Target System
	Start triggering on live data
	Start triggering on recorded data
	Selecting a trigger
	Manual jump to next trigger-event
	Manual jump to previous trigger-event
	Jump to the start of the display
	Move the display to the left
	Move the display to the right
	Jump to the end of the display
	Zoom In
	Zoom Out
Chart Interval	Time interval of the area displayed in the current section
Data Interval	Time interval of the recorded data
	Jump to the time specified in the selection field after it
	Input field for entering a time

5.3 Project tree

The project tree hierarchically displays all marker groups and their assignment to contexts. An entry with the corresponding task name is automatically created in the tree for the system tasks. System tasks are grouped into corresponding contexts once they have been assigned to cores.

An entry is also created in the project tree for user-related marker groups. Depending on the call used, the assignment to contexts in the user program (see FB_RTMon_LogMark [▶ 34] or FB_RTMon_LogMarkBase [▶ 37]) is made either in relation to the ADS port of the user program or based on a user-defined context ID.

The user-related nodes are created either manually by using the context menu entries (see Project tree [▶ 28]) or automatically if the **AutoCreateUserContexts** option (see Project node [▶ 30]) is enable or the User contexts [▶ 25] option is called.

User-related nodes are named according to their Properties page (see Context node [▶ 31] or Marker group element [▶ 32]).

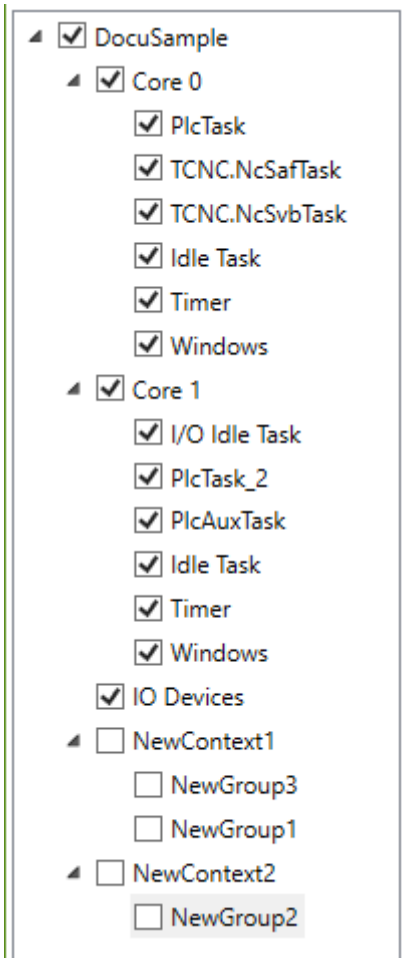
Context menu entries in the project tree

The following table shows all context menu entries in the project tree (and the node type on which they are available).

Command	Node type	Meaning
Add New User Context	Project node	Adds a user context.
Import User Context	Project node	Imports a user-related context including all subelements.
Add New User Group	User-related context node	Adds a user-related marker group.
Remove User Context	User-related context node	Deletes a user-related context.
Export User Context	User-related context node	Exports a user-related context including all subelements.
Remove User Group	User-related marker group node	Deletes a user-related marker group.

Sample:

The following figure shows the representation of a project tree as it is automatically generated after the recording is started (with the **AutoCreateUserContexts** option activated). In addition to the system tasks distributed over Core 0 and Core 1, three user-related marker groups are generated, which have not yet been named here.



5.4 Recording list

Multiple recordings can be managed in one Realtime Monitor project. These are displayed in the recording list.

Context menu entries in the recording list

The following table shows all context menu entries:

Command	Meaning
Load Recording to Chart	Loads the selected recording into the display window.
Remove Recording from List	Removes the recording from the list. The recording file is retained on the hard disk.
Delete Recording File	Removes the recording from the list and deletes the corresponding file from the hard disk.

Saving a recording

After you have finished a recording with the Realtime Monitor, you can save the data as a recording within the project by clicking the button  (**Save collected data within project**) in the toolbar [▶ 26].

Adding a recording

To add already recorded data to a Realtime Monitor project, use the "Import Recording" menu entry in the *Project* menu. The recording is then added to the end of the list and numbered accordingly in ascending order.

The data files of the Realtime Monitor contain only the name of the project. The data files themselves have no name, only a timestamp. So, if recordings are removed from the project and added again later, the displayed names (e.g. the displayed recording number) will differ. The start and end time of a loaded recording is displayed in the properties of the project (see Project node [▶ 30]).

Removing a recording

If a recording is to be removed from the project but not deleted from the hard disk, select this recording in the recording list so that it is highlighted. Then use the context menu item "Remove Recording from List".

Deleting a recording

If you want to delete a recording from the project as well as from the hard disk, select this recording in the recording list so that it is marked. Then use the context menu item "Delete Recording File".

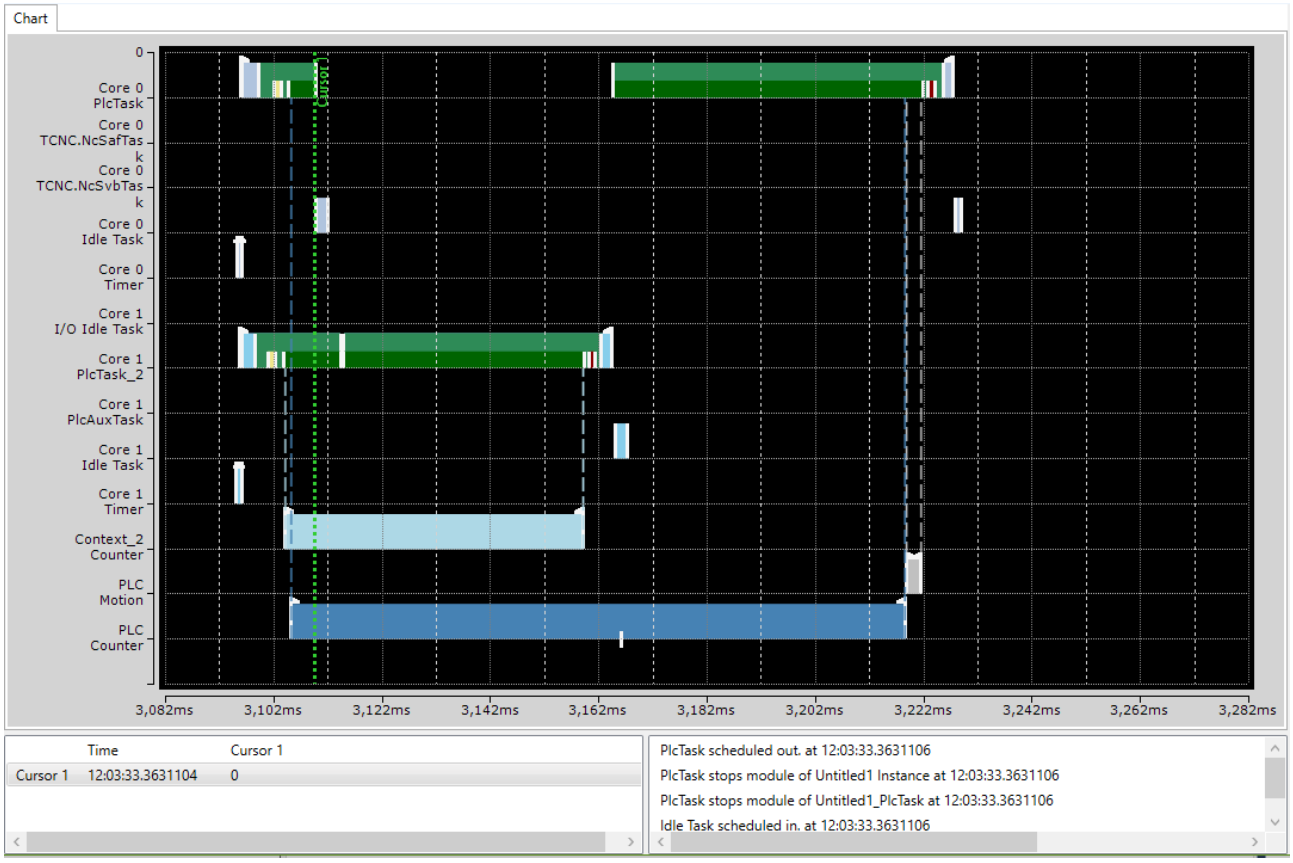
Requirement:

Recording functionality is available on Realtime Monitor version 1.2.

5.5 Display window

In the display window (chart) the (time) markers are displayed over time, sorted according to the individual marker groups.

With the help of the functions in the toolbar (see Toolbar - Real-time Monitor toolbar [▶ 26]) or accordingly using the mouse or similar operating devices, you can navigate within the display window or enlarge / reduce the display.



Via context menu entries in the display window it is possible to set, delete or move cursors to perform time measurements or analyses (see Use of cursors [▶ 17]).

5.6 Properties window

The Properties window shows the properties of the currently active (selected) element of the project tree.

The properties listed in the **Logging** area always apply to all subelements of the tree. The **Different Settings** value indicates that the values of the subelements are different. By changing the value, the values of the subelements are also changed.

5.6.1 Project node

The following settings are available on the project node of the TwinCAT 3 Realtime Monitor:

Property	Meaning
Common	
Comment	Comment on the project
Name	Name of the project
Information	
AmsNetId	AmsNetId of the target system
Connected	Connection status to target system
HyperThreading	Indicates whether hyperthreading is active.
Isolated cores	Displays the number of isolated cores used in the project.
WinRTCores	Displays the number of Windows real-time cores used in the project
XAR version	Displays the TwinCAT version of the target system.
Live Trigger	
Store Trigger Data	Stores trigger data as a recording.
Trigger Prelude	Defines the time in seconds before a trigger event (trigger advance).
Trigger Samples	Defines the number of trigger samples to be stored.
Loaded Recording	
Loaded Recording	Name of the currently loaded recording
Recording End	End time of the recording
Recording Start	Start time of the recording
Logging	
DetailedLogging	Enables detailed logging.
EnableLogging	Enables logging.
ReduceOnZoom	Reduces the display depth when zooming out (markers lying directly adjacent to one another are combined as a bar) in order to increase performance.
ShowSystemTasks	Also shows the system tasks.

The properties listed in the **Logging** area always apply to all subelements. In other words, these properties at the project level apply to the entire Realtime Monitor project. If the value after one of the properties in the Logging area is a "Different Settings", this means that the values in the individual sub-nodes differ. Changing the value at the project level sets the values for all subelements.

5.6.2 Context node

The following settings are available on the context node of the TwinCAT 3 Real-time Monitor. These differ according to real-time contexts (here the context corresponds to a computer core) and application contexts.

Real-time context:

Property	Meaning
Information	
BaseTime	Base time of the core
Comment	Comment
DefaultCore	Indicates whether the core is the default core
Id	Shows the ID of the core
Name	Shows the name of the core
RT_Percentage	Shows the set maximum real-time load
Type	Shows the type of core (WindowsRT/ isolated core)
Logging	
DetailedLogging	Enables detailed logging
EnableLogging	Turns logging on / off

Application context:

Property	Meaning
Information	
Comment	Comment
ContextId	ContextId that was transferred at the markers
Name	Name of the context

If the function block FB_RTMon_LogMark [▶ 34] is used, the port number of the PLC runtime module is automatically set as ContextId.

5.6.3 Marker group element

The following settings are available on the marker group / process nodes of the TwinCAT 3 Real-time Monitor. They differ according to real-time tasks and application processes / markers.

Real-time tasks:

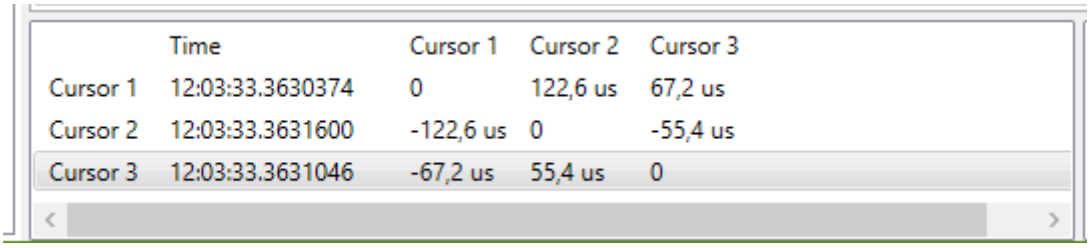
Property	Meaning
Information	
ADSPort	ADS port of the task
Comment	Comment
CpuId	CpuId on which the task is executed
CycleTime	Task cycle time
EventCount	Number of executions (within the recording time)
Name	Name of the task
OID	ObjectId of the task
Priority	Set priority
Layout	
CycleUdateColor	Color of the CycleUpdate of a task (default: green)
InputUpdateColor	Color of the InputUpdate of a task (default: yellow)
MarkColor	Marker color (default: white)
OutputUpdateColor	Color of the output update of the task (default: red)
PostCyclicUpdateColor	Color of the PostCyclicUpdate of the task (default: dark green)
PreInputUpdateColor	Color of the PreInputUpdate of the task (default: magenta)
TaskIntervalColor	Color of the task interval marker (default: light blue)
Logging	
DetailedLogging	Activate detailed logging
ShowTaskReference	Displaying the task references

User processes:

Property	Meaning
Information	
Comment	Comment
EventCount	Number of executions (within the recording time)
GroupId	ID of the marker group / process
Name	Name of the process to be displayed
Layout	
EventIntervalColor	Color for the interval / active execution of the process (default: blue)
MarkColor	Color of the markers (default: white)
Logging	
ShowSingleMarker	Enables the display of individual markers
ShowTaskReference	Enables the display of task references (assignment of process markers to real-time tasks by dashed lines)

5.7 Cursor window

All cursors that were created are displayed in the cursor window.



	Time	Cursor 1	Cursor 2	Cursor 3
Cursor 1	12:03:33.3630374	0	122,6 us	67,2 us
Cursor 2	12:03:33.3631600	-122,6 us	0	-55,4 us
Cursor 3	12:03:33.3631046	-67,2 us	55,4 us	0

Double-clicking a cursor causes the display within the chart to jump to the exact position where the cursor is positioned. The cursor is centered in the display area.

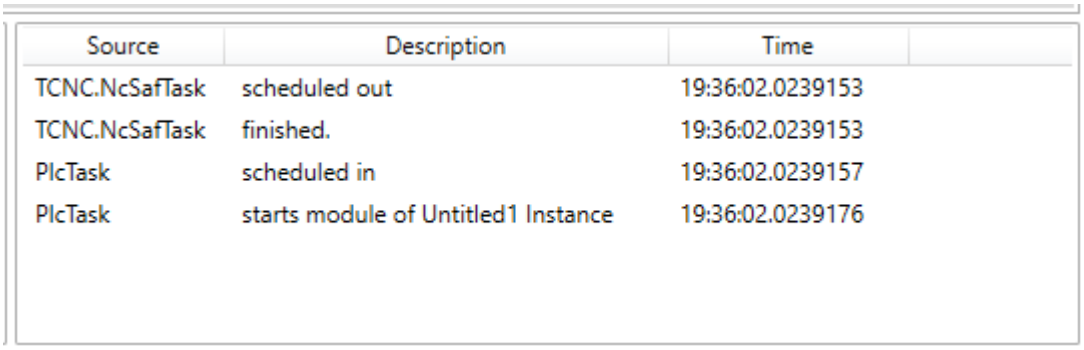
The selected cursor can be deleted using the context menu entry **Remove Cursor**.

The use of cursors is described in detail under Use of cursors [▶ 17].

5.8 Event window

The Event window shows all events taking place at this time for the active cursor. In the following figure, these are the following events for cursor 1:

- The NC-SAF task is terminated.
- The NC-SAF task is finished.
- The sheduler starts the PlcTask.
- The PlcTask starts processing of the runtime module Untitled1.



Source	Description	Time
TCNC.NcSafTask	scheduled out	19:36:02.0239153
TCNC.NcSafTask	finished.	19:36:02.0239153
PlcTask	scheduled in	19:36:02.0239157
PlcTask	starts module of Untitled1 Instance	19:36:02.0239176

6 PLC API

6.1 Function blocks

6.1.1 FB_RTMon_LogMark


```
FUNCTION_BLOCK FB_RTMon_LogMark
VAR_INPUT
    nContextId        : UINT := TwinCAT_SystemInfoVarList._AppInfo.AdsPort;
    bLogCallingTask   : BOOL := TRUE; // specifies whether a reference to the calling task should be
set with each mark
END_VAR
VAR_OUTPUT
    bError            : BOOL;          // TRUE if an error occurred
    hrErrorCode       : HRESULT;      // outputs the error code which occurred
END_VAR
```

Description:

The FB_RTMon_LogMark is an extended function block that enables the setting of "simple" (time) markers.

For "simple" markers, the context of the calling user program is used automatically. The possible marker types (sequence start & stop, interval start & stop or marker) are made available via individual methods. Only the marker ID (marker group) must be transferred by the user. This is used to identify the process to be displayed.

Optionally, an event ID is also available in which the user can transfer a user record (e.g. status of a state machine, error message …)

6.1.1.1 LogIntervalStart


```
// Starts logging interval
METHOD LogIntervalStart : HRESULT
VAR_INPUT
    nGroupId    : UINT; // Defines the group to which the interval belongs
    nEventId    : UINT; // Set to distinguish different events inside the group
END_VAR
```

Description

The method creates a marker with an interval start for the transferred marker ID.

Parameter:

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

6.1.1.2 LogIntervalStop


```
METHOD LogIntervalStop : HRESULT
VAR_INPUT
    nGroupId    : UINT; // Defines the group to which the interval belongs
    nEventId    : UINT; // Set to distinguish different events inside the group
END_VAR
```

Description

The method creates a marker with an interval stop for the transferred marker ID.

Parameter:

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

6.1.1.3 LogMark


```
// Logs a mark without start/stop
METHOD LogMark : HRESULT
VAR_INPUT
    nGroupId    : UINT; // Defines the group to which the mark belongs
    nEventId    : UINT; // Set to distinguish different events inside the group
END_VAR
```

Description

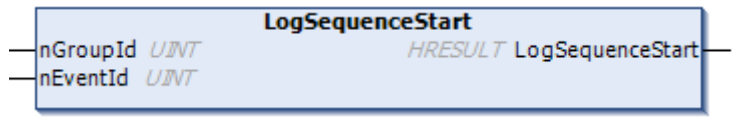
The method creates a marker for the marker ID that was transferred. Optionally, the event ID can be used to distinguish between different user events or to display additional data (formatted as UINT) in the TwinCAT 3 Real-time Monitor display.

Parameter:

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

6.1.1.4 LogSequenceStart




```
// Starts logging sequence
METHOD LogSequenceStart : HRESULT
VAR_INPUT
    nGroupId    : UINT; // Defines the group to which the sequence belongs
    nEventId    : UINT; // Set to distinguish different events inside the group
END_VAR
```

Description

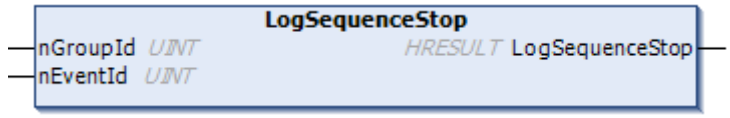
The method creates a marker with a sequence start for the marker ID that was transferred.

Parameter:

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

6.1.1.5 LogSequenceStop




```
// Stops logging sequence
METHOD LogSequenceStop : HRESULT
VAR_INPUT
    nGroupId    : UINT; // Defines the group to which the sequence belongs
    nEventId    : UINT; // Set to distinguish different events inside the group
END_VAR
```

Description

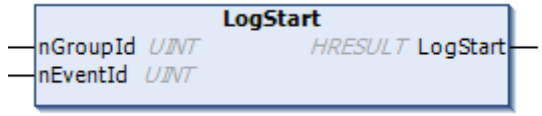
The method creates a marker with a sequence stop for the marker ID that was transferred.

Parameter:

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

6.1.1.6 LogStart




```
// Starts logging sequence and interval
METHOD LogStart : HRESULT
VAR_INPUT
    nGroupId    : UINT; // Defines the group to which the sequence and intervall belong
    nEventId    : UINT; // Set to distinguish different events inside the group
END_VAR
```

Description

The method creates a marker with a sequence and interval start for the transferred marker ID.

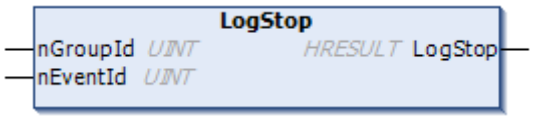
Thus this marker represents the time of a process at which it is immediately active / started.

Parameter:

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

6.1.1.7 LogStop




```
// Stops logging sequence and interval
METHOD LogStop : HRESULT
VAR_INPUT
    nGroupId    : UINT; // Defines the group to which the sequence and intervall belong
    nEventId    : UINT; // Set to distinguish different events inside the group
END_VAR
```

Description

The method creates a marker with a sequence and interval stop for the transferred marker ID.

Thus, this marker represents the point in time of a process at which it is terminated directly.

Parameter:

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

6.1.2 FB_RTMon_LogMarkBase


```
FUNCTION_BLOCK FB_RTMon_LogMarkBase
VAR_INPUT
END_VAR
VAR_OUTPUT
    bError        : BOOL;        // TRUE if an error occurred
    hrErrorCode   : HRESULT;     // outputs the error code which occurred
END_VAR
```

Description:

FB_RTMon_LogMarkBase is a basic function block that enables the setting of (time) markers.

In contrast to the function block FB_RTMon_LogMark [▶ 34], the context ID itself must be transferred here. This makes it possible to group the processes to be displayed (for example, by process type or functional unit).

Optionally, an event ID is also available in which the user can transfer a user record (e.g. status of a state machine, error message).

6.1.2.1 LogMark


```
METHOD LogMark : HRESULT
VAR_INPUT
    nContextId : UINT;     // defines the context
    nGroupId   : UINT;     // defines the group inside the context
```

```
    nEventId   : UINT;     // defines the specific event inside the group
    nMarkCtrl  : UDINT;    // mask for mark options (listed in TcMarkOption)
END_VAR
```

Description

The method creates a marker for the transferred marker group ID. The marker type is transferred using the parameter nMarkCtrl (see TcMarkOption [▶ 39]).

Optionally, the event ID can be used to distinguish between different user events or to display additional data (formatted as UINT) in the TwinCAT 3 Real-time Monitor display.

Parameter:

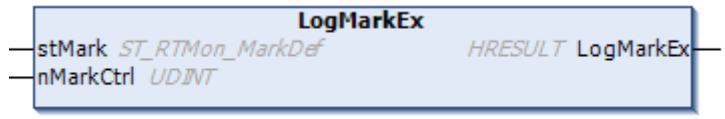
nContextId: defines the context ID under which the marker is to be grouped in the TwinCAT 3 Real-time Monitor.

nGroupId: Marker ID (marker group) for which the marker is to be written.

nEventId: optional EventId.

nMarkCtrl: defines the marker type.

6.1.2.2 LogMarkEx




```
METHOD LogMarkEx : HRESULT
VAR_INPUT
    stMark       : ST_RTMon_MarkDef;
    nMarkCtrl    : UDINT; // mask for mark options (listed in TcMarkOption)
END_VAR
```

Description

The method creates a marker. The marker is defined using the data type ST_RTMon_MarkDef [▶ 38]. The marker type is transferred using the parameter nMarkCtrl (see TcMarkOption [▶ 39]).

Parameter:

stMark: Transfer parameter for a defined marker that is to be written.

nMarkCtrl: defines the marker type.

6.2 Data types

6.2.1 ST_RTMon_MarkDef

Data type that represents a marker.

```
// defines a mark
TYPE ST_RTMon_MarkDef:
STRUCT
    nContextId : UINT;      // defines the context
    nGroupId : UINT;       // defines the group inside the context
    nEventId : UINT;       // defines the specific event inside the group
END_STRUCT
END_TYPE
```

Description

Using this data type, it is possible to define a generic marker (without type). This is then transferred in the method LogMarkEx [▶ 38] of the function block FB_RTMon_LogMarkBase [▶ 37] in addition to the marker type.

nContextId: Using the ContextId, marker groups, i.e. processes to be displayed, can be grouped (e.g. by process type or functional unit).

nGroupId: Defines the process/ process event to be displayed.

nEventId: Optional user record. This can be used, for example, to display the status of a state machine or error codes in the TwinCAT 3 Real-time Monitor.

Both the ContextId and the GroupId can be given names in the TwinCAT 3 Real-time Monitor. These can be exported or imported using the User contexts [▶ 25] or User contexts [▶ 25] functions, so that they are available for a further recording.

6.3 Global constants

6.3.1 TcMarkOption

The constants in this global variable list define the possible marker types (see Display in the Real-time Monitor [▶ 13]).

```
VAR_GLOBAL CONSTANT
    Start             : UDINT := 16#E0000000;
    Stop              : UDINT := 16#C0000000;
    SequenceStart     : UDINT := 16#A0000000;
    SequenceStop      : UDINT := 16#80000000;
    IntervalStart     : UDINT := 16#60000000;
    IntervalStop      : UDINT := 16#40000000;
    RefToCaller       : UDINT := 16#08000000; // reference to caller
END_VAR
```

In addition to the marker types, the option RefToCaller is defined, which enables the task references to be displayed in the TwinCAT 3 Real-Time Monitor. If this option is activated it must be ORed with the desired marker type.

Sample:

```
fbLogMark.LogMarkEx(markCounter, TcMarkOption.Start OR TcMarkOption.RefToCaller);
```

The sample shows the setting of a marker, "markCounter", with the marker type "Start" and the option "RefToCaller".

The option **Show Task Reference** (see Marker group element [▶ 32]) must be activated if the task references are to be displayed in the TwinCAT 3 Real-Time Monitor.

7 C++ API

7.1 Data types

7.1.1 TcMark16

Data type that represents a marker.

```
typedef struct {
USHORT ContextId;
USHORT GroupId;
USHORT EventId;
} TcMark16;
```

Description:

Using this data type, it is possible to define a generic marker (without type).

ContextId: Using the ContextId, marker groups, i.e. processes to be displayed, can be grouped (e.g. by process type or functional unit).

GroupId: Defines the process/ process event to be displayed.

EventId: Optional user record. This can be used, for example, to display the status of a state machine or error codes in the TwinCAT 3 Real-time Monitor.

> Both the ContextId and the GroupId can be given names in the TwinCAT 3 Real-time Monitor. These can be exported or imported using the User contexts [▶ 25] or User contexts [▶ 25] functions, so that they are available for a further recording.

7.2 Classes

7.2.1 CTcLogMark

```
CTcLogMark(USHORT nContextId, ITComObjectServer* ipSrv = NULL);
```

Description:

The class CTcLogMark is a C++ class that makes it possible to set (time) markers from C++ application code so that they can be displayed with the TwinCAT 3 Real-time Monitor.

7.2.1.1 LogIntervalStart

```
virtual HRESULT LogIntervalStart(USHORT GroupId, USHORT EventId);
```

Description:

The method creates a marker with an interval start for the transferred marker ID.

Parameter:

GroupId: Marker ID (marker group) for which the marker is to be written.

EventId: optional EventId.

7.2.1.2 LogIntervalStop

```
virtual HRESULT LogIntervalStop(USHORT GroupId, USHORT EventId);
```

Description:

The method creates a marker with an interval stop for the transferred marker ID.

7.2.1.3 LogMark

```
virtual HRESULT LogMark(USHORT GroupId, USHORT EventId, ULONG CtrlId);
```

Description:

The method creates a marker for the transferred marker group ID. The marker type is determined using the constants from TcLogMark.h (see Constants [▶ 42]).

Optionally, the event ID can be used to distinguish between different user events or to display additional data (formatted as USHORT) in the TwinCAT 3 Real-time Monitor display.

7.2.1.4 LogMarkEx

```
virtual HRESULT LogMarkEx(TcMark16* pMark, ULONG CtrlId);
```

Description

The method creates a marker. The marker is defined using the data type TcMark16 [▶ 40]. The marker type is determined using the constants from TcLogMark.h (see Constants [▶ 42]).

7.2.1.5 LogSequenceStart

```
virtual HRESULT LogSequenceStart(USHORT GroupId, USHORT EventId);
```

Description:

The method creates a marker with a sequence start for the marker ID that was transferred.

7.2.1.6 LogSequenceStop

```
virtual HRESULT LogSequenceStop(USHORT GroupId, USHORT EventId);
```

Description:

The method creates a marker with a sequence stop for the marker ID that was transferred.

7.2.1.7 LogStart

```
virtual HRESULT LogStart(USHORT GroupId, USHORT EventId);
```

Description:

The method creates a marker with a sequence and interval start for the transferred marker ID.

Thus this marker represents the time of a process at which it is immediately active / started.

7.2.1.8 LogStop

```
virtual HRESULT LogStop(USHORT GroupId, USHORT EventId);
```

Description

The method creates a marker with a sequence and interval stop for the transferred marker ID.

Thus, this marker represents the point in time of a process at which it is terminated directly.

7.2.1.9 SetContextId

```
virtual void SetContextId(USHORT nContextId);
```

Description:

This method sets the context ID used.

7.2.1.10 InitLogMark

```
virtual HRESULT InitLogMark(ITComObjectServer* ipSrv);
```

Description:

Initializes the instance of the CTcLog marker class.

Parameter:

ipSrv: Interface pointer to the TcObjectServer.

7.2.1.11 ReleaseLogMark

```
virtual HRESULT ReleaseLogMark();
```

Description:

Releases the resources of the instance of the CTcLogMark class.

7.3 Constants

These constants - defined in TcLogMark.h - define the possible marker types [▶ 13].

```
#define TCMARK_START 0xE0000000
#define TCMARK_STOP 0xC0000000
#define TCMARK_SEQ_START 0xA0000000
#define TCMARK_SEQ_STOP 0x80000000
#define TCMARK_IVAL_START 0x60000000
#define TCMARK_IVAL_STOP 0x40000000
#define TCMARK_REF_CALLER 0x08000000
```

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