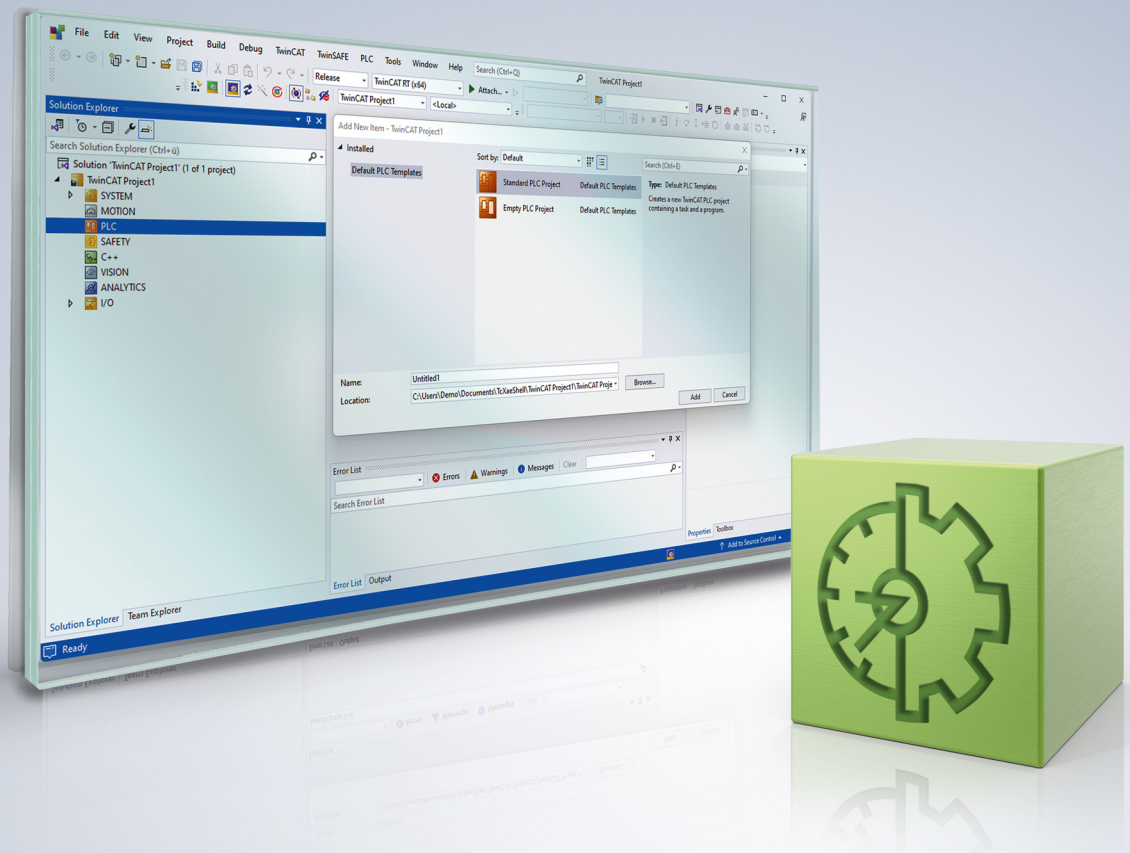
BECKHOFF New Automation Technology

Manual | EN

TwinCAT 3

Basics



2025-10-22 | Version: 1.3.1

Table of contents

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.
The documentation and the following notes and explanations must be complied with when installing and commissioning the components.
The trained specialists must always use the current valid documentation.

The trained specialists must ensure that the application and use of the products described is in line with all safety requirements, including all relevant laws, regulations, guidelines, and standards.

Disclaimer

The documentation has been compiled 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.
Claims to modify products that have already been supplied may not be made on the basis of the data, diagrams, and descriptions in this documentation.

Trademarks

Beckhoff®, ATRO®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, MX-System®, Safety over EtherCAT®, TC/BSD®, TwinCAT®, TwinCAT/BSD®, TwinSAFE®, XFC®, XPlanar®, and XTS® are registered and licensed trademarks of Beckhoff Automation GmbH.
If third parties make use of the designations or trademarks contained in this publication for their own purposes, this could infringe upon the rights of the owners of the said designations.

EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

Copyright

Third-party trademarks

Trademarks of third parties may be used in this documentation. You can find the trademark notices here: https://www.beckhoff.com/trademarks.

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.

In addition, the recommendations from Beckhoff regarding appropriate protective measures should be observed. Further information regarding information security and industrial security can be found in our https://www.beckhoff.com/secguide.

Beckhoff products and solutions undergo continuous further development. This also applies to security functions. In light of this continuous further development, Beckhoff expressly recommends that the products are kept up to date at all times and that updates are installed for the products once they have been made available. Using outdated or unsupported product versions can increase the risk of cyber threats.

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

2 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 are called by the scheduler 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 under Microsoft Windows operating systems from Windows 7 as well as under TwinCAT/BSD and Beckhoff RT Linux®. In order to meet the requirements described above for the control of industrial processes, TwinCAT 3 real-time supports the following features:

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

TwinCAT 3 multi-core support allows the available cores to be used either exclusively for TwinCAT or shared with the corresponding operating system. In the following sections, the cores are therefore referred to as "isolated" or "shared".

Real-time capable scheduling

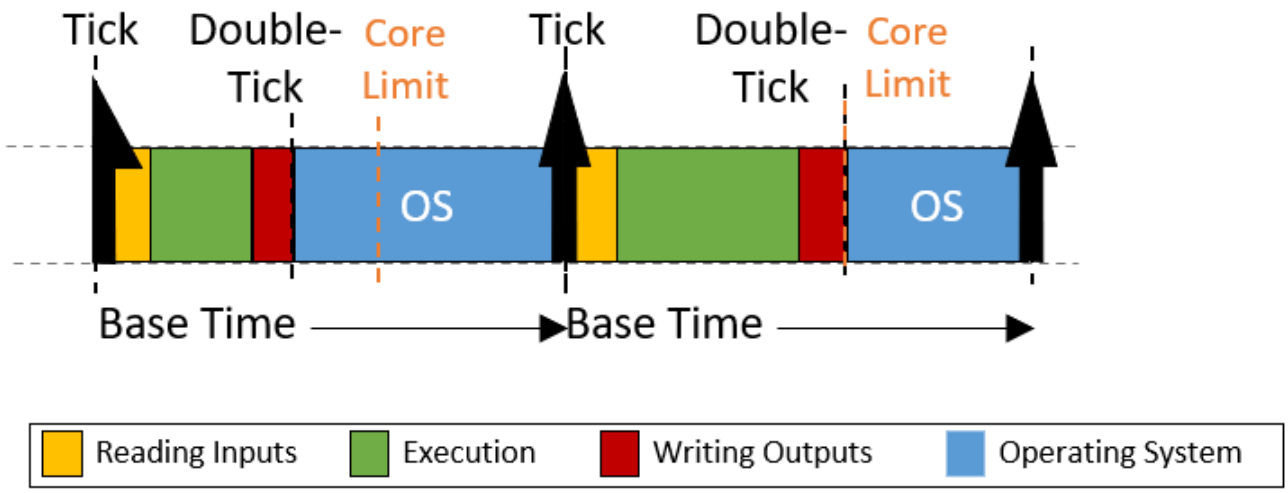
TwinCAT 3 Real-Time works with the double-tick method. This means that both switching to real-time mode and switching back is triggered by an interrupt. The interrupt when switching to the real-time mode also starts the scheduling at the same time. After an adjustable period of time, at the latest after 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.

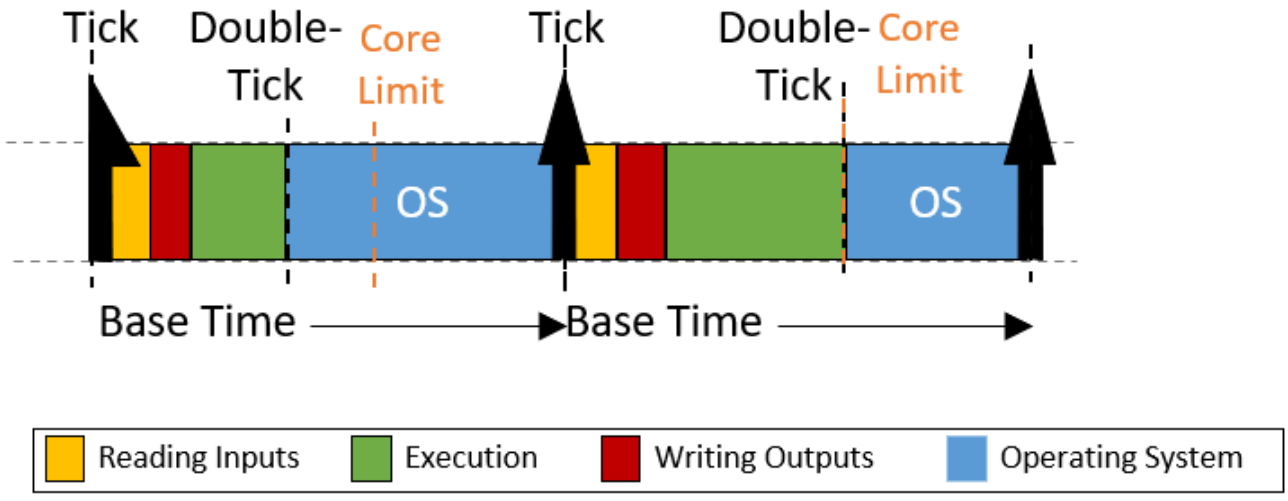
Scheduling in which the priority of a task is derived from its cycle time is also known as rate-monotonic scheduling. The TwinCAT 3 Real-Time automatically activates the "Automatic Priority Management" option. Since this is not always the best solution for every application, the priorities can be adjusted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

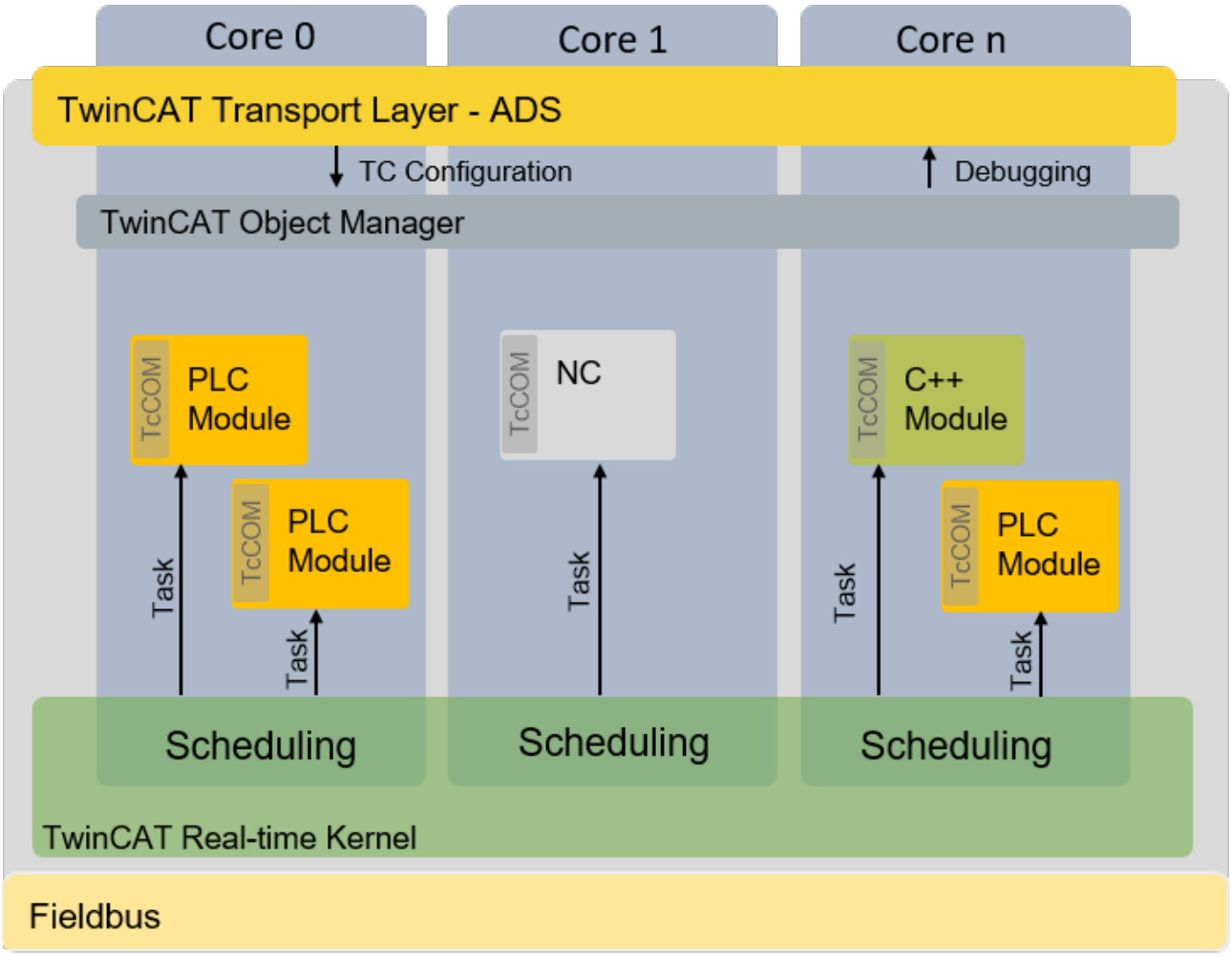
Preemptive multitasking means that the current state of a process (the CPU and floating-point registers) is saved in the event of an interrupt (e.g. by higher-priority processes), and the current process is paused. If this happens, the scheduler determines the (new) process to be executed, based on the 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 or TwinCAT/BSD 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). Under Beckhoff RT Linux®, the real-time works with the real-time extension in user mode. Direct hardware access is made possible via special network drivers.

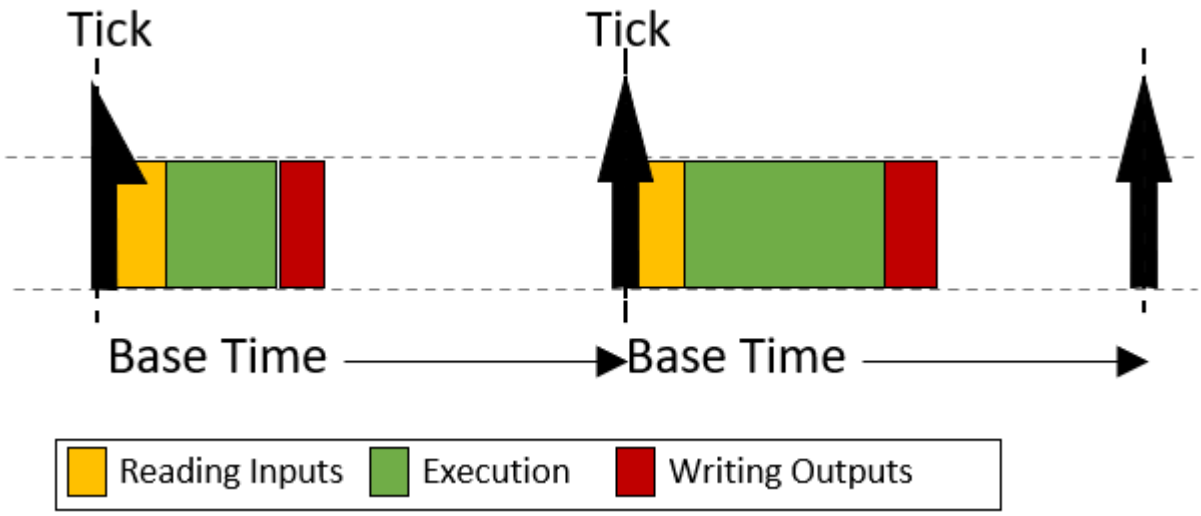
Schematic representation of the TwinCAT 3 runtime environment

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.



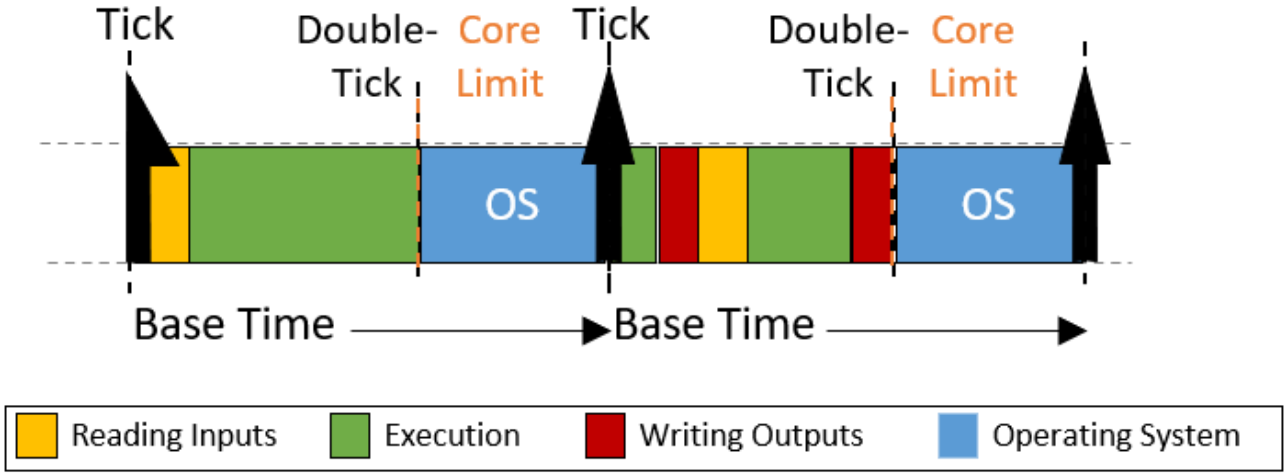
Isolated cores

As described under real-time scheduling [▶ 8], 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 Preemptive multitasking [▶ 9]. 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.

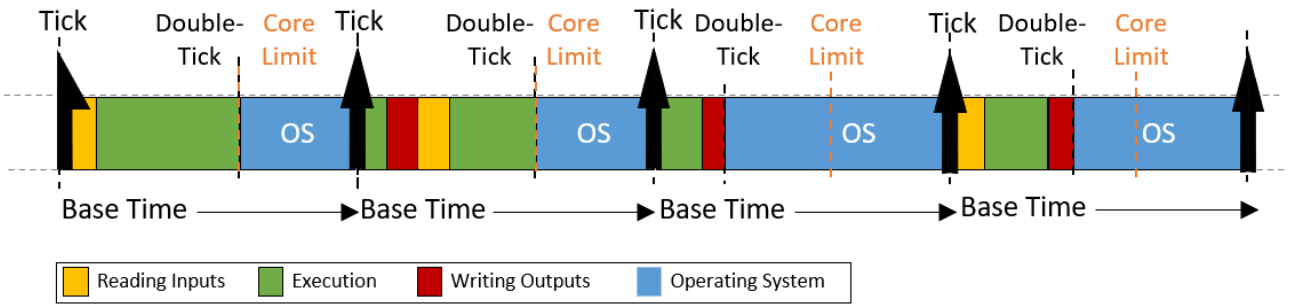


Behavior when the cycle time is exceeded

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.

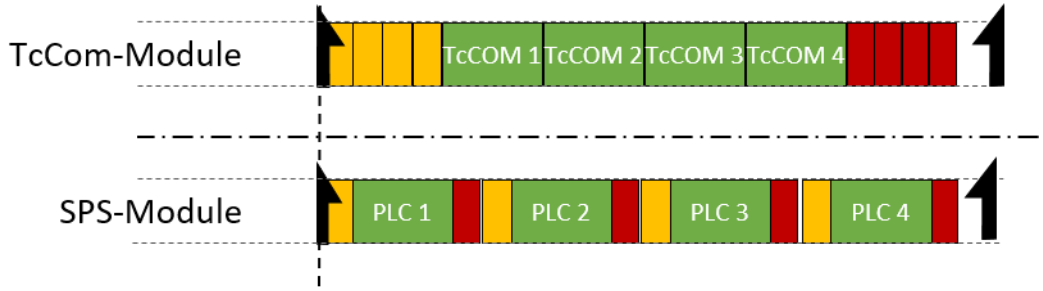


Differences in execution between PLC and "TcCom" runtime modules

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.

2.1 Tasks

A task is a runtime object that can be scheduled and triggered by a scheduler. Functions or runtime objects that are to be executed in the context of this object log on to this object. The tasks are assigned a cycle time and a priority, which the scheduler uses to schedule the execution of the tasks (see Real-time scheduling [▶ 8]). Furthermore, each task is assigned a shared memory/address space, which all tasks can access together, and an additional stack memory. This stack memory is required to allow the nested execution of functions and sub-functions. The stack also serves as a memory for local variables. The state of a task is defined by this stack and the current content of the machine registers (calculation registers). If there is a context change or a task is interrupted by a higher priority, this state is saved and restored when the task is executed again. The size of the task stack can be defined in TwinCAT (see chapter Settings tab of the real-time settings).

For sequence control of several tasks, a (real-time) system offers functions for communication and synchronization (see chapter Multi-task data access synchronization in the PLC).

The corresponding task types are described in the following chapters.

2.1.1 TwinCAT Task

TwinCAT standard tasks to which TwinCAT runtime modules can log on.

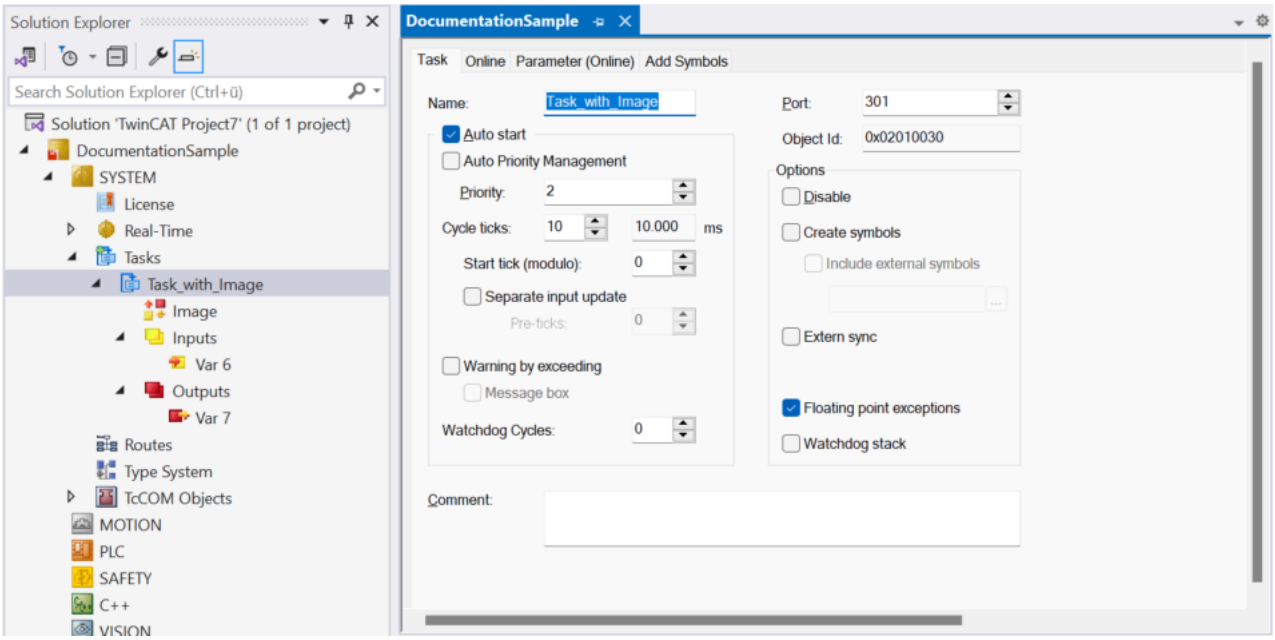
To use the tasks in a PLC, this is done by assigning a task to a task reference (see Creating a referenced task).

For TcCom modules in general, the TcCom module is assigned to tasks via the **Context** tab of the TcCom module. (See Context tab [▶ 260] in the chapter TcCOM module handling).

The settings of a task are described in the subchapter TwinCAT Task in "The TwinCAT project" documentation.

2.1.2 TwinCAT Task with Image

In contrast to a standard task (see chapter TwinCAT Task [▶ 12]), the **TwinCAT Task with Image** also has its own process image.

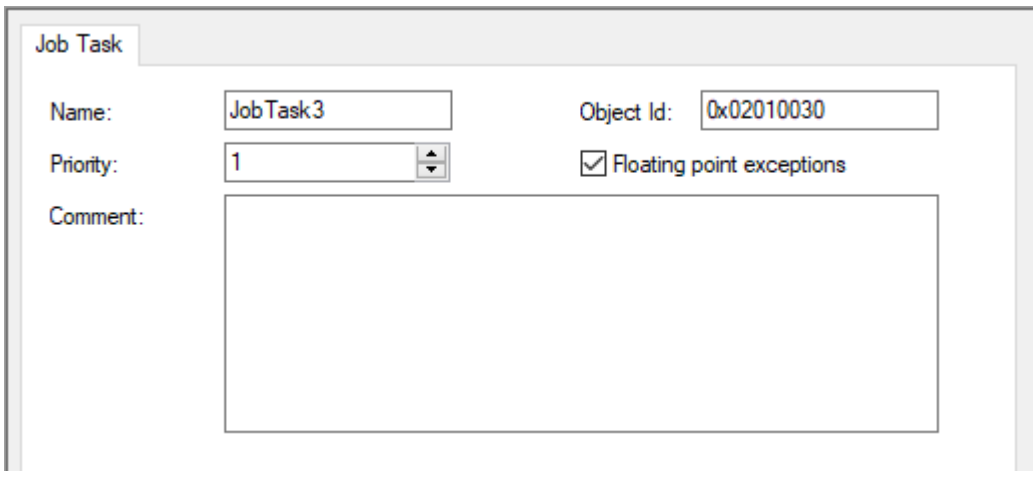


Variables can be created in this process image that are linked to other process images (e.g. from EtherCAT devices). Depending on the set cycle time and priority, the task triggers the mapping accordingly. It is therefore possible, for example, to operate cyclic bus communication without the need for a PLC or another runtime module. The variables of the process image can be accessed via ADS from the TwinCAT Scope or a non-real-time application, for example.

2.1.3 TwinCAT Job Task (Worker Task)

A Job Task is a task that is executed on demand. It is called from an application and is NOT executed cyclically. A Job Task can be created directly under Tasks or in a Job Pool. If you create the Job Task directly under Tasks, tasks (jobs) can be passed to it directly from a client application.

However, if you create the Job Task under a Job Pool, the tasks are transferred to the Job Pool from the application. This then assigns the task to the next Job Task in its pool that is next available.



Name	Name of the Job Task
Object Id	Object ID of the Job Task
Priority	Priority of the Job Task
Floating point exception	Specifies whether or not TwinCAT checks for floating point exceptions.
Comment	Optional comment on the Job Task

Select the setting **Floating point exception** for the calling task and for the Job Task.

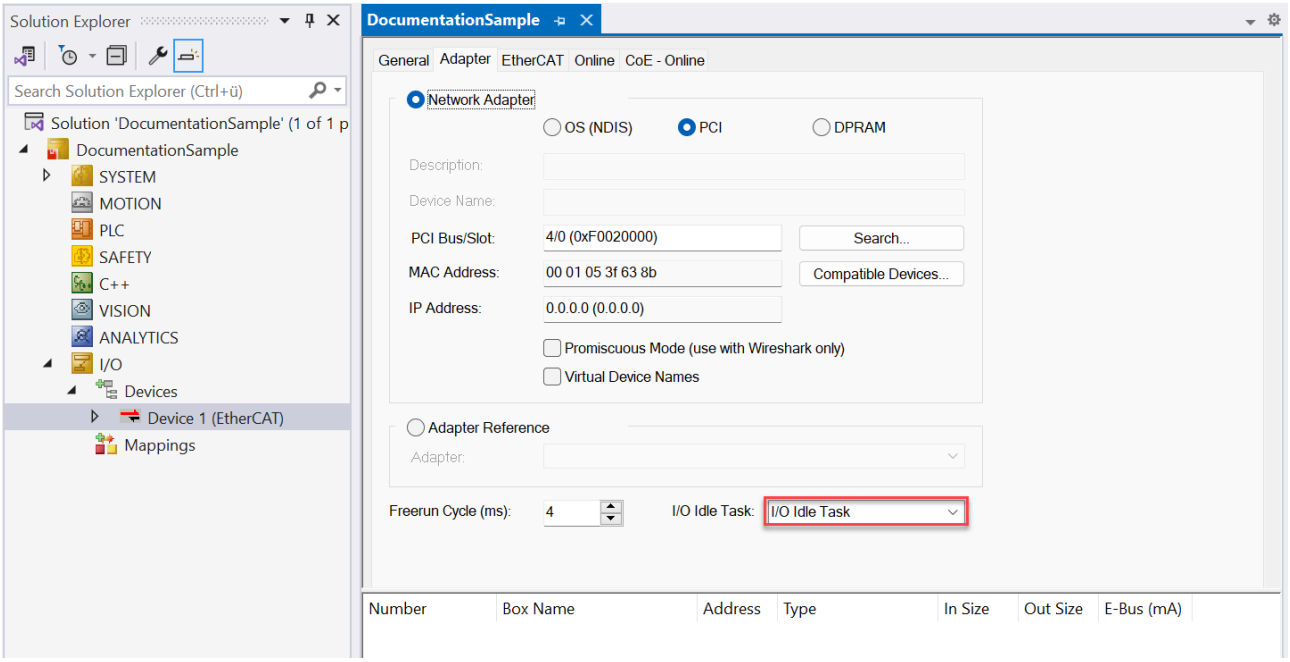
2.1.4 I/O Idle Task

The I/O Idle Task handles acyclic communication for fieldbuses, so it is responsible for:

- the State Machine of the EtherCAT Devices
- CoE and SoE communication
- Reading or setting parameters via AOE
- Mailbox communication
- Acyclic diagnostics from EtherCAT (e.g. status queries)

The I/O Idle Task is a cyclic task, but is not used for cyclic I/O communication (process data exchange). It therefore makes sense in most cases to select the priority so that it is executed after the PLC and motion tasks. As this is also acyclic communication, cycle timeouts of these tasks are generally not significant.

Since TwinCAT version 3.1.4026, it has been possible to use multiple I/O Idle Tasks (one per EtherCAT master). The choice of I/O Idle Task is made via the adapter settings of the EtherCAT master.



2.1.5 PLC-AuxTask

The PLC-AuxTask is used for communication between the PLC editors and the PLC runtime modules. This includes the download and Online Change of PLC control code as well as debugging (monitoring of values, setting of breakpoints, etc.). In addition, the PLC-AuxTask also processes the ADS messages that are sent to the runtime system independently of the development environment (TcXaeShell) (e.g. from an HMI).

The PLC-AuxTask is not a cyclic task and you should set its priority lower than this. This ensures that the cyclic tasks can interrupt the PLC-AuxTask. In the event of an online change, the new code is transferred to the target system via the PLC-AuxTask and the symbols are generated accordingly, etc. Only the “critical phase” of an online change, in which the code to be executed is exchanged, is protected in such a way that this process cannot be interrupted by the cyclical tasks.

If several PLC runtime modules use the same PLC tasks, they can influence each other through an online change.

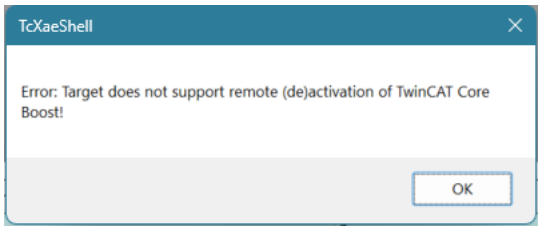
2.2 Core Boost

TwinCAT Core Boost

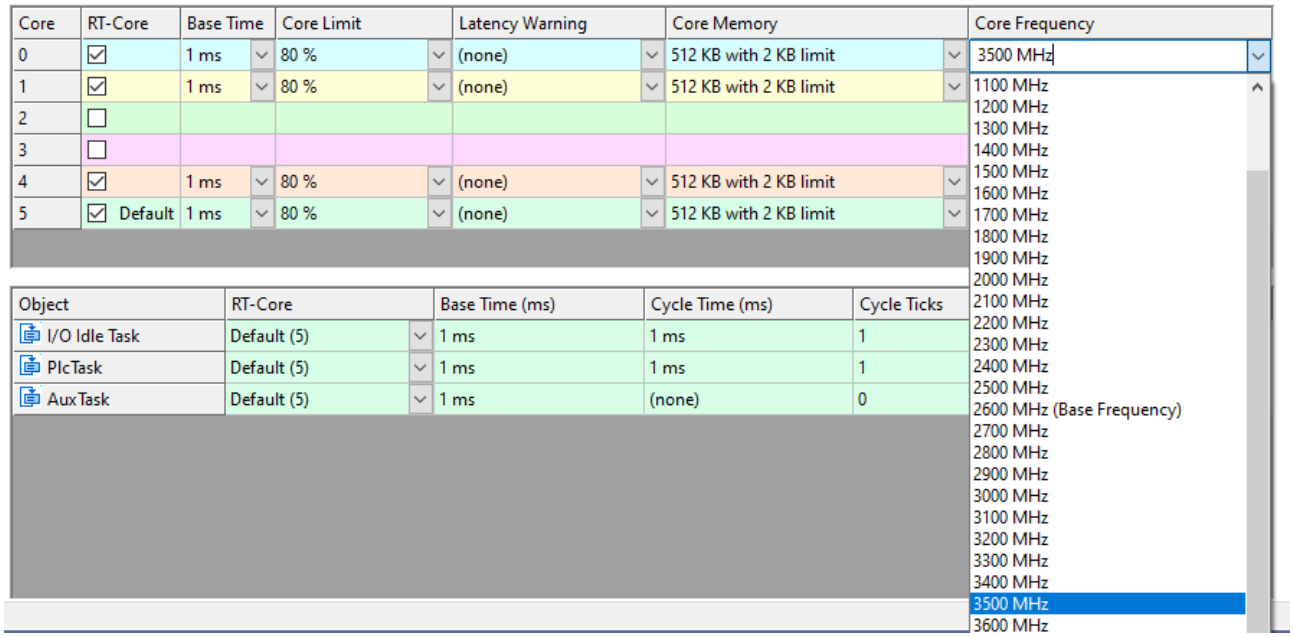
Prerequisite: Both the engineering environment and the runtime environment must use at least TwinCAT version 3.1.4026.6.

If the TwinCAT feature Core Boost is supported for a given target system and is active, this is displayed in the **TwinCAT Core Boost** selection box after pressing the **Read from Target** button. To activate or deactivate the function, these settings must be activated on the target system using the **Set on Target** button. You must restart the computer after changing this setting.

If the TwinCAT Core Boost function is not supported by a given target system, the following message appears after pressing the button **Set on Target**:



If the TwinCAT Core Boost setting is activated, a clock frequency can be defined for each real-time core. If no clock frequency is defined for a real-time core, the **Base Frequency** is automatically selected.



Correct selection of the core frequency

TwinCAT automatically monitors the clock frequencies of the individual cores based on the limits stored in the system for the temperature of the individual cores or the power consumption of the individual packages. If these limits are exceeded, TwinCAT reduces the clock frequencies of the individual cores accordingly (see also chapter Core Boost tab). If TwinCAT is forced to reduce the clock frequencies of individual real-time cores, this may have an influence on the real-time behavior set in TwinCAT. The tasks executed on this real-time core then have longer execution times, which may lead to cycle timeouts. You therefore share the responsibility for selecting the clock frequencies of the real-time cores in such a way that TwinCAT is not permanently operated in throttle mode. If the temperature limit is permanently exceeded, the system may shut down.

Selecting the clock frequency for non-real-time cores

Non-real-time cores are computer cores on which TwinCAT is not activated and which are not used in real-time, so that only processes triggered by the operating system are executed there. For the non-real-time cores, the clock frequency is automatically selected by the operating system as required. The maximum clock frequency up to which non-real-time cores can clock up is the base frequency. Starting with the 12th and 13th generations of Intel® processors, non-real-time cores can overclock up to the core boost frequency if necessary. The level of the core boost frequency is stored in the system and differs depending on the processor type.

Configurable clock frequencies:

Processor	Processor generation	Base clock	Configurable Core Boost clock
Core i3-11100HE	Intel® Core™ of the 11th generation	2.40 GHz	4.00 GHz
Core i5-11500HE	Intel® Core™ of the 11th generation	2.60 GHz	4.10 GHz
Core i7-11850HE	Intel® Core™ of the 11th generation	2.60 GHz	4.20 GHz
Core i3-13100E	Intel® Core™ of the 13th generation	3.30 GHz	4.20 GHz
Core i5-13400E	Intel® Core™ of the 13th generation	2.40 GHz	4.10 GHz
Core i7-13700E	Intel® Core™ of the 13th generation	1.90 GHz	4.00 GHz
Core i9-13900E	Intel® Core™ of the 13th generation	1.80 GHz	3.90 GHz

2.3 Core Memory

TwinCAT (3.1.4026 and 3.1.4024) enables real-time tasks to dynamically allocate memory within the real-time context. Since real-time tasks cannot allocate memory blocks directly from the operating system, TwinCAT offers various memory pools. These pools are memory blocks allocated in advance by the operating system. These memory blocks are pinned to the physical memory to avoid paging when accessing within the real-time context.

As already described in the chapter Settings tab, there are several memory pools for TwinCAT. These are:

Executable RT Memory	Executable real-time memory, this is required by the TwinCAT system and is not directly available to the user
Global RT Memory	Global real-time memory for memory allocations of TwinCAT modules (PLC and C++) in real-time context
Core Memory <n>	Real-time memory for memory allocations of the <n>th real-time core
Global ADS Memory	Data memory for ADS communication. Allocations for ADS messages between the TwinCAT components are allocated from this memory.
Tc/OS Memory	Memory pool of the Usermode runtime: allocation takes place when a Usermode runtime is started. When using a Usermode runtime, the other memory pools are served from this memory pool.

The size of the Global RT Memory can be set for each project via the **Router Memory** option in the TwinCAT 3 engineering environment. Since TwinCAT version 3.1.4026, the data memory for ADS messages has been separated from the "router memory" and is available as an independent global ADS memory. The size of the global ADS memory is determined from the size of the global RT memory and corresponds to 25% of its size, up to a maximum of 32 MB.

TwinCAT version 3.1.4026 also introduced another memory pool, the Core Memory. The Core Memory provides a dedicated pool for real-time for each individual real-time core. If the Core Memory is configured for a real-time core, an attempt is first made to provide the requested memory from this memory pool. If this is not sufficient, the memory from the global real-time memory is used.

The Core Memory thus allows parallel memory allocations from different cores to be processed in parallel and independently of each other. To access the global real-time memory, parallel memory allocations from different cores must be processed sequentially. This can lead to waiting times for many memory allocations within a real-time cycle and is therefore a performance bottleneck, e.g. in Vision applications.

See also:

- Core Management

3 Target systems

The controller that is currently being programmed with a TwinCAT development environment (TwinCAT XAE) is referred to as the target system. In this chapter, important basics for handling target systems will be explained. These are also needed to understand the documentation based on them in the chapter TE1000 XAE.

First, a connection between the development environment and the controller must be created in order to be able to program a controller. Various channels can be used for this purpose. The individual options are explained in more detail in the chapter Routing [▶ 18].

If a controller is already programmed and in the field and you want to update the machine without using the programming environment, it is necessary to know which files and folders exist, what they are needed for and how you can best exchange them. The chapters Folder and file types [▶ 203] and Machine update at file level [▶ 214] are devoted to these topics.

Additional programs may also need to be started automatically when TwinCAT is restarted (e.g. an external HMi). This is explained in the chapter Starting the program automatically [▶ 216].

If several controllers in a network are working on the same process, it is necessary to correct the timestamps of the individual controllers when collecting and evaluating data so that the collected data adheres to the exact time sequence. To achieve this, you can correct the timestamps of the individual controllers accordingly. This is described in the chapter Corrected time stamps [▶ 217].

3.1 Boot directory

The standard storage paths of the boot directory are documented below depending on the operating system of the target system.

Windows 10, Windows 11:

Kernel Mode Runtime:

- < TC3.1.4026.0: C:\TwinCAT\3.1\Boot
- >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot

User mode runtime:

C:\ProgramData\Beckhoff\TwinCAT\3.1\Runtimes\UmRT_Default\3.1\Boot

TwinCAT/BSD:

/usr/local/etc/TwinCAT/3.1/Boot

Beckhoff RT Linux®:

/etc/TwinCAT/3.1/Boot

3.2 Routing

As already described in the Philosophy chapter, TwinCAT 3 consists of an engineering environment (XAE) and a runtime environment (XAR). The engineering environment is used to configure and program the runtime environments in the field. The runtime environments (target systems) then execute the control programs in hard real time. The connection between the two environments that do not necessarily run on the same PC/IPC is established via the ADS protocol (see ADS [▶ 19] chapter). A route must be entered so that an engineering environment can communicate with a target system. This means that the other participant is entered as known on both sides (engineering environment and runtime environment).

In order to take current technical trends and requirements in terms of security and connectivity into account, you can secure the ADS connection accordingly or tunnel via current transport protocols. See Secure ADS [▶ 191] or ADS-over-MQTT [▶ 179] chapters.

3.2.1 ADS

3.2.1.1 ADS introduction

ADS Definition

The Automation Device Specification describes a device-independent and fieldbus-independent interface governing the type of access to ADS devices.

The ADS interface permits:

- communication with other ADS devices
- implementation of an ADS device

Communicating ADS Devices

In order to allow participation in ADS communication (as an ADS client or, possibly, as an ADS server) the following software objects are made available:

- ADS-DLL
  for use under e.g. C/C++

- ADS.NET [▶ 5] component
  for use under e.g. VB.NET, Visual C#

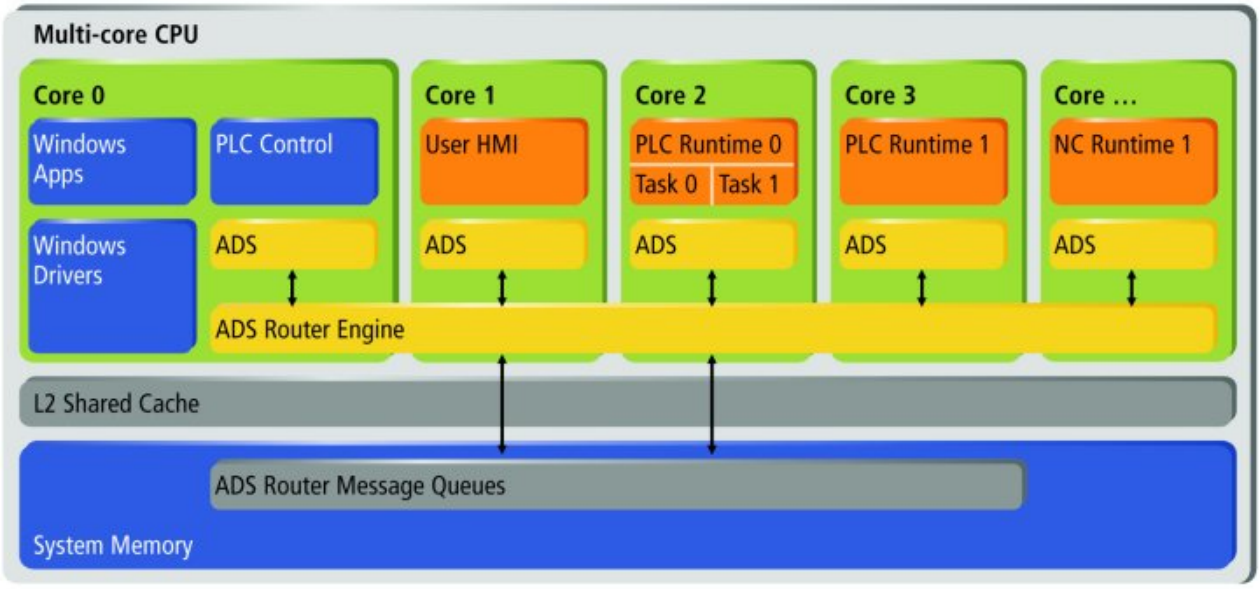
3.2.1.2 ADS device concept

The TwinCAT system architecture allows the individual modules of the software (e.g. TwinCAT PLC, User HMI, ...) to be treated as independent devices: For every task there is a software module ("Server" or "Client"). The servers in the system are the executing working "devices" in the form of software, whose operating behaviour is exactly like that of a hardware device. For this reason we can speak of "virtual" devices implemented in the software. The "clients" are programs which request the services of the "servers", e.g. a visualisation, or even a "programming device" in the form of a program. It is thus possible for TwinCAT to grow, since there can always be new servers and clients for tasks such as camshaft controllers, oscilloscopes, PID controllers etc..

The messages between these objects are exchanged through a consistent ADS (**A**utomation **D**evice **S**pecification) interface by the "message router". This manages and distributes all the messages in the system and over the TCP/IP connections.

TwinCAT message routers exist on every TwinCAT device.
This allows all TwinCAT server and client programs to exchange commands and data, to send messages, transfer status information, etc..

The following picture shows the TwinCAT device concept, based on ADS:



3.2.1.3 ADS device identification

The unique identification of ADS devices is implemented with the aid of two identifiers:

- PortNr
- NetId

AMS ports

ADS devices in a TwinCAT message router are uniquely identified by a number, called the ADS port no. This is specified and fixed for ADS devices, whereas pure ADS client applications (e.g. a HMI system) are allocated a variable port number when they first access the message router.

The following AMS port numbers are already assigned:

AMS port	Device
1	**ADS router**
2	**AMS debugger**
10	**TCom server**
11	**TCom server task, RT context**
12	**TCom server, passive level**
20	**TwinCAT debugger**
21	**TwinCAT debugger task**
30	**License server**
100	**Logger**
110	**Event logger**
120	**Application for EtherCAT devices**
130	**Event logger user mode (V2)**
131	**Event logger real-time (V2)**
132	**Event logger publisher (V2)**
200	**Ring 0 real-time**
290	**Ring 0 trace**
300	**Ring 0 IO**
400	**Ring 0 PLC (legacy)**
500	**Ring 0 NC**
501	**Ring 0 NC SEC**
511	**Ring 0 NC SPP**
520	**NC instance**
550	**Ring ISG**
600	**Ring 0 CNC**
700	**Ring 0 line**
800	**Ring 0 TC2 PLC**
801	**TC2 PLC runtime system 1**
811	**TC2 PLC runtime system 2**
821	**TC2 PLC runtime system 3**
831	**TC2 PLC runtime system 4**
850	**Ring 0 TC3 PLC**
851	**TC3 PLC runtime system 1**
852	**TC3 PLC runtime system 2**
853	**TC3 PLC runtime system 3**
854 - …	**TC3 PLC runtime system 4 - …**
900	**Cam controller**
950	**CAM tool**
1000–1199	**Ring 0 IO ports**
2000	**Ring 0 user**
2500	**Crestron server**
10000	**System service**
10201	**TCP/IP server**
10300	**System Manager**
10400	**SMS server**
10500	**Modbus server**
10502	**AMS logger**
10600	**XML data server**
10700	**Automatic configuration**

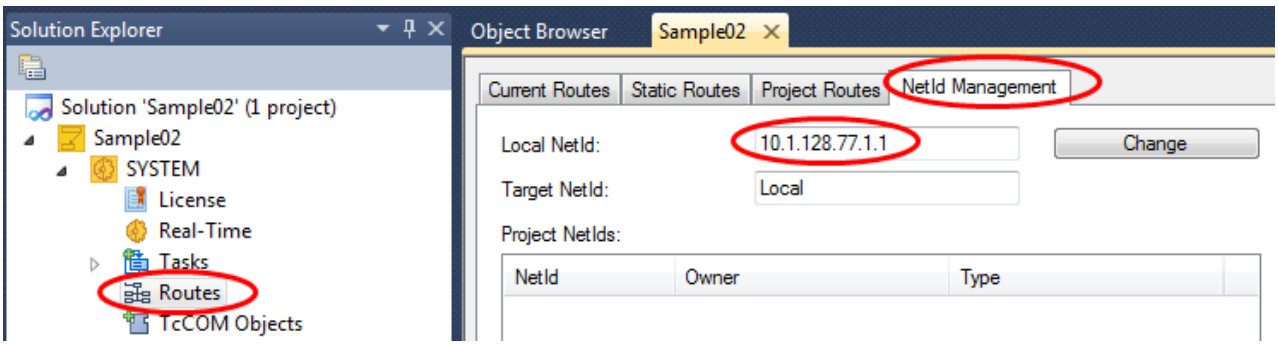
AMS port	Device
10800	**PLC control**
10900	**FTP client**
11000	**NC control system**
11500	**NC interpreter**
11600	**GST interpreter**
12000	**Track control**
13000	**CAM control**
14000	**Scope server**
14100	**Condition monitoring**
15000	**Sine CH1**
16000	**CONTROL NET**
17000	**OPC server**
17500	**OPC client**
18000	**Mail server**
19000	**Virtual COM EL60xx**
19100	**Management server**
19200	**Miele@home server**
19300	**CP-Link 3**
19310	**Touch lock**
19500	**Vision service**
19800	**HMI server**
21372	**Database server**
25000–25999	**Reserved port range for ADS servers**
25013	**FIAS server**
25014	**Bang&Olufsen server**
26000–26999	**Private port range for customers**
32768–65535	**Reserved port range for ADS clients**

AMS NetId

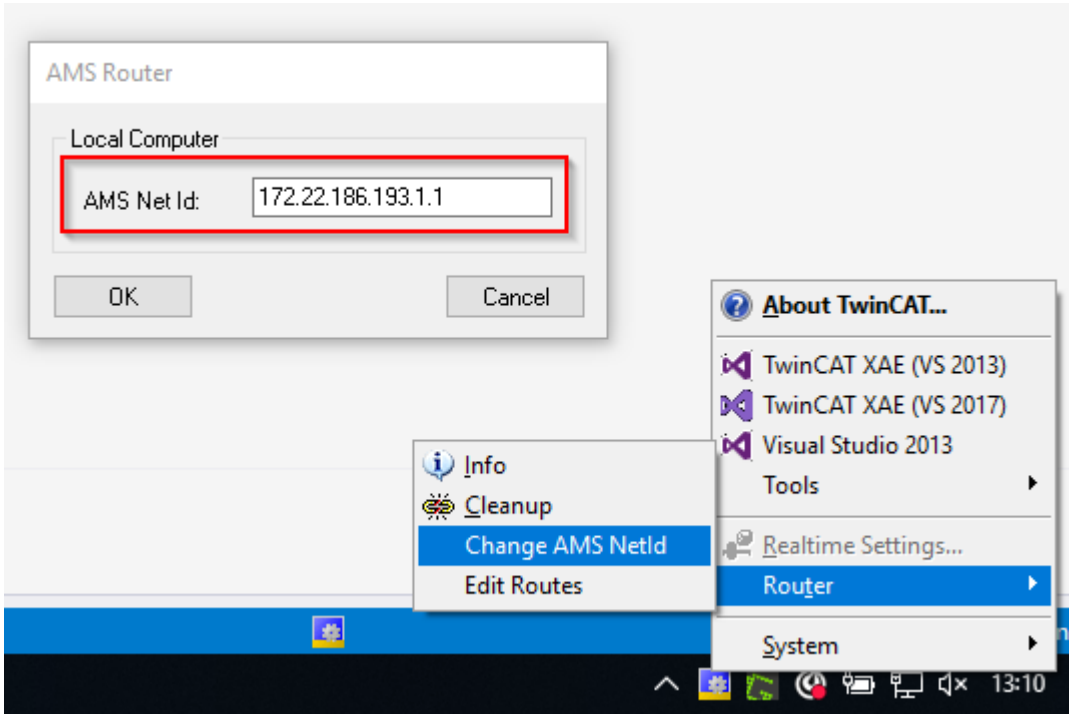
Each TwinCAT device in the network is identified by the AMS NetId. The AMS NetId consists of six octets. The first four octets can be freely selected. The last two octets (usually .1.1) serve as subnet mask for fieldbuses or further devices. The AMS NetId must be unique for all communication partners.

Configuration:

The AMS NetId of a local or remote TwinCAT device can be set in SYSTEM\Routes\NetId Management of a TC3 project.

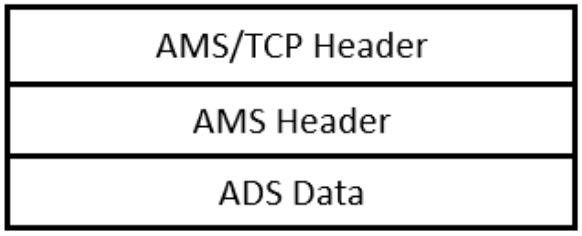


Alternatively, the AMS NetId can be configured locally via the Router category in the TwinCAT SysTray menu. The device must be restarted after changing the AMS NetId.



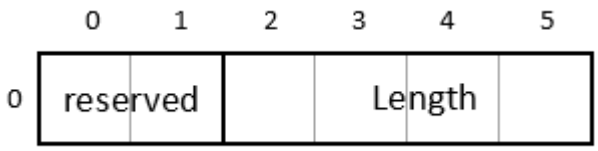
3.2.1.4 AMS/TCP Packet

3.2.1.4.1 Structure AMS/TCP Packet



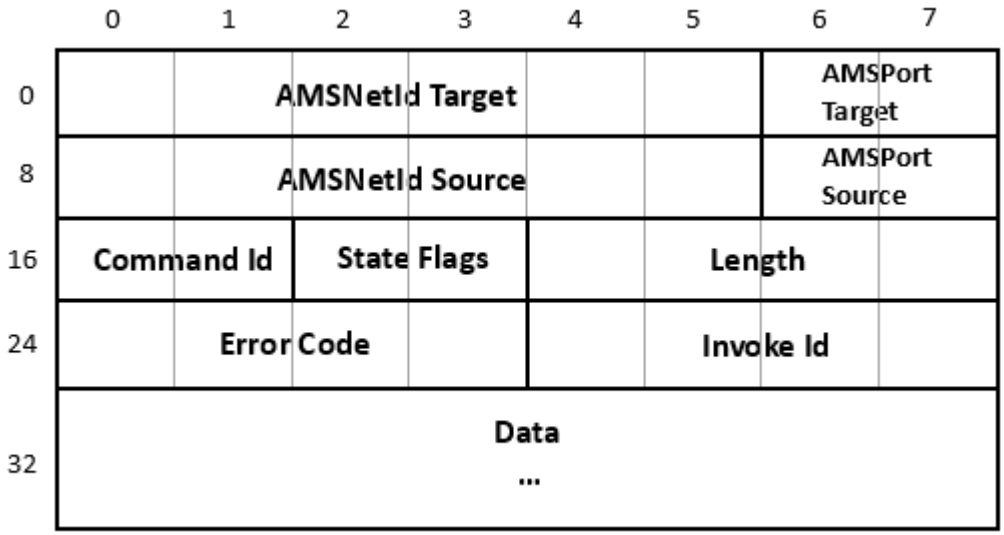
Data array	Size	Description
AMS/TCP Header	6 bytes	Contains the length of the data packet.
AMS Header	32 bytes	The AMS/TCP-Header contains the addresses of the transmitter and receiver. In addition the AMS error code , the ADS command Id and some other information.
ADS Data	n bytes	The ADS data range contains the parameter of the single ADS commands. The structure of the data array depends on the ADS command. Some ADS commands require no additional data.

3.2.1.4.2 AMS/TCP Header



Data array	Size	Description
reserved	2 bytes	These bytes must be set to 0.
Length	4 bytes	This array contains the length of the data packet. It consists of the AMS-Header and the enclosed ADS data. The unit is bytes.

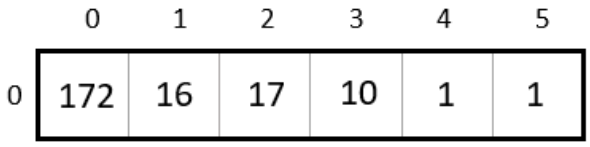
3.2.1.4.3 AMS Header



Data array	Size	Description
AMSNetId Target	6 bytes	This is the AMSNetId of the station, for which the packet is intended. Remarks see below [▶ 24].
AMSPort Target	2 bytes	This is the AMSPort of the station, for which the packet is intended.
AMSNetId Source	6 bytes	This contains the AMSNetId of the station, from which the packet was sent.
AMSPort Source	2 bytes	This contains the AMSPort of the station, from which the packet was sent.
Command Id	2 bytes	see below [▶ 25].
State Flags	2 bytes	see below [▶ 25].
Data Length	4 bytes	Size of the data range. The unit is byte.
Error Code	4 bytes	AMS error number. See ADS Return Codes.
Invoke Id	4 bytes	Free usable 32 bit array. Usually this array serves to send an Id. This Id makes is possible to assign a received response to a request, which was sent before.
Data	n bytes	Data range. The data range contains the parameter of the considering ADS commands.

AMS Net Id

The AMSNetId consists of 6 bytes and addresses the transmitter or receiver. One possible AMSNetId would be e.g.. 172.16.17.10.1.1. The storage arrangement in this example is as follows:



The AMSNetId is purely logical and has usually no relation to the IP address. The AMSNetId is configurated at the target system. At the PC for this the TwinCAT System Control is used. If you use other hardware, see the considering documentation for notes about settings of the AMS NetId.

Command Id

Cmd	Description
0x0000	Invalid
0x0001	ADS Read Device Info [▶ 26]
0x0002	ADS Read [▶ 26]
0x0003	ADS Write [▶ 27]
0x0004	ADS Read State [▶ 27]
0x0005	ADS Write Control [▶ 28]
0x0006	ADS Add Device Notification [▶ 28]
0x0007	ADS Delete Device Notification [▶ 29]
0x0008	ADS Device Notification [▶ 30]
0x0009	ADS Read Write [▶ 31]

Other commands are not defined or are used internally. Therefore the *Command Id* is only allowed to contain the above enumerated values!

State Flags

Flag	Description
0x0001	0: Request / 1: Response
0x0004	ADS command

The first bit marks, whether it´s a request or response. The third bit must be set to 1, to exchange data with ADS commands. The other bits are not defined or were used for other internal purposes.

Therefore the other bits must be set to 0!

Flag	Description
0x000x	TCP Protocol
0x004x	UDP Protocol

Bit number 7 marks, if it should be transferred with TCP or UDP.

3.2.1.4.4 ADS Commands

3.2.1.4.4.1 Command Overview

Command	Description
ADS Read Device Info [▶ 26]	Reads the name and the version number of the ADS device.
ADS Read [▶ 26]	With *ADS Read* data can be read from an ADS device
ADS Write [▶ 27]	With *ADS Write* data can be written to an ADS device.
ADS Read State [▶ 27]	Reads the ADS status and the device status of an ADS device.
ADS Write Control [▶ 28]	Changes the ADS status and the device status of an ADS device.
ADS Add Device Notification [▶ 28]	A notification is created in an ADS device.
ADS Delete Device Notification [▶ 29]	One before defined notification is deleted in an ADS device.
ADS Device Notification [▶ 30]	Data will carry forward independently from an ADS device to a Client
ADS Read Write [▶ 31]	With *ADS ReadWrite data will be written to an ADS device. Additionally, data can be read from the ADS device.*

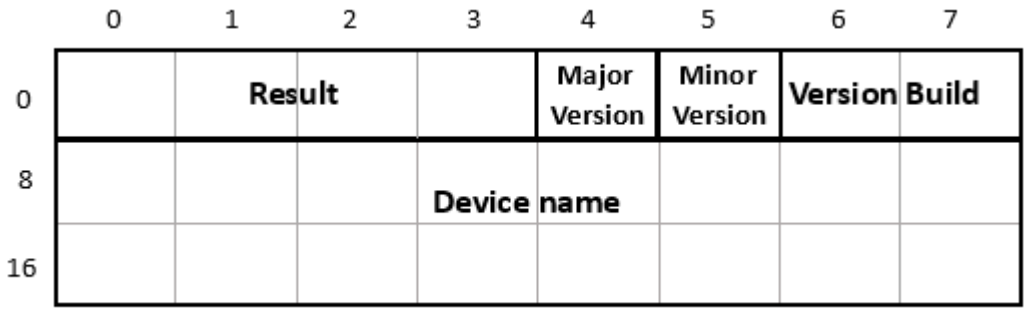
3.2.1.4.4.2 ADS Read Device Info

Reads the name and the version number of the ADS device.

Request

No additional data required

Response

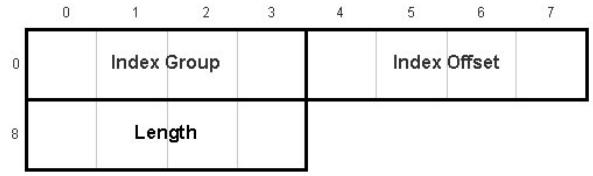


Data array	Size	Description
Result	4 bytes	ADS error number.
Major Version	1 byte	Major version number
Minor Version	1 byte	Minor version number
Version Build	2 bytes	Build number
Device Name	16 bytes	Name of ADS device

3.2.1.4.4.3 ADS Read

With *ADS Read* data can be read from an ADS device. The data are addressed by the *Index Group* and the *Index Offset*

Request



Data array	Size	Description
Index Group	4 bytes	Index Group of the data which should be read.
Index Offset	4 bytes	Index Offset of the data which should be read.
Length	4 bytes	Length of the data (in bytes) which should be read.

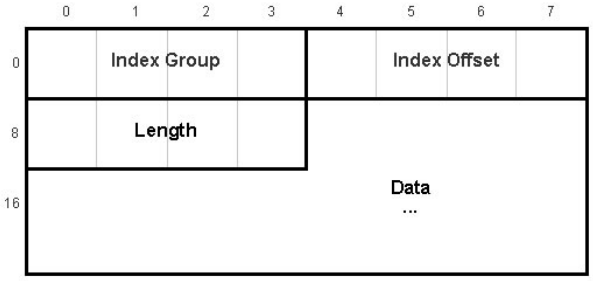
Response

Data array	Size	Description
Result	4 bytes	ADS error number
Length	4 bytes	Length of data which are supplied back.
Data	n bytes	Data which are supplied back.

3.2.1.4.4.4 ADS Write

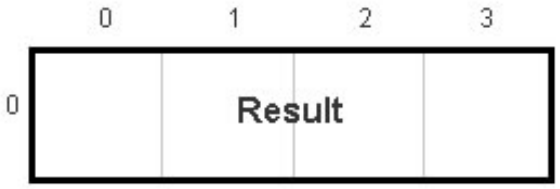
With *ADS Write* data can be written to an ADS device. The data are addressed by the *Index Group* and the *Index Offset*

Request



Data array	Size	Description
Index Group	4 bytes	Index Group in which the data should be written
Index Offset	4 bytes	Index Offset, in which the data should be written
Length	4 bytes	Length of data in bytes which are written
Data	n bytes	Data which are written in the ADS device.

Response



Data array	Size	Description
Result	4 bytes	ADS error number

3.2.1.4.4.5 ADS Read State

Reads the ADS status and the device status of an ADS device.

Request

No additional data required

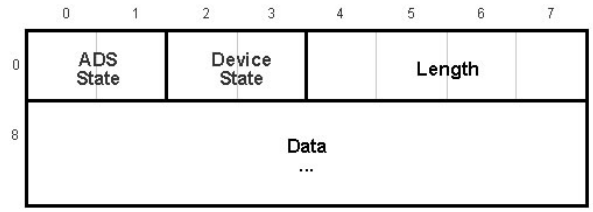
Response

Data array	Size	Description
Result	4 bytes	ADS error number.
ADS State	2 bytes	ADS status (see data type ADSSTATE of the ADS-DLL).
Device State	2 bytes	Device status

3.2.1.4.4.6 ADS Write Control

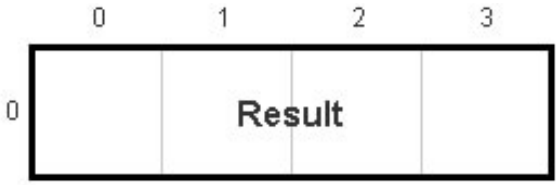
Changes the ADS status and the device status of an ADS device. Additionally it is possible to send data to the ADS device to transfer further information. These data were not analyzed from the current ADS devices (PLC, NC, ...)

Request



Data array	Size	Description
ADS State	2 bytes	New ADS status (see data type ADSSTATE of the ADS-DLL).
Device State	2 bytes	New device status.
Length	4 bytes	Length of data in byte.
Data	n bytes	Additional data which are sent to the ADS device

Response



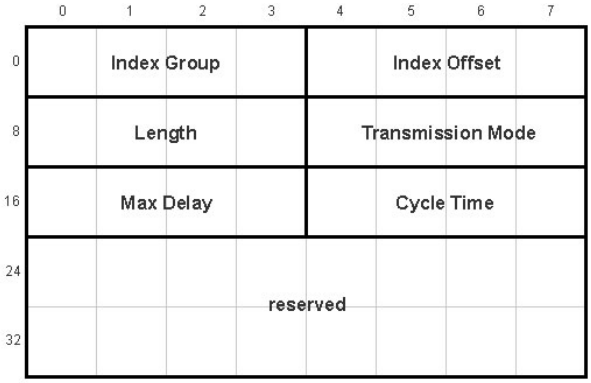
Data array	Size	Description
Result	4 bytes	ADS error number.

3.2.1.4.4.7 ADS Add Device Notification

A notification is created in an ADS device.

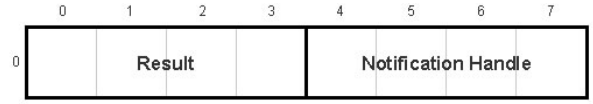
Note: We recommend to announce not more than 550 notifications per device. Otherwise increase the payload by working with structures or use sum commands.

Request



Data array	Size	Description
Index Group	4 bytes	Index Group of the data, which should be sent per notification.
Index Offset	4 bytes	Index Offset of the data, which should be sent per notification.
Length	4 bytes	Length of data in bytes, which should be sent per notification.
Transmission Mode	4 bytes	See description of the structure ADSTRANSMODE at the ADS-DLL.
Max Delay	4 bytes	At the latest after this time, the *ADS Device Notification* is called. The unit is 1ms.
Cycle Time	4 bytes	The ADS server checks if the value changes in this time slice. The unit is 1ms
reserved	16bytes	Must be set to 0

Response



Data array	Size	Description
Result	4 bytes	ADS error number
Notification Handle	4 bytes	Handle of notification

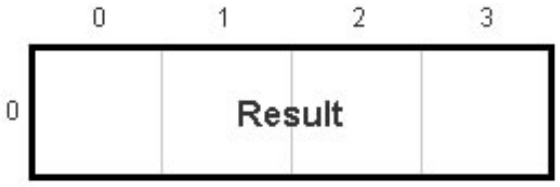
3.2.1.4.4.8 ADS Delete Device Notification

One before defined notification is deleted in an ADS device.

Request

Data array	Size	Description
Notification Handle	4 bytes	Handle of notification. The handle is created by the ADS command *Add Device Notification*

Response



Data array	Size	Description
Result	4 bytes	ADS error number

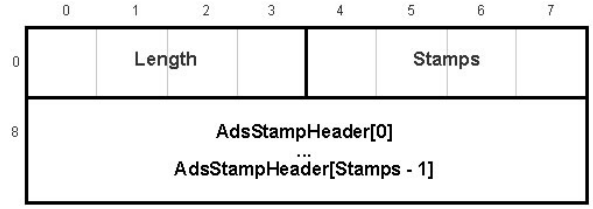
3.2.1.4.4.9 ADS Device Notification

Data will carry forward independently from an ADS device to a Client.

Request

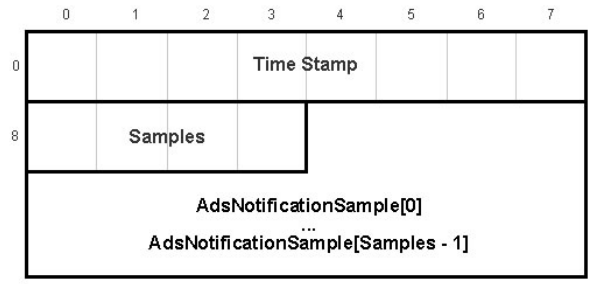
The data which are transferred at the *Device Notification* are multiple nested into one another. The *Notification Stream* contains an array with elements of type *AdsStampHeader.* This array again contains elements of type *AdsNotificationSample*.

AdsNotificationStream



Data array	Size	Description
Length	4 bytes	Size of data in byte.
Stamps	4 bytes	Number of elements of type AdsStampHeader [▶ 30]
AdsStampHeader	n bytes	Array with elements of type AdsStampHeader [▶ 30]

AdsStampHeader



Data array	Size	Description
TimeStamp	8 bytes	The timestamp is coded after the Windows FILETIME format. I.e. the value contains the number of the 100-nanosecond intervals, which passed since 1.1.1601. In addition, the local time change is not considered. Thus the time stamp is present as universal Coordinated time (UTC).
Samples	4 bytes	Number of elements of type AdsNotificationSample [▶ 31]
AdsNotificationSample	n bytes	Array with elements of type AdsNotificationSample [▶ 31]

AdsNotificationSample

Data array	Size	Description
Notification Handle	4 Bytes	Handle of notification.
Sample Size	4 Bytes	Size of data range in bytes.
Data	n Bytes	Data

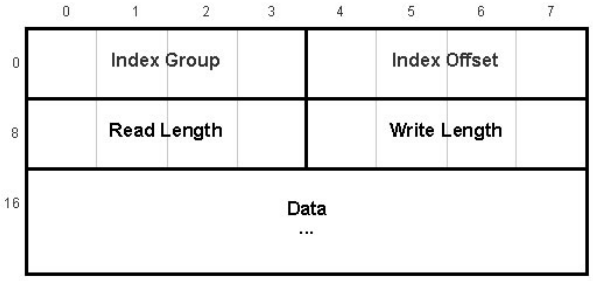
If your handle becomes invalid, one notification without data will be send once as advice.

3.2.1.4.4.10 ADS Read Write

With *ADS ReadWrite* data will be written to an ADS device. Additionally, data can be read from the ADS device.

The data which can be read are addressed by the *Index Group* and the *Index Offset*

Request



Data array	Size	Description
Index Group	4 bytes	Index Group, in which the data should be written.
Index Offset	4 bytes	Index Offset, in which the data should be written
Read Length	4 bytes	Length of data in bytes, which should be read.
Write Length	4 bytes	Length of data in bytes, which should be written
Data	n bytes	Data which are written in the ADS device.

Response

Data array	Size	Description
Result	4 bytes	ADS error number
Length	4 bytes	Length of data which are supplied back.
Data	n bytes	Data which are supplied back.

3.2.1.5 Specification for ADS devices

3.2.1.5.1 General

The PLC software can be described as a virtual field unit (Automation Device), since it is a pure software PLC. It therefore provides a Beckhoff ADS (Automation Device Specification) interface for other communication partners (e.g. other virtual field units or Windows programs), via which it can be parameterised or interrogated. Use of the ADS standardises access to the PLC and incorporates it into the range of available virtual field units.

The READ and WRITE operations take place on the PLC interface (as defined by ADS) via two numbers: the index group (16 bit) and the index offset (32 bit). The ADS interface of the PLC will be described in more detail in the following pages with regard to the group and offset indices.

Specification "Index-Group" of the PLC

The four global ranges of an ADS unit are shown as follows for the PLC as four sections in the index groups:

Index-Group (0x = hex)	Index Group description
0x00000000 0x00000FFF	reserved
0x00001000	PLC ADS parameter range
0x00002000	PLC ADS status range
0x00003000	PLC ADS unit function range
0x00004000	PLC ADS services (includes services to access PLC memory range (%M field)) [▶ 32]
0x00006000 0x0000EFFF	reserved for PLC ADS extension
0x0000F000 0x0000FFFF	general TwinCAT ADS system services (includes services to access PLC process diagram of the physical inputs and outputs) [▶ 33]

3.2.1.5.2 Specification of the PLC services

This section includes services to access the PLC memory range (%M field).

Index Group	Index Offset	Access	Data type	Description	Remarks
0x00004020	0x00000000-0x0000FFFF	R/W	UINT8[n]	**READ_M - WRITE_M** PLC memory range(%M field).Offset is byte offset.	
0x00004021	0x00000000-0xFFFFFFFF	R/W	UINT8	**READ_MX - WRITE_MX** PLC memory range (%MX field).The low word of the index offset is the byte offset. The index offset contains the bit address calculated from the byte number *8 + bit number	
0x00004025	0x00000000	R	ULONG	**PLCADS_IGR_RMSIZE** Byte length of the process diagram of the memory range	
0x00004030	0x00000000-0xFFFFFFFF	R/W	UINT8	**PLCADS_IGR_RWRB** Retain data range. The index offset is byte offset	
0x00004035	0x00000000	R	ULONG	**PLCADS_IGR_RRSIZE** Byte length of the retain range	
0x00004040	0x00000000-0xFFFFFFFF	R/W	UINT8	**PLCADS_IGR_RWDB** Data range. The index offset is byte offset.	
0x00004045	0x00000000	R	ULONG	**PLCADS_IGR_RDSIZE** Byte length of the data range	

3.2.1.5.3 Specification of the ADS system services

This section covers those ADS services which have identical meanings and effects with every TwinCAT ADS unit. In this section are also included services to access the PLC process diagram of the physical inputs and outputs.

Index Group	Index Offset	Access	Data type	Description
0x0000F003	0x00000000	R&W	W: UINT8[n] R: UINT32	**GET_SYMHANDLE_BYNAME** A handle (code word) is assigned to the name contained in the write data and is returned to the caller as a result.
0x0000F004	0x00000000			Reserved.
0x0000F005	0x00000000-0xFFFFFFFF=sym Handle	R/W	UINT8[n]	**READ_/ WRITE_SYMVAL_BYHANDLE** Reads the value of the variable identified by ‚symHdl' or assigns a value to the variable. The ‚symHdl' must first have been determined by the GET_SYMHANDLE_BYNAME services.
0x0000F006	0x00000000	W	UINT32	**RELEASE_SYMHANDLE** The code (handle) contained in the write data for an interrogated, named PLC variable is released.
0x0000F020	0x0001F400-0xFFFFFFFF	R/W	UINT8[n]	**READ_I - WRITE_I** PLC process diagram of the physical inputs (%I field). Offset is byte offset.
0x0000F021	0x000FA000-0xFFFFFFFF	R/W	UINT8	**READ_IX - WRITE_IX** PLC process diagram of the physical inputs (%IX field). The index offset contains the bit address which is calculated from base offset (0xFA000) + byte number +8 + bit number
0x0000F025	0x00000000	R	ULONG	**ADSIGRP_IOIMAGE_RISIZE**Byte length of the PLC process diagram of the physical inputs.
0x0000F030	0x0003E800-0xFFFFFFFF	R/W	UINT8[n]	**READ_Q - WRITE_Q** PLC process diagram of the physical outputs (%Q field). Offset is byte offset.
0x0000F031	0x001F4000-0xFFFFFFFF	R/W	UINT8	**READ_QX - WRITE_QX** PLC process diagram of the physical outputs(%QX field). The index offset contains the bit address which is calculated from the base offset (0x1F4000) + byte number *8 + bit number.
0x0000F035	0x00000000	R	ULONG	**ADSIGRP_IOIMAGE_ROSIZE** Byte length of the PLC process diagram of the physical outputs.

Index Group	Index Offset	Access	Data type	Description
0x0000F080	0x00000000-0xFFFFFFFF= n (number of internal sub-commands)n(max) = 500	R&W	W: n * ULONG[3] := IG1, IO1, Len1, IG2, IO2, Len2, ..., IG(n), IO(n), Len(n) R: n * ULONG + UINT8[Len1] + UINT8[Len2] + ..., + UINT8[Len(n)] := Result1, Result2, ..., Result(n), Data1, Data2, ..., Data(n)	**ADSIGRP_SUMUP_READ** The write-data contains a list of multiple, separate AdsReadReq(IG, IO, Len, Data) sub-commands. The read-data contains a list of return codes followed by the requested data.
0x0000F081	0x00000000-0xFFFFFFFF= n (number of internal sub-commands)n(max) = 500	R&W	W: (n * ULONG[3]) + UINT8[Len1] + UINT8[Len2] + ..., + UINT8[Len(n)] := **IG1, IO1, Len1,** **IG2, IO2, Len2,** **...,** **IG(n), IO(n), Len(n),** **Data1, Data2, ..., Data(n)** R: n * ULONG := **Result1, Result2, ...,** **Result(n)**	**ADSIGRP_SUMUP_WRITE** The write-data contains a list of multiple, separate AdsWriteReq(IG, IO, Len, Data) sub-commands. The read-data contains a list of return codes.

Index Group	Index Offset	Access	Data type	Description
0x0000F082	0x00000000-0xFFFFFFFF= n (number of internal sub-commands)n(max) = 500	R&W	W: (n * ULONG[4]) + UINT8[WriteLen1] + UINT8[WriteLen2] + ..., + UINT8[WriteLen(n)] := **IG1, IO1, ReadLen1, WriteLen1,** **IG2, IO2, ReadLen2, WriteLen2,** **...,** **IG(n), IO(n), ReadLen(n), ..., WriteLen(n),** **WriteData1, WriteData2, ..., WriteData(n)** R: (n * ULONG[2]) + UINT8[ReturnLen1] + UINT8[ReturnLen2] + ..., + UINT8[ReturnLen(n)] := **Result1, ReturnLen1,** **Result2, ReturnLen2,** **...,** **Result(n), ReturnLen(n),** **Read**Data1, ReadData2, ..., ReadData(n)	**ADSIGRP_SUMUP_READWRITE** The write-data contains a list of multiple, separate AdsReadWriteReq(IG, IO, readLen, writeLen, Data) sub-commands. The read-data contains a list of return codes and return data length followed by the requested data.
0x0000F083	0x00000000-0xFFFFFFFF= n (number of internal sub-commands)n(max) = 500	R&W	W: n * ULONG[3] := IG1, IO1, Len1, IG2, IO2, Len2, ..., IG(n), IO(n), Len(n) R: n * ULONG + UINT8[Len1] + UINT8[Len2] + ..., + UINT8[Len(n)] := Result1, Result2, ..., Result(n), Data1, Data2, ..., Data(n)	**ADSIGRP_SUMUP_READEX** The write-data contains a list of multiple, separate AdsReadReq(IG, IO, Len, Data) sub-commands.The read-data contains a list of return codes followed by the requested data.

Index Group	Index Offset	Access	Data type	Description
0x0000F084	0x00000000-0xFFFFFFFF= n (number of internal sub-commands)n(max) = 500	R&W	W: n * ULONG[3] := IG1, IO1, Len1, IG2, IO2, Len2, ..., IG(n), IO(n), Len(n) R: n * ULONG + UINT8[Len1] + UINT8[Len2] + ..., + UINT8[Len(n)] := Result1, Result2, ..., Result(n), Data1, Data2, ..., Data(n)	**ADSIGRP_SUMUP_READEX2** The write-data contains a list of multiple, separate AdsReadReq(IG, IO, Len, Data) sub-commands.The read-data contains a list of return codes followed by the requested data.
0x0000F085	0x00000000-0xFFFFFFFF= n (number of internal sub-commands)n(max) = 500	R&W	W: (n * ULONG[3]) := **IG1, IO1, Len1,** **IG2, IO2, Len2,** **...,** **IG(n), IO(n), Len(n)** R: (n * ULONG) + UINT8[Len1] + UINT8[Len2] + ..., + UINT8[Len(n)] := **Result1, Result2, ...,** **Result(n),** **Handle1, Handle2,...,** **Handle(n)**	**ADSIGRP_SUMUP_ADDDEVNOTE** The write-data contains a list of multiple, separate AdsAddDeviceNotifications(IG, IO, Len, Data) sub-commands.The read-data contains a list of return codes followed by the requested notification handles.
0x0000F086	0x00000000-0xFFFFFFFF= n (number of internal sub-commands)n(max) = 500	R&W	W: **Handle1, Handle2,...,** **Handle(n)** R: (n * ULONG) + UINT8[Len1] + UINT8[Len2] + ..., + UINT8[Len(n)] := **Result1, Result2, ...,** **Result(n)**	**ADSIGRP_SUMUP_DELDEVNOTE** The write-data contains a list of multiple handles.The read-data contains a list of return codes.

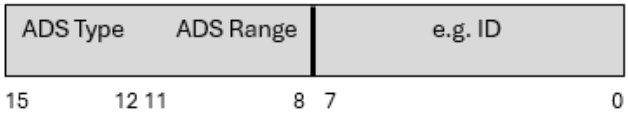
3.2.1.5.4 Specification of the NC

This documentation contains all TwinCAT 3 specific modifications and new features.

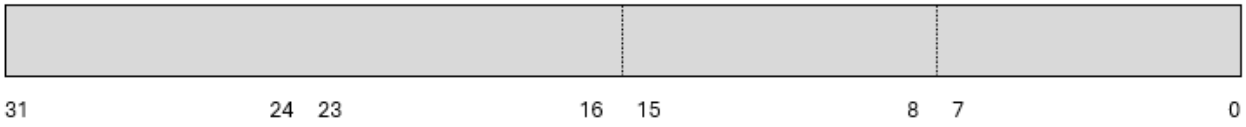
Index-Group (Hex)	Description	Remarks
0x1000	Ring-0-Manager: Parameter [▶ 40]	Optional!
0x1100	Ring-0-Manager: State [▶ 41]	Optional!
0x1200	Ring-0-Manager: Functions [▶ 41]	Optional!
0x1300	Ring-0-Manager: Cyclic process data	Not implemented!
0x2000 + ID	Channel with corresponding ID: parameters [▶ 42]	
0x2100 + ID	Channel with corresponding ID: state [▶ 45]	
0x2200 + ID	Channel with corresponding ID: functions [▶ 48]	
0x2300 + ID	Channel with corresponding ID: cyclic process data [▶ 51]	
0x3000 + ID	Group with corresponding ID: parameters [▶ 52]	Optional!
0x3100 + ID	Group with corresponding ID: state [▶ 57]	Optional!
0x3200 + ID	Group with corresponding ID: functions [▶ 63]	Optional!
0x3300 + ID	Group with corresponding ID: cyclic process data	Not implemented!
0x4000 + ID	Axis with corresponding ID: parameters [▶ 69]	
0x4100 + ID	Axis with corresponding ID: state [▶ 82]	
0x4200 + ID	Axis with corresponding ID: functions [▶ 92]	
0x4300 + ID	Axis with corresponding ID: cyclic process data [▶ 114]	
0x5000 + ID	Encoder with corresponding ID: parameters [▶ 119]	Optional!
0x5100 + ID	Encoder with corresponding ID: state [▶ 124]	Optional!
0x5200 + ID	Encoder with corresponding ID: functions [▶ 129]	Optional!
0x5300 + ID	Encoder with corresponding ID: cyclic process data [▶ 132]	Optional!
0x6000 + ID	Controller with corresponding ID: Parameter [▶ 136]	Optional!
0x6100 + ID	Controller with corresponding ID: State [▶ 140]	Optional!
0x6200 + ID	Controller with corresponding ID: Functions [▶ 143]	Optional!
0x6300 + ID	Controller with corresponding ID: cyclic process data	Not implemented!
0x7000 + ID	Drive with corr. ID: parameters [▶ 144]	Optional!
0x7100 + ID	Drive with corr. ID: state [▶ 148]	Optional!
0x7200 + ID	Drive with corr. ID: functions [▶ 150]	Optional!
0x7300 + ID	Drive with corr. ID: cyclic process data [▶ 151]	Optional!
0x**0**A0**00** + **ID**	Tables (n x m) with corresponding ID: parameters [▶ 154] 0x0A000+ID for table ID [1..255] 0x1A000+ID for table ID [256..4095] . . . 0xFA000+ID for table ID [3840..4095]	Maximum number of tables extended to 4095 (from TC3.1 B4021)
0x**0**A1**00** + **ID**	Tables (n x m) with corresponding ID: state [▶ 159] 0x0000A100+IDLowByte for table ID [1..255] 0x0001A100+IdLowByte for table ID [256..4095] … 0x000FA100+IdLowByte for table ID [3840..4095] 0x000**n**A1**00**+**IdLowByte** for table ID [1..4095] (TabID = n * 256 + IdLowByte)	

Index-Group (Hex)	Description		Remarks
0x0A200 + ID	Tables (n x m) with corresponding ID: functions [▶ 160] 0x0000A100+IDLowByte for table ID [1..255] 0x0001A100+IdLowByte for table ID [256..4095] … 0x000FA100+IdLowByte for table ID [3840..4095] 0x000nA100+IdLowByte for table ID [1..4095] (TabID = n * 256 + IdLowByte)		
0x0A300 + ID	Tables (n x m) with corresponding ID: cyclic process data 0x0000A100+IDLowByte for table ID [1..255] 0x0001A100+IdLowByte for table ID [256..4095] … 0x000FA100+IdLowByte for table ID [3840..4095] 0x000nA100+IdLowByte for table ID [1..4095] (TabID = n * 256 + IdLowByte)		Not implemented!
0xF000 ... 0xFFFF	reserved area (TwinCAT system area)		
IndexGroup:	IndexOffset:		
0xF081	0x00000000 ... 0xFFFFFFFF (n elements)	ADSIGRP_SUMUP_WRITE The *Read-Write-command* contains a list in the Write-data of multiple separate *ADS-Write-commands* (like a group request). Structure of the Write-Data: *[IdxGrp(1), IdxOff(1), WriteLen(1), ..., IdxGrp(n), IdxOff(n), WriteLen(n), WriteData(1), ..., WriteData(n)]* Structure of the Read-Data: *[* Error*(1), ..., Error(n)]*	
0xF082	0x00000000 ... 0xFFFFFFFF (n elements)	ADSIGRP_SUMUP_READWRITE The *Read-Write-command* contains a list in the Write-data of multiple separate *ADS-Read-Write-commands* (like a group request). Structure of the Write-Data: *[IdxGrp(1), IdxOff(1),ReadLen(1), WriteLen(1), ..., IdxGrp(n), IdxGrp(n), ReadLen(n), WriteLen(n), WriteData(1), ..., WriteData(n)]* Structure of the Read-Data: *[Error(1), ReadLen(1), ..., Error(n), ReadLen(n), ReadData(1), ..., ReadData(n)]*	
0xF084	0x00000000 ... 0xFFFFFFFF (n elements)	ADSIGRP_SUMUP_READ (READEX2) The *Read-Write-command* contains a list in the Write-data of multiple separate *ADS-Read-commands* (like a group request). Structure of the Write-Data: *[IdxGrp(1), IdxOff(1), ReadLen(1), ..., IdxGrp(n), IdxGrp(n), ReadLen(n)]* Structure of the Read-Data: *[Error(1), ReadLen(1), ..., Error(n), ReadLen(n), ReadData(1), ..., ReadData(n)]*	

Index Group:



Index Offset:



3.2.1.5.4.1 Specification Ring-0-Manager

3.2.1.5.4.1.1 "Index offset" specification for Ring-0 parameter (Index group 0x1000)

Index offset (Hex)	Access	Ring-0-Manager	Data type	Phys. unit	Definition range	Description	Remarks
0x00000010	Read	every	UINT32	100 ns		Cycle time SAF task	
0x00000012	Read	every	UINT32	100 ns		Cycle time SVB task	
0x00000014	Read	every	INT32	ns		Global Time Compensation Shift (for SAF Task)	
0x00000020	Read/Write	every	UINT16	1	0/1	Cyclic data consistence check and correction of the NC setpoint values	

3.2.1.5.4.1.2 "Index offset" specification for Ring-0 state (Index group 0x1100)

Index offset (Hex)	Access	Ring-0-Manager	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Read	every	UINT32	1	0, 1...255	Quantity of Channel	
0x00000002	Read	every	UINT32	1	0, 1...255	Quantity of group	
0x00000003	Read	every	UINT32	1	0, 1...255	Quantity of Axis	
0x00000004	Read	every	UINT32	1	0, 1...255	Quantity of Encoder	
0x00000005	Read	every	UINT32	1	0, 1...255	Quantity of controller	
0x00000006	Read	every	UINT32	1	0, 1...255	Quantity of Drives	
0x0000000A	Read	every	UINT32	1	0, 1...255	Quantity of table (n x m)	
0x00000010	Read	every	UINT32	1		Cycle time error counter SAF task (not scopeable)	Reserved!
0x00000014	Read	every	UINT32	1		IO-cycle time error counter SAF task (not scopeable)	Reserved!
0x00000020	Read	every	UINT32	s		Computing time SAF task (not scopeable)	Reserved!
0x00000031	Read	every	UINT32[n]	1	0, 1...255	Supplies the channel IDs for all channels in the system	
0x00000032	Read	every	UINT32[n]	1	0, 1...255	Supplies the group IDs for all groups in the system	
0x00000033	Read	every	UINT32[n]	1	0, 1...255	Supplies the axis IDs for all axes in the system	
0x00000034	Read	every	UINT32[n]	1	0, 1...255	Supplies the encoder IDs for all encoders in the system	
0x00000035	Read	every	UINT32[n]	1	0, 1...255	Supplies the controller IDs for all controllers in the system	
0x00000036	Read	every	UINT32[n]	1	0, 1...255	Supplies the drive IDs for all drives in the system	
0x0000003A	Read	every	UINT32[n]	1	0, 1...255	Supplies the table IDs for all tables in the system	
0x000001nn	Read	every	UINT32	1	0, 1...255	Supplies for the encoder ID the appropriate axis IDnn = Encoder ID	Reserved!
0x000002nn	Read	every	UINT32	1	0, 1...255	Supplies for the controller ID the appropriate axis IDnn = Controller ID	Reserved!
0x000003nn	Read	every	UINT32	1	0, 1...255	Supplies for the drive ID the appropriate axis IDnn = Drive ID	Reserved!

3.2.1.5.4.1.3 "Index offset" specification for Ring-0 functions (Index group 0x1200)

Index offset (Hex)	Access	Ring-0-Manager	Data type	Phys. unit	Definition range	Description	Remarks
0x00000020	Write	every	VOID	1		Clear cycle time error counter SAF & SVB	Reserved!

3.2.1.5.4.2 Specification Channels

3.2.1.5.4.2.1 "Index offset" specification for channel parameter (Index group 0x2000 + ID)

Index-Offset (Hex)	Access	Channel type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Read	every	UINT32	1		Channel ID	
0x00000002	Read	every	UINT8[30+1]	1		Channel name	
0x00000003	Read	every	UINT32	1	ENUM	Channel type [▶ 160]	
0x00000004	Read	every	UINT32	1	ENUM	Interpreter type [▶ 160]	
0x00000005	Read	every	UINT32	1		Program load buffer size in bytes	
0x00000006	Read	every	UINT32	1		Program no. according to job list	
0x00000007	Read/Write	every	UINT32	1	ENUM	Set load log mode [▶ 161]	
0x00000008	Read/Write	every	UINT32	1	ENUM	Set trace mode [▶ 161]	
0x00000009	Read/Write	every	UINT32	1		RESERVED	
0x0000000A	Read/Write	every	UINT32	1	0/1	Records all feeder entries in a log file named "TcNci.log"	
0x0000000B	Read/Write	every	UINT32	1	0/1	Channel specific level for NC logger messages 0: errors only 1: all NC messages	
0x00000010	ReadWrite	every	**Write**				
			{				
			UINT32	1	0..159	Start index of M function	
			UINT32	1	1..160	Number of M functions to be read	
			}				
			Read [n]				
			{				
			UINT8	1	0..159	Rule bit mask of the M function	
			INT32[10]	1	-1..159	Number of M functions to be cleared	
			}				
0x00000011	Write	Interpolation				Write M function description	Only used internally!
0x00000012	Read/Write	Interpolation	LREAL64	1		Factor for G70	
0x00000013	Read/Write	Interpolation	LREAL64	1		Factor for G71	
0x00000014	Write	Interpolation	{			Axes user symbols	not yet released
			char[32]			User symbol (null-terminated)	
			char[10]			System symbol (null-terminated)	
			}				
0x00000015	Read/Write	Interpolation	UINT16 resp. UINT32	1	0/1 default: FALSE	Activation of default G-code	NEW from TC3.1 B4014
0x00000021	Read	every	UINT32	1		Group ID (only explicit for 3D and FIFO channel)	
0x00000031	Read/Write	Interpolation	UINT16	1		Standard output port of the interpreter	Reserved function, no standard!
0x00000032	Read/Write	Interpolation	UINT16	1	0/1	Cartesian tool offset entry	Reserved function, no standard!

Index-Offset (Hex)	Access	Channel type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000040	Read/Write	Interpolation	{			**Target address of interpreter hooks**	Reserved function, no standard!
			char[6]			Ams Net ID	
			UINT16			Port	
			UINT32			Index group	
			UINT32			Index offset	
			}				
0x00000050	Read/Write	Interpolation	UINT32	1	ENUM	Reaction if at the radius compensation a bottle neck is recognized 0: Error and abort 1: Note & trouble shooting 2: Only note, without outline modulation	
0x00000051	Read/Write	Interpolation	UINT32	1	1..24	Look ahead for bottleneck detection	
0x00000052	Read/Write	Interpolation	UINT32	1	0/1	Chamfer on/off	reserved function, no standard!
0x00000053	Read/Write	Interpolation	UINT32	1		Activation for reading the currently effective interpolation rules, zero shifts and rotation 0: off 1: on	
0x00000054	Read/Write	Interpolation	UINT32	1	0/1	Retrace on/off	Reserved function, no standard!
0x00000055	Read/Write	Interpolation	UINT32[4]	1		Configuration of the cyclic channel interface for UINT32; up to 4 index offsets can be configured.	
0x00000056	Read/Write	Interpolation	UINT32[4]	1		Configuration of the cyclic channel interface for LREAL; up to 4 index offsets can be configured.	
0x00010K0L	Read/Write	every	REAL64	e.g. mm	±MAX REAL64	Value for zero shift (NPV)	
					[1..3]	Axis index K=1 → X K=2 → Y K=3 → Z	
					[1..0xA]	L=1 → G54F L=2 → G54G L=3 → G55F ...	
0x0002ww00	Read/Write	every	UINT16			Tool number: values for tool compensation	
0x0003ww00	Read/Write	every	UINT16		[1...50]	Tool type: ww = tool 1...50	
0x0004wwnn	Read/Write	every	REAL64		[1...14]	Parameter: nn = Index 1...14	
0x000500gg	Read/Write	every	REAL64	e.g. mm	≥ 0 (value) [1...9] (g)	Radius of the tolerance sphere gg = channel group (default: 1)	

3.2.1.5.4.2.2 "Index offset" specification for channel state (Index group 0x2100 + ID)

Index-Offset (Hex)	Access	Channel type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Read	every	INT32	1	ENUM	Error code Channel	
0x00000002	Read	every	UINT32	1		Number of groups in the Channel	
0x00000003	Read	every	UINT32	1	ENUM	Interpreter status [▶ 161]	Cannot be traced by oscilloscope!
0x00000004	Read	every	UINT32	1	ENUM	Interpreter/channel operation mode [▶ 161]	
0x00000005	Read	every	UINT32	1		Currently loaded program	
0x00000007	Read	every	UINT8[...]	1		Program name of currently loaded program (100 characters, null-terminated)	Max. 100 characters, null-terminated
0x00000008	Read	Interpreter	UINT32	1	[0,1]	Interpreter simulation mode 0: off (default) 1: on	Cannot be traced by oscilloscope!
0x00000010	Read	Interpreter	UINT32	1		Text index If the interpreter is in the aborted state, the current text index can be read out here	Cannot be traced by oscilloscope!
0x00000011	ReadWrite	Interpreter	**Write**				Cannot be traced by oscilloscope!
			UINT32	1		Text index	
			Read				
			UINT8[..]	1		Line of the NC part program from the text index	
0x00000012	Read	Interpreter	{				
			UINT32	1		Current display for 1: SAF 2: Interpreter 3: Error offset	
			UINT32	1		File offset	
			UINT8[260]	1		Path + program name	
			}				
0x00000013	Read	Interpreter	UINT32[18]			Display for currently effective G-code	The technology data must first be activated.
0x00000014	Read	Interpreter	{			Determines the currently effective zero shift	The technology data must first be activated.
			UINT32	1		Block counter	
			UINT32			Dummy	
			LREAL[3]	1		Zero shift G54..G57	
			LREAL[3]	1		Zero shift G58	
			LREAL[3]	1		Zero shift G59	
			}				
0x00000015	Read	Interpreter	{			Determines the currently effective rotation	The technology data must first be activated.
			UINT32	1		Block counter	
			UINT32	1		Dummy	
			LREAL[3]	1		Rotation of X, Y & Z in degrees	
			}				
0x00000016	Read	Interpreter	UINT32	1	[0,1]	Feeder Info	Only used internally! Not standard

Index-Offset (Hex)	Access	Channel type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000100	Read	every	UINT32 [n]	1	[0, 1...255]	Returns the respective axis IDs in the channel number: [1...255] axis ID's: [0, 1...255]	Cannot be traced by oscilloscope!

3.2.1.5.4.2.3 "Index offset" specification for channel functions (Index group 0x2200 + ID)

Index offset (Hex)	Access	Channel type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Write	every	UINT32	1		Load NC program with program number	
0x00000002	Write	every	VOID			Start Interpreter	
0x00000003	Write	every	VOID			RESERVED	
0x00000004	Write	every	UINT8[...]			Load NC program by name. The standard NC path does not have to be given although it may. Other paths are also permitted.	
0x00000005	Write	every	UINT16	ENUM	cf. appendix interpreter operation mode [▶ 161]	Set the interpreter/ channel operation mode	
0x00000006	Write	Interpreter	UINT8[...]			Set path for subroutines	
0x00000008	Write	Interpreter	UINT32	1		Interpreter simulation mode: 0: off (default) 1: on	Not yet released
0x0000000F	Write	every	VOID			RESERVED	
0x00000010	Write	every	VOID			"Reset" Channel	
0x00000011	Write	every	VOID			"Stop" Channel	
0x00000012	Write	every	VOID			"Retry" Channel (restart Channel)	
0x00000013	Write	every	VOID			"Skip" Channel (skip task/ block)	
0x00000014/0 x00000015	Write	every	{			"Enable Retrace" /"Disable Retrace"	Reserved function, no standard!
			UINT32	1	>0	Feeder directiion: 1: forward 2: backward	
			UINT32	1	≥ 0	Entry index	
			REAL64[3]	mm	±∞	Pos. of the main axes X, Y, Z	
			REAL64[5]	mm	±∞	Pos. of the auxiliary axes Q1, ..., Q5	
			}				
0x00000020	Write	every	VOID			"Save" zero offset shift (NPV)	
0x00000021	Write	every	VOID			"Load" zero offset shift (NPV)	
0x00000022	Write	every	VOID			"Save" tool compensations	
0x00000023	Write	every	VOID			"Load" tool compensations	
0x00000024	Write	Interpolation	{			Saves snapshot of the interpreter in a given file	
			char[32]			Filename in TwinCAT\CNC-folder	
			UINT32	1	0..1	Mask: 0x1: R-Parameters 0x2: Zeroshifts 0x4: Tool Desc	
			}				

Index offset (Hex)	Access	Channel type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000025	Write	Interpolation	{			Reads snapshot of a given file to the interpreter	
			char[32]			Filename in TwinCAT\CNC-folder	
			UINT32	1	0..1	Mask: 0x1: R-Parameters 0x2: Zeroshifts 0x4: Tool Desc	
			}				
0x00000026	Write	Interpolation	VOID			Set all tool parameters (incl. type & number) to null	
0x00000027	Write	Interpolation	VOID			Set all zero offset shifts to null	
0x00000030	Write	every	VOID			Restart (Go Ahead) of the Interpreter after programmed Interpreter stop	
0x00000040	Write	every	VOID			Triggerevent for deletion of any remaining travel in the NCI	
0x00000041	Write	every				RESERVED for fair events	
0x00000050	Write	Interpolation	VOID	1		Set *ExecIdleInfo*in the interpreter	Reserved function, no standard!
0x00000051	Write	Interpolation	UINT32	1		Set block skip mask in the interpreter parameter: *SkippingMask*	Reserved function, no standard!
0x00000052	Write	Intepolation	UINT32	1		Set *ItpOperationMode* in the interpreter parameter: OperationMode mask	Reserved function, no standard!
0x00000053	Write	Interpolation	VOID			Set *ScanningFlag* in the NC device	Reserved function, no standard!
0x00000054	Write	Interpolation				Scan position	Reserved function, no standard!
			double[8]			position	
0x00000055	Write	Interpolation				Reserved	
0x00000056	Write	Interpolation	VOID			Set Interpreter in the *Aborted* state	Reserved function, no standard!
0x00000060	Write	Interppolation	UINT16	1	0..159	Manual reset of a fast M Function	

3.2.1.5.4.2.4 "Index offset" specification for cyclic channel process data (Index group 0x2300 + ID)

Index offset (Hex)	Access	Channel type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000000	Read	every (PLC→NC)	{128 Byte}		STRUCT s. Channel interface	CHANNEL STRUCTURE (PLC→NC) Remark: Size and alignment changed.	Current PLC structure: NciChannelFromPlc *PLCTONC_NCICHANNEL_REF*
0x00000001	Read	every	UINT8[...] min. 30 Byte	1		Interpreter program display	Cannot be traced by oscilloscope!
0x00000002	Read/Write	every (PLC→NC)	UINT32	%	[0...1000000]	Speed override channel (Axis in the Channel)	1000000 = 100%
0x00000003	Read/Write	every (PLC→NC)	UINT32	%	[0...1000000]	Speed override spindle	1000000 = 100%
0x00000080	Read	every (NC→PLC)	{160 Byte}		STRUCT s. Channel interface	CHANNEL STRUCTURE (NC→PLC) Remark: Size and alignment changed.	Current PLC structure: NciChannelToPlc *NCTOPLC_NCICHANNEL_REF*
0x10000000 +RegIndex	Read/Write	every	REAL64	1	[0...999]	R parameter of the Interpreter	Cannot be traced by oscilloscope!
0x20000001	Read	every	UINT8[...] min. 30 Byte	1	[1...9]	Program display of group attention handling (SAF)	Cannot be traced by oscilloscope!

3.2.1.5.4.3 Specification Groups

3.2.1.5.4.3.1 "Index offset" specification for group parameter (Index group 0x3000 + ID)

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Read	every	UINT32	1		Group ID	
0x00000002	Read	every	UINT8[30+1]	1		Group name	
0x00000003	Read	every	UINT32	1	ENUM	Group type [▶ 161]	
0x00000004	Read	every	UINT32	µs		SAF cycle time group	
0x00000005	Read	every	UINT32	µs		SVB cycle time group	
0x00000006	Read/Write	every	UINT16	1	0/1	Single block operation mode?	
0x0000000B	Read	every	UINT32	1		Size of the SVB table (max. number of SVB entries	
0x0000000C	Read	every	UINT32	1		Size of the SAF table (max. number of SAF entries	
0x00000010	Read/Write	every	UINT32	1	[1,2...32] Default: 1	Internal SAF cycle time divisor (divides the internal SAF cycle time by this factor)	e.g. for DXD group
0x00000021	Read	Channel: every	UINT32	1		Channel ID	
0x00000022	Read	Channel: every	UINT8[30+1]	1		Channel name	
0x00000023	Read	Channel: every	UINT32	1	ENUM	Channel type [▶ 160]	
0x00000024	Read	Channel: every	UINT32	1	>0	Number in the Channel	
0x00000500	Read/Write	DXD group	INT32	ENUM	[0, 1]	Cornering velocity reduction method [▶ 161] 0: Coulomb-Scattering 1: Cosinus law 2: VeloJump	
0x00000501	Read/Write	DXD group	REAL64	1	[0.0...1.0]	Velocity reduction factor C0 transition (continuous, but neither once nor twice continuously differentiable)	
0x00000502	Read/Write	DXD group	REAL64	1	[0.0...1.0]	Velocity reduction factor C1 transition (continuous and continuously differentiable once)	
0x00000503	Read/Write	DXD group	REAL64	degree	[0.0...180.0]	Critical angle at segment transition "Low" (must be strictly less than or equal to the velocity reduction angle C0)	
0x00000504	Read/Write	DXD group	REAL64	degree	[0.0...180.0]	Critical angle at segment transition "High" (must be strictly less than or equal to the velocity reduction angle C0)	
0x00000505	Read/Write	DXD group	REAL64	mm/s	≥ 0	Minimum velocity, which must not be undershot at segment transitions, despite possible velocity reduction.	Attention: Parameter is not saved in the solution and is not transferred as NC boot parameter!
0x00000506	Read/Write	DXD group	REAL64	e.g. mm	[0.0...1000.0]	Radius of the tolerance sphere for blending	Not implemented!
0x00000507	Read/Write	DXD group	REAL64	1		Velocity reduction factor C2 transition	

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000508	Read/Write	DXD group	UINT16	1	0/1	Enables calculation of the total remaining path length	NEW from TC3.1 B4020.40
0x00000509	Read/Write	DXD group	UINT16	1	0/1 Default: 1	General activation of the software limit position monitoring for the main axes (X, Y, Z) (see encoder parameters)	
0x0000050A	Read/Write	DXD group	UINT32	1	0/1	NCI Overridetype 0: related to internal reduced velocity (without iteration) 1: related to original external (programmed) velocity 2: Relative to the internally reduced velocity (0 ... >100%)	
0x0000050C	Read	DXD group	UINT32	1	[128 ... 1024] Default: 128	User-defined maximum number of the NCI SAF tables entries	NEW from TC3.1 B4014 boot parameters
0x00000510	Read/Write	DXD group	REAL64	1	≥ 0	For reduction method VeloJump Reductionfactor for C0 transitions: X axis	Not implemented!
0x00000511	Read/Write	DXD group	REAL64	1	≥ 0	For reduction method VeloJump Reductionfactor for C0 transitions: Y axis	Not implemented!
0x00000512	Read/Write	DXD group	REAL64	1	≥ 0	For reduction method VeloJump Reductionfactor for C0 transitions: Z axis	Not implemented!
0x00000513	Read/Write	DXD group	LREAL64	1	]0.0..1.0[	Blending for auxiliary axes: If the effective path velo is smaller than the programmed one multiplied with this factor, then an accurate stop is inserted and the tolerance ball is deleted	Not yet released
0x00000514	Read/Write	DXD group	UINT32	1	[1 … 20] Default: 1	Maximum number of transferred jobs per NC cycle (from SVB to SAF)	NEW from TC3.1 B4020.40
0x00000604	Read/Write	Encoder group	REAL64	e.g. mm/s	[0.0...1000.0]	Velocity window resp. standstill window	Base Unit / s
0x00000605	Read/Write	Encoder group	REAL64	s	[0.0...60.0]	Filter time for standstill window in seconds	
0x00000606	Read/Write	Encoder group	REAL64	s	[0.0...60.0]	Dead time compensation master/slave coupling ("angle pre-control")	
0x00000701	Read	FIFO group	UINT32	1	[1...16]	FIFO dimension (m = number of axes) Note: The FIFO dimension was increased to 16.	(n x m) FIFO boot data

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000702	Read	FIFO group	UINT32	1	[1...10000]	FIFO size (length) (n = number of FIFO entries)	(n x m) FIFO boot data
0x00000703	Read	FIFO group	UINT32	1	[0, 1, 4]	Interpolation type for FIFO setpoint generator 0: INTERPOLATIONTYPE_LINEAR (default) 1: INTERPOLATIONTYPE_4POINT 4: INTERPOLATIONTYPE_CUBICSPLINE (with 6 points)	NEW from TC3.1 B4020
0x00000704	Read/Write	FIFO group	UINT32	1	[1, 2]	Override type for FIFO setpoint generator Type 1: OVERRIDETYPE_INSTANTANEOUS (default) Type 2: OVERRIDETYPE_PT2	
0x00000705	Read/Write	FIFO group	REAL64	s	> 0.0	P-T2 time for override change (T1=T2=T0)	
0x00000706	Read/Write	FIFO group	REAL64	s	≥ 0.0	Time delta for two sequenced FIFO entries (FIFO entry timebase)	
0x00000801	ReadWrite	Kinematic group	**Write**			Calculation of the kinematic forward transformation for the positions (ACS -> MCS)	
			{				
			REAL64[8]	e.g. degree	±∞	ACS (Axis Coordinate System) axis positions, max. dimension: 8	
			UINT32	1	≥ 0	Reserve	
			UINT32	1	≥ 0	Reserve	
			}				
			Read				
			{				
			REAL64[8]	e.g. mm	±∞	MCS (Machine Coordinate System) axis positions, max. dimension: 8	
			UINT32	1	≥ 0	Reserve	
			UINT32	1	≥ 0	Reserve	
			}				

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000802	ReadWrite	Kinematic group	**Write**			Calculation of the kinematic inverse transformation for the positions (MCS -> ACS)	
			{				
			REAL64[8]	e.g. mm	±∞	MCS (Machine Coordinate System) axis positions, max. dimension: 8	
			UINT32	1	≥ 0	Reserve	
			UINT32	1	≥ 0	Reserve	
			}				
			Read				
			{				
			REAL64[8]	e.g. degree	±∞	ACS (Axis Coordinate System) axis positions, max. dimension: 8	
			UINT32	1	≥ 0	Reserve	
			UINT32	1	≥ 0	Reserve	
			}				

3.2.1.5.4.3.2 "Index offset" specification for group state (Index group 0x3100 + ID)

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000001	Read	every	INT32	1	ENUM	Error code group	
0x00000002	Read	every	UINT32	1		Number of master axes	
0x00000003	Read	every	UINT32	1		Number of slave axes	
0x00000004	Read	every	UINT32	1	s. ENUM	SVB group state (state)	
0x00000005	Read	every	UINT32	1	s. ENUM	SAF group state (main state)	
0x00000006	Read	every	UINT32	1	s. ENUM	Moving state (state)	
0x00000007	Read	every	UINT32	1	s. ENUM	SAF sub-group state (sub state)	
0x00000008	Read	every	UINT32	1	s. ENUM	Referencing state (state)	
0x00000009	Read	every	UINT32	1	s. ENUM	Coupling state (state)	Cannot be traced by oscilloscope!
0x0000000A	Read	every	UINT32	1	≥0	Coupling table index	Cannot be traced by oscilloscope!
0x0000000B	Read	every	UINT32	1	≥0	current number of SVB entries/tasks	*Symbolic access: 'SvbEntries' (DXD)*
0x0000000C	Read	every	UINT32	1	≥0	Current number of SAF entries/tasks	*Symbolic access: 'SafEntries' (DXD)*
0x0000000D	Read	every	UINT32	1		Current block number (only active for interpolation group)	*Symbolic access: 'BlockNumber' (DXD)*
0x0000000E	Read	every	UINT32	1	≥0	current number of free SVB entries/tasks	Cannot be traced by oscilloscope!
0x0000000F	Read	every	UINT32	1	≥0	Current number of free SAF entries/tasks	Cannot be traced by oscilloscope!
0x00000011	Read	every	UINT16	1	0/1	Emergency Stop (E-Stop) active?	Cannot be traced by oscilloscope!

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000110	Read	PTP group	{			Internal NC information (resolutions)	Reserved!
			REAL64	e.g. mm	± ∞	ExternalEndPosition	
			REAL64	e.g. mm/s	>0	ExternalTargetVelocity	
			REAL64	e.g. mm/s^2	>0	ExternalAcceleration	
			REAL64	e.g. mm/s^2	>0	ExternalDeceleration	
			REAL64	e.g. mm/s^3	>0	ExternalJerk	
			UINT32	1	>0	ExternalOverrideType	
			REAL64	e.g. mm	± ∞	InternalEndPosition	
			REAL64	e.g. mm/s	>0	InternalTargetVelocity (refers to 100 %)	
			REAL64	%	[0 ... 100]	InternalActualOverride	
			REAL64	e.g. mm/s^2	>0	InternalAcceleration	
			REAL64	e.g. mm/s^2	>0	InternalDeceleration	
			REAL64	e.g. mm/s^3	>0	InternalJerk	
			REAL64	e.g. mm	>0	PositionResolution	
			REAL64	e.g. mm/s	≥0	VelocityResolution	
			REAL64	e.g. mm/s^2	≥0	AccelerationResolution	
			REAL64	e.g. mm/s	≥0	VelocityResolutionAtAccelerationZero	
			}				
0x00000500	Read	DXD group	REAL64	e.g. mm	≥ 0	Path rest way (remaining arc length) on the current path segment	*Symbolic access: 'SetPathRemLength'*
0x00000501	Read	DXD group	REAL64	e.g. mm	≥ 0	Racked out arc length on the current path segment	*Symbolic access: 'SetPathLength'*
0x00000502	Read	DXD group	REAL64	e.g. mm/s	≥ 0	Current path set velocity	*Symbolic access: 'SetPathVelo'*
0x00000503	Read	DXD group	REAL64	e.g. mm/s^2	± ∞	Current path set acceleration	*Symbolic access: 'SetPathAcc'*
0x00000504	Read	DXD group	REAL64	e.g. mm/s^2	≥ 0	Amount of the current vectorial set acceleration	*Symbolic access: 'SetPathAbsAcc'*
0x00000505	Read	DXD group	REAL64	e.g. mm/s	≥ 0	Maximum segment end path set velocity	*Symbolic access: 'SetPathVeloEnd'*
0x00000506	Read	DXD group	REAL64	e.g. mm/s	≥ 0	Segment maximum path set velocity	*Symbolic access: 'SetPathVeloMax'*
0x00000507	Read	DXD group	REAL64	e.g. mm	≥ 0	Current relative braking distance based on the current arc length	*Symbolic access: 'SetPathStopDist'*
0x00000508	Read	DXD group	REAL64	e.g. mm	± ∞	Safety distance = segment arc length - current arc length - relative braking distance	*Symbolic access: 'SetPathSecurityDist'*

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000509	Read	DXD group	REAL64	1	0/1	Segment transition	*Symbolic access: 'SetPathSegmentChange'*
0x0000050A	Read	DXD group	REAL64	%	[0 ... 100]	Path velocity override	*Symbolic access: 'SetPathOverride'*
0x00000511	Read	DXD group	REAL64	e.g. mm/s	≥ 0	Component of the actual path velocity	*Symbolic access: 'ActPathAbsVelo'*
0x00000512	Read	DXD group	REAL64	e.g. mm/s^2	± ∞	Actual path acceleration on the current segment	*Symbolic access: 'ActPathAcc'*
0x00000513	Read	DXD group	REAL64	e.g. mm/s^2	≥ 0	Component of the actual path acceleration on the current segment	*Symbolic access: 'ActPathAbsAcc'*
0x00000514	Read	DXD group	REAL64	e.g. mm	± ∞	Position error on the path in tangential direction (signed to indicate leading and lagging)	*Symbolic access: 'PathDiffTangential'*
0x00000515	Read	DXD group	REAL64	e.g. mm	≥ 0	Position error on the path in orthogonal direction	*Symbolic access:'PathDiffOrthogonal'*
0x00000520	Read	DXD group	REAL64	1	≥ 0	Covered arc length of the current segment, normalized to 1.0	
0x00000521	Read	DXD group	REAL64	1	0/1	Change of partial segment (radius of tolerance ball)	
0x00000522	Read	DXD group	REAL64	1	≥ 0	Total remaining path length to the last geometry entry or the next accurate stop. Refers to group parameter 0x508.	
0x00000523	Read	DXD group	REAL64	1	≥ 0	Programmed velocity of the current segment	
0x00000524	Read	DXD group	REAL64	e.g. mm	≥ 0	Path distance (arc length) travelled since the program start	from TC 3.1 B4022.31 from TC 3.1 B4024.0
0x00000530	Read	DXD group	{			Current or last MCS-target position of the main axes X, Y and Z	
			REAL64	e.g. mm	± ∞	Target position X-axis	
			REAL64	e.g. mm	± ∞	Target position Y-axis	
			REAL64	e.g. mm	± ∞	Target position Z-axis	
			}				
0x00000531	Read	DXD group	{			Current or last MCS-target position of the auxiliary axes Q1 to Q5	
			REAL64[5]	e.g. mm	± ∞	Target position of axis Q1 to Q5	
			}				

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000532	Read	DXD group	{			Reads path length, H parameter and Entry ID of the next 11 segments in relation to the current DC time	not generally released
			UINT32			DC Time	
			UINT32			Reserved	
			PreViewTab[11]			11*24 Bytes	
			}				
			PreViewTab				
			{				
			REAL64	e.g. mm		Segment length	
			UINT32	1		block number	
			UINT32	1		H-Parmeter	
			UINT32	1		Entry ID	
			UINT32	1		Reserved	
			}				
0x0000054n	Read	DXD group	REAL64	1	0/1	Within the tolerance ball of the auxiliary axis n = 1..5 Number of the auxiliary axis (not axis ID)	
0x00000546	Read	DXD group	REAL64[8]	e.g. mm	± ∞	Set position array of the (3+5) axes of the 3D group	from TC3.1 B4022.17
0x00000547	Read	DXD group	REAL64[8]	e.g. mm	± ∞	Actual position array of the (3+5) axes of the 3D group	from TC3.1 B4022.17
0x00000548	Read	DXD group	REAL64[8]	e.g. mm	± ∞	Position difference (set/actual) or lag error as array of the (3+5) axes of the 3D group	from TC3.1 B4022.17
0x00000550	Read	DXD group	{			Reads the axis IDs within a 3D group:	
			UINT32	1	[0, 1...255]	X axis ID	
			UINT32	1	[0, 1...255]	Y axis ID	
			UINT32	1	[0, 1...255]	Z axis ID	
			}				
0x00000552	Read	DXD group FIFO group Kinematic group	{ UINT32[m] }	1	[0, 1...255]	Axis allocation of the group: 1st axis ID – mth axis ID m: Dimension of the 3D group with main and auxiliary axes (X, Y, Z, Q1, Q2, Q3, Q4, Q5) or the FIFO group or the ACS axes of the kinematic group	
0x00000553	Read	Kinematic group	{			Reading the axis allocation (ID's) inside the kinematic group:	
			UINT32[8]	1	[0, 1...255]	MCS axis IDs (machine coordinate system)	
			UINT32[8]	1	[0, 1...255]	ACS axis IDs (axis coordinate system)	
			UINT32	1	≥ 0	Reserve	
			UINT32	1	≥ 0	Reserve (NEW)	
			}				

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x0000056n	Read	DXD group	REAL64	1	± ∞	Current position error of the auxiliary axis within the tolerance ball (set value side only) Only for auxiliary axes n = 1..5 Number of the auxiliary axis (not axis ID)	

3.2.1.5.4.3.3 "Index offset" specification for group functions (Index group 0x3200 + ID)

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Write	every	VOID			Reset group	
0x00000002	Write	every	VOID			Stop group	
0x00000003	Write	every	VOID			Clear group (buffer/ task)	
0x00000004	Write	PTP group, 3D group	{			Emergency stop (E-stop) (emergency stop with controlled ramp)	
			REAL64	e.g. mm/ s^2	≥ 0.0	Deceleration (must be greater than or equal to the original deceleration)	
			REAL64	e.g. mm/ s^3	≥ 0.0	Jerk (must greater than or equal to the original jerk)	
			}				
0x00000005	Write	PTP group	{			Parameterizable stop (with controlled ramp)	Reserved function, no standard!
			REAL64	e.g. mm/ s^2	≥ 0.0	Deceleration	
			REAL64	e.g. mm/ s^3	≥ 0.0	Jerk	
			}				
0x00000006	Write	PTP group, 3D group	VOID			"Step on" after Emergency Stop (E-Stop)	
0x00000050	Write	PTP group, 3D group	{			Axis allocation of the group:	
			UINT32	1	[0, 1...255]	X axis ID	
			UINT32	1	[0, 1...255]	Y axis ID	
			UINT32	1	[0, 1...255]	Z axis ID	
			}				
0x00000051	Write	PTP group, 3D group FIFO group	{			axis allocation of the group:	
			UINT32	1	[1...255]	Axis ID	
			UINT32	1	[0 ... (m-1)]	Place index of the axis in the group m: group dimension (PTP: 1;DXD: 3, FIFO: 16)	
			}				
0x00000052	Write	3D group FIFO group	{ UINT32[m] }	1	[0, 1...255]	Axis allocation of the group: First axis ID, ... , m. axis ID m: dimension of the 3D group (X, Y, Z, Q1, Q2, Q3, Q4, Q5) resp. FIFO group	
0x00000053	Write	3D group FIFO group Kinematic group	VOID			Delete the 3D axis allocation, FIFO axis allocation or Kinematic axis allocation and return of the axes to their own PTP groups	
0x00000054	Write	Kinematic group	{			Axis allocation of the kinematic group:	
			UINT32[8]	1	[0, 1...255]	MCS axis IDs (Machine Coordinate System)	
			UINT32[8]	1	[0, 1...255]	ACS axis IDs (Axis Coordinate System)	
			UINT32	1	≥ 0	Reserved	
			UINT32	1	≥ 0	Reserved (NEW)	
			}				

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000060	ReadWrite	3D group		1		Internal "feed group" command ("Feeder")	Execute command!
0x00000061	ReadWrite	3D group		1		Internal "feed group" command ("Feeder")	Execute command!
0x00000110	Write	1D group	VOID			Reference 1D group ("calibration")	
0x00000111	Write	1D group	{			New end position 1D group	
			UINT32	ENUM	s. appendix	End position type [▶ 163] (s. appendix)	
			REAL64	e.g. mm	±∞	New end position (target position)	
			}				
0x0000011A	Write	1D group	{			Set actual position 1D group	**Caution by using!** Always to SAF Port 501!
			UINT32	ENUM	s. appendix	Actual position type [▶ 163] (s. appendix)	
			REAL64	e.g. mm	±∞	Actual position for axis	
			}				
0x0000011B	Write	1D group	UINT32	1	0/1	Set reference flag ("calibrate flag")	**Caution by using!**
0x00000120	Write	1D group	{			Start 1D group (standard start):	
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			REAL64	e.g. mm	±∞	End position (target position)	
			REAL64	mm/s	≥ 0.0	Required velocity	
			}				
0x00000121	Write	1D group (SERVO)	{			Start 1D group (extended start):	
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			REAL64	e.g.mm	±∞	End position (target position)	
			REAL64	mm/s	≥0.0	Required velocity	
			UINT32	1	0/1	Standard acceleration?	
			REAL64	mm/s^2	≥ 0.0	Acceleration	
			UINT32	1	0/1	Standard deceleration?	
			REAL64	mm/s^2	≥ 0.0	Deceleration	
			UINT32	1	0/1	Standard jerk?	
			REAL64	mm/s^3	≥ 0.0	Jerk	
			}				

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000122	Write	1D group (MW servo)	{			Start 1D group (special start):	Reserved start function, no standard!
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			REAL64	e.g. mm	±∞	End position (target position)	
			REAL64	mm/s	≥0.0	required start velocity	
			REAL64	e.g. mm	±∞	Position for a new velocity level	
			REAL64	mm/s	≥0.0	new end velocity level	
			UINT32	1	0/1	Standard acceleration?	
			REAL64	mm/s^2	≥0.0	Acceleration	
			UINT32	1	0/1	Standard deceleration?	
			REAL64	mm/s^2	≥0.0	deceleration	
			UINT32	1	0/1	Standard jerk?	
			REAL64	mm/s^3	≥0.0	Jerk	
			}				
0x00000126	Write	1D group	{			Start drive output:	
			UINT32	ENUM	s. appendix	Output type [▶ 170] (s. appendix)	
			REAL64	e.g. %	±∞	Required output value (e.g. %)	
			}				
0x00000127	Write	1D group	VOID			Stop drive output	
0x00000128	Write	1D group	{			Change the drive output:	
			UINT32	ENUM	s. appendix	Output type [▶ 170] (s. appendix)	
			REAL64	e.g. %	±∞	Required output value (e.g. %)	
			}				
0x00000130	Write	1D group (SERVO)	{			1D section compensation (SERVO):	
			UINT32	ENUM	s. appendix	Compensation type [▶ 163] (s. appendix)	
			REAL64	mm/s/s	≥ 0.0	Max. acceleration increase	
			REAL64	mm/s/s	≥ 0.0	Max. deceleration increase	
			REAL64	mm/s	≥ 0.0	Max. increase velocity	
			REAL64	mm/s	≥ 0.0	Base velocity for the process	
			REAL64	e.g. mm	±∞	Path difference to be compensated	
			REAL64	e.g. mm	≥ 0.0	Path distance for compensation	
			}				
0x00000131	Write	1D group SERVO	VOID			Stop section compensation (SERVO)	

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000140 (0x00n00140)	Write	Master/Slave coupling: 1D group(SERVO)	{			Master/slave coupling (SERVO):	Extension for "flying saw"! angle >0.0 and <= 90.0 degrees(parallel saw: 90.0 degrees)
			UINT32	ENUM	s. appendix	Slave type/coupling type [▶ 164] (s. appendix)	
			UINT32	1	[1...255]	Axis ID of the master axis/group	
			UINT32	1	[0...8]	Subindex n of the master axis (default value: 0)	
			UINT32	1	[0...8]	Subindex n of the slave axis (default value: 0)	
			REAL64	1	[±1000000.0]	Parameter 1: linear: Gearing factor FlySawVelo: Reserve FlySaw: Abs. synchronous position master [mm]	
			REAL64	1	[±1000000.0]	Parameter 2: linear: Reserve FlySawVelo: Reserve FlySawPos: Abs. synchronous position slave [mm]	
			REAL64	1	[±1000000.0]	Parameter 3: linear: Reserve FlySawVelo: Angle of inclination in [DEGREE] FlySawPos: angle of inclination in [DEGREE]	
			REAL64	1	[±1000000.0]	Parameter 4: linear: Reserve FlySawVelo: Gearing factor FlySawPos: Gearing factor	
			}				
0x00000141	Write	Master/Slave decoupling: 1D group(SERVO)	VOID			Master/slave decoupling (SERVO)	
0x00000142	Write	Master / slave parameter 1D group(servo)	{			Change of the coupling parameters (SERVO):	
			REAL64	1	[±1000000.0]	Parameter 1: linear: Gearing factor	
			REAL64	1	[±1000000.0]	Parameter 2: Linear: Reserve	
			REAL64	1	[±1000000.0]	Parameter 3: Linear: Reserve	
			REAL64	1	[±1000000.0]	Parameter 4: Linear: Reserve	
			}				
0x00000144	Write	Slave stop 1D group (SERVO)	VOID			Stop the "flying saw" (SERVO)	Only for "flying saw"
0x00000149	Write	Slave tables 1D group (SERVO)	REAL64	1	±∞	set the slave table scaling of a solo table coupling (SERVO)	Only for Solo table slave
0x00000150	Write	1D group	VOID			Deactivate complete 1D group/axis (disable)	

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000151	Write	1D group	VOID			Activate complete 1D group / axis (enable)	
0x00000160	Write	1D group	VOID			Deactivate drive output of the 1D group (disable)	
0x00000161	Write	1D group	VOID			Activate drive output of the 1D group (enable)	
0x00000362	Write	High/low speed group	UINT16	1	0/1	Release parking brake? 0: automatic activation (default) 1: mandatorily always released!	
0x00000701	Write	FIFO group	VOID			Start FIFO group (FIFO table must have been filled in advance)	(n*m)-FIFO
0x00000710	Write	FIFO group	{ REAL64[x*m]}	e.g. mm	±∞	Write x FIFO entries (lines): (x*m)-values (one or more lines) n: FIFO length (number of lines) m: FIFO dimension (number of columns) range of values x: [1 ... n]	Only possible on a line-by-line basis! (integer multiple)
0x00000711	Write	FIFO group	{ REAL64[x*m]}	e.g. mm	±∞	Overwrite the last x FIFO entries (lines): (x*m)-values (one or more lines) n: FIFO length (number of lines) m: FIFO dimension (number of columns) range of values x: [1 ... n]	Only possible on a line-by-line basis! (integer multiple)
0x00000801	Write	Kinematic group	VOID			Start kinematic group	Reserved function, no standard!

3.2.1.5.4.4 Specification Axes

3.2.1.5.4.4.1 "Index offset" specification for axis parameter (Index group 0x4000 + ID)

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n00000	Read	every (Structure for all axis parameters)	{			General AXIS PARAMETER STRUCTURE (NC/CNC), also contains the sub-elements such as encoder, controller and drive (s. MC_ReadParameterSet in TcMc2.lib) Note: Size and alignment changed.	Modified from TC3
			UINT32	1		Axis ID	
			STRING[30+1]	1		Axis name	
			UINT32	1	ENUM	Axis type [▶ 161]	
			. . .	. . .	. . .	. . .	
			}			1024 bytes (instead of 512 bytes)	
0x00000001	Read	every	UINT32	1		Axis ID	
0x00000002	Read	every	STRING[30+1] UINT8[. . .]	1		Axis name	Any number of characters from TC3.1 Build 4022.32 or 4024.6
0x00000003	Read	every	UINT32	1	ENUM	Axis type [▶ 161]	
0x00000004	Read	every	UINT32	µs		Cycle time axis (SEC)	
0x00000005	Read	every	STRING[10+1]	1		Physical unit	
0x00000006	Read/Write	every	REAL64	e.g. mm/s		Ref. velocity in cam direction	
0x00000007	Read/Write	every	REAL64	e.g. mm/s		Ref. velocity in sync direction	
0x00000008	Read/Write	every	REAL64	e.g. mm/s		Velocity hand slow	
0x00000009	Read/Write	every	REAL64	e.g. mm/s		Velocity hand fast	
0x0000000A	Read/Write	every	REAL64	e.g. mm/s	[0.0...1.0E20]	Velocity rapid traverse	
0x0000000F	Read/Write	every	UINT16	1	0/1	Position range monitoring?	
0x00000010	Read/Write	every	REAL64	e.g. mm	[0.0...1.0E6]	Position range window	
0x00000011	Read/Write	every	UINT16	1	0/1	Motion monitoring?	
0x00000012	Read/Write	every	REAL64	s	[0.0...600]	Motion monitoring time	
0x00000013	Read/Write	every	UINT16	1	0/1	Loop?	
0x00000014	Read/Write	every	REAL64	e.g. mm		Looping distance (±)	
0x00000015	Read/Write	every	UINT16	1	0/1	Target position monitoring?	
0x00000016	Read/Write	every	REAL64	e.g. mm	[0.0...1.0E6]	Target position window	
0x00000017	Read/Write	every	REAL64	s	[0.0...600]	Target position monitoring time	
0x00000018	Read/Write	every	REAL64	e.g. mm		Pulse way in pos. direction	
0x00000019	Read/Write	every	REAL64	e.g. mm		Pulse way in neg. direction	
0x0000001A	Read/Write	every	UINT32	1	ENUM (≥0)	Error reaction mode: 0: instantaneous (default) 1: delayed (e.g. for Master/Slave-coupling)	
0x0000001B	Read/Write	every	REAL64	s	[0...1000]	Error delay time (if delayed error reaction is selected)	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000001C	Read/Write	every	UINT16	1	0/1	Couple slaves via actual values if not ready to operate?	
0x0000001D	Read/Write	every	REAL64	e.g. mm/s^2	[0, 0.01...1.0E10]	Acceleration for fading profile when switching from set to actual values: Default: 0 (in this case the minimum from the axis acceleration is used, i.e. MIN(Acc, Dec))	
0x0000001E	Read/Write	every	UINT32	1	ENUM (≥0)	Fast Axis Stop Signal Type: Selection of the signal type that triggers a fast axis stop (see bit 7 in Drive->nStatus4) *"0 (SignalType_OFF)",* *"1 (SignalType_RisingEdge)","2 (SignalType_FallingEdge)","3 (SignalType_BothEdges)","4 (SignalType_HighActive)","5 (SignalType_LowActive)"*	
0x00000020	Read/Write	every	UINT16	1	0/1	Allow motion commands for slave axis? Default: FALSE	
0x00000021	Read/Write	every	UINT16	1	0/1	Allow motion commands for axes with active external setpoint generator? Default: FALSE	
0x00000026	Read/Write	every	UINT32	1		Interpretation of the units (position, velocity, time) Bit 0: Velocity in x/min instead of x/s Bit 1: Position in thousandths of the base unit Bit 2: Modulo position display	See encoder! Bit array
0x00000027	Read/Write	every	REAL64	e.g. mm/s	[>0...1.0E20]	Max. allowed velocity	
0x00000028	Read/Write	every	REAL64	e.g. mm	[0.0...1.0E6]	Motion monitoring window	
0x00000029	Read/Write	every	UINT16	1	0/1	PEH time monitoring?	Position end and accurate stop
0x0000002A	Read/Write	every	REAL64	s	[0.0...600]	PEH monitoring time	
0x0000002C	Read/Write	every	REAL64	e.g. mm	[-1000.0 ...1000.0]	Backlash	
0x00000030	Read	every	UINT16	1	[0,1]	Persistent data e.g. for actual position and reference state of the encoder?	Boot parameters, cannot be changed online.

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000031	Read	every	{				Read the hardware AMS address (AMS Net ID and AMS Port No) and the EtherCAT channel number (communication channel 0,1,2,3…)
			UINT8[6]			AmsNetId	
			UINT16			AmsPortNo	
			UINT16			ChannelNo	
			} 10 bytes				
0x00000031	Read	every	{				Read the hardware AMS address (AMS Net ID and devices AMS Port No) and the EtherCAT channel number (communication channel 0,1,2,3…) Supplemented by additional NC information such as NC Drive ID, NC Drive type, etc.. NEW from TC3 Drive ObjectId and Encoder ObjectId from NC build 4437
			UINT8[6]			AmsNetId	
			UINT16			AmsPortNo	
			UINT16			ChannelNo	
			UINT16			reserved	
			UINT32	1	[0, 1...255]	NC Drive ID	
			UINT32	1		NC Drive index	
			UINT32	1	Enum	NC Drive type [▶ 170]	
			UINT32	1	[0, 1...255]	NC Encoder ID	
			UINT32	1		NC Encoder index	
			UINT32	1	Enum	NC Encoder type [▶ 166]	
			UINT32	1	[0, 1...255]	NC Axis ID	
			UINT32	1	Enum	NC Axis type [▶ 161]	
			UINT32	1		TwinCAT Drive ObjectId	
			UINT32	1		TwinCAT Encoder ObjectId	
			UINT32[3]			reserved	
			} 64 bytes				
0x00000033	Read	every	{				General APPLICATION REQUEST STRUCTURE (NC/NCI), e.g. for ApplicationHoming request (see *MC_ReadApplicationRequest* in *TcMc2.lib*) Changed in TC3
			UINT16	1	0/1	ApplRequestBit	
			UINT16	1	0: NONE (IDLE) 1: HOMING	ApplRequestType	
			UINT32			ApplCmdNo (not implemented)	
			UINT32	1	≥0	ApplCmdVersion	
			…				
			} 1024 bytes				
0x00000051	Read	Channel: every	UINT32			Channel ID	
0x00000052	Read	Channel: every	STRING[30+1]			Channel name	
0x00000053	Read	Channel: every	UINT32	1	ENUM	Channel type [▶ 160]	
0x00000054	Read	Group: every	UINT32			Group ID	
0x00000055	Read	Group: every	STRING[30+1]			Group name	
0x00000056	Read	Group: every	UINT32	1	ENUM	Group type [▶ 161]	
0x00000057	Read	every	UINT32			Number of encoders	
0x00000058	Read	every	UINT32			Number of controllers	
0x00000059	Read	every	UINT32			Number of drives	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000005A	Read	every	{			Read all sub-elements of an axis:	
			UINT32[9]	1	[0, 1...255]	Axis encoder IDs	
			UINT32[9]	1	[0, 1...255]	Axis controller IDs	
			UINT32[9]	1	[0, 1...255]	Axis drive IDs	
			} 108 bytes				
0x000000F1	Read/Write	every	REAL64	e.g. mm/s^2	Default: 1.0E5	Maximum permitted acceleration	NEW from TC 3.2
0x000000F2	Read/Write	every	REAL64	e.g. mm/s^2	Default: 1.0E6	Maximum permitted deceleration	NEW from TC 3.2
0x00000101	Read/Write	Servo	REAL64	e.g. mm/s^2	[0.01...1.0E20]	Acceleration (default data set)	
0x00000102	Read/Write	Servo	REAL64	e.g. mm/s^2	[0.01...1.0E20]	Deceleration (default data set)	
0x00000103	Read/Write	Servo	REAL64	e.g. mm/s^3	[0.1...1.0E30]	Jerk (default data set)	
0x00000104	Read/Write	Servo	REAL64	s	[0.0 ... 1.0] Default: 0.0 s	Deceleration time between velocity and position values of the setpoint generator in seconds	
0x00000105	Read/Write	Servo	UINT32	1	ENUM Default: type 1	Override type [▶ 162] for velocity: 1: Related to internal reduced velocity (without iteration) 2: Related to original external start velocity (without iteration) 3: Related to internal reduced velocity (optimization by means of iteration) 4: Related to original external start velocity (optimization by means of iteration)	
0x00000106	Read/Write	Servo	REAL64	1	[0.0 ... 1.0E6] Default: 0.0	Maximum permitted step change in velocity for dynamic reduction *DV = factor *min(A+, A-) * DT*	
0x00000107	Read/Write	Servo	UINT16	1	[0.1] Default: 1	Activates acceleration and jerk limitation for the auxiliary axis (Q1 to Q5)	
	Read/Write	Servo	REAL64	e.g. mm	[0.0..1000.0]	Radius of the tolerance sphere for the auxiliary axes	
	Read/Write	Servo	REAL64	e.g. mm	[0.0..10000.0]	Maximum allowed position deviation if the tolerance sphere is reduced Only for auxiliary axes	
0x0000010A	Read/Write	Servo	REAL64	e.g. mm/s^2	[0.01 ... 1.0E20]	Fast Axis Stop: Acceleration (s.a. Fast Axis Stop Signal Type)	
0x0000010B	Read/Write	Servo	REAL64	e.g. mm/s^2	[0.01 ... 1.0E20]	Fast Axis Stop: Deceleration (s.a. Fast Axis Stop Signal Type)	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000010C	Read/Write	Servo	REAL64	e.g. mm/s^3	[0.1 ... 1.0E30]	Fast Axis Stop: Jerk (s.a. Fast Axis Stop Signal Type)	
0x0000010D	Read/Write	Servo	UINT32	1		Index offset of the axis state that is passed in the cyclic interface as "UserData". 0x00000000: deactivated 0x00010012: Encoder position with position bias voltage (without position correction and without dead time compensation) 0x00010014: DriveActVelo 0x00010017: MC_SetPosition offsets	
0x00000201	Read/Write	Stepper motor	UINT32	1	ENUM	Operation mode stepper motor	
0x00000202	Read/Write	Stepper motor	REAL64	e.g. mm/STEP	[1.0E-6 ... 1000.0]	Distance scaling of a motor step	
0x00000203	Read/Write	Stepper motor	REAL64	e.g. mm/s	[0.0 ... 1000.0]	Minimum velocity for velocity profile	
0x00000204	Read/Write	Stepper motor	UINT32	1	[0 ... 100]	Number of steps per frequency/velocity step	
0x00000205	Read/Write	Stepper motor	UINT32	1		Motor mask as sync pulse	Not implemented!
0x00000301	Read/Write	high/low	REAL64	e.g. mm	[0.0 ... 100000.0]	Creep distance in pos. direction	
0x00000302	Read/Write	high/low	REAL64	e.g. mm	[0.0 ... 100000.0]	Creep distance in neg. direction	
0x00000303	Read/Write	high/low	REAL64	e.g. mm	[0.0 ... 100000.0]	Braking distance in pos. direction	
0x00000304	Read/Write	high/low	REAL64	e.g. mm	[0.0 ... 100000.0]	Braking distance in neg. direction	
0x00000305	Read/Write	high/low	REAL64	s	[0.0 ... 60.0]	Braking deceleration in pos. direction	
0x00000306	Read/Write	high/low	REAL64	s	[0.0 ... 60.0]	Braking deceleration in neg. direction	
0x00000307	Read/Write	high/low	REAL64	s	[0.0 ... 60.0]	Switching time from high to low velocity	
0x00000308	Read/Write	high/low	REAL64	e.g. mm	[0.0 ... 100000.0]	Creep distance stop	
0x00000309	Read/Write	high/low	REAL64	s	[0.0 ... 60.0]	Delay time to release brake	
0x0000030A	Read/Write	high/low	REAL64	s	[0.0 ... 60.0]	Pulse time in pos. direction	
0x0000030B	Read/Write	high/low	REAL64	s	[0.0 ... 60.0]	Pulse time in neg. direction	
ENCODER							
0x00n10001	Read	Encoder: every	UINT32	1	[1 ... 255]	Encoder ID n = 0: standard encoder of the axes > 0: nth encoder of the axis (optional)	
0x00n10002	Read	Encoder: every	STRING[30+1]	1	30 characters	Encoder name	
0x00n10003	Read	Encoder: every	UINT32	1	ENUM (>0)	Encoder type [▶ 166]	
0x00n10004	Read/Write	Encoder: every	UINT32	1	Byteoffset	Input address offset (I/O-Input-Image)	Change I/O address

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n10005	Read/Write	Encoder: every	UINT32	1	Byteoffset	Output address offset (I/O-Output-Image)	Change I/O address
0x00n10006	Read/Write	Encoder: every	REAL64	e.g. mm/ INC	[1.0E-12 ... 1.0E+30]	Resulting scaling factor (numerator / denominator) Note: from TC3 the scaling factor consists of two components – numerator and denominator (default: 1.0).	Writing is not allowed if the controller enable has been issued.
0x00n10007	Read/Write	Encoder: every	REAL64	e.g. mm	[±1.0E+9]	Position offset	Writing is not allowed if the controller enable has been issued.
0x00n10008	Read/Write	Encoder: every	UINT16	1	[0,1]	Encoder count direction	Writing is not allowed if the controller enable has been issued.
0x00n10009	Read/Write	Encoder: every	REAL64	e.g. mm	[0.001 ... 1.0E+9]	Modulo factor	
0x00n1000A	Read/Write	Encoder: every	UINT32	1	s. ENUM (>0)	Encoder mode [▶ 167]	
0x00n1000B	Read/Write	Encoder: every	UINT16	1	0/1	Soft end min. monitoring?	
0x00n1000C	Read/Write	Encoder: every	UINT16	1	0/1	Soft end max. monitoring?	
0x00n1000D	Read/Write	Encoder: every	REAL64	mm		Soft end position min.	
0x00n1000E	Read/Write	Encoder: every	REAL64	mm		Soft end position max.	
0x00n1000F	Read/Write	Encoder: every	UINT32	1	s. ENUM (≥0) in the appendix	Encoder evaluation direction [▶ 167] (enable for log. counting direction)	
0x00n10010	Read/Write	Encoder: every	REAL64	s	[0.0...60.0]	Filter time for actual position value in seconds (P-T1)	
0x00n10011	Read/Write	Encoder: every	REAL64	s	[0.0...60.0]	Filter time for actual velocity value in seconds (P-T1)	
0x00n10012	Read/Write	Encoder: every	REAL64	s	[0.0...60.0]	Filter time for actual acceleration value in seconds (P-T1)	
0x00n10013	Read/Write	Encoder: every	STRING[10+1]	1		Physical unit	Not implemented!
0x00n10014	Read/Write	Encoder: every	UINT32	1		Interpretation of the units (position, velocity, time) Bit 0: Velocity in x/min instead of x/s Bit 1: Position in thousandths of the base unit	Not implemented! Bit array
0x00n10015	Read	Encoder: every	UINT32	INC	[0x0... 0xFFFFFFFF]	Encoder mask (maximum value of the encoder actual value in increments Note: The encoder mask may be any numerical value (e.g. 3600000). Unlike in the past, it no longer has to correspond to a continuous series off binary one's (2^n-1).	Read-only parameter see also "Encoder Sub Mask" parameter

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n10016	Read/Write	Encoder: every	UINT16	1	0/1	Actual position correction (measurement system error correction)?	
0x00n10017	Read/Write	Encoder: every	REAL64	s	[0.0...60.0]	Filter time for actual position correction in seconds (P-T1)	
0x00n10019	Read/Write	Encoder: every	UINT32	1	ENUM (>0)	Encoder absolute dimensioning system [▶ 167]	Writing is not allowed if the controller enable has been issued.
0x00n1001A	Read	Encoder: every	UINT32	1	ENUM (>0)	Encoder position initialization	Not implemented!
0x00n1001B	Read/Write	Encoder: every	REAL64	e.g. mm	[≥0, modulo factor/2]	Tolerance window for modulo-start	
0x00n1001C	Read	Encoder: every	UINT32	1	ENUM (>0)	Encoder sign interpretation [▶ 167] (data type)	
0x00n1001D	Read	Encoder: every	UINT16	1	0/1	Incremental or absolute encoder ? 0: Incremental encoder type 1: Absolute encoder type	
0x00n10023	Read/Write	Encoder: every	REAL64	e.g. mm/ INC	[1.0E-12 ... 1.0E+30]	Component of the scaling factor: numerator (=> scaling factor numerator / scaling factor denominator)	NEW from TC3 Writing is not allowed if the controller enable has been issued.
0x00n10024	Read/Write	Encoder: every	REAL64	1	[1.0E-12 ... 1.0E+30]	Component of the scaling factor: denominator (=> scaling factor numerator / scaling factor denominator) Default: 1.0	NEW from TC3 Writing is not allowed if the controller enable has been issued.

0x00n10025	Read/Write	Encoder: every	{
			REAL64
			REAL64
			}
				e.g. mm/ INC
				1
					[1.0E-12 ... 1.0E+30]
					[1.0E-12 ... 1.0E+30]
						Component of the scaling factor: numerator
						Component of the scaling factor: denominator
						(=> scaling factor numerator / scaling factor denominator)
							NEW from TC3

0x00n10030	Read/Write	Encoder: every	UINT32	1		Internal encoder control double word for specifying the operation modes and properties	NEW from TC3
0x00n10101	Read/Write	E: INC	UINT16	1	[0,1]	Inverse search direction for ref.cam?	
0x00n10102	Read/Write	E: INC	UINT16	1	[0,1]	inverse search direction for sync pulse?	
0x00n10103	Read/Write	E: INC	REAL64	e.g. mm	[±1000000.0]	Reference position	
0x00n10104	Read/Write	E: INC	UINT16	1	[0,1]	Distance monitoring between Ref. cams and sync pulse active?	Not implemented!
0x00n10105	Read/Write	E: INC	UINT32	INC	[0 ... 65536]	Minimum gap between Ref. cams and sync pulse in increments	Not implemented!
0x00n10106	Read/Write	E: INC	UINT16	1	[0,1]	External sync pulse?	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n10107	Read/Write	E: INC	UINT32	1	s. ENUM (>0)	Reference mode [▶ 168]	
0x00n10108	Read/Write	E: INC	UINT32	1	[0x0000000F... 0xFFFFFFFF]binary mask: (2^n - 1)	Encoder Sub Mask (maximum value of the absolute range of the encoder actual value in increments) Used, for example, as a reference mark for the referencing mode "Software Sync" and for the NC Retain Data "ABSOLUTE (MODULO)", "INCREMENTAL (SINGLETURN ABSOLUTE)". Note 1: The Encoder Sub Mask must be smaller than or equal to the Encoder Mask. Note 2: The Encoder Mask must be an integer multiple of the Encoder Sub Mask. Note 3: The Encoder Sub Mask must be a continuous sequence of binary ones (2^n-1), e.g. 0x000FFFFF.	see also "Encoder Mask" parameter
0x00n10110	Read/Write	E: INC (encoder simulation)	REAL64	1	[0.0 ... 1000000.0]	Scaling/weight of the noise part for the simulation encoder	
CONTROLLER							
0x00n20001	Read	Controller: every	UINT32	1	[1 ... 255]	Controller ID n = 0: standard controller of the axes > 0: nth controller of the axis (optional)	
0x00n20002	Read	Controller: every	STRING[30+1]	1	30 characters	Controller name	
0x00n20003	Read	Controller: every	UINT32	1	ENUM (>0)	Controller type [▶ 165]	
0x00n2000A	Read/Write	Controller: every		1	ENUM (>0)	Controller mode	
0x00n2000B	Read/Write	Controller: every	REAL64	%	[0.0 ... 1.0]	Weighting of the velocity pre-control (default value: 1.0 = 100 %)	
0x00n20010	Read/Write	Controller: every	UINT16	1	0/1	Position lag monitoring Pos.?	
0x00n20011	Read/Write	Controller: every	UINT16	1	0/1	Position lag monitoring Velocity?	
0x00n20012	Read/Write	Controller: every	REAL64	e.g. mm		Max. lag error position	
0x00n20013	Read/Write	Controller: every	REAL64	s		Max. lag error filter time position	
0x00n20014	Read/Write	Controller: every	REAL64	e.g. mm/s		Max. lag error velocity	
0x00n20015	Read/Write	Controller: every	REAL64	s		Max. lag error filter time velocity	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n20100	Read/Write	P/PID (pos., (veloc.)	REAL64	1	[0.0...1.0]	Maximum output limitation (±) for controller total output	(default value: 0.5 == 50%)
0x00n20102	Read/Write	P/PID (pos.)	REAL64	e.g. mm/ s/ mm	[0.0...1000.0]	Proportional gain kp or kv Unit: Base Unit / s / Base Unit	Position control
0x00n20103	Read/Write	PID (pos.)	REAL64	s	[0.0 ... 60.0]	Integral action time Tn	Position control
0x00n20104	Read/Write	PID (pos.)	REAL64	s	[0.0 ... 60.0]	Derivative action time Tv	Position control
0x00n20105	Read/Write	PID (pos.)	REAL64	s	[0.0 ... 60.0]	Damping time Td	Position control
0x00n20106	Read/Write	PP (Pos.)	REAL64	e.g. mm/ s/ mm	[0.0...1000.0]	Additional proportional gain, kp or kv respectively, that applies above a limiting velocity in percent. Unit: Base Unit / s / Base Unit	Position control
0x00n20107	Read/Write	PP (Pos.)	REAL64	%	[0.0...1.0]	Threshold velocity in percent above which the additional proportional gain, kp or kv respectively, applies	
0x00n20108	Read/Write	P/PID (Acc.)	REAL64	s	[0.0 ... 100.0]	Proportional gain ka	Acceleration pre-control
0x00n2010D	Read/Write	P/PID	REAL64	mm	[0.0 ... 10000.0]	"Dead band" for position error (control deviation) (for P/PID controllers with velocity or torque interface)	Reserved function
0x00n2010F	Read/Write	P/PP/PID (pos.) Slave control	REAL64	(mm/s) / mm	[0.0...1000.0]	Slave coupling difference control: Proportional gain k_{cp}	Slave coupling difference control
0x00n20110	Read/Write	P (Pos.)	UINT16	1	0/1	Automatic offset calibration: active/ passive	
0x00n20111	Read/Write	P (Pos.)	UINT16	1	0/1	Automatic offset calibration: hold mode	
0x00n20112	Read/Write	P (Pos.)	UINT16	1	0/1	Automatic offset calibration: Fading mode	
0x00n20114	Read/Write	P (Pos.)	REAL64	%	[0.0 ... 1.0]	Automatic offset calibration: Pre-control limit	
0x00n20115	Read/Write	P (Pos.)	REAL64	s	[0.1 ... 60.0]	Automatic offset calibration: Time constant	
0x00n20116	Read/Write	PID (pos.)	REAL64	%	[0.0...1.0]	Maximum output limitation (±) for I part in percent (default setting: 0.1 = 10%)	
0x00n20117	Read/Write	PID (pos.)	REAL64	%	[0.0...1.0]	Maximum output limitation (±) for D part in percent (default setting: 0.1 = 10%)	
0x00n20118	Read/Write	PID (pos.)	UINT16	1	0/1	Deactivation of the I part during an active positioning process (assuming I part active)? (Default setting: 0 = FALSE)	
0x00n20120	Read/Write	P/PID (pos.)	REAL64	s	≥0	PT-1 filter value for position error (pos. control deviation)	Reserved function, no standard!

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n20202	Read/Write	P/PID (velocity)	REAL64	1	[0.0...1000.0]	Proportional gain kp or kv	Velocity control
0x00n20203	Read/Write	PID (velocity)	REAL64	s	[0.0 ... 60.0]	Integral action time Tn	Velocity control
0x00n20204	Read/Write	PID (velocity)	REAL64	s	[0.0 ... 60.0]	Derivative action time Tv	Velocity control
0x00n20205	Read/Write	PID (velocity)	REAL64	s	[0.0 ... 60.0]	Damping time Td	Velocity control
0x00n20206	Read/Write	PID (velocity)	REAL64	%	[0.0...1.0]	Maximum output limitation (±) for I-part in percent (default setting: 0.1 = 10%)	Velocity control
0x00n20207	Read/Write	PID (velocity)	REAL64	%	[0.0...1.0]	Maximum output limitation (±) for D-part in percent (default setting: 0.1 = 10%)	Velocity control
0x00n2020D	Read/Write	P/PID (velocity)	REAL64	mm/s	[0.0 ... 10000.0]	"Dead band" for velocity error (control deviation) (for P/PID controllers with velocity or torque interface)	Reserved function
0x00n20220	Read/Write	P/PID (velocity)	REAL64	s	≥0	PT-2 filter value for velocity error (vel. control deviation)	Velocity control, not standard!
0x00n20221	Read/Write	P/PID (velocity)	REAL64	s	≥0	PT-1 filter value for velocity error (vel. control deviation)	Reserved function, no standard!
0x00n20250	Read/Write	P/PI (observer)	UINT32	1	ENUM (>0)	Observer mode [▶ 165] for control in the torque interface 0: OFF (default) 1: LUENBERGER	
0x00n20251	Read/Write	P/PI (observer)	REAL64	Nm / A	>0.0	Motor: Torque constant K_T	
0x00n20252	Read/Write	P/PI (observer)	REAL64	kg m^2	>0.0	Motor: Moment of inertia J_M	
0x00n20253	Read/Write	P/PI (observer)	REAL64	Hz	[100.0 ... 2000.0] Default: 500	Bandwidth f_0	
0x00n20254	Read/Write	P/PI (observer)	REAL64	1	[0.0 ... 2.0] Default: 1.0	Correction factor k_c	
0x00n20255	Read/Write	P/PI (observer)	REAL64	s	[0.0 ... 0.01] Default: 0.001	Velocity filter (1st order): Time constant T	
0x00n20A03	Read/Write	P/PID (MW)	REAL64	cm^2	[0.0 ... 1000000]	Cylinder area A_A of the A side in cm^2	Reserved parameters!
0x00n20A04	Read/Write	P/PID (MW)	REAL64	cm^2	[0.0 ... 1000000]	Cylinder area A_B of the B side in cm^2	Reserved parameters!
0x00n20A05	Read/Write	P/PID (MW)	REAL64	cm^3/s	[0.0 ... 1000000]	Nominal volume flow Q_{nom} in cm^3/s	Reserved parameters!
0x00n20A06	Read/Write	P/PID (MW)	REAL64	bar	[0.0 ... 1000000]	Nominal pressure or valve pressure drop, P_{nom} in bar	Reserved parameters!
0x00n20A07	Read/Write	P/PID (MW)	UINT32	1	[1 ... 255]	Axis ID for the system pressure Po	Reserved parameters!
DRIVE:							
0x00n30001	Read	Drive: every	UINT32	1	[1 ... 255]	Drive ID	
0x00n30002	Read	Drive: every	STRING[30+1]	1	30 characters	Drive name	
0x00n30003	Read	Drive: every	UINT32	1	ENUM (>0)	Drive type [▶ 170]	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n30004	Read/Write	Drive: every	UINT32	1	Byteoffset	Input address offset (I/O-Input-Image)	Change I/O address
0x00n30005	Read/Write	Drive: every	UINT32	1	Byteoffset	Output address offset (I/O-Output-Image)	Change I/O address
0x00n30006	Read/Write	Drive: every	UINT16	1	[0,1]	Motor polarity	Writing is not allowed if the controller enable has been issued.
0x00n3000A	Read/Write	Drive: every	UINT32	1	ENUM (≥0)	Drive mode	
0x00n3000B	Read/Write	Drive: every	REAL64	%	[-1.0 ... 1.0]	Minimum output limit (output limitation) (default setting: -1.0 = -100%)	
0x00n3000C	Read/Write	Drive: every	REAL64	%	[-1.0 ... 1.0]	Maximum output limit (output limitation) (default setting: 1.0 = 100%)	
0x00n3000D	Read	Drive: every	UINT32	INC		Maximum number of output increments (output mask)	
0x00n30010	Read/Write	Drive: every	UINT32	1		Internal Drive Control double word to determine the drive operation modes	Reserved!
0x00n30011	Read/Write	every	UINT32	1	≥ 5	Internal drive reset counter (time in NC cycles for enable and reset)	Reserved!
0x00n30101	Read/Write	D: Servo	REAL64	e.g. mm/s	>0.0	Reference velocity at reference output (velocity pre-control)	
0x00n30102	Read/Write	D: Servo	REAL64	%	[0.0 ... 5.0]	Reference output in percent (default setting: 1.0 = 100%)	
0x00n30103	Read	D: Servo	REAL64	e.g. mm/s	>0.0	Resulting velocity at 100% output	
0x00n30104	Read/Write	D: Servo	REAL64	e.g. mm/s	±∞	Velocity offset (DAC offset) for drift calibration (offset calibration) of the axis	
0x00n30105	Read/Write	D: Servo (Sercos, Profi Drive, AX200x, CANopen)	REAL64	1	[0.0 ... 100000000.0]	Velocity scaling (scaling factor to respond to the weight in the drive)	For Sercos, Profi Drive, AX200x, CANopen
0x00n30106	Read/Write	D: Profi Drive DSC	UINT32	0.001 * 1/s	≥ 0	Profibus/Profi Drive DSC: Position control gain Kpc	Only for Profi Drive DSC
0x00n30107	Read/Write	D: Profi Drive DSC	REAL64	1	≥ 0.0	Profibus/Profi Drive DSC: Scaling for calculation of 'XERR' (default: 1.0)	Only for Profi Drive DSC
0x00n30109	Read/Write	D: Servo (Sercos, CANopen)	REAL64	1	[0.0 ... 100000000.0]	Position scaling (scaling factor to respond to the weight in the drive)	For Sercos, CANopen
0x00n3010A	Read/Write	D: Servo (Sercos, Profi Drive, AX200x, CANopen)	REAL64	1	[0.0 ... 100000000.0]	Acceleration scaling (scaling factor to respond to the weight in the drive)	For Sercos, Profi Drive, AX200x, CANopen
0x00n3010B	Read/Write	D: Servo (Sercos, Profi Drive, AX200x, CANopen)	REAL64	1	[0.0 ... 100000000.0]	Torque scaling (rotary motor) or force scaling (linear motor) (scaling factor for reacting to weighting in the drive) for "TorqueOffset" (additive moment as pre-control)	For Sercos, Profi Drive, AX200x, CANopen

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n3010C	Read/Write	D: Servo (Sercos, Profi Drive, AX200x, CANopen)	REAL64	1	[0.0 ... 100000000.0]	Torque scaling (rotary motor) or force scaling (linear motor) (scaling factor for reacting to weighting in the drive) for "SetTorque" (e.g. MC_TorqueControl) with Drive OpMode CST)	For Sercos, Profi Drive, AX200x, CANopen From TC3.1 B4024.2
0x00n30120	Read/Write	D: servo/ hydraulics/	UINT32	1	≥ 0	Table ID (0: no table)	Only for KL4xxx, M2400, Universal
0x00n30121	Read/Write	D: servo/ hydraulics	UINT32	1	≥ 0	Interpolation type 0: linear 2: spline	Only for KL4xxx, M2400, Universal
0x00n30122	Read/Write	Servo/ hydraulics	REAL64	%	[-1.0 ... 1.0]	Output offset in percent Note: Acts according to the characteristic evaluation!	Only for KL4xxx, M2400, Universal
0x00n30151	Read/Write	D: servo / non-linear	REAL64	1	[0.0 ... 100.0]	Quadrant compensation factor (relationship between quadrant I and III)	
0x00n30152	Read/Write	D: servo / non-linear	REAL64	1	[0.01 ... 1.0]	Velocity reference point in percent (1.0 = 100 %)	
0x00n30153	Read/Write	D: servo / non-linear	REAL64	1	[0.01 ... 1.0]	Output reference point in percent (1.0 = 100 %)	
0x00030301	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 1	
0x00030302	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 2	
0x00030303	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 3	
0x00030304	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 4	
0x00030305	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 5	
0x00030306	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 6	
0x00030307	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 7	
0x00030308	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Cycle 8	
0x00030310	Read/Write	D: Stepper motor	UINT8	1		Bit mask: Holding current	

3.2.1.5.4.4.2 "Index offset" specification for axis state (Index group 0x4100 + ID)

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n00000	Read	every (online structure for axis data)	{			AXIS ONLINE STRUCTURE (NC/ CNC)	Changed from TwinCAT 3, not oscilloscopeable! (NCAXISSTATE_ ONLINESTRUCT)
			INT32	1		Error state	
			INT32			Reserved	
			REAL64	e.g. mm		Actual position	
			REAL64	e.g. degrees		Modulo actual position	
			REAL64	e.g. mm		Set position	
			REAL64	e.g. degrees		Modulo set position	
			REAL64	e.g. mm/ s		Optional: Actual velocity	
			REAL64	e.g. mm/ s		Set velocity	
			UINT32	%	0...1000000	Velocity override (1000000 == 100%)	
			UINT32			Reserved	
			REAL64	e.g. mm		Lag error position	
			REAL64	e.g. mm		PeakHold value for max. neg. position lag (pos.)	
			REAL64	e.g. mm		Peak hold value for max. pos. position lag (pos.)	
			REAL64	%		Controller output in percent	
			REAL64	%		Total output in percent	
			UINT32	1	≥ 0	Axis state double word	
			UINT32	1	≥ 0	Axis control double word	
			UINT32	1	≥ 0	Slave coupling state (state)	
			UINT32	1	0; 1,2,3...	Axis control loop index	
			REAL64	e.g. mm/ s^2		Actual acceleration	
			REAL64	e.g. mm/ s^2		Set acceleration	
			REAL64	e.g. mm/ s^3		Set jerk (new from TwinCAT 3.1 B4013)	
			REAL64	e.g. 100% = 1000		Set torque or set force ("SetTorque")	
			REAL64	e.g. 100% = 1000		Actual torque or actual force (new from TwinCAT 3.1 B4013)	
			REAL64	e.g. %/s		Set torque change or set force change (time derivative of the set torque or set force) (from TwinCAT 3.1 B4024.2)	
			REAL64	e.g. 100% = 1000		Additive set torque or additive set force ("TorqueOffset") (from TwinCAT 3.1 B4024.2)	
			. . .				
			}			256 bytes	
0x00000001	Read	every	UINT32	1		Axis state error code	*Symbolic access: "ErrState"*
0x00n00009	Read	every	UINT32	1	≥ 0	Set cycle counter (SAF timestamp)	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n0000A	Read	every	REAL64	e.g. mm		Set position	*Symbolic access: "SetPos"*
0x00n0000B	Read	every	REAL64	e.g. DEGREES		Modulo set position	*Symbolic access: "SetPosModulo"*
0x00n0000C	Read	every	INT32	1		Modulo set rotation	
0x00n0000D	Read	every	REAL64	1	[-1.0, 0.0, 1.0]	Set travel direction	
0x00n0000E	Read	every	REAL64	e.g. mm/s		Set velocity	*Symbolic access: "SetVelo"*
0x00n0000F	Read	every	REAL64	e.g. mm/s^2		Set acceleration	Symbolic access: *"SetAcc"*
0x00n00010	Read	every	REAL64	e.g. mm/s^3		Set jerk (time derivative of the set acceleration)	Symbolic access: *"SetJerk"*
0x00n00011	Read	every	REAL64	e.g. Nm or N respectively, e.g. 100% = 1000		Set torque (rot. motor) or set force (linear motor) ("SetTorque")	NEW from TwinCAT 3.1 B4022 *Symbolic access: "SetTorque"*
0x00n00012	Read	every	REAL64	1		Set coupling factor (set gear ratio)	
0x00n00013	Read	every	REAL64	e.g. mm		Expected target position	
0x00n00014	Read	Servo	{			Remaining travel time and distance (SERVO):	Always to SEC Port 501!
			REAL64	s	≥ 0	Remaining travel time	
			REAL64	e.g. mm	≥ 0	Remaining distance	
			}				
0x00n00015	Read	every	UINT32	1	≥ 0	Set command number	*Symbolic access: "CmdNo"*
0x00n00016	Read	Servo	REAL64	s	≥ 0	Positioning time of the last motion command (start → target position window)	
0x00n00017	Read	Servo	REAL64	%	[0.0…1.0] 1.0=100%	Set override value for velocity Note: initially only implemented for FIFO group	NEW from TwinCAT 3.1 B4020
0x00000018	ReadWrite	Servo	**Write**			Reading the "Stop information" (stop distance, stop time)	Always to SEC Port 501!
			REAL64	e.g. mm/s^2	≥ 0	Deceleration for axis stop	
			REAL64	e.g. mm/s^3	≥ 0	Jerk for axis stop	
			Read				
			REAL64	e.g. mm	≥ 0	Stop distance	
			REAL64	s	≥ 0	Stop time	
0x00n0001A	Read	every	REAL64	e.g. mm		Uncorrected set position	
0x00n0001D	Read	every	REAL64	1	[-1.0, 0.0, 1.0]	Uncorrected set travel direction	
0x00n0001E	Read	every	REAL64	e.g. mm/s		Uncorrected set velocity	
0x00n0001F	Read	every	REAL64	e.g. mm/s^2		Uncorrected set acceleration	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000020	Read	every	UINT32	1	s. ENUM	Coupling state (state)	
0x00000021	Read	every	UINT32	1	≥ 0	Coupling table index	
0x00000022	Read	Servo master/ slave coupling Type: LINEAR, (&SPECIAL)	{			Reading the coupling parameters (SERVO):	
			REAL64	1	[±1000000.0]	Parameter 1: Linear: Gear ratio	
			REAL64	1	[±1000000.0]	Parameter 2: Linear: Reserve	
			REAL64	1	[±1000000.0]	Parameter 3: Linear: Reserve	
			REAL64	1	[±1000000.0]	Parameter 4: Linear: Reserve	
			}				
0x00000023	Read	Servo master/ slave coupling Type: LINEAR, (&SPECIAL)	REAL64	1	[±1000000.0]	Reading the gear ratio (SERVO) Type: LINEAR	
0x00000024	Read	Servo	UINT32	1	≥ 0	Number / index of the active axis control circuit (triple of encoder, controller and axis interface)	
0x00000025	Read	Servo	UINT16	1	0/1	External setpoint specification via axis interface PCLtoNC active?	
0x00000026	Read	Servo master/ slave coupling Type: SYNCHRONIZING	REAL64 [64]	1	±∞	Reading of the characteristic values of the slave synchronization profile Type: SYNCHRONIZING	Modified from TwinCAT 3
0x00000027	ReadWrite	Servo master/ slave coupling Type: TABULAR, MF	**Write**			Reading the "table coupling information"	Only port 500! Modified from TwinCAT 3
			VOID or REAL64 or DWORD, DWORD, REAL64	e.g. mm	±∞	- No data for the "current information" - optional for a certain "master axis position" - for a certain table ID and optional “master axis position” (TC 3.1 B4017)	
			Read				
			REAL64 [32]		±∞	Reading the structure for the table coupling information [▶ 173]	
0x00000028	ReadWrite	Servo master/ slave coupling Type: MULTICAM (CamAddition)	**Write**			Reading the "multi-table coupling information" (CamAddition)	Only port 500!
			UINT32	1	≥ 0	Table ID to which the query relates	
			Read				
			96 bytes			Reading the structure for the multi-table coupling information [▶ 173]	
0x00000029	Read	Servo	UINT32	1		Delayed error code (error pre-warning) in case of a delayed error reaction (see bit *ErrorPropagationDelayed*)	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000002A	Read	Servo	REAL64	e.g. mm	±∞	Position difference while fading from set position to actual position (fading part)	
0x0000002B	Read	Servo	REAL64	e.g. mm/s	±∞	Relative velocity while fading from set position to actual position (fading part)	
0x0000002C	Read	Servo	REAL64	e.g. mm/s ^2	±∞	Relative acceleration while fading from set position to actual position (fading part)	
0x0000002D	Read	Servo	UINT32	1	≥ 0	Counter for initialization command (InitializeCommandCounter)	NEW
0x0000002E	Read	Servo	UINT32	1	≥ 0	Counter for reset command (ResetCommandCounter)	NEW
0x00000030	Read	Servo	REAL64	e.g. Nm/s or N/s	±∞	Set torque change (rot. motor) or set force change (linear motor) (time derivative of the set torque or set force)	NEW from TwinCAT 3.1 B4024
0x00000031	Read/Write	Servo	REAL64	e.g. Nm or N respectively, e.g. 100% = 1000		Additive set torque (rot. motor) or additive set force (linear motor) for pre-control. ("TorqueOffset")	From TwinCAT 3.1 B4024.2 *Symbolic access: "TorqueOffset"*
0x00000040	Read	Servo	UINT32	1	≥ 0	Counter for correction of the NC setpoints in case of data inconsistency (activation with Idx-Group 0x1000 and Idx-Offset 0x0020)	NEW from TwinCAT 3.1 B4020
0x00000050	Read	every	UINT32	1		Set travel phase (SWGenerator)	Cannot be traced by oscilloscope!
0x00000051	Read	every	UINT16	1		Is the axis disabled?	Cannot be traced by oscilloscope!
0x00n00060	Read/Write	every (online setpoint structure) 40 bytes	{			Simple AXIS SETPOINT STRUCTURE (NC/CNC)	Cannot be traced by oscilloscope! from TC 3.1 B4022.30
			REAL64	e.g. mm		Set position	
			REAL64	e.g. mm/s		Set velocity	
			REAL64	e.g. mm/s^2		Set acceleration / deceleration	
			REAL64	1	[-1.0, 0.0, 1.0]	Set travel direction	
			REAL64	e.g. mm/s^3		Set jerk	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n00060	Read/Write	every (online setpoint structure) 56 bytes	{			Extended AXIS SETPOINT STRUCTURE (NC/CNC)	Cannot be traced by oscilloscope! from TC 3.1 B4022.29
			REAL64	e.g. mm		Set position	
			REAL64	e.g. mm/s		Set velocity	
			REAL64	e.g. mm/s^2		Set acceleration / deceleration	
			REAL64	1	[-1.0, 0.0, 1.0]	Set travel direction	
			REAL64	e.g. mm/s^3		Set jerk	
			REAL64	Nm or N or %		Set torque or set force	
			REAL64	Nm/s or N/s or %/s		time derivative of the set torque or set force (ramp)	
			}				
0x00n00061	Read/Write	every (online dynamics setpoint structure) 32 bytes	{			AXIS DYNAMIC SETPOINT STRUCTURE (NC/CNC)	from TC 3.1 B4022.30
			REAL64	e.g. mm/s		Set velocity	
			REAL64	e.g. mm/s^2		Set acceleration / deceleration	
			REAL64	1	[-1.0, 0.0, 1.0]	Set travel direction	
			REAL64	e.g. mm/s^3		Set jerk	
			}				
0x00n00061	Read/Write	every (online dynamics setpoint structure) 48 bytes	{			AXIS DYNAMIC SETPOINT STRUCTURE (NC/CNC)	from TC 3.1 B4022.29
			REAL64	e.g. mm/s		Set velocity	
			REAL64	e.g. mm/s^2		Set acceleration / deceleration	
			REAL64	1	[-1.0, 0.0, 1.0]	Set travel direction	
			REAL64	e.g. mm/s^3		Set jerk	
			REAL64	Nm or N or %		Set torque or set force	
			REAL64	Nm/s or N/s or %/s		time derivative of the set torque or set force (ramp)	
			}				
0x00n00062	Read/Write	every (online TORQUE setpoint structure) 16 bytes	{			TORQUE SETPOINT STRUCTURE (NC/CNC)	from TC 3.1 B4022.30
			REAL64	Nm or N or %		Set torque or set force	
			REAL64	Nm/s or N/s or %/s		time derivative of the set torque or set force (ramp)	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000063	ReadWrite	only for SERCOS/SoE and CANopen/ CoE	**Write**			Read active "Drive Operation Mode"	NEW from TC 3.1 B4022 (NC 4443) Always to SEC Port 501!
			UINT32	1		Reserve	
			UINT32	1		Reserve	
			Read				
			INT32	ENUM [▶ 171] (see appendix)	[0; 1, 2, 3, …] Special cases: ≥ 100: SoE <0: CoE	Currently active "Drive Operation Mode" (generic modes)	
			UINT32	1		Reserve	
0x00n10002	Read	every (Encoder)	REAL64	e.g. mm		Actual position (charge with actual position compensation value) n = 0: standard encoder of the axes > 0: nth encoder of the axis (optional)	*Symbolic access: "ActPos"*
0x00n10003	Read	every (Encoder)	REAL64	e.g. DEGREES		Modulo actual position	*Symbolic access: "ActPosModulo"*
0x00n10004	Read	every (Encoder)	INT32	1		Modulo actual rotation	
0x00n10005	Read	every (Encoder)	REAL64	e.g. mm/s		Optional: Actual velocity	*Symbolic access: "ActVelo"*
0x00n10006	Read	every (Encoder)	REAL64	e.g. mm/s^2		Optional: Actual acceleration	*Symbolic access: "ActAcc"*
0x00n10007	Read	every (Encoder)	INT32	INC		Encoder actual increments	
0x00n10008	Read	every (Encoder)	INT64	INC		Software - actual increment counter	
0x00n10009	Read	every (Encoder)	UINT16	1	0/1	Reference flag ("calibrate flag")	
0x00n1000A	Read	every (Encoder)	REAL64	e.g. mm		Actual position correction value (measurement system error correction)	
0x00n1000B	Read	every (Encoder)	REAL64	e.g. mm		Actual position without actual position compensation value	Cannot be traced by oscilloscope!
0x00n10010	Read	every (Encoder)	REAL64	e.g. mm/s		Actual velocity without actual position compensation value	
0x00n10012	Read	every (Encoder)	REAL64	e.g. mm		Unfiltered actual position (charge with actual position compensation value)	
0x00n10014	Read	Encoder: SoE, CoE, MDP 742	REAL64	e.g. mm/s		Optional: actual drive velocity (transferred directly from SoE, CoE or MDP 742 drive)	NEW from TwinCAT 3.1 B4020.30
0x00n10015	Read	every (Encoder)	REAL64	e.g. mm/s		Optional: Unfiltered actual velocity	
0x00n10017	Read		REAL64	e.g. mm		Reading out the MC_SetPosition offset	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n10018	Read	PTP axis Encoder axis	UINT32	0/1	0/1	Returns the status of reinitialization after NC encoder reinitialization has been started (Index Group 0x4200+ID; Index Offset 0x00n0003B). n = 0: Standard encoder of the axis n > 0: n-th encoder of the axis (optional)	Port501
0x00n10101	Read	INC (Encoder)	REAL64	e.g. mm		Read back of the position difference between activation of the internal hardware latch and the time when it becomes valid	Cannot be traced by oscilloscope!
0x00n20001	Read	R: every	INT32	1		Error state of the controller n = 0: standard controller of the axes > 0: nth controller of the axis (optional)	
0x00n20002	Read	R: every	REAL64	e.g. mm/s		Controller output in absolute units	*Symbolic access: "CtrlOutput"*
0x00n20003	Read	R: every	REAL64	%		Controller output in percent	Cannot be traced by oscilloscope!
0x00n20004	Read	R: every	REAL64	V		Controller output in volts	Cannot be traced by oscilloscope!
0x00n2000D	Read	R: every	REAL64	e.g. mm		Lag error position (without dead time compensation)	Base Unit
0x00n2000F	Read	R: every	REAL64	e.g. mm		Lag error position (with dead time compensation)	*Symbolic access: "PosDiff"*
0x00n20010	Read	R: every	REAL64	e.g. mm		Peak hold value for maximum negative lag error of the position	
0x00n20011	Read	R: every	REAL64	e.g. mm		Peak hold value for minimum positive lag error of the position	
0x00n20012	Read	R: every	REAL64	e.g. mm/s		Lag error velocity	Not implemented!
0x00n20021	Read	R: every	REAL64	e.g. mm		Difference (deviation) between the lag error position of the master axis and that of the slave axis (master lag error minus slave lag error)	*Symbolic access: "PosDiffCouple"*
0x00n20022	Read	R: every	REAL64	e.g. mm		PeakHold value for the maximum negative difference between master and slave axis lag error of the position	Base Unit
0x00n20023	Read	R: every	REAL64	e.g. mm		PeakHold value for the maximum positive difference between master and slave axis lag error of the position	Base Unit

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n20101	Read	R: P/PID (Pos.)	REAL64	e.g. mm/s		P part of the controller in absolute units	
0x00n20102	Read	R: PID (Pos.)	REAL64	e.g. mm/s		I part of the controller in absolute units	
0x00n20103	Read	R: PID (Pos.)	REAL64	e.g. mm/s		D part of the controller in absolute units	
0x00n20104	Read	R: PID (Pos.)	UINT16	1	0/1	Limitation of the I part active?	
0x00n20105	Read	R: PID (Pos.)	UINT16	1	0/1	Limitation of the D part active?	
0x00n20106	Read	R: PID (Pos.)	UINT16	1	0/1	ARW measures of the I-part active? ARW: Anti Reset Windup	Not implemented!
0x00n20110	Read	R: PID (Pos.)	REAL64	e.g. mm/s		Acceleration pre-control Yacc of the controller in absolute units Note: function depends on controller type!	Acceleration pre-control
0x00n20111	Read	R: PP (Pos.)	REAL64	mm/s/mm	≥0	Internal interpolated proportional gain kp or kv	PP controller
0x00n20201	Read	R: P,PID (velocity)	REAL64	e.g. mm/s		Velocity part of the controller	
0x00n20202	Read	R: P,PID (velocity)	REAL64	%		Velocity part of the controller in percent	Cannot be traced by oscilloscope!
0x00n20203	Read	R: P,PID (velocity)	REAL64	V		Velocity part of the controller in volts	Cannot be traced by oscilloscope!
0x00n20201	Read	R: P/PID (velocity)	REAL64	e.g. mm/s		P part of the controller in absolute units	
0x00n20202	Read	R: P/ PID (veloc.)	REAL64	e.g. mm/s		I part of the controller in absolute units	
0x00n20203	Read	R: P/ PID (veloc.)	REAL64	e.g. mm/s		D part of the controller in absolute units	
0x00n20204	Read	R: P/ PID (veloc.)	UINT16	1	0/1	Limitation of the I part active?	
0x00n20205	Read	R: P/ PID (veloc.)	UINT16	1	0/1	Limitation of the D part active?	
0x00n20206	Read	R: P/ PID (veloc.)	UINT16	1	0/1	ARW measures for the I part active? (ARW: Anti Reset Windup)	
0x00n2020A	Read	R: P/ PID (veloc.)	REAL64	e.g. mm/s		Total input size of the velocity controller	
0x00n20A00	Read	R: PID (MW)	REAL64	%	[-1.0...1.0]	Offsetting of the set velocity (pre-control)	Reserved parameters!
0x00n20A01	Read	R: PID (MW)	REAL64	e.g. mm/s		P part of the controller in absolute units or percent (according to output weight)	Reserved parameters!
0x00n20A02	Read	R: PID (MW)	REAL64	e.g. mm/s		I part of the controller in absolute units or percent (according to output weight)	Reserved parameters!
0x00n20A03	Read	R: PID (MW)	REAL64	e.g. mm/s		D part of the controller in absolute units or percent (according to output weight)	Reserved parameters!
0x00n20A04	Read	R: PID (MW)	UINT16	1	0/1	Limitation of the I part active?	Reserved parameters!

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n20A05	Read	R: PID (MW)	UINT16	1	0/1	Limitation of the D part active?	Reserved parameters!
0x00n20A06	Read	R: PID (MW)	UINT16	1	0/1	ARW measures for the I part active? ARW: Anti Reset Windup	Reserved parameters!
0x00n20A10	Read	R: PID (MW)	REAL64	e.g. mm/s		Acceleration pre-control Yacc of the controller in absolute units	Reserved parameters!
0x00n30001	Read	D: every	INT32	1		Error state of the drive	
0x00n30002	Read	D: every	REAL64	e.g. mm/s		Total output in absolute units	*Symbolic access: "DriveOutput""*
0x00n30003	Read	D: every	REAL64	%		Total output in percent	
0x00n30004	Read	D: every	REAL64	V		Total output in volts	Cannot be traced by oscilloscope!
0x00n30005	Read	D: every	REAL64	e.g. mm/s		PeakHold value for maximum negative total output	
0x00n30006	Read	D: every	REAL64	e.g. mm/s		PeakHold value for maximum positive total output	
0x00n30007	Read	D: every	REAL64	e.g. 100% = 1000, e.g. Nm or N		Actual torque or actual force respectively (typically 100% = 1000)	from TwinCAT 3.1 B4022 *Symbolic access: "ActTorque"*
0x00n30008	Read	D: every	REAL64	e.g. Nm/s or N/s	±∞	Actual torque change or actual force change respectively (time derivative of the actual torque or actual force respectively)	from TwinCAT 3.1 B4024
0x00n30013	Read	D: every	REAL64	%		Total output in percent (based on non-linear characteristic curve!)	
0x00n30014	Read	D: every	REAL64	V		Total output in volt (based on non-linear characteristic curve!)	Cannot be traced by oscilloscope!
0x00n3011A	Read	D: Servo (Sercos, CANopen)	REAL64	e.g. mm		Optional output filtering: Filtered set position	NEW For Sercos, CANopen
0x00n3011E	Read	D: Servo (Sercos, CANopen)	REAL64	e.g. mm/s		Optional output filtering: Filtered set velocity	NEW For Sercos, CANopen
0x00n3011F	Read	D: Servo (Sercos, CANopen)	REAL64	e.g. mm/s^2		Optional output filtering: Filtered set acceleration / set deceleration	NEW For Sercos, CANopen

3.2.1.5.4.4.3 "Index offset" specification for axis functions (Index group 0x4200 + ID)

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000001	Write	every	VOID			Reset axis	For FIFO axes too!
0x00000002	Write	every	VOID			Stop axis	For FIFO axes too!
0x00000003	Write	every	VOID			Clear axis (task)	For FIFO axes too!
0x00000004	Write	every	{			Emergency stop (with controlled ramp)	Only for PTP axes!
			REAL64	e.g. mm/ s^2	> 0.0	Deceleration (must be greater than or equal to the original deceleration)	
			REAL64	e.g. mm/ s^3	> 0.0	Jerk (must greater than or equal to the original jerk)	
			}				
0x00000005	Write	PTP axis	{			Parameterizable stop (with controlled ramp)	Only for PTP axes! Reserved function, no standard!
			REAL64	e.g. mm/ s^2	> 0.0	Deceleration	
			REAL64	e.g. mm/ s^3	> 0.0	Jerk	
			}				
0x00000009	Write	PTP axis	{			Oriented stop (oriented end position)	Only for PTP axes!
			REAL64	e.g. degrees	≥ 0.0	Modulo end position (modulo target position)	
			REAL64	e.g. mm/ s^2	> 0.0	Deceleration (currently not active)	
			REAL64	e.g. mm/ s^3	> 0.0	Jerk (not yet implemented)	
			}				
0x00000010	Write	every	VOID			Reference axis ("calibration")	
0x00000011	Write	every	{			New end position axis	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	End position type [▶ 163] (see appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	New end position (target position)	
			}				
0x00000012	Write	every	{			New end position and new velocity axis	
			UINT32	ENUM	s. appendix	Command type [▶ 163] (s. appendix)	
			UINT32	ENUM	s. appendix	End position type [▶ 163] (see appendix)	
			REAL64	e.g. mm	±∞	New end position (target position)	
			REAL64	e.g. mm/s	≥ 0.0	New final velocity (requested travel velocity)	
			REAL64	e.g. mm	±∞	Optional: Switchover position from which the new travel profile is activated	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000015	Write	every	{			New dynamic parameters for active positioning	
			REAL64	e.g. mm/ s^2	> 0.0	Acceleration	
			REAL64	e.g. mm/ s^2	> 0.0	Deceleration	
			REAL64	e.g. mm/ s^3	> 0.0	Optional: Jerk (not yet implemented)	
			}				
0x00000016	**ReadWrite**	every SERVO	**Write**(80 bytes)			Universal Axis Start (UAS): Merge of single commands, such as axis start, and online changes in combination with "Buffer Mode" (see TcMc2.lib)	Always to SEC Port 501! Modified from TwinCAT 3
			{				
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			UINT32	1	≥ 0	Bit mask for checks and operation modes (Default value: 0)	
			REAL64	e.g. mm	±∞	End position (target position)	
			REAL64	e.g. mm/s	≥ 0.0	Required velocity *Vrequ*	
			REAL64	e.g. mm/ s^2	≥ 0.0	Optional: Acceleration	
			REAL64	e.g. mm/ s^2	≥ 0.0	Optional: Deceleration	
			REAL64	e.g. mm/ s^3	≥ 0.0	Optional: Jerk	
			UINT32	ENUM	s. appendix	Buffer mode [▶ 162] (command buffer)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	Optional: Blending position (command blending position)	
			REAL64	e.g. mm/s	≥ 0.0	Optional: Initial segment velocity *Vi* *(0 ≤ Vi ≤ Vrequ)*	
			REAL64	e.g. mm/s	≥ 0.0	Optional: Segment end velocity *Vf* *(0 ≤ Vf ≤ Vrequ)*	
			}				
			Read				
			{				
			UINT16	1	≥ 0	Command number (job number)	
			UINT16	1	≥ 0	Command status	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000017	**ReadWrite**	SERVO	**Write**(80 bytes)			"Master/slave decoupling" and "Universal axis start (UAS)": Merge of decoupling command of a slave axis (IdxOffset: 0x00000041) and the subsequent universal axis start (UAS) (IdxOffset: 0x00000016)	Not yet released!
			{				
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			UINT32	1	≥ 0	Bit mask for checks and operation modes (Default value: 0)	
			REAL64	e.g. mm	±∞	End position (target position)	
			REAL64	e.g. mm/s	≥ 0.0	Required velocity *Vrequ*	
			REAL64	e.g. mm/s^2	≥ 0.0	Acceleration	
			REAL64	e.g. mm/s^2	≥ 0.0	Deceleration	
			REAL64	e.g. mm/s^3	≥ 0.0	Jerk	
			UINT32	ENUM	s. appendix	Buffer mode [▶ 162] (command buffer)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	Optional: Blending position (command blending position)	
			REAL64	e.g. mm/s	≥ 0.0	Optional: Initial segment velocity *Vi* *(0 ≤ Vi ≤ Vrequ)*	
			REAL64	e.g. mm/s	≥ 0.0	Optional: Segment end velocity *Vf* *(0 ≤ Vf ≤ Vrequ)*	
			}				
			Read				
			{				
			UINT16	1	≥ 0	Command number (job number)	
			UINT16	1	≥ 0	Command status	
			}				
0x00000018	Write	every	VOID			Release axis lock for motion commands (TcMc2)	
0x00000019	Write	every	UINT32	1	> 0	Set external axis error (runtime error)	**Caution when using!**
0x00n0001A	Write	every	{			Set actual axis position	**Caution when using!** For FIFO axes too! Always to SEC Port 501! Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Actual position type [▶ 163] (see appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	Actual position for axes n = 0: standard encoder of the axis n > 0: n-th encoder for the axis (optional)	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n0001B	Write	every	UINT32	1	0/1	Set reference flag ("calibrate flag") n = 0: Standard encoder for the axis n > 0: n-th encoder for the axis (optional)	**Caution when using!** For FIFO axes too!
0x00n0001C	Write	SERVO	{			Set only actual axis position without manipulating the set position (also for slave and with active process)	**Caution when using!**
			UINT32	ENUM	s. appendix	Actual position type [▶ 163] (see appendix)	
			REAL64	e.g. mm	±∞	Actual position for axes n = 0: standard encoder of the axes > 0: nth encoder of the axis (optional) **Caution when using!**	
			}				
0x00n0001D	Write	every	{			Actual value setting of the axis on the drive side (position interface and encoder offset of zero assumed!) n = 0: Standard encoder for the axis n > 0: n-th encoder for the axis (optional)	**Caution when using!** Only for CANopen!
			UINT32	ENUM	s. appendix	Actual position type [▶ 163] (see appendix)	
			REAL64	e.g. mm	±∞	Actual position for axis	
			}				
0x00n0001E	Write	every	{			Set a new encoder scaling factor on the fly (in motion of the axis)	**Caution when using!** Always to SEC Port 501! Modified from TwinCAT 3
			UINT16	ENUM	1	Encoder scaling factor type 1: Absolute 2: Relative	
			UINT16			ControlWord	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/ INC	[1.0E-8 ... 100.0]	New encoder scaling factor n = 0: Standard encoder for the axis n > 0: n-th encoder for the axis (optional)	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n0001F	Write	every	{			Set actual axis position on the fly (in motion of the axis)	**Caution when using!** Always to SEC Port 501!
			UINT32	ENUM		Position type for setting actual value on the fly 1: Absolute 2: Relative	
			UINT32	1		Control double word, e.g. for "clearing the lag error"	
			REAL64			Reserve	
			REAL64	e.g. mm	±∞	New actual axis position	
			UINT32			Reserve	
			UINT32			Reserve	
			}				
0x00000020	Write	every 1D start	{			Standard axis start:	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	End position (target position)	
			REAL64	e.g. mm/s	≥0.0	Required velocity	
			}				
0x00000021	Write	every 1D start	{			Extended axis start (SERVO):	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	End position (target position)	
			REAL64	e.g. mm/s	≥ 0.0	Required velocity	
			UINT32	0/1	0/1	Standard acceleration?	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/ s^2	≥ 0.0	Acceleration	
			UINT32	0/1	0/1	Standard deceleration?	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/ s^2	≥ 0.0	Deceleration	
			UINT32	0/1	0/1	Standard jerk?	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/ s^3	≥ 0.0	Jerk	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000022	Write	SERVO(MW)	{			Special axis start (SERVO):	Reserved start function, no standard! Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Start type [▶ 162] (s. appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	End position (target position)	
			REAL64	mm/s	≥ 0.0	Required start velocity	
			REAL64	e.g. mm	±∞	Position for a new velocity level	
			REAL64	e.g. mm/s	≥ 0.0	New end velocity level	
			UINT32	0/1	0/1	Standard acceleration?	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/s^2	≥ 0.0	Acceleration	
			UINT32	0/1	0/1	Standard deceleration?	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/s^2	≥ 0.0	Deceleration	
			UINT32	0/1	0/1	Standard jerk?	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/s^3	≥ 0.0	Jerk	
			}				
0x00000023	Write	SERVO	{			Start external setpoint specification (setting by cyclic axis interface PLCtoNC)	Modified from TwinCAT 3
			UINT32	ENUM	1: Absolute 2: Relative	Start type [▶ 162]	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	New end position (target position) optional!	
			REAL64			Reserve (TwinCAT 3)	
			}				
0x00000024	Write	SERVO	VOID			Stop/disable external setpoint specification (cycl. axis interface PLCtoNC)	
0x00000025	Write	SERVO	{			Start reversing operation for positioning (SERVO):	Modified from TwinCAT 3
			UINT32	ENUM	1	Start type [▶ 162] (default: 1)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	End position 1 (target position)	
			REAL64	e.g. mm	±∞	End position 2 (target position)	
			REAL64	0/1	0/1	Required velocity	
			REAL64	s	≥ 0.0	Idle time	
			}				
0x00000026	Write	every	{			Start drive output	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Output type [▶ 170] (s. appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. %	±∞	Required output value (e.g. %)	
			}				
0x00000027	Write	every	VOID			Stop drive output	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000028	Write	every	{			Change the drive output:	
			UINT32	ENUM	s. appendix	Output type [▶ 170] (s. appendix)	
			REAL64	e.g. %	±∞	Required output value (e.g. %)	
			}				
0x00000029	Write	every	VOID			Instantaneously adopt current override value and freeze until next override change!	Reserved function, no standard!

0x0000002A	Write	every	{
			32 bytes
			}
						Calculate and set encoder offset	Reserved function, no standard!

0x0000002B	ReadWrite	every	WriteData: s. 'UAS' ReadData: s. 'UAS'			Stop external setpoint generator and continuous endless motion ('UAS': Universal axis start)	Reserved function, no standard!
0x0000002C	Write	every	UINT32		≥ 0	Set "homing state" (for internal use)	New from TwinCAT 3

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000002D	ReadWrite	Servo	Write			Switches an NC-controlled axis to "Cyclic Synchronous Torque Mode" (CST) and sets a torque setpoint for it.	**Danger during use!** (* see end of table)
			{				
			UINT32			Torque-axis start type: 0x3001: Absolute 0x3002: Relative	
			UINT32	1 (bit array)		Internal control mask (bit array): 00000000_00000001 (bit 0): Use manual torque for initialization. 10000000_000000000 (bit 31): Update/ refresh parameter for current command in 'ContinuousUpdate' mode (fTorqueRamp, fVelocityLimitHigh, fVelocityLimitLow), do not increase cmd no.	
			UINT32	0/1	0/1	Mode: 0: Default (discrete) 1: ContinuousUpdate	
			UINT32	ENUM	see appendix	Buffer mode [▶ 162] only ABORTING possible	
			REAL64	Nm or %	[0.0 … 1.0E10]	Torque target value (signed value)	
			REAL64	Nm/s or %/s	[0.0 … 1.0E10]	Torque change velocity	
			REAL64	e.g. mm/s	[0.0 ... 1.0E10] 'VelocityLimitHigh' must be greater than or equal to 'VelocityLimitLow' (both values can be negative).	Velocity limit high	
			REAL64	e.g. mm/s	[0.0 … 1.0E10]	Velocity limit low	
			REAL64	e.g. mm/s^2	[0.0 … 1.0E10]	Acceleration	
			REAL64	e.g. mm/s^2	[0.0 … 1.0E10]	Deceleration	
			REAL64	Nm or %	[0.0 … 1.0E10]	Optional: Manual torque start value (sync value)	
			}				
			Read				
			{				
			UINT16	1	>=0	Command number (job number)	
			UINT16	1	>=0	Command status	
			}				
0x0000002E						Reserved	
0x0000002F						Reserved	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000030	Write	SERVO	{			Start section compensation (SERVO)	Only affects older TwinCAT 2 systems
			UINT32	ENUM	s. appendix	Compensation type [▶ 163] (see appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/ s^2	≥ 0.0	Max. acceleration increase	
			REAL64	e.g. mm/ s^2	≥ 0.0	Max. deceleration increase	
			REAL64	e.g. mm/s	> 0.0	Max. increase velocity	
			REAL64	e.g. mm/s	> 0.0	Base velocity for the process	
			REAL64	e.g. mm	±∞	Path difference to be compensated	
			REAL64	e.g. mm	> 0.0	Path distance for compensation	
			}				
0x00000030	ReadWrite	SERVO returns the actually implemented parameters as return values	{ **READ+WRITE:**			Start section compensation (SERVO) Note: only contained in 'TcMc2.lib' or 'Tc2_MC2.library'	Changed from TwinCAT 2 211R3 TwinCAT 3
			UINT32	ENUM	s. appendix	Compensation type [▶ 163] (see appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/ s^2	≥ 0.0	=> Max. acceleration increase <= Returns the implemented acceleration increase (new in 'TcMc2.lib' or 'Tc2_MC2.library')	
			REAL64	e.g. mm/ s^2	≥ 0.0	=> Max. deceleration increase <= Returns the implemented deceleration increase (new in 'TcMc2.lib' or 'Tc2_MC2.library')	
			REAL64	e.g. mm/s	> 0.0	=> Requested max. increase velocity <= Returns the implemented increase velocity	
			REAL64	e.g. mm/s	> 0.0	Base velocity for the process	
			REAL64	e.g. mm	±∞	=> Requested path difference to be compensated <= Returns the implemented path difference	
			REAL64	e.g. mm	> 0.0	=> Requested max. distance for compensation <= Returns implemented distance	
			UINT32	1	≥ 0	<= Returns Warning ID (e.g. 0x4243)	
			UINT32			Reserve (TwinCAT 3)	
			}				
0x00000031	Write	SERVO	VOID			Stop section compensation (SERVO)	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000032	Write	SERVO	{			Start reversing operation with velocity jumps (SERVO): (can be used to determine the velocity step response)	Modified from TwinCAT 3
			UINT32	ENUM	1	Start type [▶ 162] (default: 1)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/s	±∞	Required velocity 1 (negative values also permitted)	
			REAL64	e.g. mm/s	±∞	Required velocity 2 (negative values also permitted)	
			REAL64	s	> 0.0	Travel time for velocity 1 and 2	
			REAL64	s	≥ 0.0	Idle time	
			UINT32	1	0, 1,2,3...	Optional: Number of repetitions, Default "0": unlimited in time	
			UINT32			Reserve (TwinCAT 3)	
			}				
0x00000033	Write	SERVO	{			Sine oscillation sequence - used as single sinus oscillation (sinus generator) - used as sinus oscillation sequence (e.g. for bode plot)	Modified from TwinCAT 3
			UINT32	ENUM	1	Start type [▶ 162] (fixed to start type 1 yet)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/s	> 0.0	Base amplitude (e.g. 2.5 mm/s)	
			REAL64	Hz	[0.0 .... 10.0]	Base frequency (e.g. 1.953125 Hz)	
			REAL64	e.g. mm/s	≥ 0.0	Start amplitude at begin (e.g. 0.0 mm/s)	
			REAL64	e.g. mm/ REV	> 0.0	Feed constant motor (per motor turn) (e.g. 10.0 mm/REV)	
			REAL64	Hz	≥ 1.0	Frequency range: start frequency (e.g. 20.0 Hz)	
			REAL64	Hz	≤ 1/(2*dT)	Frequency range: stop frequency (e.g. 500.0 Hz)	
			REAL64	s	> 0.0	Step duration (e.g. 2,048s)	
			UINT32	1	[1 ... 200]	Number of measurements (step cycles) (e.g. 20)	
			UINT32	1		Number of parallel measurements (e.g. 1) not used yet!	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000034	Write	SERVO	{			Phasing - Start Phasing - Stop Phasing	
			UINT32	ENUM	1	PhasingType: 1: ABSOLUTE 2: RELATIVE 4096: STOP	
			UINT32	1	≥ 0	Control Mask Bit 0: Continuous Update	
			UINT32	1	≥ 0	Master axis ID (for multi master)	
			UINT32			Reserve	
			REAL64	e.g. mm	±∞	Phase shift	
			REAL64	e.g. mm/s	> 0.0	Velocity	
			REAL64	e.g. mm/s^2	≥ 0.0	Acceleration	
			REAL64	e.g. mm/s^2	≥ 0.0	Deceleration	
			REAL64	e.g. mm/s^3	≥ 0.0	Jerk	
			REAL64[4]			Reserve	
			UINT32			Reserve	
			UINT32	1	ENUM	Buffer mode (NOT IMPLEMENTED)	
			REAL64	e.g. mm	±∞	Blending position (NOT IMPLEMENTED)	
			}				
0x00n0003B	Write	PTP axis Encoder axis	VOID			Triggers NC encoder reinitialization to valid IO values n = 0: Standard encoder of the axis n > 0: n-th encoder of the axis (optional)	**Danger during use!** There must be no controller enable (position jump) The axis status index offset 0x00n10018 can be used to read out whether NC encoder reinitialization has been completed. Port 501

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000040 (0x00n00040)	Write	Master/Slave coupling (SERVO)	{			Master/Slave coupling (SERVO):	Extension for "flying saw"! Angle >0.0 and £ 90.0 degrees (parallel saw: 90.0 degrees)
			UINT32	ENUM	s. appendix	Slave type [▶ 164]/ coupling type (see appendix)	
			UINT32	1	[1...255]	Axis ID of the master axis/group	
			UINT32	1	[0...8]	Subindex n of the master axis (default: value: 0)	
			UINT32	1	[0...8]	Subindex n of the slave axis (default: value: 0)	
			REAL64	1	[±1000000.0]	Parameter 1: Linear: Gear ratio FlySawVelo: Reserve FlySaw: Abs. synchron position master [mm]	
			REAL64	1	[±1000000.0]	Parameter 2:Linear: Reserve FlySawVelo: Reserve FlySawPos: Abs. synchron position slave [mm]	
			REAL64	1	[±1000000.0]	Parameter 3: Linear: Reserve FlySawVelo: Angle of inclination in [DEGREES] FlySawPos: Angle of inclination in [DEGREES]	
			REAL64	1	[±1000000.0]	Parameter 4:Linear: Reserve FlySawVelo: Gear ratio FlySawPos: Gear ratio	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000040 (0x00n00040)	Write	Master/Slave coupling (SERVO)	{			Master/Slave coupling (SERVO):	Multi master coupling (MC_GearInMultiMaster) Version V1 and V2 Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Slave type [▶ 164]/ coupling type (see appendix)	
			UINT32	1	[1...255]	Axis ID of the master axis/group	
			UINT32	1	[1...8]	Subindex n of the master axis (default: value: 0)	
			UINT32	1	[1...8]	Subindex n of the slave axis (default: value: 0)	
			UINT32	1	[0...255]	Axis ID master 2	
			UINT32	1	[0...255]	Axis ID master 3	
			UINT32	1	[0...255]	Axis ID master 4	
			UINT32	1	[0...255]	Reserve (axis ID master 5)	
			UINT32	1	[0...255]	Reserve (axis ID master 6)	
			UINT32	1	[0...255]	Reserve (axis ID master 7)	
			UINT32	1	[0...255]	Reserve (axis ID master 8)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm/ s^2		Maximum acceleration/ deceleration of the slave axis	
			UINT32	1	≥ 0	Control mask, not previously used (check and operation mode for profile)	
			UINT32			Reserve (TwinCAT 3)	
			Extension V2 (Optional):				
			REAL64	e.g. mm/ s^2	≥ 0.0	Maximum deceleration of the slave axis	
			REAL64	e.g. mm/ s^3	≥ 0.0	Maximum jerk of the slave axis	
			REAL64	e.g. mm/s	≥ 0.0	Maximum velocity of the slave axis	
			REAL64			Reserve	
			REAL64			Reserve	
			} 64 or 104 bytes				
0x00000041	Write	Master/slave decoupling (SERVO)	VOID			Master/slave decoupling (SERVO)	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000041	Write	Master/Slave decoupling with configurable follow-up function (SERVO)	{			Master/slave decoupling with configurable follow-up function (e.g. new end position, new velocity, stop, E-stop) (SERVO)	Not yet released! Modified from TC3
			UINT32	ENUM	s. appendix	Decoupling type [▶ 164] (see appendix)	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	Optional: New end position	
			REAL64	e.g. mm/s	> 0.0	Optional: New requested velocity	
			REAL64	e.g. mm/s^2	≥ 0.0 (0: Default)	Optional: Acceleration for new end position, new velocity and emergency stop (E-stop)	
			REAL64	e.g. mm/s^2	≥ 0.0 (0: Default)	Optional: Deceleration for new end position, new velocity and emergency stop (E-stop)	
			REAL64	e.g. mm/s^3	≥ 0.0 (0: Default)	Optional: Jerk for new end position, new velocity and emergency stop (E-stop)	
			}				
0x00000042	Write	Master/Slave coupling Type: LINEAR (&SPECIAL)	{			Change of the coupling parameters (SERVO):	
			REAL64	1	[±1000000.0]	Parameter 1: Linear: Gear ratio	
			REAL64	1	[±1000000.0]	Parameter 2: Linear: Reserve	
			REAL64	1	[±1000000.0]	Parameter 3: Linear: Reserve	
			REAL64	1	[±1000000.0]	Parameter 4: Linear: Reserve	
			}				
0x00000043	Write	Master/slave table coupling Type: TABULAR	{			Change of the table coupling parameters (SERVO):	
			REAL64	mm	±∞	Slave position offset	
			REAL64	mm	±∞	Master position offset	
			}				
0x00000043	Write	Master/slave table coupling Type: TABULAR and "Motion Function"	{			Change of the table coupling parameters (SERVO):	Also for "Motion Function"
			REAL64	mm	±∞	Slave position offset	
			REAL64	mm	±∞	Master position offset	
			REAL64	1	±∞ (<> 0.0)	Slave position scaling	
			REAL64	1	±∞ (<> 0.0)	Master position scaling	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000043	Write	Master/slave table coupling Type: TABULAR	{			Change of the table coupling parameters (SERVO):	
			REAL64	mm	±∞	Slave position offset	
			REAL64	mm	±∞	Master position offset	
			REAL64	1	±∞ (<> 0.0)	Slave position scaling	
			REAL64	1	±∞ (<> 0.0)	Master position scaling	
			REAL64	e.g. mm	±∞	Absolute master activation position	
			}				
0x00000044	Write	Slave-Stop (SERVO)	VOID			Stop the "flying saw" (SERVO)	Only for "flying saw"
0x00000045 (0x00n00045)	Write	Master/slave table coupling (SERVO)	{			Master/slave table coupling (SERVO):	
			UINT32	ENUM	s. appendix	Slave type/coupling type [▶ 164] (see appendix)	
			UINT32	1	[1...255]	Axis ID of the master axis	
			UINT32	1	[0...8]	Subindex n of the master axis (default: value: 0)	
			UINT32	1	[0...8]	Subindex n of the slave axis (default value: 0)	
						SOLO TABLE SECTION	
			REAL64	mm	±∞	Slave position offset (type: TABULAR)	
			REAL64	mm	±∞	Master position offset (type: TABULAR)	
			UINT32	1	[0,1]	Slave positions absolute (type: TABULAR)	
			UINT32	1	[0,1]	Master positions absolute (type: TABULAR)	
			UINT32	1	[1...255]	Table ID of the coupling table (type: TABULAR)	
						MULTI TABLE SECTION	
			UINT16	1	[0...8]	Number of tables (type: MULTITAB) Note: Misused as interpolation type for solo tables	
			UNIT16	1	[0...8]	Number of profile tables (type: MULTITAB)	
			UNIT32[8]	1	[1...255]	Tables IDs of the coupling tables (type: MULTITAB)	
			}				
0x00000046	Write	Master/slave multi-tables	UINT32	1	[1...255]	Correction table activation, correction table ID	
0x00000046	Write	Master/slave multi-tables	{			Activation of correction table	Modified from TwinCAT 3
			UINT32	1	[1...255]	Correction table ID	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	Absolute master activation position	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000047	Write	Master/slave multi-tables	UINT32	1	[1..255]	Deactivation of profile table at the end of the cycle, table ID of the current monocyclic profile table	
0x00000048	ReadWrite	Master/slave multi-tables	Write: UINT32	1	[1..255]	Reading the last correction offset: Table ID of the correction table	
			Read: REAL32	e.g. mm	±∞	Offset by departing the correction table with the according table ID	
0x00000049	Write	Master/slave table coupling Type: TABULAR	REAL64	1	±∞	Change the slave table scaling factor for the slave table column (Default value: 1.0)	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000004A(0x00n0004A)	Write	Master/Slave Universal Table Coupling (SERVO)	{			Master/Slave Solo Table Coupling (SERVO):	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Slave type/coupling type [▶ 164] (see appendix)	
			UINT32	1	[1...255]	Axis ID of the master axis	
			UINT32	1	[0...8]	Subindex n of the master axis (default: value: 0)	
			UINT32	1	[0...8]	Subindex n of the slave axis (default: value: 0)	
			UINT32	1	1...255]	Table ID of the coupling table (type: TABULAR)	
			UINT32	1		Table interpolation type	
			REAL64	mm	±∞	Slave position offset (type: TABULAR)	
			REAL64	mm	±∞	Master position offset (type: TABULAR)	
			REAL64	mm	±∞	Slave position scaling (type: TABULAR)	
			REAL64	mm	±∞	Master position scaling (type: TABULAR)	
			UINT32	1	[0,1]	Slave position absolute ? (Type: TABULAR)	
			UINT32	1	[0,1]	Master positions absolute ? (Type: TABULAR)	
			UINT32	ENUM	s. appendix	Activation type of the change: 0: 'instantaneous' (default) 1: 'at master cam position' 2: 'at master axis position' 3: 'next cycle'	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	mm	±∞	Activation position	
			UINT32	ENUM	s. appendix	Master scaling type: 0: user defined (default) 1: scaling with auto offset 2: off	
			UINT32	ENUM	s. appendix	Slave scaling type: 0: user defined (default) 1: scaling with auto offset 2: off	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000004A(0x00n0004A)	Write	Master/Slave Universal Table Coupling (SERVO)	{			Master/Slave Solo Table Coupling (SERVO):	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Slave type/coupling type [▶ 164] (see appendix)	
			UINT32	1	[1...255]	Axis ID of the master axis	
			UINT32	1	[0...8]	Subindex n of the master axis (default: value: 0)	
			UINT32	1	[0...8]	Subindex n of the slave axis (default: value: 0)	
			UINT32	1	1...255]	Table ID of the coupling table (type: TABULAR)	
			UINT32	1		Table interpolation type	
			REAL64	mm	±∞	Slave position offset (type: TABULAR)	
			REAL64	mm	±∞	Master position offset (type: TABULAR)	
			REAL64	mm	±∞	Slave position scaling (type: TABULAR)	
			REAL64	mm	±∞	Master position scaling (type: TABULAR)	
			UINT32	1	[0,1]	Slave position absolute ? (Type: TABULAR)	
			UINT32	1	[0,1]	Master positions absolute ? (Type: TABULAR)	
			UINT32	ENUM	s. appendix	Activation type of the change: 0: 'instantaneous' (default) 1: 'at master cam position' 2: 'at master axis position' 3: 'next cycle'	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	mm	±∞	Activation position	
			UINT32	ENUM	s. appendix	Master scaling type: 0: user defined (default) 1: scaling with auto offset 2: off	
			UINT32	ENUM	s. appendix	Slave scaling type: 0: user defined (default) 1: scaling with auto offset 2: off	
			Extension for MultiCam:				
			UINT32	ENUM	s. appendix	Cam Operation Mode	
			UINT32	1	[1…255]	Reference table ID	
			BYTE[104]			Reserve (TwinCAT 3)	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000004B(0x00n0004B)	Write	Master/slave universal flying saw (SERVO)	{			Master/slave synchronization coupling (SERVO):	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Slave type/coupling type (see appendix)	
			UINT32	1	[1...255]	Axis ID of the master axis	
			UINT32	1	[0...8]	Subindex n of the master axis (default: value: 0)	
			UINT32	1	[0...8]	Subindex n of the slave axis (default: value: 0)	
			REAL64	1	±∞ (<> 0.0)	Gear ratio	
			REAL64	mm	±∞	Master synchron position	
			REAL64	mm	±∞	Slave synchron position	
			REAL64	mm/s	≥ 0.0	Slave velocity (optional)	
			REAL64	mm/s^2	≥ 0.0	Slave acceleration (optional)	
			REAL64	mm/s^2	≥ 0.0	Slave deceleration (optional)	
			REAL64	mm/s^3	≥ 0.0	Slave jerk (optional)	
			UINT32	1	≥ 0	Bit mask (default value: 0)	
			UINT32			Reserve (TwinCAT 3)	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x0000004D(0x00n0004D)	Write	Master/slave table coupling Type: TABULAR and MF	{			Change in table scaling (SERVO):	Modified from TwinCAT 3
			UINT32	ENUM	s. appendix	Activation type of the change 0: 'instantaneous' (default) 1: 'at master cam position' 2: 'at master axis position' 3: 'next cycle'	
			UINT32			Reserve (TwinCAT 3)	
			REAL64	e.g. mm	±∞	Activation position	
			UINT32	ENUM	s. appendix	Master scaling type 0: user defined (default) 1: scaling with auto offset 2: off	
			UINT32	ENUM	s. appendix	Slave scaling type 0: user defined (default) 1: scaling with auto offset 2: off	
			REAL64	e.g. mm	±∞	Master position offset	
			REAL64	e.g. mm	±∞	Slave position offset	
			REAL64	1	±∞ (<> 0.0)	Master position scaling	
			REAL64	1	±∞	Slave position scaling	
			Optional extension for MultiCam:				
			UINT32	1	≥ 0	Cam Table ID	
			UINT32			Reserve (TwinCAT 3)	
			}				
0x00000050	Write	every	VOID			Deactivate complete axis (disable)	
0x00000051	Write	every	VOID			Activate complete axis (enable)	
0x00000052	Write	SERVO	{			Change of the active axis control loop (triple from encoder, controller and axis interfaces) with/without external setpoint specification:	Modified from TwinCAT 3
			UINT32	1	≥ 0	Number/index of the axis control loop (Default value: 0)	
			UINT32	ENUM	s. appendix (>0)	Switching type for synchronization behavior [▶ 174] 1: 'Standard'	
			REAL64	1	±∞	Synchronization value for switching (optional)	
			UINT32	0/ 1	0/1	External setpoint specification by means of axis interface ? Note: Not used so far!	
			UINT32			Reserve (TwinCAT 3)	
			}				

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00000060	Write	every	VOID			Deactivate drive output (disable)	
0x00000061	Write	every	VOID			Activate drive output (enable)	
0x00000062	Write	high/low	UINT16	1	0/1	Release parking brake? 0: automatic activation (default) 1: mandatorily always released Note: Reset to '0' when resetting the axis!	
0x00000063	Write	only for SERCOS/SoE and CANopen/ CoE	{			Activate "Drive Operation Mode" (e.g. Position Velo, Torque, etc.)	NEW from TC 3.1 B4022 (NC 4443) Always to SEC Port 501!
			INT32	ENUM [▶ 171] (see appendix)	[0; 1, 2, 3, …] Special cases: ≥ 100: SoE < 0: CoE	New "Drive Operation Mode" (generic modes)	
			UINT32	1	0	Reserve	
			UINT32	1	0	Reserve	
			UINT32	1	0	Reserve	
			}				
0x00000070	Write	every	VOID			Return of the axis from, e.g. a 3D group to its own PTP group	

* The following warning relates to index offset 0x0000002D:

⚠ DANGER

Danger to life or risk of serious injury or damage to property due to unintentional movements of the axis

When using the function block, the axis is switched to CST mode. After using the function block (especially after error situations), the axis may still be in CST mode. This can lead to sudden and unplanned movements (especially with lifting axes) when the axis is released.

- Ensure that there is no hazard as defined by the risk assessment.
- Check the current operation mode via the function block MC_ReadDriveOperationMode.
- If the axis is not in a position-related operation mode (CSV/CSP), transfer it before an enable:
  – *directly* with MC_WriteDriveOperationMode into the desired position-related operation mode (CSV/CSP) or
  – *indirectly* with MC_Halt / MC_Stop into the desired position-related operation mode (CSV/CSP) (from TwinCAT 3.1.4024.40)
  Other function blocks that switch the axis indirectly into a position-related operation mode can only do this to a limited extent and are therefore not to be used for a deliberate operation mode change.

⇨ Subsequently, it is necessary to check again whether the axis is really in a position-related operation mode (CSV/CSP), if not, an abort with error handling is required.

3.2.1.5.4.4.4 "Index offset" specification for cyclic axis process data (Index group 0x4300 + ID)

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n00000	Read/Write	every (PLC→NC)	{ 128 bytes}		STRUCT see axis interface	AXIS STRUCTURE (PLC→NC) n = 0: standard axis interface n > 0: n-th axis interface (optional)	Write command only optional! Consider safety aspects! *PLCTONC_AXIS_REF*
0x00n00001	Read/Write	every (PLC→NC)	UINT32	1	>0	Control double word	Write command only optional! *Symbolic access possible!* "ControlDWord"
0x00n00002	Read/Write	every (PLC→NC)	UINT16	1	0/1	Controller enable	Cannot be traced by oscilloscope!
0x00n00003	Read/Write	every (PLC→NC)	UINT16	1	0/1	Feed enable plus	Cannot be traced by oscilloscope!
0x00n00004	Read/Write	every (PLC→NC)	UINT16	1	0/1	Feed enable minus	Cannot be traced by oscilloscope!
0x00n00007	Read/Write	every (PLC→NC)	UINT16	1	0/1	Referencing cam	Cannot be traced by oscilloscope!
0x00n00021	Read/Write	every (PLC→NC)	UINT32	%	0...1000000	Velocity override (1000000 == 100%)	Write command only optional! *Symbolic access possible!* "OverrideV"
0x00n00022	Read/Write	every (PLC→NC)	UINT32	1	ENUM	Operation mode axis	Write command only optional!
0x00n00025	Read/Write	every (PLC→NC)	REAL64	e.g. mm		Actual position correction value (measurement system error correction)	Write command only optional!
0x00n00026	Read/Write	every (PLC→NC)	REAL64	e.g. mm/s		External controller component (position controller component)	Write command only optional!
0x00n00027	Read/Write	every (PLC→NC)	{			External setpoint generation	Write command only optional! Modified from TC3
			REAL64	e.g. mm	±∞	External set position	
			REAL64	e.g. mm/s	±∞	External set velocity	
			REAL64	e.g. mm/s^2	±∞	External set acceleration	
			INT32	1	+1, 0, -1	External set travel direction	
			UINT32			Reserve (TC3)	
			REAL64			Reserve (TC3)	
			}				
0x00n00080	Read	every (PLC→NC)	{ 256 bytes}		STRUCT see axis interface	AXIS STRUCTURE (NC→PLC) Note: size and alignment changed n = 0: standard axis interface n > 0: n-th axis interface (optional)	Changed from TC3.*NCTOPLC_AXIS_REF*

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n00071	Read	every (PLC→NC)	UINT8	1	>0	State double word: byte 1	
0x00n00072	Read	every (PLC→NC)	UINT8	1	>0	State double word: byte 2	
0x00n00073	Read	every (PLC→NC)	UINT8	1	>0	State double word: byte 3	
0x00n00074	Read	every (PLC→NC)	UINT8	1	>0	State double word: byte 4	
0x00n00081	Read	every (PLC→NC)	UINT32	1	>0	State double word (complete)	*Symbolic access possible!* "StateDWord"
0x00n00082	Read	every (PLC→NC)	UINT16	1	0/1	Axis is ready for operation	Cannot be traced by oscilloscope!
0x00n00083	Read	every (PLC→NC)	UINT16	1	0/1	Axis has been referenced	Cannot be traced by oscilloscope!
0x00n00084	Read	every (PLC→NC)	UINT16	1	0/1	Axis in protected operation mode (e.g. slave axis)	Cannot be traced by oscilloscope!
0x00n00085	Read	every (PLC→NC)	UINT16	1	0/1	Axis is in rapid mode	Cannot be traced by oscilloscope!
0x00n00088	Read	every (PLC→NC)	UINT16	1	0/1	Axis has invalid I/O data	Cannot be traced by oscilloscope!
0x00n00089	Read	every (PLC→NC)	UINT16	1	0/1	Axis is in an error state	Cannot be traced by oscilloscope!
0x00n0008A	Read	every (PLC→NC)	UINT16	1	0/1	Axis moving to larger values	Cannot be traced by oscilloscope!
0x00n0008B	Read	every (PLC→NC)	UINT16	1	0/1	Axis moving to smaller values	Cannot be traced by oscilloscope!
0x00n0008C	Read	every (PLC→NC)	UINT16	1	0/1	Axis is at a logical standstill (only setpoints are considered) (position controller?)	Cannot be traced by oscilloscope!
0x00n0008D	Read	every (PLC→NC)	UINT16	1	0/1	Axis is being referenced	Cannot be traced by oscilloscope!
0x00n0008E	Read	every (PLC→NC)	UINT16	1	0/1	Axis is in position window	Cannot be traced by oscilloscope!
0x00n0008F	Read	every (PLC→NC)	UINT16	1	0/1	Axis is at target position (target position reached)	Cannot be traced by oscilloscope!
0x00n00090	Read	every (PLC→NC)	UINT16	1	0/1	Axis has constant velocity or rotary speed	Cannot be traced by oscilloscope!
0x00n0009A	Read	every (PLC→NC)	UINT16	1	0/1	Operation mode not executed (busy)	Cannot be traced by oscilloscope!
0x00n0009B	Read	every (PLC→NC)	UINT16	1	0/1	Axis has instructions, is carrying instructions out	Cannot be traced by oscilloscope!
0x00n000B1	Read	every (PLC→NC)	UINT32	1	≥0	Axis error code	
0x00n000B2	Read	every (PLC→NC)	UINT32	1	ENUM	Motion state of the axis (master state [▶ 171] / slave state [▶ 171])	*Symbolic access possible!* "AxisState"

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n000B3	Read	every (PLC→NC)	UINT32	1	ENUM	Operation mode of the axis (rev. NC)	
0x00n000B4	Read	every (PLC→NC)	UINT32	1	ENUM	Axis referencing status	*Symbolic access possible!* "HomingState"
0x00n000B5	Read	every (PLC→NC)	UINT32	1	ENUM	Axis coupling state	*Symbolic access possible!* "CoupleState"
0x00n000B6	Read	every (PLC→NC)	UINT32	1	≥0	SVB entries/tasks of the axis (PRE table)	
0x00n000B7	Read	every (PLC→NC)	UINT32	1	≥0	SAF entries/tasks of the axis (EXE table)	
0x00n000B8	Read	every (PLC→NC)	UINT32	1	≥0	Axis ID	
0x00n000B9	Read	every (PLC→NC)	UINT32	1	≥0	Operation modes state double word:Bit 0: Position range monitoring active? Bit 1: target position window monitoring active? Bit 2: looping distance active? Bit 3: physical motion monitoring active? Bit 4: PEH time monitoring active? Bit 5: backlash compensation active? Bit 6: delayed error reaction mode active? Bit 7: modulo operation mode active (modulo axis)? Bit 16: following error monitoring position active? Bit 17: following error monitoring vel. active? Bit 18: end position monitoring min. active? Bit 19: end position monitoring max. active? Bit 20: actual position correction active?	
0x00n000BA	Read	every (PLC→NC)	REAL64	e.g. mm		Actual position (calculated absolute value)	
0x00n000BB	Read	every (PLC→NC)	REAL64	e.g. mm		Modulo actual position	
0x00n000BC	Read	every (PLC→NC)	INT32	1		Modulo rotations	
0x00n000BD	Read	every (PLC→NC)	REAL64	e.g. mm/s		Actual velocity (optional)	
0x00n000BE	Read	every (PLC→NC)	REAL64	e.g. mm		Following error position	
0x00n000BF	Read	every (PLC→NC)	REAL64	e.g. mm		Set position	
0x00n000C0	Read	every (PLC→NC)	REAL64	e.g. mm/s		Set velocity	

Index offset (Hex)	Access	Axis type	Data type	Phys. unit	Definition range	Description	Note
0x00n000C1	Read	every (PLC→NC)	REAL64	e.g. mm/ s^2		Set acceleration	
0x00n10000	Read/Write	Encoder: every (NC→IO)	{ 40 bytes }		STRUCT see encoder IO interface	ENCODER OUTPUT STRUCTURE (NC→IO, 40 bytes)*NCENCODERSTRUCT_OUT2*	Write command only optional! Consider safety aspects!
0x00n10080	Read	Encoder: every (IO→NC)	{ 40 bytes }		STRUCT see encoder IO interface	ENCODER-INPUT-STRUCTURE (IO→NC, 40 bytes)*NCENCODERSTRUCT_IN2*	
0x00n30000	Read/Write	Drive: every (NC→IO)	{ 40 bytes }		STRUCT see drive IO interface	DRIVE-OUTPUT-STRUCTURE (NC→IO, 40 bytes)*NCDRIVESTRUCT_OUT2*	Write command only optional! Consider safety aspects!
0x00n30080	Read	Drive: every (IO→NC)	{ 40 bytes }		STRUCT see drive IO interface	DRIVE-INPUT-STRUCTURE (NC→IO, 40 bytes)*NCDRIVESTRUCT_IN2*	

3.2.1.5.4.5 Specification Encoder

3.2.1.5.4.5.1 "Index offset" specification for encoder parameter (Index group 0x5000 + ID)

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000001	Read	every	UINT32	1	[1 ... 255]	Encoder ID	
0x00000002	Read	every	UINT8[30+1]	1	30 characters	Encoder name	
0x00000003	Read	every	UINT32	1	s. ENUM (>0)	Encoder type [▶ 166]	
0x00000004	Read/Write	every	UINT32	1	Byteoffset	Input address offset (IO-Input-Image)	change I/O address
0x00000005	Read/Write	every	UINT32	1	Byteoffset	Output address offset (IO-Output-Image)	change I/O address
0x00000006	Read/Write	every	REAL64	e.g. mm/ INC	[1.0E-12 ... 1.0E+30]	resulting scaling factor (numerator / denominator) Note: from TC3 the scaling factor consists of two components – numerator and denominator (default: 1.0).	Writing is not allowed if the controller enable has been issued.
0x00000007	Read/Write	every	REAL64	e.g. mm	[±1.0E+9]	Position offset	Writing is not allowed if the controller enable has been issued.
0x00000008	Read/Write	every	UINT16	1	[0,1]	encoder count direction	Writing is not allowed if the controller enable has been issued.
0x00000009	Read/Write	every	REAL64	e.g. mm	[0.001 ... 1.0E+9]	modulo factor	
0x0000000A	Read/Write	every	UINT32	1	s. ENUM (>0) in the appendix	Encoder mode [▶ 167]	
0x0000000B	Read/Write	every	UINT16	1	0/1	soft end min. monitoring?	
0x0000000C	Read/Write	every	UINT16	1	0/1	soft end max. monitoring?	
0x0000000D	Read/Write	every	REAL64	mm		Soft end position min.	
0x0000000E	Read/Write	every	REAL64	mm		Soft end position max.	
0x0000000F	Read/Write	every	UINT32	1	s. ENUM (≥0) in the appendix	Encoder evaluation direction [▶ 167] (enable for log. counting direction)	
0x00000010	Read/Write	every	REAL64	s	[0.0...60.0]	Filter time for actual position value in seconds (P-T1)	
0x00000011	Read/Write	every	REAL64	s	[0.0...60.0]	Filter time for actual velocity value in seconds (P-T1)	
0x00000012	Read/Write	every	REAL64	s	[0.0...60.0]	filter time for actual acceleration value in seconds (P-T1)	
0x00000013	Read/Write	every	UINT8[10+1]	1		physical unit	Not implemented!
0x00000014	Read/Write	every	UINT32	1		interpretation of the units (position, velocity, time) Bit 0: velocity in x/min instead of x/s Bit 1: position in thousandths of the base unit	Not implemented! bit array

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000015	Read/Write	every	UINT32	INC	[0x0... 0xFFFFFFFF]	Encoder mask (maximum value of the encoder actual value in increments) Note: The encoder mask may be any numerical value (e.g. 3600000). Unlike in the past, it no longer has to correspond to a continuous series off binary one's (2^n-1).	Axis has to be disabled for write access. see also "Encoder Sub Mask" parameter
0x00000016	Read/Write	every	UINT16	1	0/1	Actual position correction (measurement system error correction)?	
0x00000017	Read/Write	every	REAL64	s	[0.0...60.0]	Filter time for actual position correction in seconds (P-T1)	
0x00000018	Read/Write	every	UINT32	1	[0x0... 0xFFFFFFFF]	Filter mask for raw incremental value (0x0: full pass)	
0x00000019	Read/Write	every	UINT32	1	s. ENUM (≥0) in the appendix	Encoder absolute dimensioning system [▶ 167]	Writing is not allowed if the controller enable has been issued.
0x0000001A	Read/Write	every	UINT32	1	s. ENUM (≥0)	Encoder position initialization	Not implemented!
0x0000001B	Read/Write	every	REAL64	e.g. mm	[≥0, modulo factor/2]	Tolerance window for modulo-start	
0x0000001C	Read	every	UINT32	1	s. ENUM (≥0)	Encoder sign interpretation [▶ 167] (data type)	
0x0000001D	Read	every	UINT16	1	0/1	Incremental or absolute encoder ? 0: incremental encoder type 1: absolute encoder type	
0x00000020	Read/Write	every	UINT32	1	s. ENUM (≥0)	Encoder dead time compensation mode 0: off (Default) 1: on (with velocity) 2: on (with velocity and acceleration)	
0x00000021	Read/Write	every	UINT32	1		Control double word (32 bits) for the encoder dead time compensation: Bit 0 = 0: relative I/O times (default) Bit 0 = 1: absolute I/O times	
0x00000022	Read/Write	every	INT32	ns	[±1.0E+9]	Sum of the parameterized time shifts for the encoder dead time compensation (typically positive numerical values)	
0x00000023	Read/Write	every	REAL64	e.g. mm/ INC	[1.0E-12 ... 1.0E+30]	Component of the scaling factor: numerator (=> scaling factor numerator / scaling factor denominator)	NEW from TC3 Writing is not allowed if the controller enable has been issued.

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000024	Read/Write	every	REAL64	1	[1.0E-12 ... 1.0E+30]	Component of the scaling factor: denominator (=> scaling factor numerator / scaling factor denominator) Default: 1.0	NEW from TC3 Writing is not allowed if the controller enable has been issued.
0x00000025	Read/Write	every	{ REAL64 REAL64 } 16 bytes	e.g. mm/ INC 1	[1.0E-12 ... 1.0E+30] [1.0E-12 ... 1.0E+30]	Component of the scaling factor: numerator Component of the scaling factor: denominator (=> scaling factor numerator / scaling factor denominator)	NEW from TC3
0x00000030	Read/Write	every	UINT32	1		Internal encoder control double word for specifying the operation modes and properties	NEW from TC3
0x00000101	Read/Write	INC	UINT16	1	[0,1]	inverse search direction for ref.cam?	
0x00000102	Read/Write	INC		1	[0,1]	inverse search direction for sync pulse?	
0x00000103	Read/Write	INC	REAL64	e.g. mm	[±1.0E+9]	Reference position	
0x00000104	Read/Write	INC	UINT16	1	[0,1]	distance monitoring between Ref. cams and sync pulse active?	Not implemented!
0x00000105	Read/Write	INC	UINT32	INC	[0 ...65536]	minimum distance between Ref. cams and sync pulse in increments	Not implemented!
0x00000106	Read/Write	INC	UINT16	1	[0,1]	external sync pulse?	
0x00000107	Read/Write	INC	UINT32	1	s. ENUM (>0)	Referencing mode (Sync Condition) [▶ 168]	
0x00000108	Read/Write	INC	UINT32	1	[0x0000000F... 0xFFFFFFFF]binary mask: (2^n - 1)	Encoder Sub Mask (maximum value of the absolute range of the encoder actual value in increments) Used, for example, as a reference mark for the referencing mode "Software Sync" and for the NC Retain Data "ABSOLUTE (MODULO)", "INCREMENTAL (SINGLETURN ABSOLUTE)". Note 1: The Encoder Sub Mask must be smaller than or equal to the Encoder Mask. Note 2: The Encoder Mask must be an integer multiple of the Encoder Sub Mask. Note 3: The Encoder Sub Mask must be a continuous sequence of binary ones (2^n-1), e.g. 0x000FFFFF.	NEW see also param. "Encoder Mask"

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000109	Read/Write	INC	UINT32	1	s. ENUM (≥0)	Homing Sensor Source [▶ 168] Sets the source of the digital input of the referencing cam.	
0x00000110	Read/Write	INC (encoder simulation)	REAL64	1	[0.0 ... 1000000.0]	scaling/weight of the noise part for the simulation encoder	

3.2.1.5.4.5.2 "Index offset" specification for encoder state (Index group 0x5100 + ID)

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000001	Read	every	INT32			Error state encoder	
0x00000002	Read	every	REAL64			Actual position (charge with actual position compensation value)	Symbolic access possible! *'ActPos'*
0x00000003	Read	every	REAL64			Modulo actual position	Symbolic access possible! *'ActPosModulo'*
0x00000004	Read	every	INT32			Modulo actual rotation	
0x00000005	Read	every	REAL64			Optional: Actual velocity	Base unit / s *Symbolic access possible! 'ActVelo'*
0x00000006	Read	every	REAL64			Optional: Actual acceleration	Base unit / s^2 *Symbolic access possible! 'ActAcc'*
0x00000007	Read	every	INT32			Encoder actual increments	
0x00000008	Read	every	INT64			Software - actual increment counter	
0x00000009	Read/Write	every	UINT16			Reference flag ("calibrate flag")	
0x0000000A	Read	every	REAL64			Actual position correction value (measuring system error correction)	
0x0000000B	Read	every	REAL64			Actual position without actual position compensation value	
0x0000000C	Read	every	REAL64	e.g. mm		Actual position compensation value due to the dead time compensation	
0x0000000D	Read	every	REAL64	s		Sum of time shift for encoder dead time compensation (parameterized and variable dead time)Note: A dead time is specified in the system as a positive value.	
0x0000000E	Read	every	REAL64	e.g. mm		Internal position offset as a correction value for a value reduction to the base period (modulo range)	
0x00000010	Read	every	REAL64	e.g. mm/s		Actual velocity without actual position compensation value	
0x00000012	Read	every	REAL64	e.g. mm		Unfiltered actual position (charge with actual position compensation value)	
0x00000013	Read	every	REAL64	e.g. mm		Filtered actual position (offset with actual position correction value, without dead time compensation)	
0x00000014	Read	Type: SoE, CoE, MDP 742	REAL64	e.g. mm/s		Optional: actual drive velocity (transferred directly from SoE, CoE or MDP 742 drive)	Base Unit / s NEW from TC3.1 B4020.30
0x00000015	Read	every	REAL64	e.g. mm/s		Optional: Unfiltered actual velocity	Base Unit / s

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000016	Read	every	**READ**(16 bytes * N)			Read the actual position buffer	
			{				
			UINT32	ns	≥0	DcTimeStamp with 32 bits	
			UINT32			Reserve	
			REAL64	e.g. mm	±∞	Actual position for the associated timestamp	
			} [N]				
0x00000017	Read		REAL64	e.g. mm		Reading out the MC_SetPosition offset	
0x00000101	Read	INC	REAL64	e.g. mm		Read back the position difference between the hardware latch being activated and becoming valid	Cannot be traced by oscilloscope!
0x00000200	**Read Write**	**Function group "TouchProbeV2": - SERCOS/ SoE - EtherCAT/ CoE (CANopen DS402) - SoftDrive (TCom), - MDP 511 (EL5101, EL5151, EL5021, EL7041, EL7342)**	**WRITE**(24 bytes)			Read "Touch Probe" state (state of external latch)	Only for SAF-port 501
			{				
			UINT32	1	[1,2,3,4]	Probe unit (probe 1, 2, 3, 4)	
			UINT32[5]			Reserved	
			}				
			READ(64 bytes)				
			{				
			UINT32	1	[0/1]	Touch probe rising edge active?	
			UINT32	1	[0/1]	Touch probe rising edge became valid?	
			REAL64	e.g. mm		Touch probe rising edge position value	
			UINT32	1	≥0	Touch probe rising edge counter (continuous mode)	
			UINT32			Reserved	
			UINT32	1	[0/1]	Touch probe falling edge active?	
			UINT32	1	[0/1]	Touch probe falling edge became valid?	
			REAL64	e.g. mm		Touch probe falling edge position value	
			UINT32	1	≥0	Touch probe falling edge counter (continuous mode)	
			UINT32[5]			Reserved	
			}				
0x00000201	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	UINT16	1	[0,1]	"External latch function" active? or "Touch probe function" active ? *(edge-independent)*	Cannot be traced by oscilloscope!
0x00000201	Read	**CANopen**	UINT32[4]	1	[0,1]	"External latch functions 1 to 4" active? or "Touch probe functions 1 to 4" active?	Cannot be traced by oscilloscope!

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000202	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	UINT16	1	[0,1]	External latch value became valid? or touch probe latched? *(edge-independent)*	see also Axis interface NcToPlc (state double word)
0x00000202	Read	**CANopen**	UINT32[4]	1	[0,1]	External latch values 1 to 4 became valid? or touch probes 1 to 4 latched?	see also Axis interface NcToPlc (state double word)
0x00000203	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	UINT32	INC		External / touch probe hardware incremental latch value	
0x00000204	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	UINT64	INC		External / touch probe Software incremental latch value	
0x00000205	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	REAL64	e.g. mm		External / touch probe position latch value	Base Unit
0x00000205	Read	**CANopen**	REAL64[4]	e.g. mm		External touch probe values / position latch values	Base Unit
0x00000206	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	UINT32	INC		Difference hardware incremental latch values (NewLatch - LastLatch)	Cannot be traced by oscilloscope!
0x00000207	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	UINT64	INC		Difference software incremental latch values (NewLatch - LastLatch)	Cannot be traced by oscilloscope!
0x00000208	Read	**KL5101, SERCOS, AX2xxx, ProviDrive**	REAL64	e.g. mm		Difference position latch values (NewLatch - LastLatch)	Cannot be traced by oscilloscope! Base Unit
0x00000210	Read	**KL5101, AX2xxx, ProviDrive**	UINT16	1	[0,1]	"External latch function" for *rising edge* active? or "Touch probe function" for *rising edge* active?	Cannot be traced by oscilloscope!
0x00000210	Read	**CANopen**	UINT16[4]	1	[0,1]	"External latch function" for *rising edge* active? or "Touch probe function" for *rising edge* active?	Cannot be traced by oscilloscope!
0x00000211	Read	**KL5101, AX2xxx, ProviDrive**	UINT16	1	[0,1]	"External latch function" for *falling edge* active? or "Touch probe function" for *falling edge* active?	Cannot be traced by oscilloscope!
0x00000211	Read	**CANopen**	UINT16[4]	1	[0,1]	"External latch function" for *falling edge* active? or "Touch probe function" for *falling edge* active?	Cannot be traced by oscilloscope!

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Note
0x00000212	Read	**CANopen**	UINT16	1	[0,1]	Status of "Touch Probe 1" input signal	Cannot be traced by oscilloscope! From TC3.1 B4024.11
0x00000213	Read	**CANopen**	UINT16	1	[0,1]	Status of "Touch Probe 2" input signal	Cannot be traced by oscilloscope! From TC3.1 B4024.11

3.2.1.5.4.5.3 "Index offset" specification for encoder functions (Index group 0x5200 + ID)

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x0000001A	Write	every	{			Set actual position encoder/axis	Base Unit
			UINT32	ENUM	s. appendix	Actual position type [▶ 163] (s. appendix)	
			REAL64	mm	±∞	Actual position for encoder/axis **Caution when using!**	
			}				
0x0000001B	Write	every	VOID			Re-initialization of the actual encoder position Note: Takes effect for reference system „ABSOLUTE MULTITURN RANGE (with single overflow)“ and „ABSOLUTE SINGLETURN RANGE (with single overflow)“.	NEW from TC3
0x00000200	Write	Function group "TouchProbeV2": - SERCOS/ SoE, - EtherCAT/ CoE (CANopen DS402) - SoftDrive (TCom), - MDP 511 (EL5101, EL5151, EL5021, EL7041, EL7342)	{			Activate "Touch Probe" (external latch)	Only for SAF-port 501
			UINT32	1	[1,2,3,4]	Probe unit (probe 1, 2, 3, 4)	
			UINT32	1	[0,1]	Signal edge (0=rising edge, 1=falling edge)	
			UINT32	1	[1,2]	Probe mode (1=single, 2=continuous, ...)	
			UINT32	1	[1,2,3,4; 128,129]	Signal source (1=input 1, 2=input 2, ...)	
			UINT32			Reserved	
			UINT32			Reserved	
			} 24 bytes				
0x00000201	Write	KL5101,SERCOS,AX2xxx,PROFIDrive	VOID			Activate "External Latch" or activate "measuring probe function" *(typically rising edge)*	
0x00000201	Write	CANopen	UINT32[4]			Activate "External Latch" 1 to 4 or activate "measuring probe function" 1 to 4 *(typically rising edge)*	
0x00000202	Write	KL5101,SERCOSAX2xxx,PROFIDrive	VOID			Activate "external latch" or activate "measuring probe function" *(falling edge)*	
0x00000202	Write	CANopen	UINT32[4]			Activate "external latch" 1 to 4 or activate "measuring probe function" 1 to 4 *(falling edge)*	

Index-Offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000205	Write	Function group "TouchProbeV2": - SERCOS/ SoE, - EtherCAT/ CoE (CANopen DS402) - SoftDrive (TCom), - MDP 511 (EL5101, EL5151, EL5021, EL7041, EL7342)	{			Deactivate "touch probe" (external latch)	Only for SAF-port 501
			UINT32	1	[1,2,3,4]	Probe unit (probe 1, 2, 3, 4)	
			UINT32	1	[0,1]	Signal edge (0=rising edge, 1=falling edge)	
			UINT32			Reserved	
			UINT32			Reserved	
			UINT32			Reserved	
			UINT32			Reserved	
			} 24 bytes				
0x00000205	Write	KL5101,SERCOS,AX2xxx,PROFIDrive	VOID			Deactivate "external latch" or deactivate "measuring probe function"	
0x00000205	Write	CANopen	UINT32[4]			Deactivate "external latch" or deactivate "measuring probe function"	
0x00000210	Write	KL5101,SERCOS,AX2xxx,PROFIDrive	REAL64	e.g. mm	±∞	Set "External latch event" and "External latch position"	Only for EtherCAT:

3.2.1.5.4.5.4 "Index offset" specification for cyclic encoder process data (Index group 0x5300 + ID)

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000000	Read/Write	every (NC→IO)	{		STRUCT s. encoder interface	ENCODER-OUTPUT-STRUCTURE (NC→IO, 40 Byte) NCENCODERSTRUCT_OUT2	Write command only optional! Consider safety aspects!
			INT32	INC	≥ 0	nDataOut1	
			INT32	INC	≥ 0	nDataOut2	
			UINT8	1	≥ 0	nCtrl1	
			UINT8	1	≥ 0	nCtrl2	
			UINT8	1	≥ 0	nCtrl3	
			UINT8	1	≥ 0	nCtrl4	
			INT32	INC	≥ 0	nDataOut3	
			INT32	INC	≥ 0	nDataOut4	
			INT32	INC	≥ 0	nDataOut5	
			INT32	INC	≥ 0	nDataOut6	
			UINT8	1	≥ 0	nCtrl5	
			UINT8	1	≥ 0	nCtrl6	
			UINT8	1	≥ 0	nCtrl7	
			UINT8	1	≥ 0	nCtrl8	
			INT32	1	≥ 0	Reserved	
			INT32	1	≥ 0	Reserved	
			} 40 bytes				
0x00000000	Read/Write	every (NC→IO), optional 64 bit encoder interface (e.g. MDP513 with 64Bit)	{		STRUCT s. encoder interface	Optional ENCODER-OUTPUT-STRUCTURE (NC→IO, 80 Byte) NCENCODERSTRUCT_OUT3	Write command only optional! Consider safety aspects! NEW from TC3
			UINT64	INC	≥ 0	nDataOut1	
			UINT64	INC	≥ 0	nDataOut2	
			UINT64	INC	≥ 0	nDataOut3	
			UINT64	INC	≥ 0	nDataOut4	
			UINT64	INC	≥ 0	nDataOut5	
			UINT64	INC	≥ 0	nDataOut6	
			UINT64	INC	≥ 0	nDataOut7	
			UINT64	INC	≥ 0	nDataOut8	
			UINT16	1	≥ 0	nCtrl1	
			UINT16	1	≥ 0	nCtrl2	
			UINT16	1	≥ 0	nCtrl3	
			UINT16	1	≥ 0	nCtrl4	
			UINT16	1	≥ 0	nCtrl5	
			UINT16	1	≥ 0	nComCtrl	
			INT32	1	≥ 0	reserved	
			} 80 bytes				

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Write	Every (NC→IO)	{		STRUCT s. encoder interface	Bitwise access to ENCODER-OUTPUT-STRUCTURE (NC→IO, 40 Byte) NCENCODERSTRUCT_OUT2	Write command only optional! Consider safety aspects!
			UINT32	1	[0 … 39]	ByteOffset Relative address offset [0..39] in output structure. E.G.: To write “nControl1” the ByteOffset must be 8.	
			UINT32	1	[0x00000000… 0xFFFFFFFF]	BitSelectMask (BSM) The mask defines write enabled bits in a DWORD. Zero bits are protected and remain unaffected.	
			UINT32	1	[0x00000000… 0xFFFFFFFF]	Value Only those bits in value are overwritten where BSM equals 1.	
			}				
0x00000080	Read	every (IO→NC)	{		STRUCT s. encoder interface	ENCODER-INPUT-STRUCTURE (IO→NC, 40 Byte) NCENCODERSTRUCT_IN2	
			INT32	INC	≥ 0	nDataIn1	
			INT32	INC	≥ 0	nDataIn2	
			UINT8	1	≥ 0	nState1	
			UINT8	1	≥ 0	nState2	
			UINT8	1	≥ 0	nState3	
			UINT8	1	≥ 0	nState4 (Bit0: *WcState*, Bit1: *InputToggle*)	
			INT32	INC	≥ 0	nDataIn3	
			INT32	INC	≥ 0	nDataIn4	
			INT32	INC	≥ 0	nDataIn5	
			INT32	INC	≥ 0	nDataIn6	
			UINT8	1	≥ 0	nState5	
			UINT8	1	≥ 0	nState6	
			UINT8	1	≥ 0	nState7	
			UINT8	1	≥ 0	nState8	
			INT32	[ns]	≥ 0	nDcInputTime (absolute/ relative *DcInputShift* for deadtime compensation)	
			INT32	1	≥ 0	Reserved	
			} 40 bytes				

Index offset (Hex)	Access	Group type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000080	Read	every (NC→IO), optional 64 bit encoder interface (e.g. MDP513 with 64Bit)	{		STRUCT s. encoder interface	optional ENCODER-INPUT-STRUCTURE (IO→NC, 80 Byte) NCENCODERSTRUCT_IN3	NEW from TC3
			UINT64	INC	≥ 0	nDataIn1	
			UINT64	INC	≥ 0	nDataIn2	
			UINT64	INC	≥ 0	nDataIn3	
			UINT64	INC	≥ 0	nDataIn4	
			UINT64	INC	≥ 0	nDataIn5	
			UINT64	INC	≥ 0	nDataIn6	
			UINT64	INC	≥ 0	nDataIn7	
			UINT64	INC	≥ 0	nDataIn8	
			UINT16	1	≥ 0	nState1	
			UINT16	1	≥ 0	nState2	
			UINT16	1	≥ 0	nState3	
			UINT16	1	≥ 0	nState4	
			UINT16	1	≥ 0	nState5	
			UINT16	1	≥ 0	nComState (Bit0: *WcState*, Bit1: *InputToggle*)	
			INT32	[ns]	≥ 0	nDcInputTime (absolute/ relative *DcInputShift* for deadtime compensation)	
			} 80 bytes				

3.2.1.5.4.6 Specification Controller

3.2.1.5.4.6.1 "Index offset" specification for controller parameter (Index group 0x6000 + ID)

Index offset (Hex)	Access	Controller type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000001	Read	every	UINT32	1	[1 ... 255]	Controller ID	
0x00000002	Read	every	UINT8[30+1]	1	30 symbol	Controller name	
0x00000003	Read	every	UINT32	1	s. ENUM (>0)	Controller type [▶ 165]	
0x0000000A	Read/Write	every	UINT32	1	s. ENUM (>0)	Controller mode	DEFAULT: 1=STANDARD
0x0000000B	Read/Write	every	REAL64	%	[0.0 ... 1.0]	Weight of the velocity pre control (standard value: 1.0 = 100 %)	
0x00000010	Read/Write	every	UINT16	1	0/1	Following error monitoring positon?	
0x00000011	Read/Write	every	UINT16	1	0/1	Following error monitoring velocity?	
0x00000012	Read/Write	every	REAL64	mm	[0.0…1.0E.6]	Max. following error position	
0x00000013	Read/Write	every	REAL64	s	[0.0...600]	Max. following error time position	
0x00000014	Read/Write	every	REAL64	mm/s	[0.0…1.0E.6]	Max. following error velocity	
0x00000015	Read/Write	every	REAL64	s	[0.0…1.0E.6]	Max. following error time velocity	
0x00000021	Read/Write	every	REAL64	1	[0.0...1000000.0]	Scaling factor (multiplier) for position differences between master and slave axis (conversion in the same coordinate system)	Reserved function, no standard!
0x00000100	Read/Write	P/PID (Pos., (velocity)	REAL64	1	[0.0...1.0]	Maximum output limitation ( ) for controller total output	(Standard value: 0.5 == 50%)
0x00000102	Read/Write	P/PID (Pos.)	REAL64	mm/s/ mm	[0.0...1000.0]	Proportional amplification factor k_p resp. k_v	Base unit / s / base unit position control
0x00000103	Read/Write	PID (Pos.)	REAL64	s	[0.0 ... 60.0]	Integral action time Tn	Position control
0x00000104	Read/Write	PID (Pos.)	REAL64	s	[0.0 ... 60.0]	Derivative action time Tv	position control
0x00000105	Read/Write	PID (Pos.)	REAL64	s	[0.0 ... 60.0]	Damping time Td	Position control
0x00000106	Read/Write	PP (Pos.)	REAL64	mm/s/ mm	[0.0...1000.0]	Add proportional amplification factor kp resp. kv that applies above a limit velocity in percent.	Base unit / s / base unit position control
0x00000107	Read/Write	PP (Pos.)	REAL64	%	[0.0...1.0]	Threshold level velocity in percent, above which the additional proportional amplification factor kp resp. kv applies.	(Standard value: 0.01 == 1%)
0x00000108	Read/Write	P/PID (Acc.)	REAL64	s	[0.0 ... 100.0]	proportional amplification factor ka	Acceleration pre control
0x0000010A	Read/Write	every	UINT32	1	ENUM	Filter for maximum slope of the nominal velocity (acceleration restricted): 0: Off, 1: Velo, 2: Pos+Velo	Reserved function, no standard!
0x0000010B	Read/Write	every	REAL64	mm/s^2		Filter value for the maximum slope of the nominal velocity (max. acceleration)	Reserved function, no standard!
0x0000010D	Read/Write	P/PID	REAL64	mm	[0.0 ... 10000.0]	'dead band' for position error (position deviation) (for P/PID-controller with velocity or torque interface)	Reserved function

Index offset (Hex)	Access	Controller type	Data type	Phys. unit	Definition range	Description	Remarks
0x0000010F	Read/Write	P/PP/PID (Pos.) slave-control	REAL64	(mm/s) / mm	[0.0...1000.0]	Slave coupling control: Proportional gain k_{cp} for position deviation between master and slave	Slave coupling control
0x00000110	Read/Write	P (Pos.)	UINT16	1	0/1	Automatic offset calibration: active/passive	
0x00000111	Read/Write	P (Pos.)	UINT16	1	0/1	Automatic offset calibration: hold mode	
0x00000112	Read/Write	P (Pos.)	UINT16	1	0/1	Automatic offset calibration: fading mode	
0x00000114	Read/Write	P (Pos.)	REAL64	%	[0.0 ... 1.0]	Automatic offset calibration: pre control limit	(Standard value: 0.05 == 5%)
0x00000115	Read/Write	P (Pos.)	REAL64	s	[0.1 ... 60.0]	automatic offset calibration: time constant	
0x00000116	Read/Write	PID (Pos.)	REAL64	%	[0.0...1.0]	Maximum output limitation ( ) for I- part in percent (default setting: 0.1 == 10 %)	
0x00000117	Read/Write	PID (Pos.)	REAL64	%	[0.0...1.0]	Maximum output limitation ( ) for D- part in percent (default setting: 0.1 == 10 %)	
0x00000118	Read/Write	PID (Pos.)	UINT16	1	0/1	Switch off the I-part during an active positioning process (as far as I-part active)? (default setting: 0 = FALSE)	
0x00000120	Read/Write	P/PID (Pos.)	REAL64	s	≥0	PT-1 filter time for position error (position-difference)	Reserved function, no standard!
0x00000202	Read/Write	P/PID (velocity)	REAL64	1	[0.0...1000.0]	Proportional amplification factor k_p resp. k_v	Velocity control
0x00000203	Read/Write	PID (velocity)	REAL64	s	[0.0 ... 60.0]	Integral-action time T_n	Velocity control
0x00000204	Read/Write	PID (velocity)	REAL64	s	[0.0 ... 60.0]	Derivative action time T_v	Velocity control
0x00000205	Read/Write	PID (velocity)	REAL64	s	[0.0 ... 60.0]	Damping timeT_d	Velocity control
0x00000206	Read/Write	PID (velocity)	REAL64	%	[0.0...1.0]	Maximum output limitation ( ) for I-part in percent (default setting: 0.1 == 10 %)	Velocity control
0x00000207	Read/Write	PID (velocity)	REAL64	%	[0.0...1.0]	Maximum output limitation ( ) for D-part in percent (default setting: 0.1 = 10 %)	Velocity control
0x0000020D	Read/Write	P/PID (velocity)	REAL64	mm/s	[0.0 ... 10000.0]	'dead band' for velocity error (velocity deviation) (for P/PID-controller with velocity or torque interface)	Reserved function
0x00000220	Read/Write	P/PID (velocity)	REAL64	s	≥0	PT-2 filter time for velocity error (velocity-difference)	Velocity control, no standard!
0x00000221	Read/Write	P/PID (velocity)	REAL64	s	≥0	PT-1 filter time for velocity error (velocity-difference)	Reserved function, no standard!

Index offset (Hex)	Access	Controller type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000250	Read/Write	P/PI (observer)	UINT32	1	s. ENUM (≥0)	OBSERVER mode [▶ 165] for controller with torque interface 0: OFF (default) 1: LUENBERGER	
0x00000251	Read/Write	P/PI (observer)	REAL64	Nm / A	>0.0	Motor: torque constant K_T	
0x00000252	Read/Write	P/PI (observer)	REAL64	kg m^2	>0.0	Motor: moment of inertia J_M	
0x00000253	Read/Write	P/PI (observer)	REAL64	Hz	[100.0 ... 2000.0] Default: 500	Bandwidth f_0	
0x00000254	Read/Write	P/PI (observer)	REAL64	1	[0.0 ... 2.0] Default: 1.0	Correction factor k_c	
0x00000255	Read/Write	P/PI (observer)	REAL64	s	[0.0 ... 0.01] Default: 0.001	Velocity filter (1. order): filter time constant T	
0x00000A03	Read/Write	PID (MW)	REAL64	cm^2	[0.0 ...1000000]	Cylinder area A_A of side A in cm^2	
0x00000A04	Read/Write	PID (MW)	REAL64	cm^2	[0.0 ...1000000]	Cylinder area A_B of side B in cm^2	
0x00000A05	Read/Write	PID (MW)	REAL64	cm^3/s	[0.0 ...1000000]	Nominal volume flow Q_{nenn} in cm^3/s	
0x00000A06	Read/Write	PID (MW)	REAL64	bar	[0.0 ...1000000]	nominal pressure resp. valve pressure reduction P_{nenn} in bar	
0x00000A07	Read/Write	PID (MW)	UINT32	1	[1 ... 255]	Axis ID for the system pressure P_o	

3.2.1.5.4.6.2 "Index offset" specification for controller state (Index group 0x6100 + ID)

Index offset (Hex)	Access	Controller type	Data type	Phys. unit	Definition range	Description	Note
0x00000001	Read	every	INT32			Error state controller	
0x00000002	Read	every	REAL64	e.g. mm/s		Controller output in absolute units	Base Unit / s *Symbolic access possible! "CtrlOutput"*
0x00000003	Read	every	REAL64	%		Controller output in percent	Cannot be traced by oscilloscope!
0x00000004	Read	every	REAL64	V		Controller output in volts	Cannot be traced by oscilloscope!
0x0000000D	Read	every	REAL64	mm		Following error position (without dead time compensation)	Base Unit
0x0000000E	Read	every	REAL64	mm		Following error position (without set position correction)	Base Unit
0x0000000F	Read	every	REAL64	mm		Following error position (with set position correction and dead time compensation)	Base Unit *Symbolic access possible! "PosDiff"*
0x00000010	Read	every	REAL64	mm		Peak hold value for maximum negative following error of the position	Base Unit
0x00000011	Read	every	REAL64	mm		Peak hold value for minimum positive following error of the position	Base Unit
0x00000012	Read	every	REAL64	mm/s		Following error velocity	Base Unit / s
0x00000021	Read	every	REAL64	mm		Difference (deviation) between the following error from master and slave axis (master error minus slave error)	Base Unit *Symbolic access possible via axis!* *"PosDiffCouple"*
0x00000022	Read	every	REAL64	mm		PeakHold value for the maximum negative difference between master and slave axis following error of the position	Base Unit
0x00000023	Read	every	REAL64	mm		PeakHold value for the maximum positive difference between master and slave axis following error of the position	Base Unit
0x00000101	Read	P/PID (pos.)	REAL64	e.g. mm/s		P-part of the controller in absolute units	
0x00000102	Read	PID (pos.)	REAL64	e.g. mm/s		I-part of the controller in absolute units	
0x00000103	Read	PID (pos.)	REAL64	e.g. mm/s		D-part of the controller in absolute units	
0x00000104	Read	PID (pos.)	UINT16	1	0/1	Limitation of the I-part active?	
0x00000105	Read	PID (pos.)	UINT16	1	0/1	Limitation of the D-part active?	
0x00000106	Read	PID (pos.)	UINT16	1	0/1	ARW measures for the I-part active?	ARW: Anti Reset Windup

Index offset (Hex)	Access	Controller type	Data type	Phys. unit	Definition range	Description	Note
0x0000010F	Read	P/PP/PID (veloc.)	REAL64	e.g. mm/s		Proportion of automatic offset compensation in absolute units	NEW
0x00000110	Read	PID (pos.)	REAL64	e.g. mm/s		Acceleration pre-control Y_{acc} of the controller in absolute units Note: function depends on controller type!	Acceleration pre-control
0x00000111	Read	PP (Pos.)	REAL64	mm/s/mm	≥0	Internal interpolated proportional gain kp or kv	PP controller
0x0000011A 0x0000011B 0x0000011C 0x0000011D 0x0000011E 0x0000011F 0x00000120 0x00000121 0x00000122 0x00000123 0x00000124	Read	P (Pos.)	UINT32 REAL64 REAL64 REAL64 REAL64 REAL64 REAL64 REAL64 REAL64 REAL64 REAL64	1 mm mm/s mm/s mm/s^2 mm mm mm/s mm/s^2 mm/s mm/s^2		Set velocity filter: InternalPhase InternalPosSollError! TestVeloSoll InternalLimitedVeloSoll InternalAccSollRel InternalPosSollRel PosSollCorrected! VeloSollCorrected! AccSollCorrected! TestVeloSollCorrected TestAccSollCorrected	List!Reserved function, no standard!
0x00000201	Read	P,PID (velocity)	REAL64	e.g. mm/s		Velocity part of the controller	Base Unit / s
0x00000202	Read	P,PID (velocity)	REAL64	%		Velocity part of the controller in percent	Cannot be traced by oscilloscope!
0x00000203	Read	P,PID (velocity)	REAL64	V		Velocity part of the controller in volts	Cannot be traced by oscilloscope!
0x00000201	Read	P/PID (velocity)	REAL64	e.g. mm/s		P-part of the controller in absolute units	
0x00000202	Read	P/PID (velocity)	REAL64	e.g. mm/s		I-part of the controller in absolute units	
0x00000203	Read	P/PID (velocity)	REAL64	e.g. mm/s		D-part of the controller in absolute units	
0x00000204	Read	P/PID (velocity)	UINT16	1	0/1	Limitation of the I-part active?	
0x00000205	Read	P/PID (velocity)	UINT16	1	0/1	Limitation of the D-part active?	
0x00000206	Read	P/PID (velocity)	UINT16	1	0/1	ARW measures for the I-part active?	ARW: Anti Reset Windup
0x0000020A	Read	P/PID (velocity)	REAL64	e.g. mm/s		Total input size of the velocity controller	
0x00000250	Read	P/PI (observer)	REAL64	e.g. mm		Observer: position difference (actual position - observer position	
0x00000251	Read	P/PI (observer)	REAL64	e.g. mm		Observer: position	
0x00000252	Read	P/PI (observer)	REAL64	e.g. mm/s		Observer: velocity 2 (for P-part)	
0x00000253	Read	P/PI (observer)	REAL64	e.g. mm/s		Observer: velocity 1 (for I-part)	
0x00000254	Read	P/PI (observer)	REAL64	e.g. mm/s^2		Observer: acceleration	

Index offset (Hex)	Access	Controller type	Data type	Phys. unit	Definition range	Description	Note
0x00000255	Read	P/PI (observer)	REAL64	A		Observer: motor actual current	
0x00000256	Read	P/PI (observer)	UINT16	1	0/1	Observer: limitation of the I-part active?	
0x00000A00	Read	PID (MW)	REAL64	%	[-1.0...1.0]	Calculation of the set velocity (pre-control) in percent	
0x00000A01	Read	PID (MW)	REAL64	e.g. mm/s		P-part of the controller in absolute units or percent (according to output weight)	
0x00000A02	Read	PID (MW)	REAL64	e.g. mm/s		I-part of the controller in absolute units or percent (according to output weight)	
0x00000A03	Read	PID (MW)	REAL64	e.g. mm/s		D-part of the controller in absolute units or percent (according to output weight)	
0x00000A04	Read	PID (MW)	UINT16	1	0/1	Limitation of the I-part active?	
0x00000A05	Read	PID (MW)	UINT16	1	0/1	Limitation of the D-part active?	
0x00000A10	Read	PID (pos.)	REAL64	e.g. mm/s		Acceleration pre-control Y_{acc} of the controller in absolute units	Acceleration pre-control

3.2.1.5.4.6.3 "Index offset" specification for controller functions (Index group 0x6200 + ID)

Index offset (Hex)	Access	controller type	Data type	Phys. unit	Definition range	Description	Remarks

3.2.1.5.4.7 Specification Drive

3.2.1.5.4.7.1 "Index offset" specification for drive parameter (Index group 0x7000 + ID)

Index offset (Hex)	Access	Drive type	Data type	Phys. Unit	Definition range	Description	Note
0x00000001	Read	every	UINT32	1	[1 ... 255]	Drive ID	
0x00000002	Read	every	UINT8[30+1]	1	30 characters	Drive name	
0x00000003	Read	every	UINT32	1	s. ENUM (>0)	Drive type [▶ 170]	
0x00000004	Read/Write	every	UINT32	1	Byteoffset	Input address offset (IO-Input-Image)	change I/O address
0x00000005	Read/Write	every	UINT32	1	Byteoffset	Output address offset (IO-Output-Image)	change I/O address
0x00000006	Read/Write	every	UINT16	1	[0,1]	motor polarity	Writing is not allowed if the controller enable has been issued.
0x0000000A	Read/Write	every	UINT32	1	s. ENUM (>0)	drive mode	Default: 1 = STANDARD
0x0000000B	Read/Write	every	REAL64	%	[-1.0 ... 1.0]	Minimum output limit (output limitation) (default setting: -1.0 == -100%)	
0x0000000C	Read/Write	every	REAL64	%	[-1.0 ... 1.0]	Maximum output limit (output limitation) (default setting: 1.0 == 100%)	
0x0000000D	Read	every	UINT32	INC		Maximum number of output increments (output mask)	
0x00000010	Read/Write	every	UINT32	1		Internal Drive Control double word to determine the drive operation modes	Reserved!
0x00000011	Read/Write	every	UINT32	1	≥ 5	Internal drive reset counter (time in NC cycles for enable and reset)	Reserved!
0x00000020	Read/Write	every	UINT32	1	see ENUM (≥0) see appendix	Drive dead time compensation mode 0: Off (default) 1: On (with velocity) 2: On (with velocity and acceleration)	
0x00000021	Read/Write	every	UINT32	1		Control double word (32 bits) for the drive dead time compensation: Bit 0 = 0: relative IO times (default) Bit 0 = 1: absolute IO times	
0x00000022	Read/Write	every	INT32	ns	[±1.0E+9]	Sum of the parameterized time shifts for the drive dead time compensation (typically positive numerical values)	
0x00000031	Read/Write	every	REAL64	e.g. %/ INC	[-1.0E+30 ... 1.0E+30]	Scaling factor for actual torque value of drive (or actual value of force or current respectively) e.g. AX5xxx: 0.1 => ±100%	NEW from TC3.1

Index offset (Hex)	Access	Drive type	Data type	Phys. Unit	Definition range	Description	Note
0x00000032	Read/Write	every	REAL64	s	[0.0 ... 60.0]	P-T1 filter time for actual torque value (or actual value of force or current respectively)	NEW from TC3.1
0x00000033	Read/Write	every	REAL64	s	[0.0 ... 60.0]	P-T1 filter time for temporal derivation of the actual torque value (or actual value of force or current respectively)	NEW from TC3.1
0x00000101	Read/Write	Servo	REAL64	e.g. mm/s	>0.0	Reference velocity at reference output (velocity pre-control)	Base Unit / s
0x00000102	Read/Write	Servo	REAL64	%	[0.0 ... 5.0]	reference output in percent	
0x00000103	Read	Servo	REAL64	e.g. mm/s	>0.0	resulting velocity at 100% output	Base Unit / s
0x00000104	Read/Write	Servo	REAL64	e.g. mm/s	±∞	velocity offset (DAC offset) for drift calibration (offset calibration) of the axis	Base Unit / s
0x00000105	Read/Write	Servo (Sercos, Profi Drive, AX200x, CANopen)	REAL64	1	[0.0 ... 100000000.0]	velocity scaling (scaling factor to react to the weight in the drive)	For Sercos, Profi Drive, AX200x, CANopen
0x00000106	Read/Write	Profi Drive DSC	UINT32	0.001 * 1/s	≥ 0	Profibus/Profi Drive DSC: position control gain Kpc	Only for Profi Drive DSC
0x00000107	Read/Write	Profi Drive DSC	REAL64	1	≥ 0.0	Profibus/Profi Drive DSC: scaling for calculating 'XERR' (Default: 1.0)	Only for Profi Drive DSC
0x00000109	Read/Write	Servo	REAL64	1	[0.0 ... 100000000.0]	Position scaling (scaling factor to react to the weight in the drive)	For Sercos, CANopen
0x0000010A	Read/Write	Servo	REAL64	1	[0.0 ... 100000000.0]	Acceleration scaling (scaling factor to react to the weight in the drive)	For Sercos, Profi Drive, AX200x, CANopen
0x0000010B	Read/Write	Servo	REAL64	1	[0.0 ... 100000000.0]	Torque scaling (rotary motor) or force scaling (linear motor) (scaling factor for reacting to weighting in the drive) for "TorqueOffset" (additive moment as pre-control)	For Sercos, Profi Drive, AX200x, CANopen
0x0000010C	Read/Write	Servo	REAL64	1	[0.0 ... 100000000.0]	Torque scaling (rotary motor) or force scaling (linear motor) (scaling factor for reacting to weighting in the drive) for "SetTorque" (e.g. MC_TorqueControl) with Drive OpMode CST)	For Sercos, Profi Drive, AX200x, CANopen From TC 3.1 B4024.2
0x0000010D	Read/Write	Servo (Sercos, CANopen)	REAL64	s	[0.0 ... 1.0]	Damping time for drive velocity output	For Sercos, CANopen
0x0000010E	Read/Write	Servo (Sercos, CANopen)	REAL64	s	[0.0 ... 1.0]	Damping time for drive acceleration output	For Sercos, CANopen
0x0000010F	Read/Write	Servo (Sercos, CANopen)	REAL64	s	[0.0 ... 1.0]	Damping time for drive torque output or force output	For Sercos, CANopen

Index offset (Hex)	Access	Drive type	Data type	Phys. Unit	Definition range	Description	Note
0x00000120	Read/Write	Servo/ hydraulics/	UINT32	1	≥ 0	Table ID (0: no table)	Only for KL4xxx, M2400, Universal
0x00000121	Read/Write	Servo/ hydraulics	UINT32	1	≥ 0	Interpolation type 0: Linear 2: Spline	Only for KL4xxx, M2400, Universal
0x00000122	Read/Write	Servo/ hydraulics	REAL64	%	[-1.0 ... 1.0]	Output offset in percent Note: Acts according to the characteristic evaluation!	Only for KL4xxx, M2400, Universal
0x00000151	Read/Write	Servo / non-linear	REAL64	1	[0.0 ... 100.0]	Quadrant compensation factor (relationship between quadrant I and III)	
0x00000152	Read/Write	Servo / non-linear	REAL64	1	[0.01 ... 1.0]	Velocity reference point in percent (1.0 == 100 %)	
0x00000153	Read/Write	Servo / non-linear	REAL64	1	[0.01 ... 1.0]	Output reference point in percent (1.0 == 100%)	
0x00000301	Read/Write	Stepper motor	UINT8			Bit mask: cycle 1	
0x00000302	Read/Write	Stepper motor	UINT8			Bit mask: cycle 2	
0x00000303	Read/Write	Stepper motor	UINT8			Bit mask: cycle 3	
0x00000304	Read/Write	Stepper motor	UINT8			Bit mask: cycle 4	
0x00000305	Read/Write	Stepper motor	UINT8			Bit mask: cycle 5	
0x00000306	Read/Write	Stepper motor	UINT8			Bit mask: cycle 6	
0x00000307	Read/Write	Stepper motor	UINT8			Bit mask: cycle 7	
0x00000308	Read/Write	Stepper motor	UINT8			Bit mask: cycle 8	
0x00000310	Read/Write	Stepper motor	UINT8			Bit mask: holding current	

3.2.1.5.4.7.2 "Index offset" specification for drive state (Index group 0x7100 + ID)

Index offset (Hex)	Access	Drive type	Data type	Phys. unit	Definition range	Description	Note
0x00000001	Read	every	INT32			Error state drive	
0x00000002	Read	every	REAL64	e.g. mm/s		Total output in absolute units	Base unit / s *Symbolic access possible!* "DriveOutput"
0x00000003	Read	every	REAL64	%		Total output in percent	
0x00000004	Read	every	REAL64	V		Total output in volts	Cannot be traced by oscilloscope!
0x00000005	Read	every	REAL64	e.g. mm/s		PeakHold value for maximum negative total output	Base Unit / s
0x00000006	Read	every	REAL64	e.g. mm/s		PeakHold value for maximum positive total output	Base Unit / s
0x00000007	Read	every	REAL64	e.g. 100% = 1000, e.g. Nm or N		Actual torque or actual force respectively (typically 100% = 1000)	from TC3.1 B4022 *Symbolic access possible!* "ActTorque"
0x00000008	Read	every	REAL64	e.g. Nm/s or N/s	±∞	Actual torque change or actual force change respectively (time derivative of the actual torque or actual force respectively)	from TC3.1 B4024
0x0000000C	Read	every	REAL64	e.g. mm		Set position correction value for drive output on account of dead time compensation	
0x0000000D	Read	every	REAL64	s		Sum of the time shifts for drive dead time compensation (parameterized and variable dead time) Note: a dead time is specified in the system as a positive value.	
0x00000013	Read	every	REAL64	%		Total output in percent (based on non-linear characteristic curve!)	
0x00000014	Read	every	REAL64	V		Total output in volt (based on non-linear characteristic curve!)	Cannot be traced by oscilloscope!
0x0000011A	Read	Servo (Sercos, CANopen)	REAL64	e.g. mm		Optional output filtering: Filtered set position	NEW For Sercos, CANopen
0x0000011E	Read	Servo (Sercos, CANopen)	REAL64	e.g. mm/s		Optional output filtering: Filtered set velocity	NEW For Sercos, CANopen
0x0000011F	Read	Servo (Sercos, CANopen)	REAL64	e.g. mm/s^2		Optional output filtering: Filtered set acceleration / set deceleration	NEW For Sercos, CANopen

Index offset (Hex)	Access	Drive type	Data type	Phys. unit	Definition range	Description	Note
0x00000200	ReadWrite		**READ:**			Reading the state of the digital inputs 1 to 8	from TC3.1 B4024.12
			UINT32	1	0/1	State of the selected input	Only for SAF-Port 501!
			WRITE:				
			UINT32	1	[1…8]	Selection of input 1 to 8	

3.2.1.5.4.7.3 "Index offset" specification for drive functions (Index group 0x7200 + ID)

Index offset (Hex)	Access	Drive type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000102	Write	SERVO	{			Remove and delete the characteristic drive table	Only for SAF-port 501!
			ULONG	1	>0	Table-ID s.a. axis function with index offset 0x00000012	
			}				

3.2.1.5.4.7.4 "Index offset" specification for cyclic drive process data (Index group 0x7300 + ID)

Index offset (Hex)	Access	Drive type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000000	Read/Write	every (NC→IO)	{		STRUCT s. drive interface	DRIVE-OUTPUT-STRUCTURE (NC→IO, 40 Byte) *NCDRIVESTRUCT_OUT 2*	Write command only optional! Consider safety aspects!
			INT32	INC	≥ 0	nOutData1	
			INT32	INC	2^31	nOutData2	
			UINT8	1	≥ 0	nControl1	
			UINT8	1	≥ 0	nControl2	
			UINT8	1	≥ 0	nControl3	
			UINT8	1	≥ 0	nControl4	
			INT32	INC	≥ 0	nOutData3	
			INT32	INC	≥ 0	nOutData4	
			INT32	INC	≥ 0	nOutData5	
			INT32	INC	≥ 0	nOutData6	
			UINT8	1	≥ 0	nControl5	
			UINT8	1	≥ 0	nControl6	
			UINT8	1	≥ 0	nControl7	
			UINT8	1	≥ 0	nControl8	
			INT32	1	≥ 0	Reserved	
			INT32	1	≥ 0	Reserved	
			}				
0x00000001	Write	every (NC→IO)	{		STRUCT s. drive interface	Bitwise access to DRIVE-OUTPUT-STRUCTURE (NC→IO, 40 Byte) *NCDRIVESTRUCT_OUT 2*	Write command only optional! Consider safety aspects
			UINT32	1	[0 … 39]	ByteOffset Relative address offset [0..39] in output structure. E.G.: To write “nControl1” the ByteOffset must be 8.	
			UINT32	1	[0x00000000… 0xFFFFFFFF]	BitSelectMask (BSM) The mask defines write enabled bits in a DWORD. Zero bits are protected and remain unaffected.	
			UINT32	1	[0x00000000… 0xFFFFFFFF]	Value Only those bits in value are overwritten where BSM equals 1.	
			}				

Index offset (Hex)	Access	Drive type	Data type	Phys. unit	Definition range	Description	Remarks
0x00000080	Read	every (IO→NC)	{		STRUCT s. drive interface	DRIVE-INPUT-STRUCTURE (IO→NC, 40 Byte) *NCDRIVESTRUCT_IN2*	
			INT32	INC	≥ 0	nInData1	
			INT32	INC	≥ 0	nInData2	
			UINT8	1	≥ 0	nStatus1	
			UINT8	1	≥ 0	nStatus2	
			UINT8	1	≥ 0	nStatus3	
			UINT8	1	≥ 0	nStatus4	
			INT32	INC	≥ 0	nInData3	
			INT32	INC	≥ 0	nInData4	
			INT32	INC	≥ 0	nInData5	
			INT32	INC	≥ 0	nInData6	
			UINT8	1	≥ 0	nStatus5	
			UINT8	1	≥ 0	nStatus6	
			UINT8	1	≥ 0	nStatus7	
			UINT8	1	≥ 0	nStatus8	
			INT32	1	≥ 0	Reserved	
			INT32	1	≥ 0	Reserved	
			}				

3.2.1.5.4.8 Specification Tables

3.2.1.5.4.8.1 "Index offset" specification for table parameter (Index group 0xA000 + ID)

Index offset (Hex)	Access	Table type	Data type	Phys. unit	Definition range	Description	Note
0x00000001	Read	every	UINT32	1	[1 ... 255]	Table ID	
0x00000002	Read	every	UINT8[30+1]	1	30 characters	Table name	
0x00000003	Read	every	UINT32	1	s. ENUM (>0)	Table sub types [▶ 172]	
0x00000004	Read	every	UINT32	1	s. ENUM (>0)	Table main types [▶ 172]	
0x00000010	Read	every	UINT32	1	[0... 16777216]	Number of lines (n)	
0x00000011	Read	every	UINT32	1	[0... 16777216]	Number of columns (m)	
0x00000012	Read	every	UINT32	1	≥0	Number of total elements (n*m)	
0x00000013	Read	equidistant table	REAL64	e.g. mm	≥0.0	Step size (position delta) (equidistant tables)	Base Unit
0x00000014	Read	cyclical table	REAL64	e.g. degrees	≥0.0	Master period (cyclical tables)	Base Unit
0x00000015	Read	cyclical table	REAL64	e.g. degrees	≥0.0	Slave difference per master period (cyclic tables)	Base Unit
0x0000001A	Read/Write	"Motion Function" (laws of motion)	{			Activation type for online changes of table data (MF only)	Modified from TC3
			UINT32	ENUM	s. appendix	Activation mode 0: 'instantaneous' (default) 1: 'master cam pos.' 2: 'master' axis pos.' 3: 'next cycle' 4: 'next cycle once' 5: 'as soon as possible' 6: 'off' 7: 'delete queued data'	
			UINT32			Reserve (TC3)	
			REAL64	e.g. mm	± ∞	Activation position	
			UINT32	ENUM	s. appendix	Master scaling type 0: user defined (default) 1: scaling with auto offset 2: off	
			UINT32	ENUM	s. appendix	Slave scaling type 0: user defined (default) 1: scaling with auto offset 2: off	
			}				
0x00000020	Read/Write	every	{			Write single value [n,m]:	
			UINT32	1	[0 ... 16777216]	n-th line	
			UINT32	1	[0 ... 16777216]	m-th column	
			REAL64	e.g. mm	± ∞	Single value	
			}				
0x00000021	ReadWrite	every	*REAL64	e.g. mm	± ∞	Read slave position for the specified master position (related to the "raw values" in the table)	

Index offset (Hex)	Access	Table type	Data type	Phys. unit	Definition range	Description	Note
0x00000022	ReadWrite	"Motion Function" (laws of motion)	**Write**			Read the "Motion Function" as a "point cloud"	Only possible on a line-by-line basis! (integer multiple) Changed in TC3
			{				
			UINT 16	1	0 /1	Prompt consistent data adoption?	
			UINT16	1	Bit mask (≥0)	Select bit mask (number of columns m is master position plus number of bits): Bit 0: Pos (Slave) Bit 1: Velo (Slave) Bit 2: Acc (Slave) Bit 3: Jerk (Slave)	
			UINT32			Reserve (TC3)	
			REAL64	e.g. mm	± ∞	Startposition (Master)	
			REAL64	e.g. mm	> 0.0	Step size	
			}				
			Read				
			{				
			REAL64[x*m]	e.g. mm	± ∞	Read from x lines from the master start position: (x*m) values (one or more lines)	
			}				
0x00000023	ReadWrite	every	**Write**			Read slave values for the specified master position (related to the "raw values" in the table)	
			REAL64	e.g. mm	± ∞	Master position	
			Read				
			{				
			REAL64	e.g. mm	± ∞	Slave position	
			REAL64	mm/s	± ∞	Slave velocity	
			REAL64	mm/s^2	± ∞	Slave acceleration	
			}				

Index offset (Hex)	Access	Table type	Data type	Phys. unit	Definition range	Description	Note
0x00000024	ReadWrite	every	**Write**			Calculation of the master position for a given slave position	
			REAL64	e.g. mm	± ∞	Slave position	
			REAL64	e.g. mm		Start position of the master	
			REAL64	e.g. mm		Offset to the slave position of the cam plate	
			REAL64	1		Scaling of the slave position of the cam plate	
			REAL64	e.g. mm		Offset to the master position of the cam plate	
			REAL64	1		Scaling of the master position of the cam plate	
			REAL64			Position accuracy of the master (default: 1.0E-3)	
			REAL64[5]			Reserved (40 bytes)	
			Read				
			{				
			UINT32			Lower master position valid	
			UINT32			Upper master position valid	
			REAL64	e.g. mm		Lower absolute master axis position	
			REAL64	e.g. mm		Upper absolute master axis position	
			REAL64	e.g. mm		Lower master cam plate position	
			REAL64	e.g. mm		Upper master cam plate position	
			REAL64	e.g. mm		Lower slave position offset	
			REAL64	e.g. mm		Upper slave position offset	
			REAL64[5]			Reserved (40 bytes)	
			}				
0x00000050	Read/Write	every	REAL64 [64]	1	± ∞	Characteristic values in the table [▶ 174]	
0x00000050	ReadWrite	every	**Write**			Read the characteristic values in a table in relation to the nominal master velocity	Modified from TC3
			REAL64 [64]	...	± ∞	Optional nominal master reference velocity "fMasterVeloNom" (standardized => 1.0 mm/s), the remaining elements are not evaluated	
			Read				
			REAL64 [64]	...	± ∞	Read the characteristic values in a table [▶ 174]	

Index offset (Hex)	Access	Table type	Data type	Phys. unit	Definition range	Description	Note
0x00000115	Write	monotonic linear, monotonic cyclic,	{			Set/change the table scaling:	
			REAL64	1	[± 1000000.0]	Original weighting of the table	
			REAL64	e.g. mm	[± 1000000.0]	Master column position offset	
			REAL64	1	[± 1000000.0]	Scaling of the master column	
			REAL64	e.g. mm	[± 1000000.0]	Position offset of the slave column	
			REAL64	1	[± 1000000.0]	Scaling of the slave column	
			REAL64	e.g. mm	[± 1000000.0]	Lower range limit (starting position)	
			REAL64	e.g. mm	[± 1000000.0]	Upper range limit (end position)	
			}				
0x01000000 +n-th start line	Read/ Write[<=16777216]	every	{ REAL64[x*m] }	e.g. mm	± ∞	Read/write from x lines from the nth line: (x*m) values (one or more lines) Value range n: [0 ... 16777216]	Only possible on a line-by-line basis! (integer multiple)
0x02000000 +m-th start column	Read/ Write[<=16777216]	every	{ REAL64[x*n] }	e.g. mm	± ∞	Read/write x columns from the mth column: (x*n) values (one or more columns)Value range m: [0 ... 16777216]	Only possible on a column-by-column basis! (integer multiple)
0x05000000 +n-th start line	Read/ Write[<=16777216]	"Motion Function" (motion laws) Data:STRUCT [x*m]	{			Read/write x lines from the nth line: (x*m) structures (one or more lines) Value range n: [0 ... 16777216]	Only possible on a line-by-line basis! (integer multiple) Modified from TC3
			UINT32	1		Abs. point index (not evaluated)	
			UINT16	ENUM		Function type 1: Polynomial 1 15: Polynomial 5	
			UINT16	ENUM		Point type 0: default 1: ignore	
			INT32	1		Rel. address index at end point (Default: 1)	
			UINT32			Reserve (TC3)	
			REAL64	mm		Master position	
			REAL64	mm		Slave position	
			REAL64	mm/s		Slave speed	
			REAL64	mm/s^2		Slave acceleration	
			REAL64	mm/s^3		Slave jerk	
			}				

Index offset (Hex)	Access	Table type	Data type	Phys. unit	Definition range	Description	Note
0x06000000 +m-th start column	Read/ Write[<=16777216]	"Motion Function" (motion laws) Data:STRUCT [x* n]	{			Read/write x columns from the mth column: (x*n) structures (one or more columns) Value range m: [0 ... 16777216]	Only possible on a column-by-column basis! (integer multiple)
			UINT32	1		Abs. point index (not evaluated)	Modified from TC3
			UINT16	ENUM		Function type 1: Polynomial 1 15: Polynomial 5	
			UINT16	ENUM		Point type 0: default 1: ignore	
			INT32	1		Rel. address index at end point (Default: 1)	
			UINT32			Reserve (TC3)	
			REAL64	mm		Master position	
			REAL64	mm		Slave position	
			REAL64	mm/s		Slave speed	
			REAL64	mm/s^2		Slave acceleration	
			REAL64	mm/s^3		Slave jerk	
			}				

3.2.1.5.4.8.2 "Index offset" specification for table state (Index group 0xA100 + ID)

Index offset (Hex)	Access	Table type	Data type	Phys. unit	Definition range	Description	Remarks
0x0000000A	Read	every	INT32	1	≥ 0	'User Counter' (number of table user)	Cannot be traced by oscilloscope!

3.2.1.5.4.8.3 "Index offset" specification for table functions (Index group 0xA200 + ID)

Index offset (Hex)	Access	Table type	Data type	Phys. unit	Definition range	Description	Remarks
0x00010000	Write	every	{			Generates table with dimension (n*m):	Table types: 1,2,3,4 Dimension: at least 2x1
			UINT32	1	s. ENUM (>0)	Table type [▶ 172] (s. appendix)	
			UINT32	1	[2...16777216]	Quantity of lines	
			UINT32	1	[1...16777216]	Quantity of columns	
			}				
0x00010001	Write	valve diagram	{			Generates valve diagram table with dimension (n*m):	Table types: 1,3 Dimension: at least 2x1
			UINT32	1	s. ENUM (>0)	Table type [▶ 172] (s. appendix)	
			UINT32	1	[2...16777216]	Quantitiy of lines	
			UINT32	1	[1...16777216]	Quantitiy of columns	
			}				
0x00010010	Write	"Motion Function" (law of motion)	{			Generates "Motion Function" table with dimension (n*m):	Table types: 3,4 Dimension: at least 2x1
			UINT32	1	s. ENUM (>0)	Table type (s. appendix)	
			UINT32	1	[2...16777216]	Quantity of lines	
			UINT32	1	[1...16777216]	Quantity of columns	
			}				
0x00020000	Write	every	VOID			Deletes table with dimension (n*m)	Table types: 1,2,3,4
0x00030000	Write	every	VOID			Initialized table Initialization is no longer needed, because now it happens automatically in the following casesa) by coupling with table b) by selecting the slave position (s. table para.)	

3.2.1.5.4.9 Appendix

Enum Channel types

Define	Channel types
1	Standard
2	Interpreter
3	FIFO
4	Kinematic transformation

Enum Interpreter types

Define	Interpreter types
0	NOT DEFINED
1	NC Interpreter DIN 66025 (GST)
2	NC Interpreter DIN 66025 (Classic Dialect)

Enum Interpreter Operation modes

Define	interpreter/channel operation mode
0x0	Default (deactivates the other modes)
0x1	Single block mode in the NC core (Block execution task/SAF)
0x1000	reserved
0x2000	reserved
0x4000	Single block mode in the interpreter

Enum Interpolation load log mode

Define	Load log mode
0	Loader log off
1	Source only
2	Source & Compiled

Enum Interpolation Trace mode

Define	Trace mode
0	Trace off
1	Trace line numbers
2	Trace Source

Enum Interpreter state

moved to: System Manager interface for the interpreter - interpreter element

Enum Group types

Define	Group types
0	NOT DEFINED
1	PTP-Group + x Slave
2	1D-Group + x Slave
3	2D-Group + x Slave
4	3D-Group + x Slave
5	High/low speed + x Slave
6	Low cost stepper motor (dig. IO) + x Slave
7	Table Group + x Slave
9	Encoder Group + x Slave
11	FIFO Group + x Slave
12	Kinematic Transformation Group + x Slave

Enum Curve velocity reduction method

moved to: System Manager interface for the interpreter - group element

Enum Axis types

Define	Axis types
0	NOT DEFINED
1	Continuous axis (Servo)
2	Discrete axis (high/low speed)
3	Continuous axis (stepper motor)
5	Encoder axis
6	Continuous axis (with operation mode switch for position/pressure control)
7	Time Base Generator
100	

Enum Stepper motor operation mode

Define	Stepper motor operation mode
0	NOT DEFINED
1	2-phase excitation (4 cycles)
2	1-2-phase excitation (6 cycles)
3	Power section

Enum Override types for PTP axes (velocity override)

Define	Override types
1	Reduced Old variant, replaced by "(3) Reduced (iterated)"
2	Original Old variant, replaced by "(4) Original (iterated)"
3	Reduced (iterated) Default value: the override value is related to the velocity which is internally reduced in a special case. This results in a directly proportional velocity (=> linear relationship) for the entire override range from 0 to 100%.
4	Original (iterated) The override value is always referred to the velocity programmed by the user. If this velocity cannot be driven, however, then a maximum override value results from which no higher velocity can be reached (=> limitation).

Enum Group/axis start types

Define	Group/axis start types
0	NOT DEFINED
1	Absolute start
2	Relative start
3	Continuous start positive
4	Continuous start negative
5	Modulo start (OLD)
261	Modulo start on the shortest distance
517	Modulo start in positive direction (with modulo tolerance window)
773	Modulo start in negative direction (with modulo tolerance window)
4096	Stop and lock (axis locked for motion commands)
8192	Halt (without motion lock)

Enum Command buffer types (buffer mode) for universal axis start (UAS)

Define	Buffer mode
0	ABORTING (default) (instantaneous, aborts current movement and deletes any buffered commands)
1	BUFFERED (stored in command buffer to be executed after an active movement)
18	BLENDING LOW (buffered, no stop, runs through intermediate target position at the lowest velocity of two commands)
19	BLENDING PREVIOUS (buffered, no stop, runs through intermediate target position at the velocity of the active command)
20	BLENDING NEXT (buffered, no stop, runs through intermediate target position at the velocity of the buffered command)
21	BLENDING HIGH (buffered, no stop, runs through intermediate target position at the highest velocity of two commands)

Enum End position types (new end position)

Define	End position types
0	NOT DEFINED
1	Absolute position
2	Relative position
3	Continuous position positive
4	Continuous position negative
5	Modulo position

Enum Command types for new end position with new velocity (new end position and/or new velocity)

Define	Command types for new end position with new velocity
0	NOT DEFINED
1	Position (instantaneous)
2	Velocity (instantaneous)
3	Position and velocity (instantaneous)
9	Position (switching position)
10	Velocity (switching position)
11	Position and velocity (switching position)

Enum Actual position types (set actual position)

Define	Actual position types
0	NOT DEFINED
1	Absolute position
2	Relative position
5	Modulo position

Enum Compensation types (section compensation or superimposed)

Define	Compensation types
0	NOT DEFINED
1	VELOREDUCTION_ADDITIVEMOTION The max. velocity VelocityDiff is reduced. The path over which the compensation trip is effective consists of length + distance.
2	VELOREDUCTION_LIMITEDMOTION The max. velocity VelocityDiff is reduced. The path over which the compensation trip is effective is defined by the Length parameter.
3	LENGTHREDUCTION_ADDITIVEMOTION The max. available path is reduced and consists of length + distance. The system tries to utilize the max. veloc. VelocityDiff.
4	LENGTHREDUCTION_LIMITEDMOTION The max. available path is reduced and is limited by the Length parameter. The system tries to utilize the max. veloc. VelocityDiff.

Enum Slave types

Define	Slave types
0	NOT DEFINED
1	Linear
2	Flying saw (velocity, jerk restricted profile)
3	Flying saw (position and velocity, jerk restricted profile)
5	Synchronization generator (velocity, jerk restricted profile)
6	Synchronization generator (position and velocity, jerk restricted profile)
10	Tabular
11	Multi-tabular
13	'Motion Function' (MF)
15	Linear with cyclic gearing factor change (ramp filter for acceleration limits)
100	Specific

Enum Slave decoupling types (for subsequent axis command)

Define	Slave decoupling types (for subsequent axis command)
0	Stop, E-stop or P-stop (default) (STOP)
1	Oriented stop (O-stop) (ORIENTEDSTOP)
2	Reduce any acceleration to 0 (force-free) and continue to endless target position (ENDLESS)
3	Continue to endless target position at new requested velocity (ENDLESS_NEWVELO)
4	New end position (NEWPOS)
5	New end position and new requested velocity (NEWPOSANDVELO)
6	Logical decoupling and stopping of axis immediately without velocity ramp (INSTANTANEOUSSTOP)

Enum Controller types

Define	Controller types
0	NOT DEFINED
1	P-controller (standard) (Position)
2	PP-controller (with ka) (Position)
3	PID-controller (with ka) (Position)
5	P-controller (Velocity)
6	PI controller (Velocity)
7	High/low speed controller (Position)
8	Stepper motor controller (Position)
9	SERCOS controller (Position in the drive)
10	RESERVED
11	RESERVED
12	RESERVED
13	RESERVED
14	TCom Controller (Soft Drive) (Position in the drive)

Enum Controller Observer mode

Define	Controller observer mode
0	No observer active (default)
1	"Luenberger" observer (classic observer design)

Enum Encoder types

Define	Encoder types
0	NOT DEFINED
1	Simulation Encoder (Incremental)
2	M3000 Encoder (Multi/Single-Turn) (Absolute)
3	M31x0 / M2000 Encoder (Incremental)
4	MDP 511 Encoder: EL7041, EL7342, EL5101, EL5151, EL2521, EL5021, IP5101 (Incremental)
5	MDP 500/501 Enc.: EL5001, IP5009, KL5001 (SSI) (Absolute)
6	MDP 510 Encoder: KL5051, KL2502-30K Encoder (BiSSI) (Incremental)
7	KL30xx Encoder (Analog) (Absolute)
8	SERCOS and EtherCAT SoE (Position) (Incremental)
9	SERCOS and EtherCAT SoE (Position and velocity) (Incremental)
10	Binary encoder (0/1) (Incremental)
11	M2510 Encoder (Absolut)
12	FOX50 Encoder (Absolute)
14	AX2000 (Lightbus) (Incremental)
15	Provi-Drive MC (Simodrive 611U) (Incremental)
16	Universal encoder (variable bit mask) (Incremental)
17	NC rear panel (Incremental)
18	Special CANopen type (e.g. Lenze Drive 9300) (Incremental)
19	MDP 513 (DS402): CANopen and EtherCAT CoE (AX2xx-B1x0/ B510, EL7201) (Incremental)
20	AX2xx-B900 (Ethernet) (Incremental)
21	KL5151 Encoder (Incremental)
24	IP5209 Encoder (Incremental)
25	KL2531/KL2541 Encoder (Stepper Motor) (Incremental)
26	KL2532/KL2542 Encoder (DC motor), KL2535/KL2545 (PWM current terminal) (Incremental)
27	Time base encoder (Time Base Generator) (Incremental)
28	TCom Encoder (Soft Drive) (Incremental)

Enum Encoder mode

Define	Encoder mode
0	NOT DEFINED
1	Determination of position
2	Determination of position and velocity
3	Determination of position, velocity and acceleration

Enum Encoder evaluation direction (log. counting direction)

Define	Encoder evaluation direction (log. counting direction)
0	Evaluation in positive and negative counting direction (default configuration, i.e. compatible with the previous state)
1	Evaluation only in positive counting direction
2	Evaluation only in negative counting direction
3	Evaluation neither in positive nor in negative counting direction (evaluation blocked)

Not for all encoder types; only for KL5101, KL5151, KL2531, KL2541, IP5209, Universal encoder, etc.

	Encoder types		
Encoder evaluation direction (log. counting direction)	KL5101, ...	Universal Encoder	other types
0: positive and negative	√	√	—
1: only positive	√	√	—
2: only negative	√	√	—
3: blocked	√	√	—

Enum Encoder sign interpretation (data type)

Define	Sign interpretation (data type) of the encoder actual increments
0	NOT DEFINED (default configuration, i.e. compatible with the previous state)
1	UNSIGNED: unsigned interpretation of the encoder actual increments
2	SIGNED: signed interpretation of the encoder actual increments

For KL30xx/KL31xx only for the time being

Enum Encoder absolute dimensioning system

Define	Encoder absolute dimensioning system
0	INC: Incremental absolute dimension system with underflow and overflow offset (default, i.e. compatible with the previous state)
1	ABS: Absolute dimension system without underflow and overflow offset (no underflow or overflow of the encoder allowed)
2	ABS MODULO: Conditionally absolute dimension system, since it has underflow and overflow offset (absolute value that modulo (endless) continues)

Not for all encoder types; only for Profi Drive MC, M3000, KL5001/EL5001, IP5009, SERCOS, UNIVERSAL, etc.

Enum referencing mode for incremental encoder

Define	Parameter text	Referencing mode for incremental encoder
0	Default	NOT DEFINED (default assignment, i.e. compatible with the previous status)
1	Homing Sensor Only (PLC cam or digital input)	Latch event: shutdown of the PLC cam (negative edge)
2	Hardware Sync (feedback reference pulse)	Latch event: hardware sync pulse (zero track)
3	Hardware Latch 1 (pos. Edge)	Latch event: external hardware latch with positive edge (measuring probe or, respectively, measurement on the fly with positive edge)
4	Hardware Latch 1 (neg. Edge)	Latch event: external hardware latch with negative edge (measuring probe or, respectively, measurement on the fly with negative edge)
5	Software Sync	Latch event: synthetically emulated software sync pulse (software zero track); PREREQUISITE: absolute per motor revolution, e.g. resolver!
6	Hardware Latch 1 (pos. Edge), Drive defined	Latch event: hardware latch event defined in the drive with positive edge (e.g. for SoftDrive)
7	Hardware Latch 1 (neg. edge), Drive defined	Latch event: hardware latch event defined in the drive with negative edge (e.g. for SoftDrive)
20	Application (PLC code)	User-specific implementation of referencing (PLC code): user request is signaled to the PLC by means of the ApplicationRequest bit

	: latch event					
Encoder types	**0: not defined**	**1: PLC cam (neg. edge)**	**2: hardware sync pulse (zero/C-track)**	**3: external hardware latch with pos. edge**	**4: external hardware latch with neg. edge**	**5: software sync pulse (software zero track)**
AX2xxx-B200 (Lightbus)	—	√	√	√	√	√ (resolver only)
AX2xxx-B510 (CANopen)	—	√	—	—	—	√ (resolver only) (see "Reference mask" parameter)
AX2xxx-B1x0 (EtherCAT)	—	√	√	√	√	√ (resolver only) (fixed 20-bit)
AX2xxx-B900 (Ethernet)	—	√	√	√	√	√ (resolver only)
Sercos	—	√	√	√ (AX5xxx specific implemented)	√	√ (see "Reference mask" parameter)
Profi Drive	—	√	√	√	√	√
KL5101 IP5109	—	√	√	√	√	√
KL5111	—	√	√	—	—	√
KL5151	—	√	√	√	√	√ (not meaningful)
IP5209	—	√	√	—	—	√ (not meaningful)
CANopen (e.g. Lenze)	—	√	—	√ (input E1)	√ (input E2)	√ (resolver only) (fixed 16-bit)
other types	—	—	—	—	—	—

Enum Homing Sensor Source

The parameter sets the source of the digital input of the referencing cam (homing sensor). At the same time it is determined whether the signal is Active High or Active Low.

Define	Parameter text	Homing Sensor Source
0	Default: PLC cam (MC_Home)	Referencing cam is provided by the PLC. Input bCalibrationCam of the MC_Home function block.
1	Digital Input 1 (Active High), device dependent mapping	Drive->Inputs->nState8.bit0 or E1 of MDP703/733 device e.g. 7031,7041,7201,7411
2	Digital Input 2 (Active High), device dependent mapping	Drive->Inputs->nState8.bit1 or E2 of MDP703/733 device e.g. L7031,7041,7201,7411
3	Digital Input 3 (Active High)	Drive->Inputs->nState8.bit2
4	Digital Input 4 (Active High)	Drive->Inputs->nState8.bit3
5	Digital Input 5 (Active High)	Drive->Inputs->nState8.bit4
6	Digital Input 6 (Active High)	Drive->Inputs->nState8.bit5
7	Digital Input 7 (Active High)	Drive->Inputs->nState8.bit6
8	Digital Input 8 (Active High)	Drive->Inputs->nState8.bit7
9	Digital Input 1 (Active Low), device dependent mapping	Drive->Inputs->nState8.bit2
10	Digital Input 2 (Active Low), device dependent mapping	Drive->Inputs->nState8.bit0 or E1 of MDP703/733 device e.g. L7031,7041,7201,7411
11	Digital Input 3 (Active Low)	Drive->Inputs->nState8.bit1 or E2 of MDP703/733 device e.g. L7031,7041,7201,7411
12	Digital Input 4 (Active Low)	Drive->Inputs->nState8.bit2
13	Digital Input 5 (Active Low)	Drive->Inputs->nState8.bit3
14	Digital Input 6 (Active Low)	Drive->Inputs->nState8.bit4
15	Digital Input 7 (Active Low)	Drive->Inputs->nState8.bit5
16	Digital Input 8 (Active Low)	Drive->Inputs->nState8.bit6

Digital Input [1-8]

A digital input linked to the NC process is used. For this purpose, a general Drive Status Byte with 8 digital inputs is defined in the process image (Drive->Inputs->nState8), which can serve as a signal source for the homing sensor. A digital input to be used must therefore be mapped manually to the desired position in this byte.

The digital inputs 1 and 2 may differ depending on the hardware used. For the MDP703/733 hardware (e.g. EL7031, EL7041, EL7201, EL7411) the direct digital inputs E1 and E2 of the terminal are used instead, which are located in the Drive.nState2 byte of the terminal at bit position 3 (E1) and 4 (E2). The lower two bits of Drive.nState8 are not assigned in this case.

Enum Drive types

Define	Drive types
0	NOT DEFINED
1	Analog Servo Drive: M2400 DAC 1 (Analog)
2	Analog Servo Drive: M2400 DAC 2 (Analog)
3	Analog Servo Drive: M2400 DAC 3 (Analog)
4	Analog Servo Drive: M2400 DAC 4 (Analog)
5	MDP 252 Drive: Analog Servo Drive: KL4xxx, KL2502-30K (Analog)
6	MDP 252 Drive: Analog Servo Drive (non-linear): KL4xxx, KL2502-30K (Analog)
7	High/low speed drive (Digital)
8	Stepper motor drive (Digital)
9	SERCOS-Drive (Digital)
10	MDP 510 Drive: KL5051 (BiSSI-Interface) (Digital)
11	AX2000 (Lightbus) (Digital)
12	Provi-Drive MC (Simodrive 611U) (Digital)
13	Universal Drive (Analog)
14	NC rear panel (Analog)
15	Special CANopen type (e.g. Lenze Drive 9300) (Digital)
16	MDP 742 (DS402): CANopen and EtherCAT CoE (AX2xx-B1x0/ B510) (Digital)
17	AX2xx-B900 Drive (Ethernet) (Digital)
20	KL2531/KL2541 Encoder (Stepper Motor) (Digital)
21	KL2532/KL2542 Encoder (DC motor), KL2535/KL2545 Encoder (PWM current terminal) (Digital)
22	TCom Drive (Soft Drive) (Digital)
23	MDP 733 Drive: Profile MDP 733 (EL7332, EL7342, EP7342) (Digital)
24	MDP 703 Drive: Profile MDP 703 (EL7031, EL7041, EP7041) (Digital)

Enum Drive-Output-Start types

Define	Enum Drive-Output-Start types
0	NOT DEFINED
1	Output value in percent
2	Output as velocity, e.g. m/min

Enum Drive Operation Mode

Define	Drive Operation Mode (generic operation modes independent from drive)
0	DEFAULT Mode (reactivates the NC default operation mode if mode is known)
1 (standard type)	torque control
2 (standard type)	velocity control with feedback 1
3 (standard type)	velocity control with feedback 2
4 (standard type)	position control with feedback 1 (lag less)
5 (standard type)	position control with feedback 2 (lag less)
6 (CANopen/CoE specific)	torque control with commutation angle
17 (oversampling type)	torque control using dynamic container
18 (oversampling type)	velocity control with feedback 1 using dynamic container
19 (oversampling type)	velocity control with feedback 2 using dynamic container
20 (oversampling type)	position control with feedback 1 (lag less) using dynamic container
21 (oversampling type)	position control with feedback 2 (lag less) using dynamic container
38 (CANopen/CoE specific)	IO drive controlled homing mode (for third party devices)
100 (Sercos/SoE specific)	Sercos/SoE primary operation mode 0 (s. S-0-0032)
101 (Sercos/SoE specific)	Sercos/SoE secondary operation mode 1 (s. S-0-0033)
102 (Sercos/SoE specific)	Sercos/SoE secondary operation mode 2 (s. S-0-0034)
103 (Sercos/SoE specific)	Sercos/SoE secondary operation mode 3 (s. S-0-0035)
104 (Sercos/SoE specific)	Sercos/SoE secondary operation mode 4 (s. S-0-0284)
105 (Sercos/SoE specific)	Sercos/SoE secondary operation mode 5 (s. S-0-0285)
106 (Sercos/SoE specific)	Sercos/SoE secondary operation mode 6 (s. S-0-0286)
107 (Sercos/SoE specific)	Sercos/SoE secondary operation mode 7 (s. S-0-0287)

Enum Moving phases / Movement state for master axes

Define	Moving phases / Movement state (distinction between internal and external setpoint generation)
Internal setpoint generation	
0	Setpoint generator not active (INACTIVE)
1	Setpoint generator active (RUNNING)
2	Velocity override is zero (OVERRIDE_ZERO)
3	Constant velocity (PHASE_VELOCONST)
4	Acceleration phase (PHASE_ACCPOS)
5	Deceleration phase (PHASE_ACCNEG)
External setpoint generation:	
41	External setpoint generation active (EXTSETGEN_MODE1)
42	Internal and external setpoint generation active (EXTSETGEN_MODE2)

Enum Moving phases / Movement state for slave axes

Define	Moving phases / Movement state
0	Slave generator not active (INACTIVE)
11	Slave is in a movement pre-phase (PRE-PHASE)
12	Slave is synchronizing (SYNCHRONIZING)
13	Slave is synchronized and moves synchronously (SYNCHRON)

Only for slaves of the type synchronization generator for the time being

Enum Table main types

Define	Table main types
1	(n*m) Cam plate tables (Camming)
10	(n*m) Characteristic curves tables (Characteristics) (e.g. hydraulic valve characteristic curves) Only non-cyclic table sub-types (1, 3) are supported!
16	(n*m) "Motion Function" tables (MF) Only non-equidistant table sub-types (3, 4) are supported!

Enum Table sub-types

Define	Table sub types
1	(n*m) Table with equidistant master positions and no cyclic continuation of the master profile (equidistant linear)
2	(n*m) Table with equidistant master positions and cyclic continuation of the master profile (equidistant cyclic)
3	(n*m) Table with non-equidistant, but strictly monotonously increasing master positions and a non-cyclic continuation of the master profile (monotonously linear)
4	(n*m) Table with non-equidistant, but strictly monotonously increasing master positions and a cyclic continuation of the master profile (monotonously cyclic)

Enum Table interpolation types

Define	Table interpolation types between the reference points
0	Linear interpolation (NC_INTERPOLATIONTYPE_LINEAR) (Standard)
1	4-point interpolation (NC_INTERPOLATIONTYPE_4POINT) (for equidistant table types only)
2	Cubic spline interpolation of all reference points ("global spline") (NC_INTERPOLATIONTYPE_SPLINE
3	Sliding cubic spline interpolation via n interpolation points ("local spline") (NC_INTERPOLATIONTYPE_SLIDINGSPLINE)

Enum table operation mode

Define	Table operation mode for adding, exchange and removal of tables
0	(default)
1	Additive – addition of a further table
2	Exchange – replacement of an existing table with a new table
3	Remove – removal of an existing table

Structure of tabular (cam) coupling informationen

Tables		(CAM) Coupling information
nTableID;	1.	cam table ID
nTableMainType;	2.	e.g. CAMMING, CHARACTERISTIC, MOTIONFUNCTION
nTableSubType;	3.	e.g. EQUIDIST_LINEAR, EQUIDIST_CYCLE, NONEQUIDIST_LINEAR, NONEQUIDIST_CYCLE
nInterpolationType;	4.	e.g. LINEAR, 4POINT, SPLINE
nNumberOfRows;	5.	number of rows/elements
nNumberOfColumns;	6.	number of columns
fMasterCamStartPos	7.	master camming start position (first point in tabular)
fSlaveCamStartPos	8.	slave camming start position (first point in tabular)
fRawMasterPeriod;	9.	master period/cycle (raw value, not scaled)
fRawSlaveStroke;	10.	slave difference per master period/cycle (raw value, not scaled)
fMasterAxisCouplingPos	11.	total absolute master offset of cam origin when slave has been coupled
fSlaveAxisCouplingPos	12.	total absolute slave offset of cam origin when slave has been coupled
nMasterAbsolute	13.	master absolute position (0/1)
nSlaveAbsolute	14.	slave absolute position (0/1)
fMasterOffset;	15.	total master offset
fSlaveOffset;	16.	total slave offset
fMasterScaling;	17.	total master scaling
fSlaveScaling;	18.	total slave scaling
fSumOfSlaveStrokes	19.	sum of the slave srokes up to “fActualMasterAxisPos”
fSumOfSuperpositionDistance	20.	sum of superposition distance (position compensation offset)
fActualMasterAxisPos;	21.	actual master axis setpos (absolute)
fActualSlaveAxisPos;	22.	actual slave axis setpos (absolute)
fActualMasterCamPos;	23.	actual master cam setpos
fActualSlaveCamPos;	24.	actual master cam setpos
nSlaveStateDWord	25.	slave state DWORD (s. AxisRef)
. . .	. . .	. . .

Structure of the characteristic values

Characteristic values		
fMasterVeloNom;	1.	master nominal velocity (standardized: => 1.0)
fMasterPosStart;	2.	master start position
fSlavePosStart;	3.	slave start position
fSlaveVeloStart;	4.	slave start velocity
fSlaveAccStart;	5.	slave start acceleration
fSlaveJerkStart;	6.	slave start jerk
fMasterPosEnd;	7.	master end position
fSlavePosEnd;	8.	slave end position
fSlaveVeloEnd;	9.	slave end velocity
fSlaveAccEnd;	10.	slave end acceleration
fSlaveJerkEnd;	11.	slave end jerk
fMPosAtSPosMin;	12.	master pos. at slave min. position
fSlavePosMin;	13.	slave minimum position
fMPosAtSVeloMin;	14.	master pos. at slave min. velocity
fSlaveVeloMin;	15.	slave minimum velocity
fMPosAtSAccMin;	16.	master pos. at slave min. acceleration
fSlaveAccMin;	17.	slave minimum acceleration
fSVeloAtSAccMin;	18.	slave velocity at slave min. acceleration
fSlaveJerkMin;	19.	slave minimum jerk
fSlaveDynMomMin;	20.	slave minimum dynamic momentum (NOT SUPPORTED YET!)
fMPosAtSPosMax;	21.	master pos. at slave max. position
fSlavePosMax;	22.	slave maximum position
fMPosAtSVeloMax;	23.	master pos. at slave max. velocity
fSlaveVeloMax;	24.	slave maximum velocity
fMPosAtSAccMax;	25.	master pos. at slave max. acceleration
fSlaveAccMax;	26.	slave maximum acceleration
fSVeloAtSAccMax;	27.	slave velocity at slave max. acceleration
fSlaveJerkMax;	28.	slave maximum jerk
fSlaveDynMomMax;	29.	slave minimum dynamic momentum (NOT SUPPORTED YET!)
fSlaveVeloMean;	30.	slave mean absolute velocity
fSlaveAccEff;	31.	slave effective acceleration
nCamTableID;	32.	Cam table ID
nNumberOfRows;	33.	Number of rows/entries e.g. number of points
nNumberOfColums;	34.	Number of columns (typically1 or 2)
nCamTableType;	35.	cam table type (10=EQUIDIST, 11=NONEQUIDIST, 22=MOTIONFUNC, 23=CHARACTERISTIC)
nPeriodic;	36.	linear or cyclic/periodic
nReserved	37.	reserved

Enum Axis control loop switch types

Define	Axis control loop switch types
0	NOT DEFINED
1	Simple switching (similar to an axis reset) (STANDARD)
2	Switching/synchronization by means of I/D-part of the controller to an internal initial value (jerk-free/smooth)
3	Switching/synchronization by means of I/D-part of the controller to a parameterizable initial value

3.2.2 AmsNAT

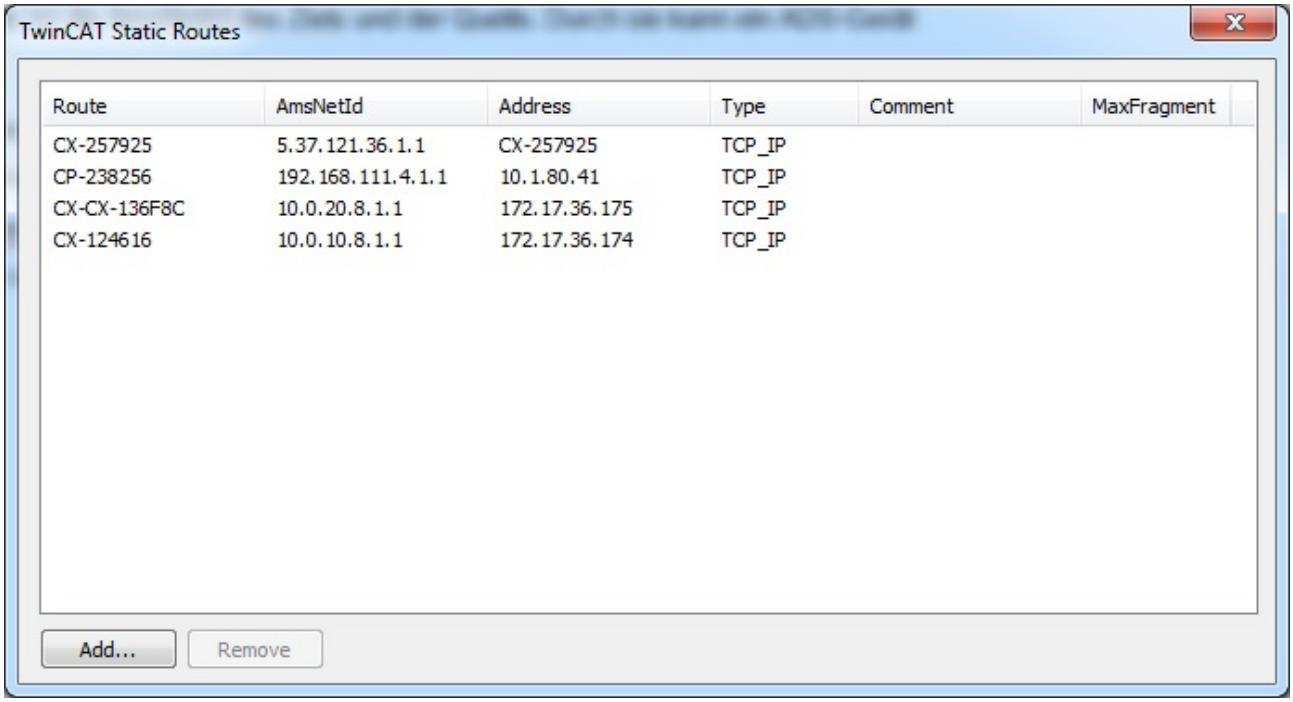
3.2.2.1 Introduction

For a better understanding of the AmsNAT function it is important to know the difference between ADS and AMS and to know what an ADS route is.

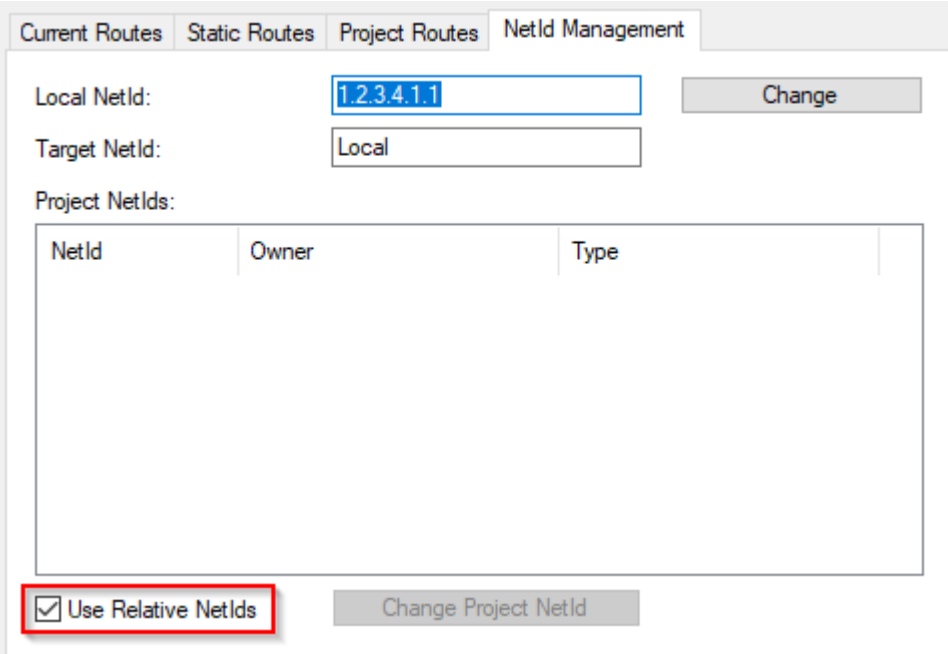
ADS (Automation Device Specification) is the TwinCAT communication protocol that specifies the interaction between two ADS devices. For example, it defines what operations can be executed on another ADS device, what parameters are necessary for that and what return value is sent after execution.

AMS (Automation Message Specification) specifies the exchange of the ADS data. A major component of the communication protocol is the AmsNetId. This is specified in the AMS/ADS package for the source and target device. An ADS device can be explicitly addressed using the AmsNetId.

A **route** between two devices must be setup in TwinCAT so that they can communicate. This route is configured on both sides and typically contains the route name, the AmsNetId and the address of the communication partner as well as the type of connection. The configuration of new routes and an overview of existing routes in a TwinCAT system are shown in the following figure.



If the hardware should be scanned on the target, relative NetIDs have to be used:



3.2.2.2 General description

The AmsNAT function enables XAE systems to establish routes to two or more controllers having the same AmsNetId (Figure 2). Beyond that, AmsNAT offers a solution with which different ADS devices with the same AmsNetId can communicate with one another via ADS. Virtual AmsNetIds are used with AmsNAT. A virtual AmsNetId is a unique address for a connected ADS device that is replaced by the real AmsNetId of the target system during communication. This means that the AmsNAT function ensures, in all communication that takes place via ADS, that the AmsNetId of the target system is replaced.

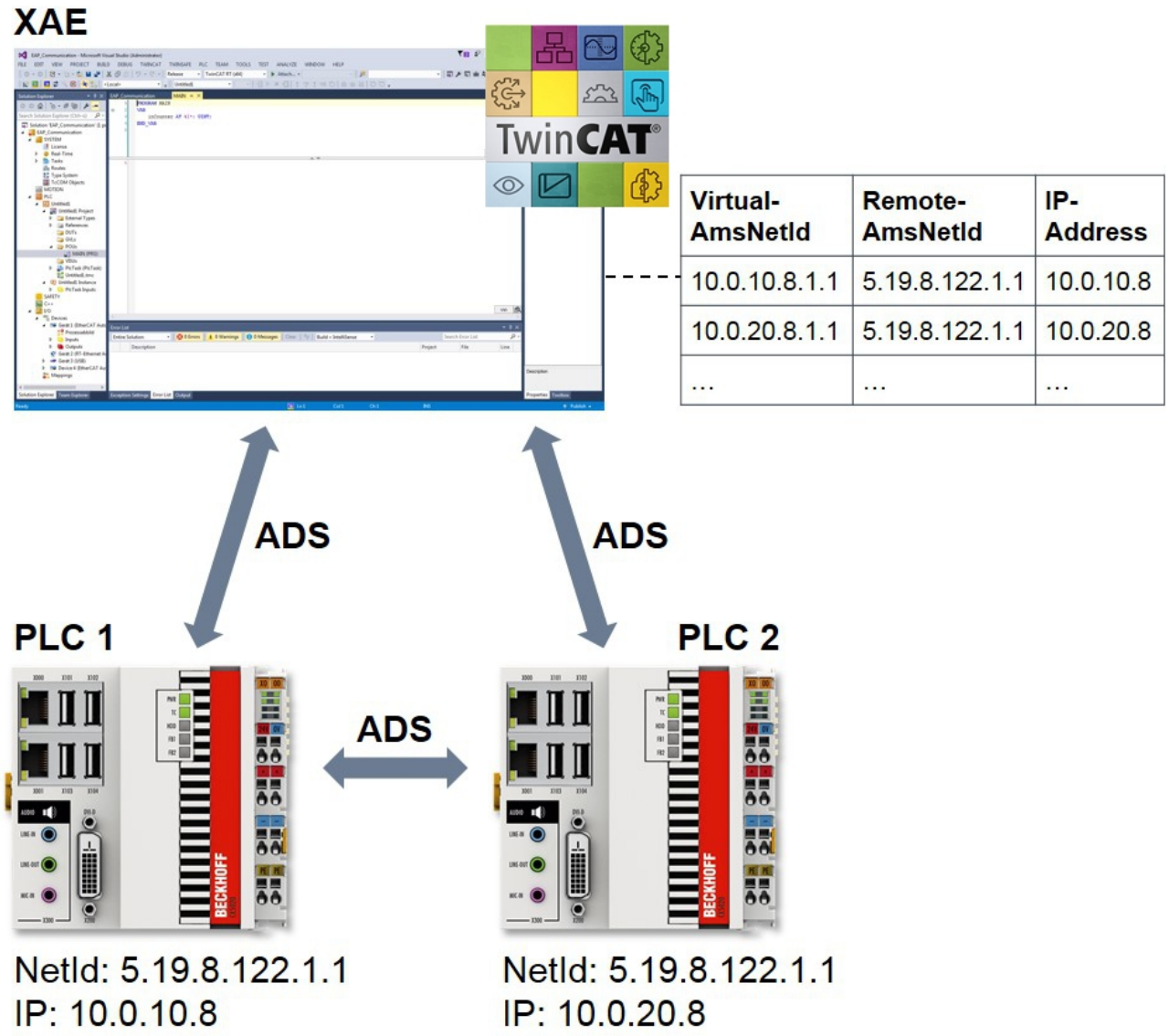


Fig. 1: Communication with/between TwinCAT systems with the same NetId

3.2.2.3 Motivation

A frequently occurring application in series mechanical engineering is the cloning (i.e. the making of a 1:1 copy) of a controller. When using TwinCAT, the result of this is that all cloned instances possess the same AmsNetId. This is not a problem at first. However, if the cloned instances are to be connected in parallel with the same engineering system or are to communicate with one another by ADS, this is initially impossible because the AmsNetId is not unique. The AmsNAT function removes precisely this restriction by virtue of the fact that the systems work with virtual AmsNetIds. These can be configured with very little effort.

The AmsNAT function can be used for any route to an ADS device. This provides a high degree of flexibility and the AmsNetIds no longer have to be adapted to the machine computers, which leads to a significant reduction in time and effort for configuration.

3.2.2.4 Functioning

The way AmsNAT functions will now be explained on the bases of a typical application. In the application case, a TwinCAT engineering system and two TwinCAT runtimes exist with the same AmdNetId and IP address. The configuration is illustrated in Figure 3. The engineering system is to send an AdsRead command to PLC 1, from which a corresponding response is expected. Since both runtimes possess an

identical IP address, two IP NATs are additionally used. Their task is to implement unambiguous addressing. In order to do so, the first three positions of the local IP address are replaced by the first three positions of the global IP address or vice versa, depending on the direction of communication.

In the first step of the application example, the engineering system sends an AdsRead command to PLC 1. Since this AmdNetId is a virtual one, the TwinCAT system service replaces it by the remote AmsNetId 5.19.8.122.1.1 with the help of its routing table. This is the real AmsNetId existing on the system. It is entered in the field "AmsNetId Target" of the AMS packet.

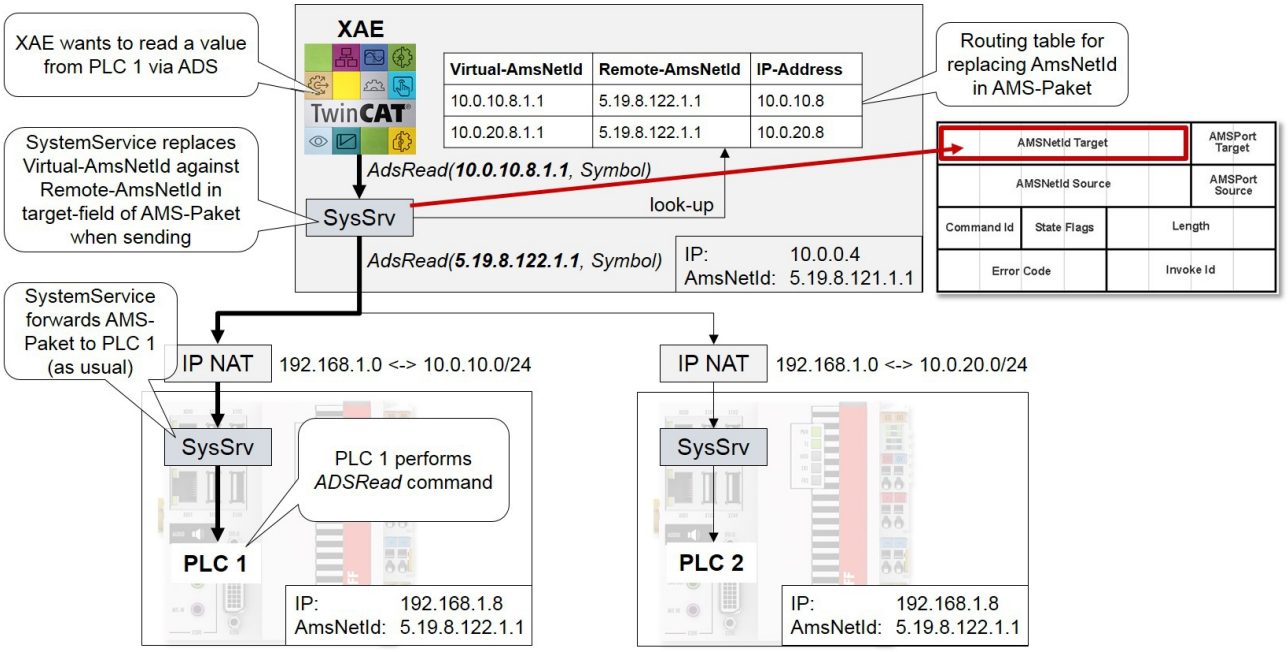


Fig. 2: Sequence for sending an AdsRead command using AmsNAT

The TwinCAT system service of PLC 1 relays the AMS packet unchanged. PLC 1 executes the AdsRead command and then sends the corresponding response to the engineering system. Figure 4 shows the communication sequence for the response.

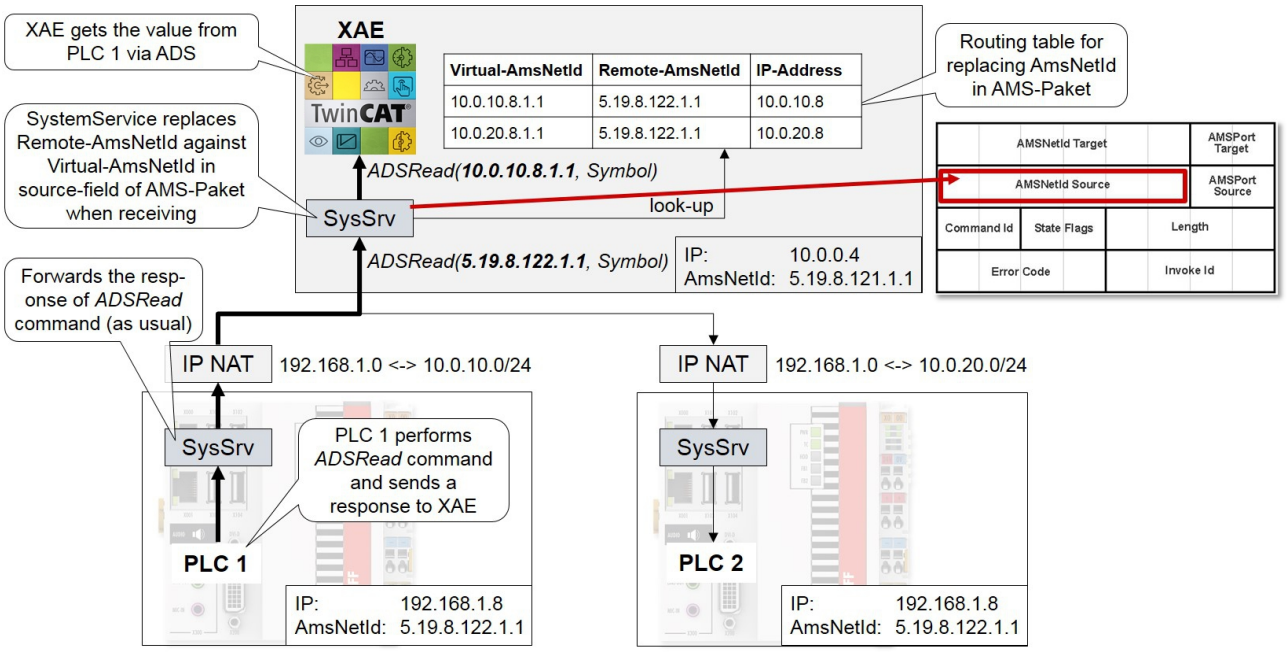


Fig. 3: Sequence for sending the response to an AdsRead command

For the response, the TwinCAT system service of PLC 1 initially relays the AMS packet unchanged. It subsequently reaches the TwinCAT system service of the engineering system. Since the real AmsNetId of PLC 1 is entered in the field "AmsNetId Source" of the AMS packet, it must be replaced by the virtual AmsNetId on the basis of the routing table. The engineering system can then clearly assign and process the response.

When using the AmsNAT function the transmitted data are not changed, only the AMS header. Therefore it should be noted that if configuration data contain the AmsNetId this can lead to the virtual AmsNetId being used. One possibility for the engineering of I/O devices is the use of relative AmsNetIds. In this case the last two characters of the AmsNetId are taken into account and the first four characters are ignored.

3.2.2.5 Configuration

To configure AmsNAT, open the file *StaticRoutes.xml*, which is located in the TwinCAT installation directory under the path *TwinCAT\3.1\Target*. In this file, define the attribute "RemoteNetId" for each route as shown subsequent.

```
<?xml version="1.0" encoding="UTF-8"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
   <RemoteConnections>
      <Route>
         <Name>CX-111111</Name>
         <Address>10.0.10.8</Address>
         <NetId RemoteNetId="5.19.8.122.1.1">10.0.10.8.1.1</NetId>
         <Type>TCP_IP</Type>
      </Route>
      <Route>
         <Name>CX-222222</Name>
         <Address>10.0.20.8</Address>
         <NetId RemoteNetId="5.19.8.122.1.1">10.0.20.8.1.1</NetId>
         <Type>TCP_IP</Type>
      </Route>
   </RemoteConnections>
</TcConfig>
```

The actual AmsNetId assigned to the remote ADS device is specified with the attribute "RemoteNetId". It does not have to be unique. Only the AmsNetId of the target system defined in the field <NetId> is known in the TwinCAT system with configured AmsNAT function.

Restart the TwinCAT system service in order to activate the preset configuration of the AmsNAT function. To do this, switch the TwinCAT system from Run mode to Config mode. If TwinCAT is already in Config mode, reopen this in order to load the settings made.

3.2.3 ADS-over-MQTT

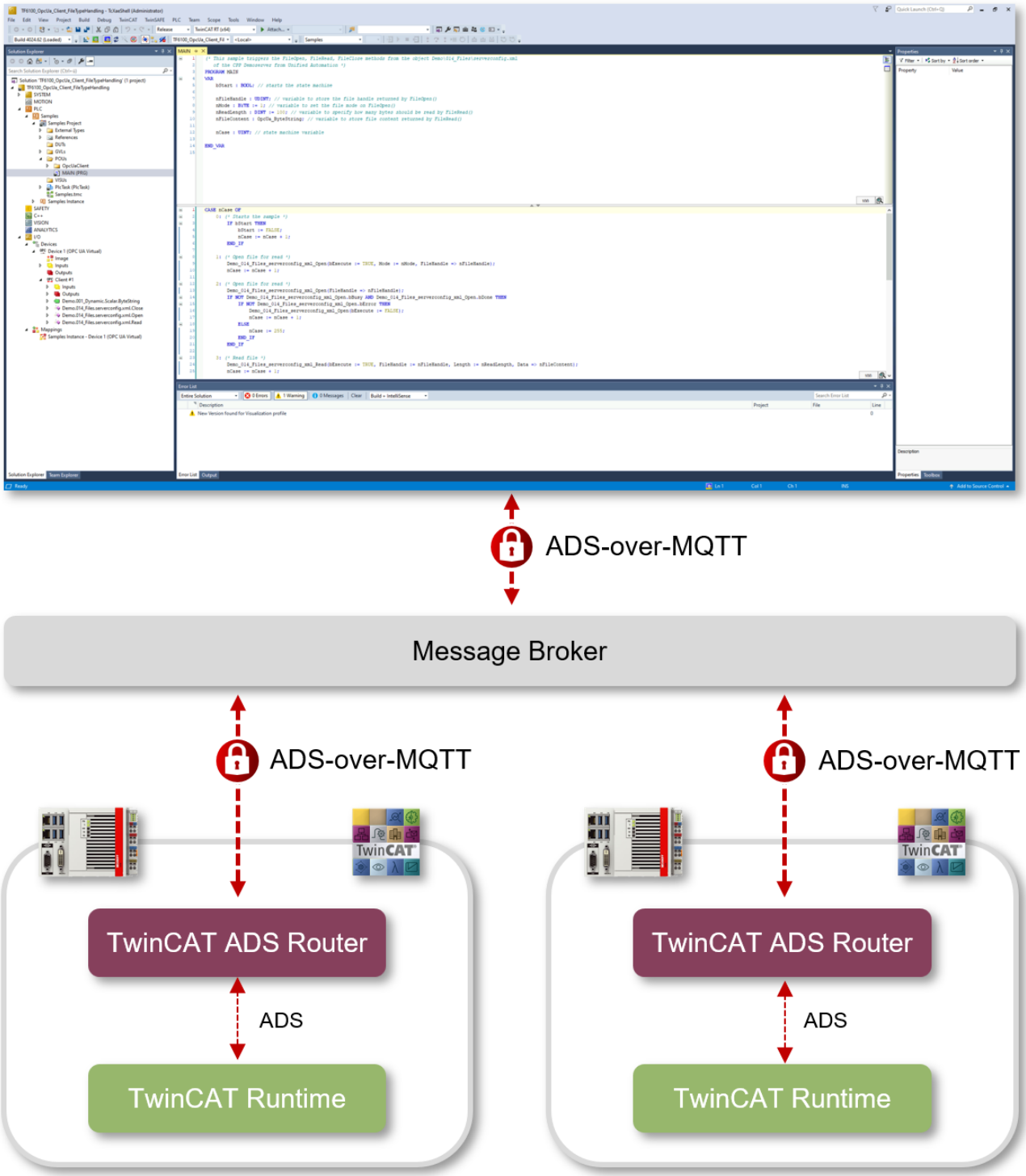
3.2.3.1 Overview

Beckhoff ADS (Automation Device Specification) is a communication protocol developed by Beckhoff for efficient data exchange in industrial automation systems. It serves as the backbone for the integration of devices and software into the PC-based control technology from Beckhoff.

From the perspective of the ADS protocol, ADS-over-MQTT is an additional transport channel over which ADS can be transported. Decoupling communication via an MQTT message broker results in a number of advantages, particularly in terms of scalability and flexibility when integrating additional ADS applications. Security mechanisms such as TLS can be used at the transport layer to secure the communication connection.

With ADS-over-MQTT, the entire data exchange is transparent for the ADS applications, because only the ADS router needs to know and hold the corresponding information on the MQTT transport channel. In particular, this also enables easy retrofitting for existing applications.

The main use case for ADS-over-MQTT is a classic remote maintenance and remote diagnostics scenario, where the TwinCAT engineering environment (TwinCAT XAE) needs to connect to one or more controllers for remote debugging. The following diagram illustrates the architecture being created here.



However, there are many other use cases for ADS-over-MQTT, especially when it comes to the aggregation of multiple distributed PLC systems.

This document provides an overview of the usage possibilities as well as a technical description of how a "virtual ADS network" can be configured over an MQTT message broker.

Benefits of an MQTT-based ADS network

- **Subnets, NAT-based networks and firewalls:**
  Incoming TCP/IP connections are used in both directions in a classic ADS setup. This makes it necessary for the devices to be located in the same network in the normal case. In distributed systems with different subnets this leads to complex configurations in order to make the ADS routes available. In the case of MQTT-based ADS networks, only an outgoing TCP/IP connection is used by the devices. This allows the broker in the higher-level network to broker between all devices. Due to the outgoing connections, a typical firewall can be used and no incoming ports need to be registered.

- **Access control:**
  After creating the appropriate routes, bidirectional communication can be executed in a classic ADS setup. An access by device A, which accesses B, also allows device B to access A. The MQTT-based ADS network can be configured so that device A can access B, but not the other way around.
- **Security / encryption:**
  The communication from TwinCAT to the broker can be encrypted by TLS (with certificates or PreSharedKey (PSK)). In this case, the transporting MQTT protocol is encrypted, so the ADS protocol can be transmitted unencrypted in the payload.
- **Retrofitting:**
  ADS-over-MQTT is transparent for the ADS applications, which means that they do not need to be changed.

NOTICE

ADS access means full access

As described in Security Advisory 2017-01, ADS offers full access to a device.
Secure ADS offers authorization as well as encryption for the communication; therefore, it represents a transport encryption. Hence, if an ADS route exists, then full access exists.
Dedicated, role-related access to individual files is offered by solutions such as OPC UA.

3.2.3.2 Installation

3.2.3.2.1 System Requirements

The following system requirements apply for the installation and operation of this product.

Technical data	Description
Operating system	Windows 10 Windows Server 2022 TwinCAT/BSD TwinCAT/Linux®
Target platforms	PC architecture (x86, x64, Arm®)
TwinCAT version	TwinCAT 3 (from Build 4022.0)
TwinCAT installation level	TwinCAT 3 XAE, XAR, ADS
Required TwinCAT license	---
Supports TwinCAT 3 Usermode Runtime	Yes, see also Configuration file [▶ 186]

MQTT Message Broker

To use this product, an MQTT message broker is required via which the communication connection is established. Any MQTT message broker can be used, e.g. Mosquitto or HiveMQ. The use of managed cloud services, such as AWS IoT Core, is also possible.

Plugin for Mosquitto Message Broker

The supplied plugin for the Mosquitto Message Broker is currently only available for the Windows operating system.

3.2.3.2.2 Installation

The ADS-over-MQTT feature is a fixed part of the basic TwinCAT installation, both on XAE, XAR and ADS installations, and no further installations are required on the TwinCAT side. To install the MQTT message broker, please consult the documentation for your message broker software.

3.2.3.3 Technical introduction

3.2.3.3.1 Quick Start

This documentation article is intended to allow you an initial, quick start in how to use this product. Carry out the following steps to establish an ADS-over-MQTT connection to an MQTT message broker and to send and receive ADS messages.

Message Broker installation

This document assumes that you have a locally installed and working MQTT message broker. As an example we use the Mosquitto Message Broker here, but you can use any message broker.

Overview

For demonstration purposes, two TwinCAT devices are to establish an ADS-over-MQTT connection with the message broker. We then use TwinCAT XAE (Engineering) on the first device to establish a connection to the second system via the ADS-over-MQTT route. To keep the installation scenario as simple as possible, both devices should be on the same network.

Device 1:

- Mosquitto Message Broker
- TwinCAT 3 XAE

Device 2:

- TwinCAT 3 XAE or XAR

Note the IP address or the host name of Device 1. In the latter case, make sure that the name resolution works in your network.

Message Broker setup

The Mosquitto Message Broker has been delivered since version 2.x with a configuration that requires security measures to be set up to ensure secure operation of the message broker. In the following, we will show you how to modify the Mosquitto Message Broker configuration so that an unsecured communication connection can be established with the broker. However, this should be done exclusively for testing purposes in a trusted operating environment. For productive operation, we recommend using a secure broker configuration.

1. Install the Mosquitto Message Broker on your system.
2. Make a backup of the *mosquitto.conf* file from the Mosquitto installation directory. This is typically located at *C:\Program Files\mosquitto.*
3. Open the *mosquitto.conf* file with a text editor of your choice and remove the existing content. Add the following content and save the file.

```
listener 1883
allow_anonymous true
```

4. Restart the Mosquitto Message Broker, either via the corresponding Windows service or manually via the console or *mosquitto.exe*.

⇨ You have now configured the Mosquitto Message Broker to listen for incoming client connections on port 1883 and it does not require any security (neither user authentication nor client certificates).

Windows firewall on Device 1

Please enable the standard MQTT port 1883/tcp as an incoming port in the Windows firewall of Device 1 so that Device 2 can establish a connection to the message broker.

You can now start configuring TwinCAT.

Configuration of the first TwinCAT device

The TwinCAT ADS router on this device should now establish a route to the local message broker. Create a new XML file, e.g. with Notepad, and insert the following content.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
<RemoteConnections>
  <Mqtt>
    <Address Port="1883">127.0.0.1</Address>
    <Topic>VirtualAmsNetwork1</Topic>
    </Mqtt>
  </RemoteConnections>
</TcConfig>
```

Save this XML file under any name in the following directory and restart TwinCAT for the changes to take effect.

```
\TwinCAT\3.1\Target\Routes
```

Configuration of the second TwinCAT device

The TwinCAT ADS router on this device should establish a route to the message broker on device 1. Create a new XML file, e.g. with Notepad, and insert the following content.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
<RemoteConnections>
  <Mqtt>
    <Address Port="1883">%IPAddress%</Address>
    <Topic>VirtualAmsNetwork1</Topic>
    </Mqtt>
  </RemoteConnections>
</TcConfig>
```

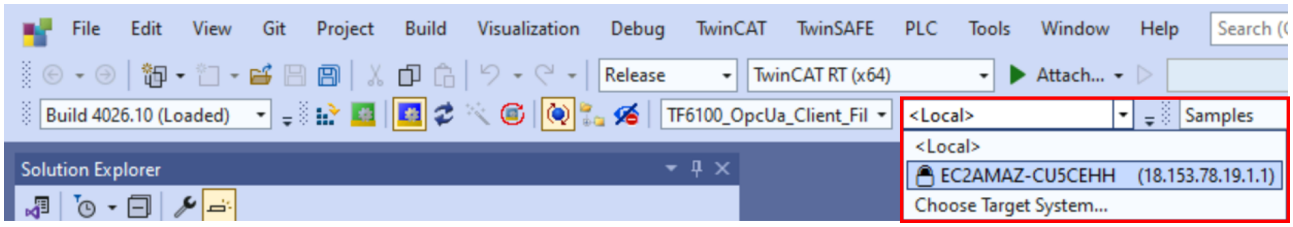
Replace the entry %IPAddress% with the IP address or the host name of device 1. Save this XML file under any name in the following directory and restart TwinCAT for the changes to take effect.

```
\TwinCAT\3.1\Target\Routes
```

Connecting the engineering

Now start TwinCAT XAE on Device 1 and create a new TwinCAT project. Alternatively, you can also open an existing project. For this tutorial, we only need the toolbar to establish a connection to a remote ADS device.

You will now find TwinCAT Device 2 in the toolbar and can establish a connection to it.

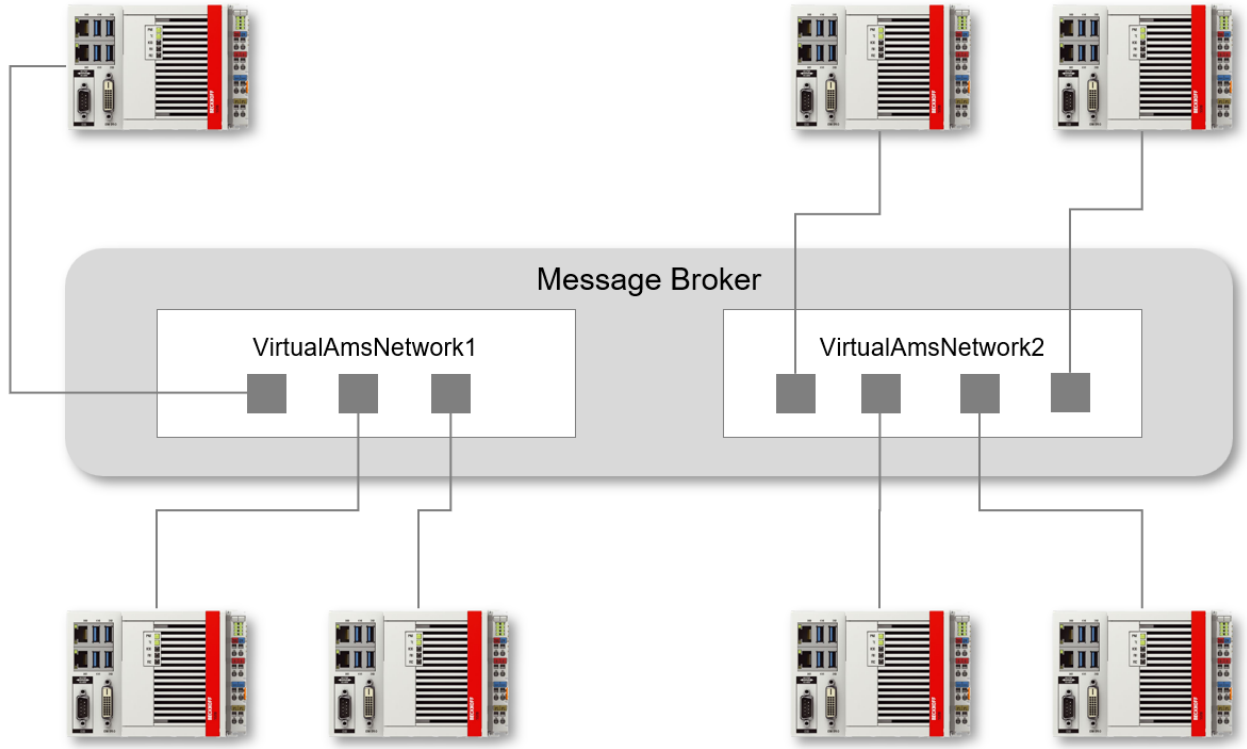


Next steps

After you have successfully established an ADS-over-MQTT connection to the message broker, we recommend that you reset the Mosquitto Message Broker to its default settings. For this, please take the backup file of *mosquitto.conf* that you created in the previous steps. This file, together with the broker documentation, is a good basis for further steps, e.g. to set up a secure message broker operating environment considering client/server certificates and user authentication.

3.2.3.3.2 Virtual networks

When configuring ADS-over-MQTT, so-called "virtual networks" can be defined. This allows ADS devices to be distributed into independent networks. Only the devices within a network can communicate with each other. At MQTT level, this distribution takes place on the basis of a common basic topic.



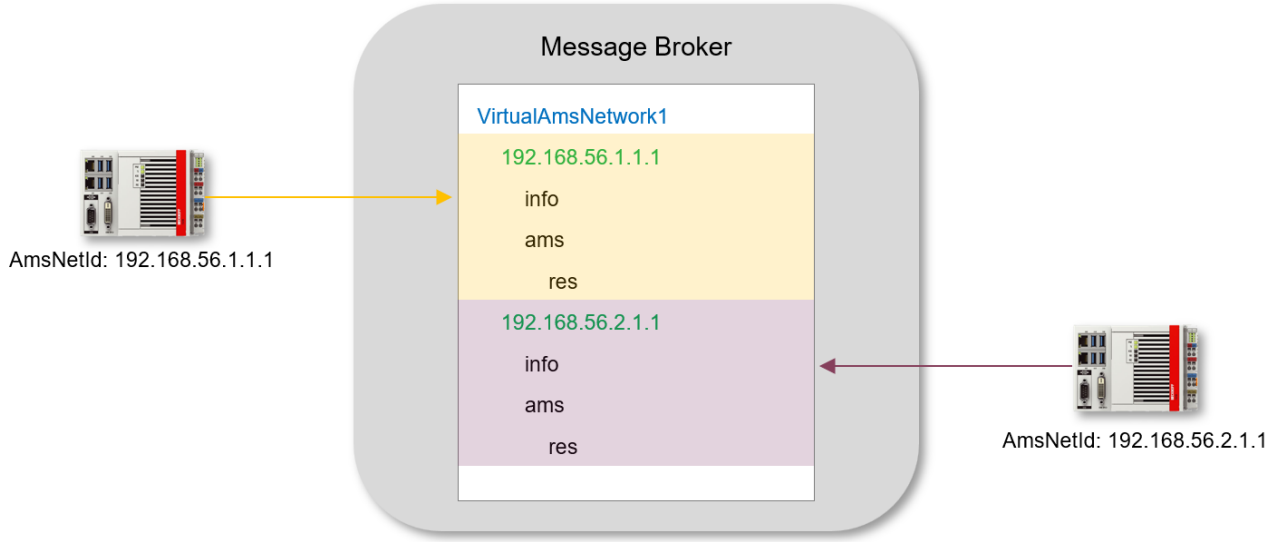
These virtual networks can be defined at client level using the ADS-over-MQTT configuration file [▶ 186] and, if required, access rights can be assigned using the TcMqttPlugin [▶ 189] for the Mosquitto Message Broker.

3.2.3.3.3 Communication flow

To enable data exchange and Device Discovery via ADS-over-MQTT, all ADS devices use a uniform topic structure on the message broker. The topic structure depends on the name of the configured virtual network [▶ 183] and the AMS Net ID of the respective device.

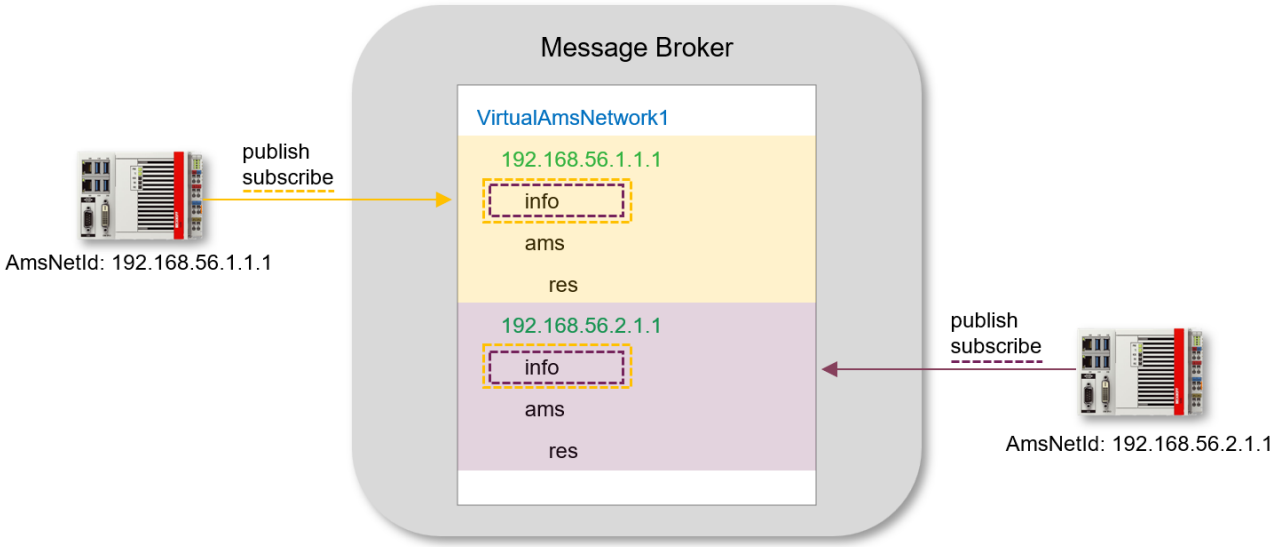
Type	Topic
Discovery	<NetworkName>/<AmsNetId>/info
Communication	<NetworkName>/<AmsNetId>/ams <NetworkName>/<AmsNetId>/ams/res

Each ADS device therefore has its own "topic area" on the message broker. The following figure illustrates this relationship.



Discovery

A connecting TwinCAT ADS router sends a retain message with device information to its discovery topic, at the same time it subscribes to the topic <NetworkName>/+/info, so that it is informed about all other connected routers.



The messages to the discovery topic contain an XML structure with device information, for example the host name and the TwinCAT version used:

```
<info>
  <online name="EC2AMAZ-2RRSQS6" osVersion="10.0.20348" osPlatform="2"
tcVersion="3.1.4026.10">true</online>
</info>
```

If the message broker does not support retain messages, this can be taken into account in the ADS-over-MQTT configuration file [▶ 186]. In this case, a communication handshake would take place instead of a retain message: a newly connecting device logs on to its discovery topic and all other connected devices respond with another message on their discovery topic. This ensures that devices can find each other even with message brokers that do not support retain messages. The disadvantage is an increased volume of messages in larger operating environments with frequent reconnects.

Communication

A TwinCAT ADS router subscribes to its communication topic (<NetworkName>/<AmsNetId>/ams/#) immediately after the connection is established. The ADS commands to this router are then sent to <NetworkName>/<AmsNetId>/ams, while the responses are received via the <NetworkName>/<AmsNetId>/ams/res topic.

3.2.3.3.4 Configuration file

The TwinCAT ADS router is configured by an XML file to establish an ADS-over-MQTT connection with a message broker. This configuration file is stored under any name in the following directory:

```
\TwinCAT\3.1\Target\Routes
```

In the Examples [▶ 191] chapter, you will find example configuration files for all the use cases described below.

Activating a new ADS-over-MQTT configuration

New or changed ADS-over-MQTT configurations are only adopted when the TwinCAT ADS router is initialized. This takes place, for example, in the TwinCAT transitions from RUN to CONFIG or CONFIG to CONFIG.

Path information

Please ensure that you use the correct spelling for your operating system for any path details in the configuration file.

TwinCAT 3 Usermode Runtime

You can operate ADS-over-MQTT in the TwinCAT 3 Usermode Runtime. Only the basic paths of the Usermode Runtime need to be taken into account. In the delivery state, for example, the base directory for the router configuration files is defined as follows:

%ProgramData%\Beckhoff\TwinCAT\3.1\Runtimes\UmRT_Default\3.1\Target\Routes\

Other path details for ADS-over-MQTT specific topics (see Technical introduction [▶ 182]) are otherwise retained.

Basic configuration

The basic configuration always contains the following elements:
Address of the message broker, its TCP port and the name of the virtual network [▶ 183].
The address of the broker and the TCP port at which it can be reached are specified via the <Address> node. The virtual network is defined via the <Topic> node. In the following example, a connection is established to a locally (127.0.0.1) installed message broker and TCP port 1883. “VirtualAmsNetwork1” is defined as the virtual network.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
 <RemoteConnections>
  <Mqtt>
   <Address Port="1883">127.0.0.1</Address>
   <Topic>VirtualAmsNetwork1</Topic>
  </Mqtt>
 </RemoteConnections>
</TcConfig>
```

NoRetain

The communication flow [▶ 184] for device discovery can be customized via the NoRetain attribute. When setting NoRetain = true, the device search function is no longer based on retain messages. Instead, a handshake mechanism is used to identify all connected ADS devices.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
<RemoteConnections>
    <Mqtt NoRetain="true">
        <Address Port="1883">mybroker.someurl.com</Address>
        <Topic>VirtualAmsNetwork1</Topic>
    </Mqtt>
</RemoteConnections>
</TcConfig>
```

Unidirectional

Incoming ADS messages can be blocked for this system via the unidirectional attribute. A typical use case could be an engineering system, for example, which should be able to reach the runtime systems via ADS, but not vice versa.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
<RemoteConnections>
    <Mqtt Unidirectional="true">
        <Address Port="1883">mybroker.someurl.com</Address>
        <Topic>VirtualAmsNetwork1</Topic>
    </Mqtt>
</RemoteConnections>
</TcConfig>
```

TLS

The <TLS> node can be used to define settings for securing the transport channel via TLS. Various connection options are available, e.g. the configuration of client certificates or PSK. Our examples [▶ 191] show all possible configuration variants.

TLS IgnoreCn

The IgnoreCn attribute can be used to disable the verification of the CommonName (CN) from the server certificate.

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
<RemoteConnections>
    <Mqtt>
        <Address Port="8883">mybroker.someurl.com</Address>
        <Topic>VirtualAmsNetwork1</Topic>
        <Tls IgnoreCn="false">
            <Ca>C:\TwinCAT\3.1\Target\Certificates\mybroker\CA.pem</Ca>
        </Tls>
    </Mqtt>
</RemoteConnections>
</TcConfig>
```

TLS PSK

When using TLS with a pre-shared key (PSK), you can either specify the PSK as a hex-coded, 64-character string, or leave the conversion to TwinCAT internally using Sha256(Identity + Pwd). In the latter case, the IdentityCaseSensitive attribute can be used to specify that TwinCAT should use the identity as the UpperCase for the calculation. Our examples [▶ 191] show both possible configuration variants.

User

```
<?xml version="1.0" encoding="ISO-8859-1"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
 <RemoteConnections>
  <Mqtt>
   <Address Port="1883">127.0.0.1</Address>
   <Topic>VirtualAmsNetwork1</Topic>
   <User>CX-12345</User>
  </Mqtt>
 </RemoteConnections>
</TcConfig>
```

The <User> element specifies an identity that can be used in the TcMqttPlugin [▶ 189] to configure access rights between ADS devices. However, the identity is usually defined by other means, e.g. the CommonName (CN) of a client certificate.

Optionally, the <Mqtt> element can contain a ClientId attribute to specify the MQTT ClientID. This is otherwise formed from the <User> and an arbitrary string.

3.2.3.3.5 Enabling/disabling

You can enable or disable an ADS-over-MQTT route at runtime without having to restart the TwinCAT system. This allows you, for example, to enable the route only in the case of service and to assign this function to a key switch or link it to user inputs via the HMI.

Enabling/disabling is performed via an ADS interface in the TwinCAT System Service. You can use a special attribute in the route configuration file to define a default status that the route should have after a TwinCAT start.

Route configuration file

In the configuration file of an ADS-over-MQTT route, you can specify a default status that the route should have after a TwinCAT start. This attribute (“Disabled”) is specified at the <Mqtt> node. If assigned the value “true”, the ADS-over-MQTT route is not established automatically after TwinCAT is started and must be established via the ADS interface.

```
<?xml version="1.0"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:noNamespaceSchemaLocation="http://www.beckhoff.com/schemas/2015/12/TcConfig">
    <RemoteConnections>
        <Mqtt Disabled="true">
            <Name>MyBroker</Name>
            <Address Port="1883">myMessageBrokerAddress</Address>
            <Topic>VirtualAmsNetwork1</Topic>
        </Mqtt>
    </RemoteConnections>
</TcConfig>
```

ADS interface

The ADS interface is defined as follows.

```
ADS-Kommando: AdsWriteRequest
ADS-Port: 10000
IndexGroup: 808
IndexOffset: siehe unten
Data: Identifizierung der Route, siehe unten
```

The IndexOffset indicates whether you want to enable/disable a route permanently or temporarily. In this case, “permanent” means that the enabled/disabled state is retained even after a TwinCAT restart. The following options are available:

IndexOffset	Name	Description
1	ADS_ROUTE_DISABLE	Disables the route permanently.
2	ADS_ROUTE_ENABLE	Enables the route permanently.
3	ADS_ROUTE_DISABLE_TMP	Disables the route temporarily.
4	ADS_ROUTE_ENABLE_TMP	Enables the route temporarily.

The data area of the AdsWriteRequest specifies which ADS-over-MQTT route is to be addressed. This is done via definition in a string. The format is as follows and corresponds to a composition of the <Address> and <Topic> nodes of the configuration file. The keyword “MQTT” is fixed here.

```
MQTT:<Address>:<Topic>
```

Alternatively, you can also add a <name> node to the configuration file, which you can then use for referencing. The name used here must be unique across all ADS routes. In the example above, you would then use the following string in the data area of the AdsWriteRequest:

```
MQTT:MyBroker
```

PLC example

A corresponding example [▶ 191] is available for download.

3.2.3.3.6 Security

There are options for securing the communication. A TLS connection on the basis of X.509 certificates or a Pre-Shared Key (PSK) can be used for this. It is recommended that communication be secured with TLS especially when communicating over non-trustworthy networks (e.g. the Internet). In the chapters Configuration file [▶ 186] and Samples [▶ 191] you will find explanations and sample configuration files for operating ADS-over-MQTT via TLS.

The broker itself must be operated in a trustworthy environment, as all messages on the broker are unsecured.

Compromising of the virtual ADS network

Even when communication between the devices and the broker takes place in encrypted form via TLS, the devices are not secured among one another. The ADS commands are present on the broker in unencrypted form.
If a device is compromised, the attacker can execute all ADS commands via the rights gained. These commands also include file reading operations or operations for starting processes.

Two methods can be used to configure access rights between individual ADS devices:

- Configuration of access rights via Access Control Lists [▶ 190] (using Mosquitto as an example)
- Configuration of access rights via a plugin [▶ 189] (only for Mosquitto)

3.2.3.3.6.1 Mosquitto plugin

A plugin was developed especially for the Mosquitto Message Broker to enable the definition of access rights between the individual TwinCAT ADS routers.
Please also note the system requirements [▶ 181] for operating this plugin.

The plugin is delivered with the TwinCAT installation under TwinCAT 3.1 Build 4024. Build 4026 requires the installation of the corresponding package (TwinCAT.XAE.MqttPlugin). The plugin is installed in the following directory and can be referenced from there in the Mosquitto configuration.

```
\TwinCAT\AdsApi\TcMqttPlugin
```

The plugin is available in a 32-bit and a 64-bit version, depending on which version you use of the Mosquitto Message Broker. The plugin is then integrated into the configuration of the Mosquitto Message Broker as follows:

```
auth_plugin <Path>TcMqttPlugin.dll
auth_opt_xml_file <Path>MyACL.xml
```

The *MyACL.xml* file contains the access configuration to the broker itself, as well as the configuration of the communication between the connected TwinCAT ADS routers. This configuration is explained in more detail in the following section.

Configuration

The plugin offers the option of configuring virtual AMS networks. To do this, specify which device can access which other device for each target device. In contrast to the classic ADS routes, these connections are directional: A target therefore does not also have the right to access the source.

```
<TcMqttAclConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="C:\TwinCAT\3.1\Config\Modules\TcMqttAclConfig.xsd">
  <Ams>
    <Topic>VirtualAmsNetwork1</Topic>
    <User>
      <Name>EngineeringStation</Name>
    </User>
    <User>
      <Name>CX-12345</Name>
      <Access>EngineeringStation</Access>
    </User>
    <User>
      <Name>CX-56789</Name>
      <Access>EngineeringStation</Access>
```

```
    </User>
  </Ams>
</TcMqttAclConfig>
```

The name of the Ams network is defined within an <Ams> node. It is used in the MQTT topics employed for the identification of the networks. Individual <User> elements describe the devices. These elements have a <Name> attribute that describes the MQTT identity with which the connection was established. The identity can be transferred via various TLS mechanisms, e.g. via the TLS-PSK Identity or the CommonName (CN) of a client certificate. Our samples [▶ 191] here show possible configuration variants.

Access-authorized devices are defined via the <Access> element. In the sample above, the "EngineeringStation" identity has access to two CX devices, but the CX devices do not have access to the "EngineeringStation" or to each other.

The configuration file is reloaded cyclically so that a restart of the broker is not necessary.

Restrictions with regard to the AmsNetId to be registered

With this configuration each validly connected device can assume an arbitrary AmsNetId and thus an identity from the point of view of ADS. This can be further restricted as required:

```
<User>
  <Name>CX-56789</Name>
  <Access>EngineeringStation</Access>
  <NetId>192.168.56.1.1.1</NetId>
</User>
```

As soon as at least one NetId is specified, only one NetId can be registered from this list. An alternative solution would be to enter the NetId in the CommonName (CN) of the client certificate.

3.2.3.3.6.2 Mosquitto ACL

Many message brokers allow the configuration of Access Control Lists (ACLs) to restrict client interactions to certain topics. The following chapter shows this configuration using the Mosquitto Message Broker as an example. The procedure for granting access rights described here differs from that of the TcMqttPlugin [▶ 189]. This specifies which other ADS devices have access to an ADS device. With the (Mosquitto) ACL it is exactly the other way around, because here it is specified for an ADS device which other ADS devices it is allowed to access.

Overview

The Mosquitto Message Broker allows the configuration of an Access Control List, which is defined as a separate configuration file and referenced in the main configuration of the broker. This configuration entry is shown below as an example:

```
acl_file C:\Program Files\mosquitto\mosquitto.acl
```

You can also find a complete configuration file in our samples [▶ 191] for download.

In the ACL file, you can define authorizations for publishing and subscribing to certain topics and specify them separately for each user. The access rights for a user are always introduced by the following line:

```
user <username>
```

Subsequently the reading and writing rights are defined according to the following scheme:

```
topic [read|write|readwrite] <topicName>
```

Configuration for ADS-over-MQTT

For ADS-over-MQTT, two things must be ensured according to the communication flow [▶ 184]: access of all ADS devices to the discovery topics and sending/receiving via the communication topics.
The ADS device must always have read/write access to its own topic. The device receives read rights for the discovery topic of other ADS devices.
To exchange ADS messages, an ADS device must have read/write access to the communication topic of the

devices. The ADS device is identified by its own identity on the message broker. This identity can, for example, originate from a PSK or correspond to the CommonName (CN) of a client certificate. The following configuration illustrates these relationships.

```
user <identity>
topic readwrite <VirtualAmsNetworkName>/<OwnAmsNetId>/#
topic read <VirtualAmsNetworkName>/+/info
topic readwrite <VirtualAmsNetworkName>/+/ams/#
```

If an ADS device is to be denied access to another device, it must be ensured that there are no write permissions for the topic with the target AmsNetId.

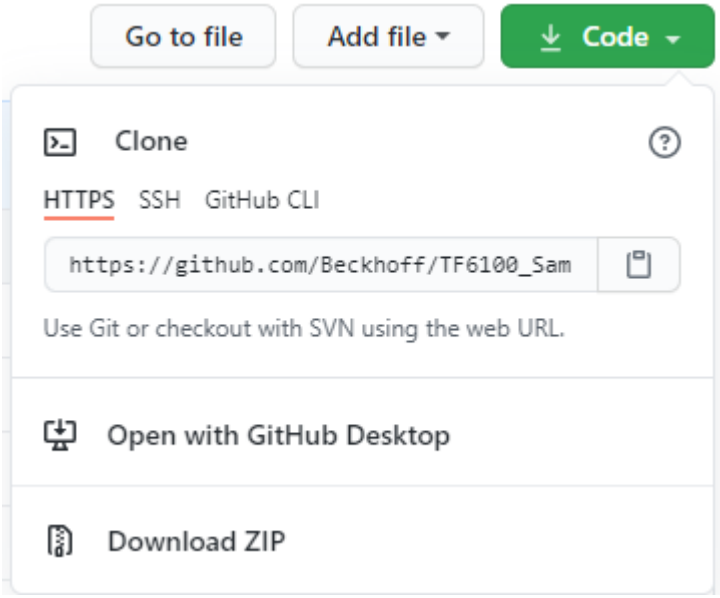
The familiar TcMqttPlugin option that an ADS device may register only one AmsNetId is also possible with the Mosquitto ACL. To do this, the entry <OwnAmsNetId> must be replaced by precisely one foreseen AmsNetId. If it is to be possible for the ADS device to register with an arbitrary AmsNetId, then the wildcard (#) has to be set for <OwnAmsNetId>.

The following is an example of the access rights entries for communication between two ADS devices:

```
user EngineeringStation
topic readwrite VirtualAmsNetwork1/18.153.78.19.1.1/#
topic read VirtualAmsNetwork1/+/info
topic readwrite VirtualAmsNetwork1/+/ams/#
user CX-12345
topic readwrite VirtualAmsNetwork1/3.120.15.8.1.1/#
topic read VirtualAmsNetwork1/+/info
topic readwrite VirtualAmsNetwork1/+/ams/#
```

3.2.3.4 Samples

Sample code and configurations for this product can be obtained from the corresponding repository on GitHub: https://github.com/Beckhoff/ADS-over-MQTT_Samples. There you have the possibility to clone the repository or download a ZIP file with the sample.



3.2.4 Secure ADS

3.2.4.1 General description

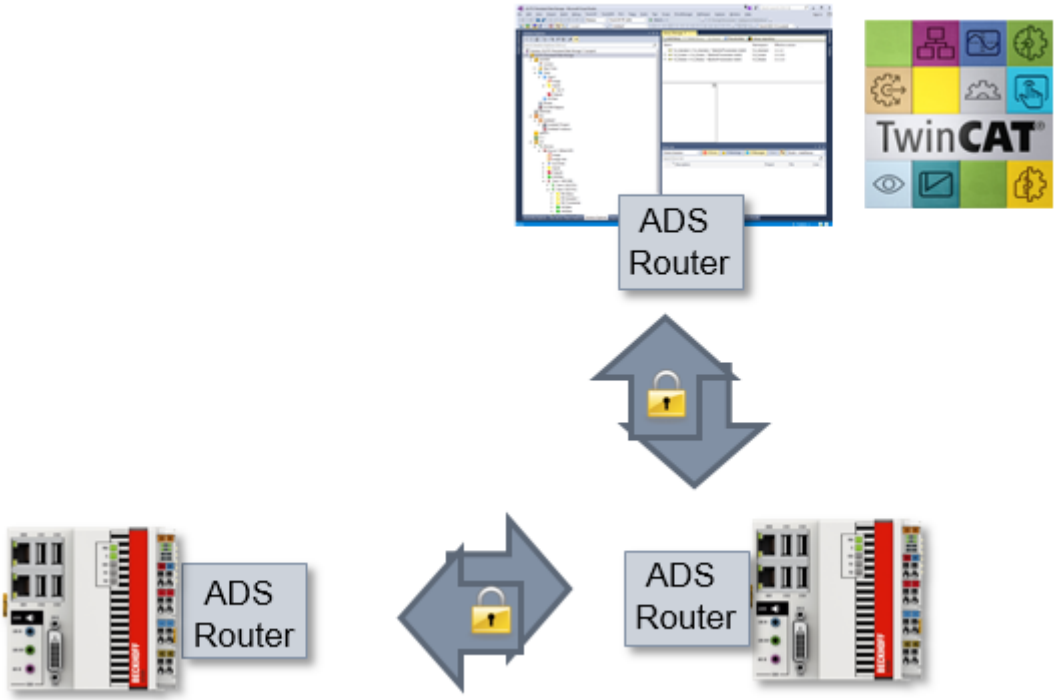
From TwinCAT 3.1 Build 4024.0

The functionality described here is available from TwinCAT 3.1. 4024.0.

Secure ADS is an additional transport channel from the point of view of the ADS protocol. Precisely the same ADS commands are transmitted via a secure connection as via other communication protocols.

To this end a connection encrypted by means of TLSv1.2 is established from one TwinCAT router to another.

Due to the implementation inside the TwinCAT router, existing applications do not need to be modified. They can be made to use the encrypted connection by simply parameterizing the used route.



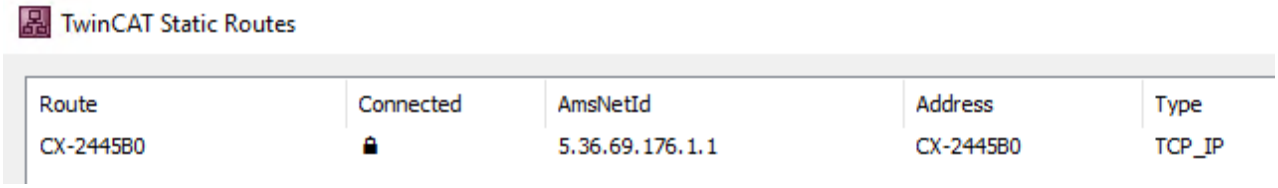
This documentation illustrates the different options of Secure ADS, in particular with regard to the provision of the keys.

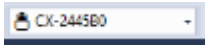
Detection of a Secure ADS route

TwinCAT displays a Secure ADS route with a lock icon.

It is displayed at the appropriate points:

- Route overview of a system



- When selecting the target system in the XAE engineering environment:
- 

3.2.4.2 Limitations

From TwinCAT 3.1 Build 4024.0

The functionality described here is available from TwinCAT 3.1. 4024.0.

- Secure ADS is available only between ADS routers.

- Like all other ADS connections, Secure SDS connections represent full access for the connected systems as is also described in the Security Advisory 2017-01.
  This access is configurable per system through unidirectional [▶ 194] ADS routes.

3.2.4.3 Requirements

From TwinCAT 3.1 Build 4024.0

The functionality described here is available from TwinCAT 3.1. 4024.0.

- Secure ADS is a component of TC1000 and can be used without license costs.
- The devices used require network communication. Incoming Secure ADS is communicated via the TCP port 8016.
- Appropriate certificates may need to be generated and signed for TLS encryption.

3.2.4.4 Technical introduction

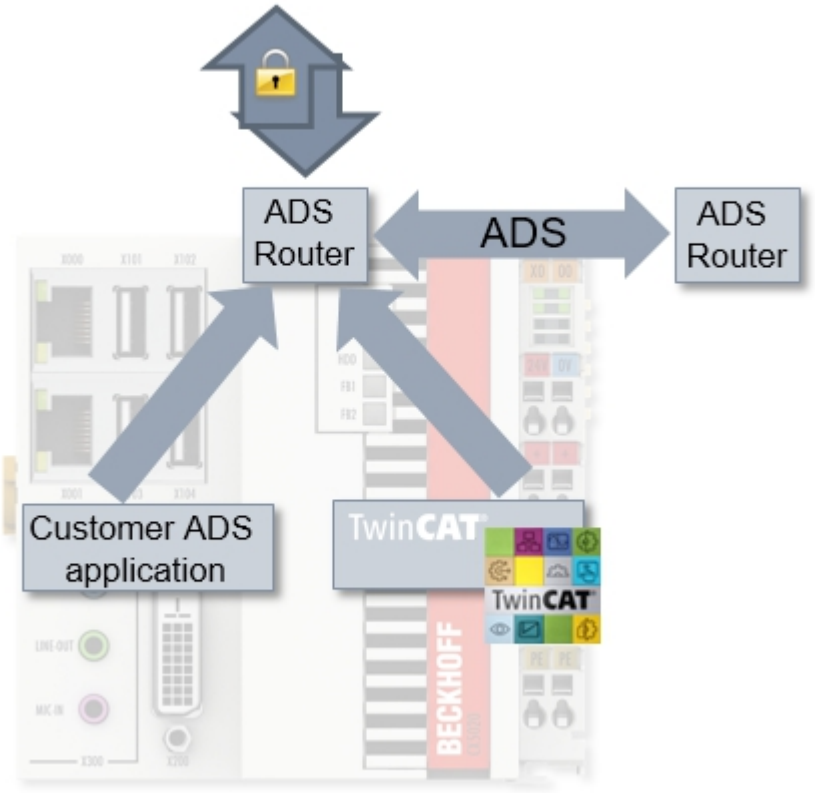
In this section the basic mode of operation is described, irrespective of the specific configuration.

Secure ADS introduced an additional communication channel for the familiar ADS protocol. This can be used by programs without them having to be adapted for the new communication channel.

From the point of view of security, therefore, it is a transport encryption, but not an end-to-end encryption between the components, because all applications running locally on a device can use this encrypted connection together – exactly as with ADS routes also.

Local realization

Secure ADS is part of the ADS router and is also configured here. The ADS router establishes an encrypted connection to another TwinCAT router and makes it available to the applications. Care must therefore be taken that the ADS devices do not themselves communicate applications in encrypted form, but that this takes place between the routers.



Transparent retrofitting

The realization of Secure ADS inside the TwinCAT router makes the retrofitting of applications possible. None of the ADS applications (client and server) – this also includes applications written by the customer – need to be recompiled.

The ADS applications use ADS routes to identify the communication partner. This ADS route is independent of the transport channel and is described in the TwinCAT router.

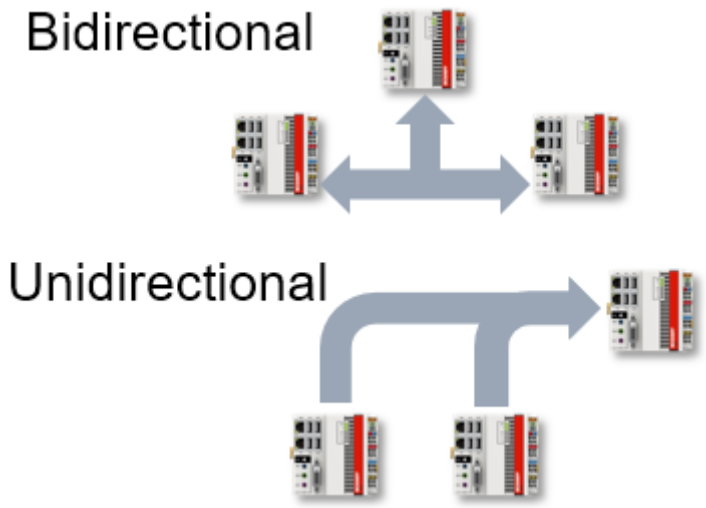
If the used route is switched to a Secure ADS connection, the ADS traffic is transported in encrypted form.

3.2.4.4.1 Directed ADS communication

One of the properties of ADS routes is that they can be directed. This property was supplemented within the scope of Secure ADS, but is generally available for routes.

Once they have been opened at network level, ADS routes are used for communication on both sides by the respective ADS applications. This behavior is very efficient, but may be undesirable. For example, an engineering computer (XAE) is supposed to have access to a runtime (XAR) system in the normal case, but it is not necessary for an XAR system to access the XAE system via ADS.
Therefore, this direction can be limited in that a corresponding system (the XAE in the example) does not accept any ADS request commands via the route.

The chapter Configuration [▶ 196] describes the procedure for limiting the properties.



3.2.4.4.2 Server

A normal ADS route is established by both devices as soon as it is required.
Once a route has been established it is used in both directions.
A server configuration is offered as an extension for Secure ADS. Such a configuration represents the basis for setting up specific routes.

```
<TcConfig>
  <RemoteConnections>
    <Server>
      …
    </Server>
  </RemoteConnections>
</TcConfig>
```

For PSK [▶ 199] and certificates provided by the customer [▶ 200] this is used to store the initial configuration on one side.
When setting up the specific route, the server entries are then checked to see if rights exist. If this is the case, a normal route will be set up.

3.2.4.4.3 Key exchange

Secure ADS offers three ways of providing the keys required for encryption; these are described here with their advantages and disadvantages.

What they all have in common is that the respective device has to be isolated with respect to access to the secrets (Pre-Shared Keys, certificates). If these secrets are compromised, the system has to be set up again in order to restore the integrity of the complete system.

Self-Signed Certificates (SSC)

When starting for the first time (e.g. after the installation), TwinCAT generates a self-signed certificate.

The use of such certificates has the advantage that they are generated and are available locally. In order to establish a basis for trust, however, a check of the certificates must be performed among all communication devices.

These certificates are thus suitable for the initial commissioning or also for static machines that can make do without dynamics in the system structure or the entity authorized to access.

From TwinCAT 4024.0 these certificates will be provided as standard when used. The chapter Configuration [▶ 197] describes how they are used to establish an ADS route.

Validity periods of the certificates

The certificates generated have a fixed validity period from 1/1/2000 to 1/1/2061. From the point of view of security this is too long, meaning that organizational measures have to be taken to meet the security demands. With this excessively long validity period, Beckhoff ensures that communication does not fail, even if, for example, incorrect times are set in the local system.

If this behavior is not desired, you can generate and use your own certificates (see Certificates provided by the customer).

Pre-Shared Keys (PSK)

Pre-Shared Keys can be stored in a TwinCAT system. These are used to authorize the incoming ADS routes when establishing the connection.

As the Pre-Shared Keys have to be configured they are particularly suitable for granting access, for example, to maintenance staff. The Pre-Shared Keys can be bound to a specific person.

Pre-Shared Keys do not have a validity period like that foreseen for certificates. They are also stored directly in files so that they are not stored as a hash value (as is usually the case with passwords). They are therefore not protected against direct viewing.

The chapter Configuration [▶ 199] describes how Pre-Shared Keys are used on both sides of the communication.

Certificates provided by the customer (CA with certificates)

Secure ADS also provides customers with the option of generating and managing their own certificates.

As a result, dynamic constellations in particular are easily mappable, because there can be a common Certificate Authority (CA). All devices that trust this CA can communicate in encrypted form with one another with no further configuration, even if they have never encountered one another before.

The chapter Configuration [▶ 200] describes how these certificates can be integrated into TwinCAT.

NOTICE

Expiry of the certificates

Certificates have an expiry date. Organizational measures must be taken to replace certificates before their expiry.

3.2.4.5 Configuration

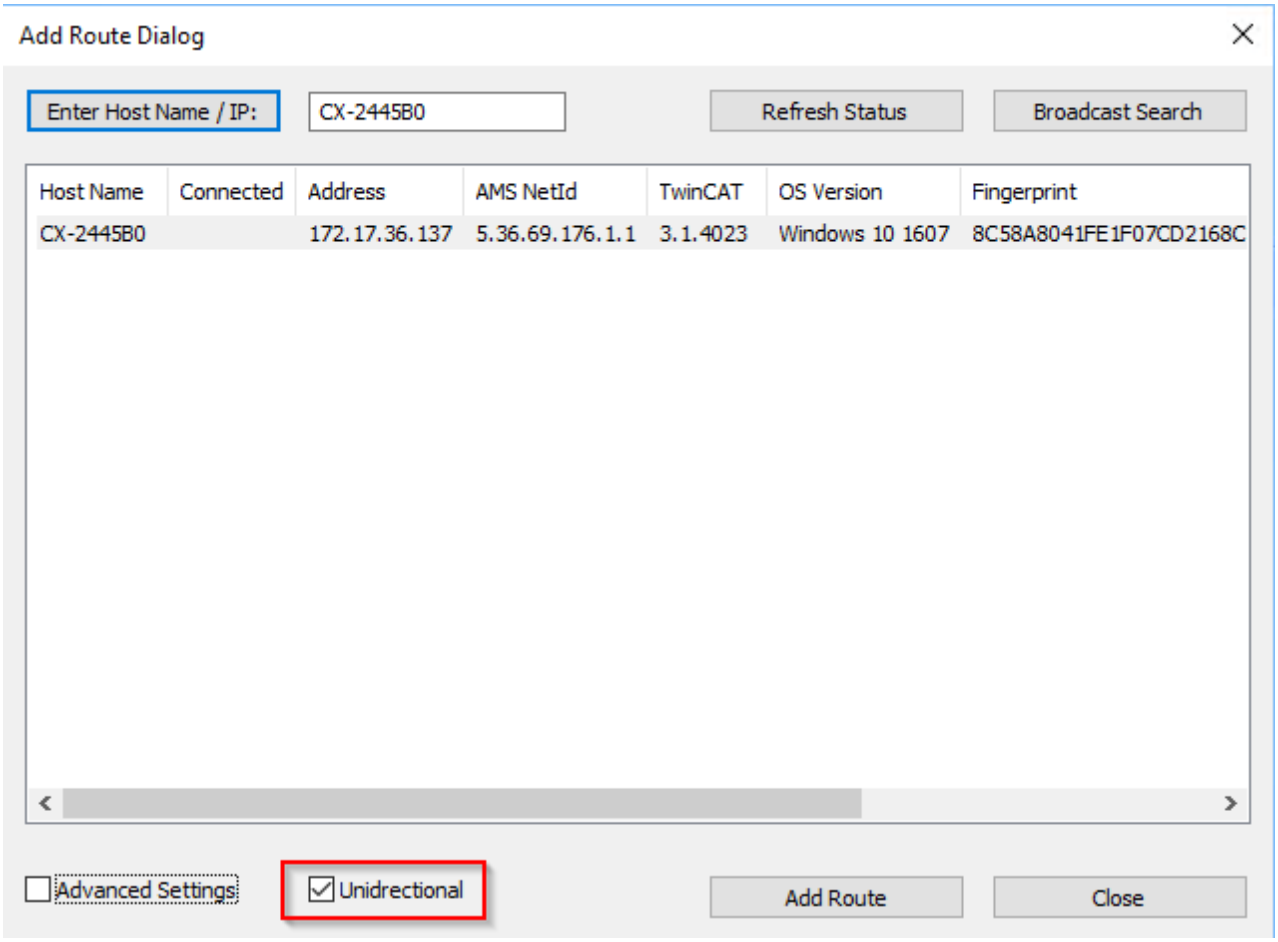
Secure ADS offers three ways of providing the keys required for the encryption. At this point the configurations will be described separately from one another.

While the Server vs. Route configuration is described within the three ways, directed ADS connections [▶ 196] are illustrated independently.

3.2.4.5.1 Directed ADS communication

The configuration of a directed ADS communication takes place using the checkbox **Unidirectional** when creating the route.

If this checkbox is set, TwinCAT will not accept any ADS command calls from the opposite target system via the associated route. TwinCAT itself sends ADS command calls (requests) and receives responses.



In the XML configuration this setting is made via the attribute `Unidirectional="true"`:

```
<RemoteConnections>
<Route Unidirectional="true">
<Name>CX-123456</Name>
<Address>CX-123456</Address>
<NetId>5.36.69.176.1.1</NetId>
<Type>TCP_IP</Type>
<Flags>128</Flags>
<Tls>
…
</Tls>
</Route>
</RemoteConnections>
```

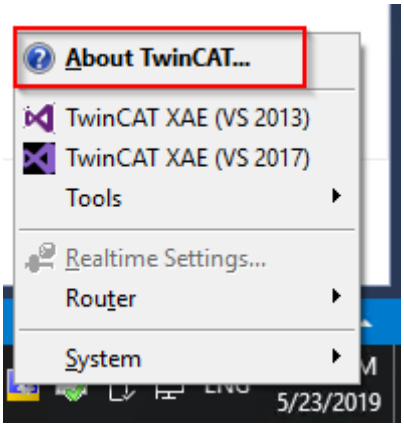
3.2.4.5.2 Self-Signed Certificates (SSC)

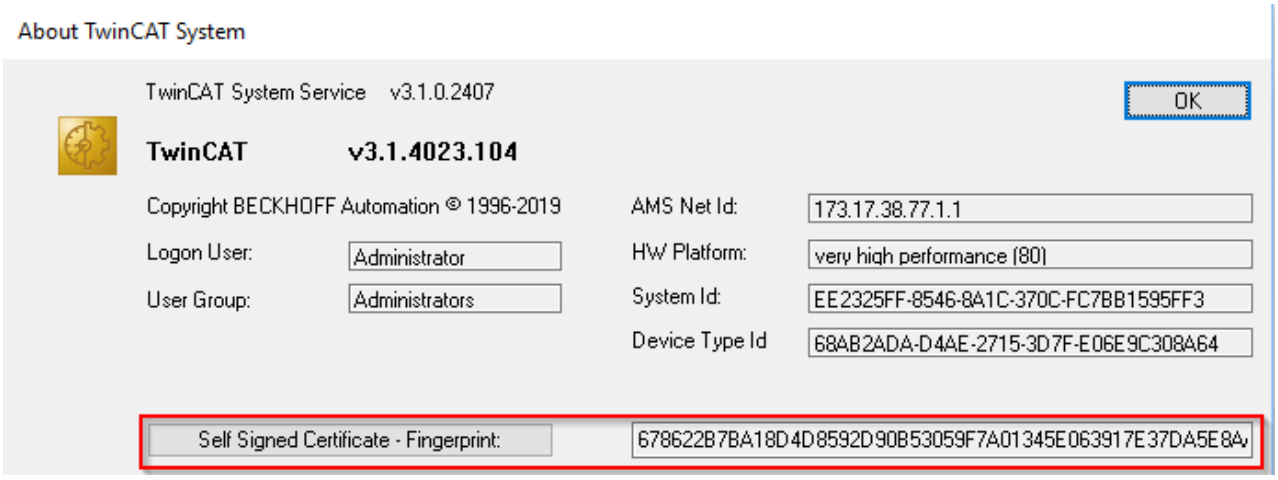
When setting up the connection, Self-Signed Certificates require the checking of the communication device, as no trust basis automatically exists.

This check is made possible in TwinCAT by the fingerprint of the opposite system.

Displaying the SSC fingerprint on a system

The fingerprint of your own system is displayed in the **About TwinCAT** dialog:



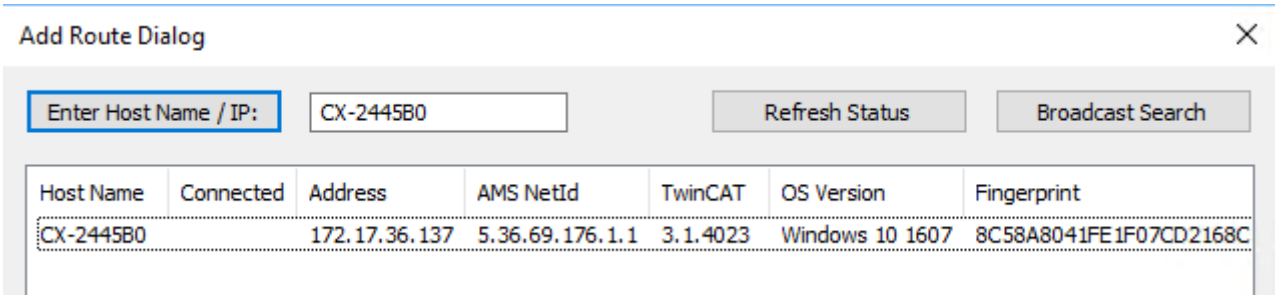


The button **Self Signed Certificate - Fingerprint:** copies the fingerprint listed on the right to the clipboard.

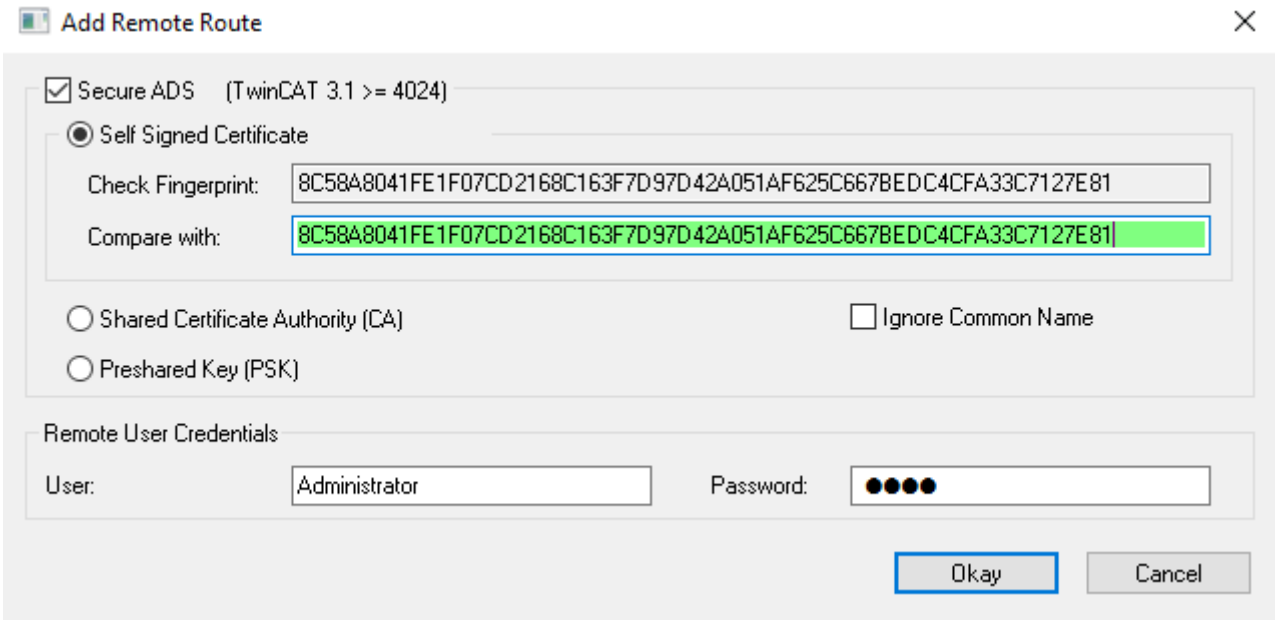
This dialog does not exist for CE systems. The fingerprint can be displayed here in the file `\Hard Disk\TwinCAT\3.1\Target\TcSelfSigned.xml`.

Establishment of the connection

The fingerprint is displayed purely for information and cryptographically unsecured following the discovery:



The final checking of the fingerprint takes place when setting up the route:



The **Compare with** field can be used, for example, with copy & paste for checking: If the same fingerprint is entered there the field appears green, otherwise it is red.

Thus, an RDP connection, for example, can be used to copy the fingerprint of a system to the clipboard via the **Self Signed Certificate - Fingerprint** button and to enter it here.

So that the target system will accept the route establishment, a system login with corresponding administrator rights that is valid there is used.
These login data are already transmitted in encrypted form.

With CE systems the host name is always entered with TwinCAT 3.1 4024.5, even if **IP address** was selected when creating the route. Therefore, if a network without a functioning host name lookup is to be used, the host name must be changed manually by the IP address in the file `\Hard Disk\TwinCAT\3.1\Target\StaticRoutes.xml`.

3.2.4.5.3 Pre-Shared Keys (PSK)

Pre-Shared Keys are set up on one side as a server and on the other side for authentication and authorization.

Setting up Pre-Shared Keys as a server

Pre-Shared Keys are normally used with server connections.
The configuration takes place via an entry in the route configuration.

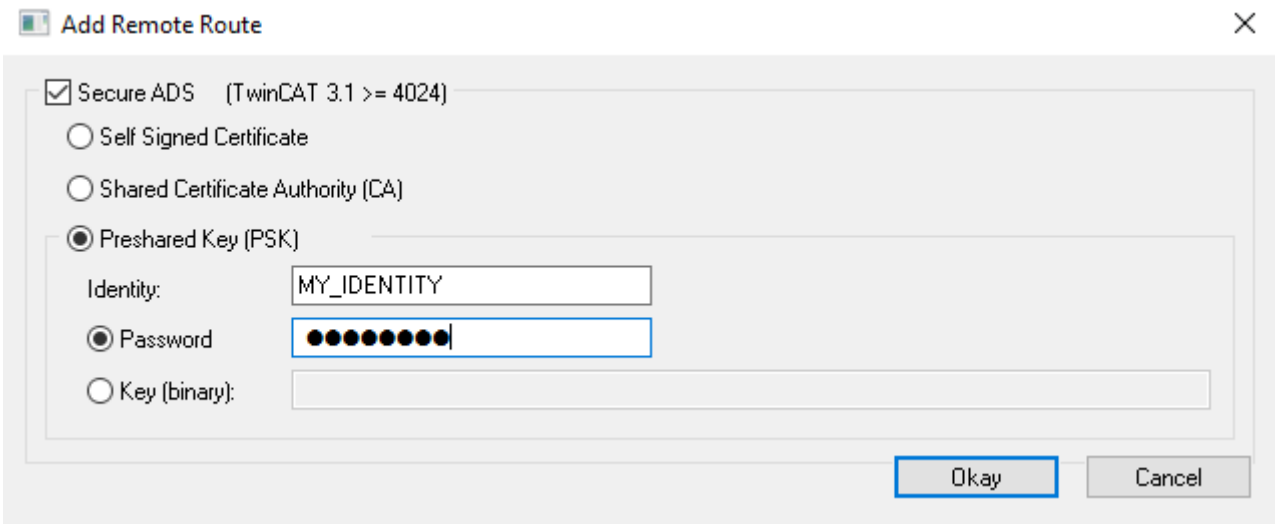
To do this, the following entries can be made in the file *C:\TwinCAT\3.x\Target\StaticRoutes.xml* :

```
<?xml version="1.0"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<RemoteConnections>
<Server>
<Tls>
<Psk>
<Identity>MY_IDENTITY</Identity>
<Pwd>MySecret</Pwd>
</Psk>
<Psk>
<Identity>MY_IDENTITY2</Identity>
<Pwd>MyOtherSecret</Pwd>
</Psk>
</Tls>
</Server>
</RemoteConnections>
</TcConfig>
```

Saved changes are accepted when the TwinCAT router is initialized, which takes place, for example, during the transition RUN->CONFIG or CONFIG->CONFIG.

Use of a Pre-Shared Key server

When adding a route, the entry **Pre-Shared Key (PSK)** is selected and the corresponding credentials are entered.



If this is successful, a specific route is stored in the target system and is used for the future establishment of connections.

3.2.4.5.4 Certificates provided by the customer (CA with certificates)

The configuration of certificates provided by the customer takes place via an entry in the route configuration.

To do this, the following entries can be made in the file *C:\TwinCAT\3.x\Target\StaticRoutes.xml* :

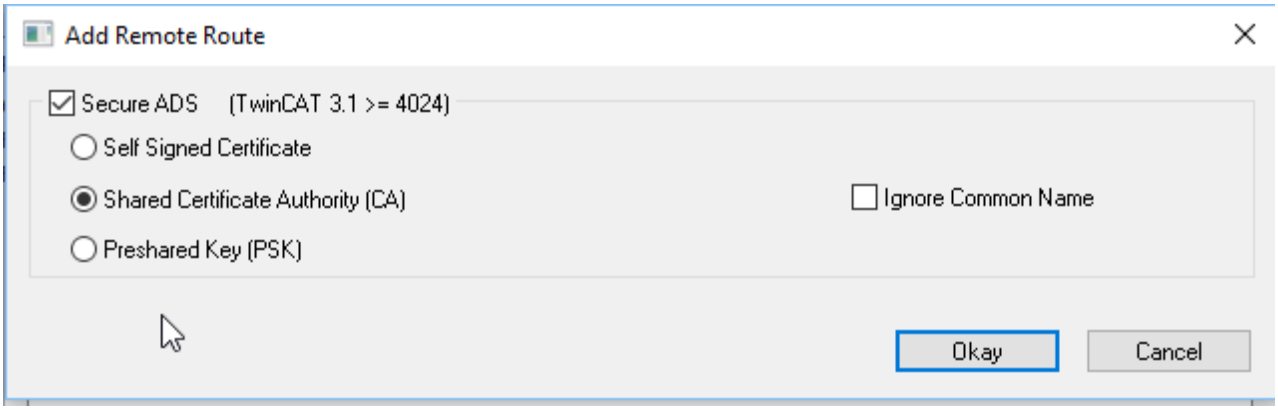
```
<?xml version="1.0"?>
<TcConfig xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
<RemoteConnections>
<Server>
<Tls IgnoreCn="true"> <!--see below-->
  <Ca>C:\TwinCAT\3.1\Target\CACerts\rootCA.pem</Ca>
  <Cert>C:\TwinCAT\3.1\Target\CACerts\ipc.crt</Cert>
               <Key>C:\TwinCAT\3.1\Target\CACerts\ipc.key</Key>
            </Tls>
         </Server>
</RemoteConnections>
</TcConfig>
```

Saved changes are accepted when the TwinCAT router is initialized, which takes place, for example, during the transition RUN->CONFIG or CONFIG->CONFIG.

The certificates are X.509 certificates, which can be generated, for example, with OpenSSL. If the key (XML-Element `<Key>`) is to be protected by a password, this can be specified via the XML element `<KeyPwd>`. The .der and .pem formats are supported.

The "CommonName" of the certificate must correspond to the name used when establishing the connection (XML-Element `<Name>`). This behavior can be deactivated with the option `IgnoreCn=" true"`.

If both sides have suitable certificates of a common CA, the route can be created without further information using this dialog:



As described under Server [▶ 195], a specific route is created on both sides as a result of this.

3.2.4.5.5 Deactivating ADS

- The unencrypted ADS is transmitted via the TCP port 48898 (0xBF02)
- The discovery ("Broadcast Search") is transmitted via the UDP Port 48899 (0xBF03)

Both ports can be blocked in the firewall.

The target system can be configured with respect to the ports to be used.

The following keys are available below KEY_LOCAL_MACHINE\SOFTWARE\[WOW6432Node\]Beckhoff\TwinCAT3\System:

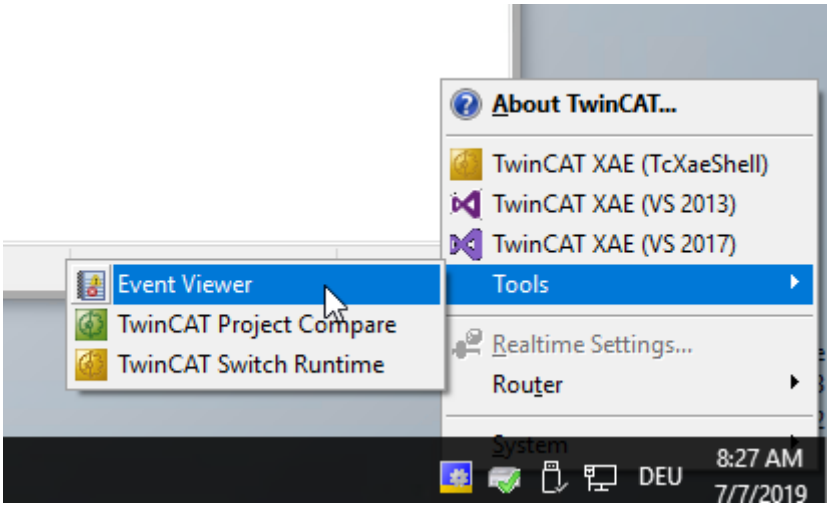
ADS Ports		
DisableAdsTcpListening	REG_DWORD	1 = prevents the opening of the TCP port 0xBF02 for unencrypted ADS.
DisableAdsTlsListening	REG_DWORD	1 = prevents the opening of the TCP port 8016 for Secure ADS
DisableAdsDiscovery	REG_DWORD	1 = prevents the opening of the UDP port 0xBF03 for the ADS discovery ("Broadcast Search")

The attribute `SecureOnly="True"` can additionally be used via the StaticRoutes.xml file. The ADS port 0xBF02 is thereby kept open, but no further ADS communication is allowed via the port.

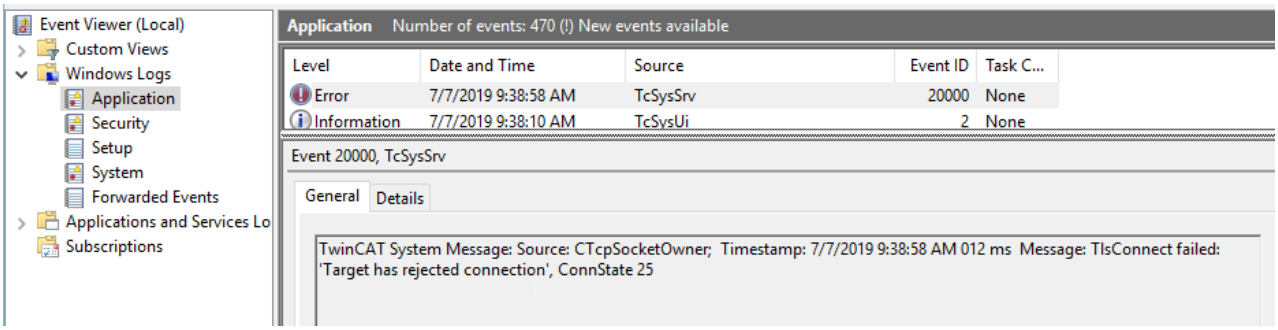
```
<RemoteConnections SecureOnly="True">
```

3.2.4.5.6 Logging

Secure ADS writes information about failed connection establishments in the Windows Event Log, which is available via the TwinCAT System Tray icon.



The messages can be found under the category **Windows Logs > Application**:



3.2.4.6 Sample

3.2.4.6.1 Certificates provided by the customer (CA with certificates)

At this point certificates are generated by means of Open SSL and can be used for the Secure ADS connection.

These instructions do not represent comprehensive advice on the creation and handling of certificates. In particular the validity periods must be observed, which necessitates organizational measures in order to ensure replacement before the expiry of the validities (in this case: 3600 days for CA and 360 days for the respective certificates).

In this example a Certificate Authority (CA) is generated that signs a certificate for both sides (called IPC and CX here) of the communication.

The meaning of the call parameters can be viewed in detail via `openssl help`.

✓ OpenSSL is installed and is available from the command line.

1. Generate a key for the Certificate Authority that will be trusted later.
   ```
   openssl genrsa -out rootCA.key 2048
   ```

2. Generate the certificate with a validity period of 3600 days. Owner information is added via the parameter "-subj".
   ```
   openssl req -x509 -new -nodes -key rootCA.key -sha256 -subj "/C=DE/ST=NRW/
   L=Verl/O=Bk/OU=TCPM/CN=RootCA" -days 3600 -out rootCA.pem
   ```

3. Generate a key for the IPC
   ```
   openssl genrsa -out ipc.key 2048
   ```

4. Generate a Certificate Signing Request (CSR) for this key:
   Please note: The address specified as CN (IP address in this case) must be used as the name when establishing the connection. Alternatively, the route must be parameterized with IgnoreCN.
   ```
   openssl req -out ipc.csr -key ipc.key -subj "/C=DE/ST=NRW/L=Verl/O=Bk/
   OU=TCPM/CN=192.168.2.1" -new
   ```
5. Sign the CSR of the IPC with the CA with a validity of 360 days
   ```
   openssl x509 -req -in ipc.csr -CA rootCA.pem -CAkey rootCA.key
   -CAcreateserial -out ipc.crt -days 360 -sha256
   ```
   ⇨ The route can now be set up on the IPC using these files: rootCA.pem, ipc.key and ipc.pem
6. Generate a key for the CX
   ```
   openssl genrsa -out cx.key 2048
   ```
7. Generate a Certificate Signing Request (CSR) for this key:
   Please note: The address specified as CN (IP address in this case) must be used as the name when establishing the connection. Alternatively, the route must be parameterized with IgnoreCN.
   ```
   openssl req -out cx.csr -key cx.key -subj "/C=DE/ST=NRW/L=Verl/O=Bk/OU=TCPM/
   CN=192.168.2.2" -new
   ```
8. Sign the CSR of the IPC with the CA with a validity of 360 days
   ```
   openssl x509 -req -in cx.csr -CA rootCA.pem -CAkey rootCA.key -CAcreateserial
   -out cx.crt -days 360 -sha256
   ```
   ⇨ The route can now be set up on the CX using these files: rootCA.pem, cx.key and cx.pem

⇨ The route can be used.

3.3 Folder and file types

3.3.1 TwinCAT PLC project files

3.3.1.1 Port_xxx.app

Binary file of the PLC project

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	-	-

3.3.1.2 Port_xxx.autostart

Empty file that activates the Autostart option

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate Autostart option (project-independent system setting).
Requirement	-	

3.3.1.3 Port_xxx.cid

File containing the Compileinfo_IDs

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	-	-

3.3.1.4 Port_xxx.crc

File containing the checksum of the PLC project

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	-	-

3.3.1.5 Port_xxx.occ

Symbolics of the PLC project

- The file contains the changes of the symbolics of the PLC project for an online change.
- If the **Symbolic Mapping** option is not activated, this file also contains the changes of the mapping configuration for an activate/update boot project.
- On activating the configuration the occ file is reset in both directories.

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	-	-

3.3.1.6 Port_xxx.oce

The file contains the changes of the event classes at the time of an OnlineChange, which are used in a PLC project.

Storage location

	Project directory	TwinCAT boot directory
Path	-	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	-	When changing the event classes used and OnlineChange.
Requirement	-	-

3.3.1.7 Port_xxx.ocm

Description file of the mapping configuration

- If the **Symbolic Mapping** option is activated, this file contains the changes of the mapping configuration of the PLC project for an activate/update boot project.
- On activating the configuration the ocm file is reset in both directories.

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a TwinCAT project. • Recreating a TwinCAT project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	-	-

3.3.1.8 Port_xxx_boot.tizip

Archive folder containing the COMPILEINFO file of the boot project

The COMPILEINFO file contains the compilation information and the login information of the PLC project.

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_Boot\<*Platform*>\Plc\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	-	-

3.3.1.9 Port_xxx_act.tizip

Archive folder containing the COMPILEINFO file of the currently running PLC project

Storage location

	Project Directory	TwinCAT boot directory
Path	-	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	-	• PLC login with change
Requirement	-	-

3.3.1.10 Port_xxx.bootdata

Boot file that saves the persistent data

Once the TwinCAT system has started and the PLC has been loaded, the file extension .bootdata is renamed .bootdata-old.

Storage location

	Project Directory	TwinCAT boot directory
Path	-	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	-	• Stop the TwinCAT system. • Use of FB_WritePersistentData.
Requirement	-	-

3.3.1.11 Port_xxx.bootdata-old

Backup file for the persistent data

The file is deleted once the new boot file has been completely written.

Storage location

	Project Directory	TwinCAT boot directory
Path	-	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	-	• Activate configuration. • Restarting the TwinCAT system.
Requirement	-	-

3.3.1.12 PLC_Name.tpzip

Archive folder of the PLC project

The scope of the content is configurable in the project properties.

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_Boot\<*Platform*>*CurrentConfig*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	-	-

3.3.1.13 PLC_Name.tmc

TC3 module description file

Storage location

	Project Directory	TwinCAT boot directory
Path	A)..\<*Solution name*>\<*Project name*>\<*PLC name*>\ B)..\<*Solution name*>\<*Project name*>_Boot\<*Platform*>\Plc\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	A) - B) TMC activated as target file	• TMC activated as target file

3.3.1.14 PLC_Name.tpy

TC2 PLC description file

Storage location

	Project Directory	TwinCAT boot directory
Path	A)..\<*Solution name*>\<*Project name*>\<*PLC name*>\ B)..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc*\	• < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc* • >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Activate boot project. • PLC login with boot project update
Requirement	A) - B) TPY activated as target file	• TPY activated as target file

3.3.2 TwinCAT C++ project files

File	Description	Further information
Engineering / XAE		
*.sln	Visual Studio Solution file, hosts TwinCAT and non-TwinCAT projects	
*.tsproj	TwinCAT project, collection of all nested TwinCAT projects, such as TwinCAT C++ or TwinCAT PLC project	
_Config/	Folder contains further configuration files *(*.xti)* that belong to the TwinCAT project.	See menu Tools| Options| TwinCAT| XAE-Environment| File Settings
_Deployment/	Folder for compiled TwinCAT C++ drivers	
*.tmc	TwinCAT Module Class file (XML-based)	See TwinCAT Module Class Editor (TMC)
*.rc	Resource file	See Set version/vendor information
.vcxproj.	Visual Studio C++ project files	
*ClassFactory.cpp/.h	Class Factory for this TwinCAT driver	
*Ctrl.cpp/.h	Upload and remove drivers for TwinCAT UM platform	
*Driver.cpp/.h	Upload and remove drivers for TwinCAT RT platform	
*Interfaces.cpp/.h	Declaration of the TwinCAT COM interface classes	
*W32.cpp./.def/.idl		
*.cpp/.h	One C++/Header file per TwinCAT module in the driver. Insert user code here.	
Resource.h	Required by *.rc file	
TcPch.cpp/.h	Used for creating precompiled headers	
%TC_INSTALLPATH% \Repository\<Vendor>\<PrjName>\<Version>\<Platform>*.tmx	Compiled driver that is loaded via the TcLoader. TwinCAT 3.1.4024.x: *C:\TwinCAT\3.1\Repository\C++ Module Vendor\Untitled1\0.0.0.1\TwinCAT RT *\Unititled1.tmx* From TwinCAT 3.1.4026.x: C:\ProgramData\Beckhoff\TwinCAT\3.1\Repository\C++ Module Vendor\Untitled1\0.0.0.1\TwinCAT RT *\Unititled1.tmx	See Versioned C++ Projects
%TC_INSTALLPATH% \CustomConfig\Modules*	Published TwinCAT C++ project normally TwinCAT 3.1.4024.x: *C:\TwinCAT\3.1\CustomConfig\Modules** From TwinCAT 3.1.4026.x: C:\ProgramFiles (x86)\Beckhoff\TwinCAT\3.1\Config\Modules*	See Export modules
Runtime / XAR		
%TC_BOOTPRJPATH% \CurrentConfig*	Current configuration setup *Windows:* TwinCAT 3.1.4024.x: *C:\TwinCAT\3.1\Boot* From TwinCAT 3.1.4026.x:	

File	Description	Further information
	Windows: C:\ProgramData\Beckhoff \TwinCAT\3.1\Boot *TwinCAT/BSD: /usr/local/etc/TwinCAT/3.1/Boot*	
%TC_DRIVERAUTOINSTALLPATH% *.sys/pdb	Compiled, platform-specific driver that is loaded via the operating system. *Windows:* TwinCAT 3.1.4024.x: *C:\TwinCAT\3.1\Driver\AutoInstall (loaded by the system)* From TwinCAT 3.1.4026.x: *<not available>* *Please migrate to TMX based C++ projects* *TwinCAT/BSD®:* *<not available>*	
%TC_INSTALLPATH% \Boot\Repository\<Vendor>\<PrjName>\<Version>*.tmx	Compiled platform-specific driver that is loaded via the TcLoader. *Windows:* TwinCAT 3.1.4024.x: *C:\TwinCAT\3.1\Boot\Repository\C++ Module Vendor\Untitled1\0.0.0.1\Untitled1.tmx* From TwinCAT 3.1.4026.x: C:\ProgramData\Beckhoff \TwinCAT\3.1\Boot\Repository\C++ Module Vendor\Untitled1\0.0.0.1\Untitled1.tmx *TwinCAT/BSD: /usr/local/etc/TwinCAT/3.1/Boot\/Repository\C++ Module Vendor\Untitled1/0.0.0.1/Untitled1.tmx*	
%TC_BOOTPRJPATH% \TM\OBJECTID.tmi	TwinCAT Module Instance file Describes variables of the driver File name is *ObjectID.tmi* Windows: TwinCAT 3.1.4024.x: *C:\TwinCAT\3.1\Boot\TMI\OTCID.tmi* From TwinCAT 3.1.4026.x: Windows: C:\ProgramData\Beckhoff \TwinCAT\3.1\Boot\TMI\OTCID.tmi *TwinCAT/BSD: /usr/local/etc/TwinCAT/3.1/Boot/TMI/OTCID.tmi*	
Temporary files		
*.sdf	IntelliSense Database	
*.suo / *.v12.suo	User-specific and Visual Studio-specific files	
*.tsproj.bak	Automatically generated backup file from *tsproj*	
ipch/	Intermediate directory created for precompiled headers	

3.3.3 TwinCAT project files

3.3.3.1 CurrentConfig.xml

Description file of the current configuration.

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>\	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot
Time of creation	• Creating a TwinCAT project. • Recreating a TwinCAT project.	• Activate configuration.
Requirement	-	-

3.3.3.2 CurrentConfig.tszip

Archive folder containing the tsproj file and all referenced xti files.

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>\	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot
Time of creation	• Creating a TwinCAT project. • Recreating a TwinCAT project.	• Activate configuration.
Requirement	• Auto Save <TwinCAT project name> to Target as Archive is active	

3.3.4 PLC HMI files

3.3.4.1 Port_xxx.textlistname.txt

For each text list existing in the project, a file is created containing all the entries in this text list.

Storage location

	Project Directory	TwinCAT boot directory
Path	..\<*Solution name*>\<*Project name*>_*Boot*\<*Platform*>*Plc**Port_xxx**Visu*	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Online Change / Download
Requirement	• Target and/or web visualization object added.	

3.3.4.2 Port_xxx Folder

In this folder a further folder "Visu" is automatically created in which the files and the images of the PLC HMI are saved in turn.

Storage location

	Project Directory	TwinCAT boot directory
Path	*..\<Solution name>\<Project name>_Boot\<Platform>\ Plc*	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot\Plc • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration.
Requirement	• Target and/or web visualization object added.	

3.3.5 PLC HMI files (Target Visualization)

3.3.5.1 tc3plchmi.ini

Configuration file containing the settings of the target visualization client

Storage location

	Project Directory	TwinCAT boot directory
Path	*..\<Solution name>\<Project name>_Boot\<Platform>\ Plc*	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot\Plc • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Online Change / Download
Requirement	• Target visualization object added.	

3.3.6 PLC HMI Web files

3.3.6.1 port_xxx.imagepoolcollection.csv

File containing a list of the entries of all image pools available in the PLC project

Storage location

	Project Directory	TwinCAT boot directory
Path	*..\<Solution name>\<Project name>_Boot\<Platform>\ Plc\Port_xxx\Visu*	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Online Change / Download
Requirement	• Web visualization object added.	

3.3.6.2 webvisu.cfg.json

Configuration file containing the settings of the web visualization object

Storage location

	Project Directory	TwinCAT boot directory
Path	*..\<Solution name>\<Project name>_Boot\<Platform>\Plc\Port_xxx\Visu*	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Online Change / Download
Requirement	• Web visualization object added.	

3.3.6.3 webvisu.htm

HTML page used to display the visualization in the internet browser

Storage location

	Project Directory	TwinCAT boot directory
Path	*..\<Solution name>\<Project name>_Boot\<Platform>\Plc\Port_xxx\Visu*	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Online Change / Download
Requirement	• Web visualization object added.	

3.3.6.4 webvisu.js

File containing the Java Script logic that is used in the visualization

Storage location

	Project Directory	TwinCAT boot directory
Path	*..\<Solution name>\<Project name>_Boot\<Platform>\Plc\Port_xxx\Visu*	• < TC3.1.4026.0: C:\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu • >=TC3.1.4026.0: C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc\Port_xxx\Visu
Time of creation	• Creating a PLC project. • Recreating a PLC project.	• Activate configuration. • Online Change / Download
Requirement	• Web visualization object added.	

3.4 Machine update at file level

3.4.1 Overview

If no TwinCAT 3 development environment (XAE) is available, you can update the boot data of a TwinCAT PLC system or a complete TwinCAT system by means of a file copy.

- Performing a PLC update [▶ 215]

- Performing a C++ update [▶ 215]
- Performing an update of the complete machine [▶ 216]
- Cloning a machine [▶ 216]

A description of the various files as well as information on their storage location within the associated project (project directory) and on the machine (TwinCAT boot directory) can be found in the section Folder and file types [▶ 203].

3.4.2 Performing a PLC update

✓ TwinCAT version TC3.1.4022.0 or higher

✓ Boot data has been generated for the machine platform by creating (or recreating) the PLC project. A connection to the target system is not required when creating (or recreating) the project.

✓ The process image and the hardware configuration have not changed since the last update.

✓ The **Symbolic Mapping** option is activated in the PLC project settings.

1. Copy the boot data of the PLC project, i.e. all files and folders, from the folder *..\<Solution name>\<Project name>_Boot\<Platform>\Plc*.
2. Replace the boot data in the machine's TwinCAT PLC boot directory with the copied boot data.
   ⇨ < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\Plc*
   ⇨ >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\Plc*
3. Restart the machine's TwinCAT system.

⇨ The boot data of the TwinCAT PLC system and thus the PLC runtime itself are updated.

Source code update

If you store the source code of the PLC project on the runtime system in addition to the boot data, you can also copy the archive folder from the folder *..\<Solution name>\<Project name>_Boot\<Platform>\ CurrentConfig* to the folder *CurrentConfig* of the boot directory on the runtime system during a file level update.

< TC3.1.4026.0: *C:\TwinCAT\3.1\Boot\CurrentConfig*

>=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot\CurrentConfig*

3.4.3 Performing a C++ Update

Runtime data can be transferred from one machine to another via file copy if both machines are from the same platform and are connected with equivalent hardware equipment.

The following steps describe a simple procedure for transferring a binary configuration from one machine ("source") to another ("target").

1. Purge the boot folder on the source machine.
   ⇨ < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot*
   ⇨ >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot*
2. Create (or enable) the module on the source machine.
3. Transfer the boot folder from the source to the target machine.
   This folder also contains the repository which contains the required TMX files. The folder is located at the following location on both the source and target machines.
   ⇨ < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot*
   ⇨ >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot*
4. For TwinCAT driver projects (.sys): Transfer the driver *MYDRIVER.sys* and if necessary also the PDB file.
   ⇨ < TC3.1.4026.0: *C:\TwinCAT\3.1\Driver\AutoInstall\MYDRIVER.sys*
   ⇨ >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Driver\AutoInstall\MYDRIVER.sys*

5. For TwinCAT driver projects (.sys) and if the drivers are new on a machine:
   TwinCAT must perform a registration once. Switch TwinCAT to Run mode via SysTray (right click -> **System** -> **Start/Restart**).
   Alternatively, this call can be used (replace “%1” as driver name):
   ⇨ < TC3.1.4026.0:
   ```
   sc create %1 binPath= c:\TwinCAT\3.1\Driver\AutoInstall\%1.sys type=
   kernel start= auto group= "file system" DisplayName= %1 error= normal
   ```
   ⇨ >=TC3.1.4026.0:
   ```
   sc create %1 binPath= C:
   \ProgramData\Beckhoff\TwinCAT\3.1\Driver\AutoInstall\%1.sys type= kernel
   start= auto group= "file system" DisplayName= %1 error= normal
   ```

⇨ You can now start the target machine.

Handling licenses

Note that licenses cannot be transferred in this way. Please use preinstalled licenses, volume licenses, or other methods for providing licenses.

3.4.4 Performing an update of the complete machine

✓ Boot data has been generated for the machine platform by creating (or recreating) the TwinCAT project. A connection to the target system is not required when creating (or recreating) the project.

✓ The real hardware configuration corresponds to the project configuration.

✓ If the machine update is to be performed on multiple machines rather than on a specific machine, the following options are enabled:
Use Relative NetIds in the routes settings (System > Routes, NetIdManagement tab) and
Virtual Device Names in the adapter settings of all network and USB devices
(e.g. I/O > Devices > EtherCAT Master, Adapter tab)
The network adapter names of the machine must match the adapter name in the configuration.

1. Copy the boot data of the TwinCAT project, i.e. all files and folders, from the folder *..\<Solution name>\<Project name>_Boot\<Platform>*.
2. Replace the boot data in the machine’s TwinCAT boot directory with the copied boot data.
   ⇨ < TC3.1.4026.0: *C:\TwinCAT\3.1\Boot*
   ⇨ >=TC3.1.4026.0: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Boot*
3. If you use C++ modules, copy the C++ drivers (see chapter Performing a C++ update [▶ 215]).
4. Restart the machine’s TwinCAT system.

⇨ The boot data of the TwinCAT system and thus the TwinCAT system itself are updated.

3.4.5 Cloning a machine

To transfer the boot data of a TwinCAT or PLC project from one machine to another, copy the boot data from the boot directory of the first machine and replace the boot data in the boot directory of the other machine.

If the TwinCAT system whose boot data is to be copied is in Run mode and persistent data is also to be exchanged, the TwinCAT system should first be switched from Run to Config mode so that the persistent data is saved in the .bootdata file and is available for copying in the boot directory. (See Port_xxx.bootdata [▶ 206])

3.5 Starting the program automatically

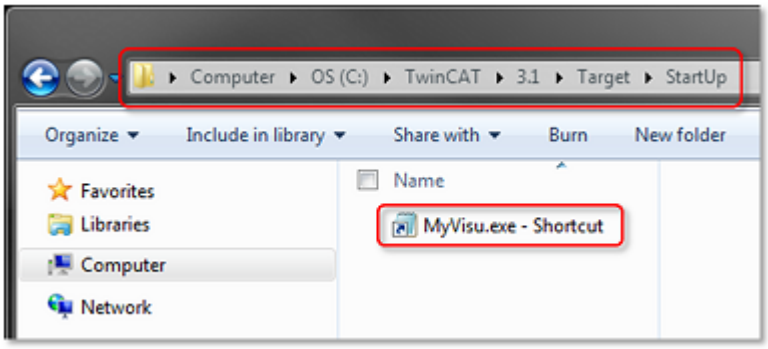
TwinCAT 3 offers the option to start selected programs automatically after startup. This is especially useful for programs where TwinCAT must be started before execution, e.g. visualization software.

To start a program automatically after TwinCAT startup, a shortcut of the program must be created in a special startup folder in the TwinCAT directory. The program itself must be installed locally on the same PC as TwinCAT. After the first activation of the Run Mode after starting the TwinCAT runtime system, the shortcuts in the Startup folder are executed.

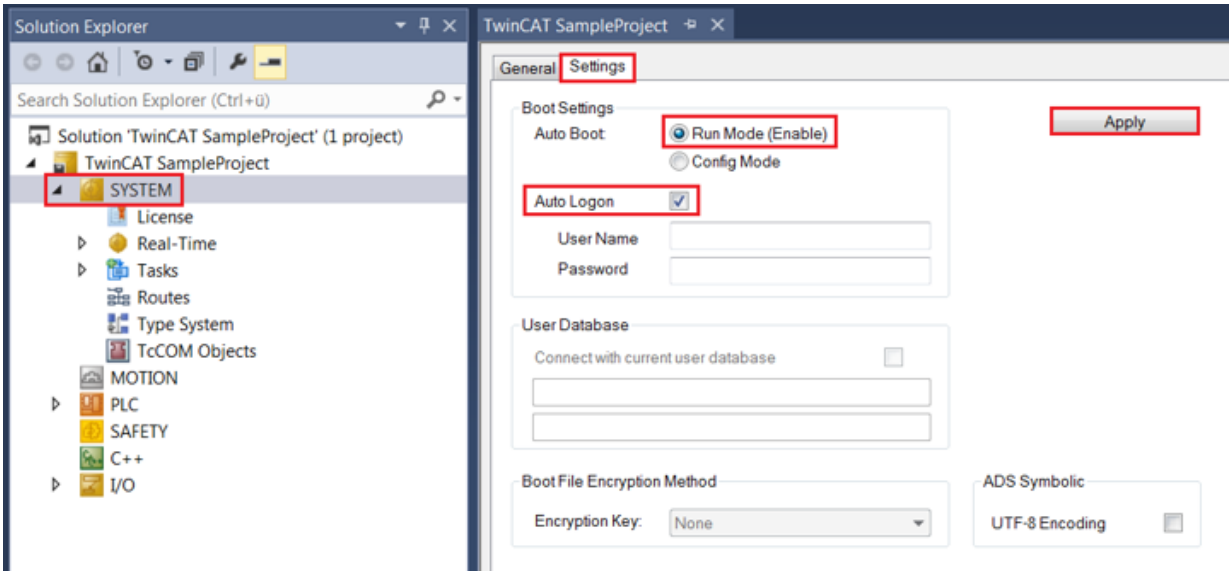
The path *<TwinCAT>\3.x\Target\StartUp* leads to the startup folder. The designation results as follows:

<TwinCAT>	TwinCAT installation folder • < TC3.1.4026.0: C:\TwinCAT\ • >=TC3.1.4026.0: C:\Program Files (x86)\Beckhoff\TwinCAT\
3.x	TwinCAT version (all versions of TwinCAT are stored in separate folders in the TwinCAT installation folder).
x	Placeholder for the build of TwinCAT, e.g. "3.1".

1. Save a shortcut to the program in the folder *<TwinCAT>\3.x\Target\StartUp*.



2. Make sure that TwinCAT starts in Run Mode.
3. In the TwinCAT project tree, double-click on **SYSTEM** and select the **Settings** tab.



4. Enable the options **Run Mode (Enable)** and **Auto Logon.**
5. Click **Apply**.

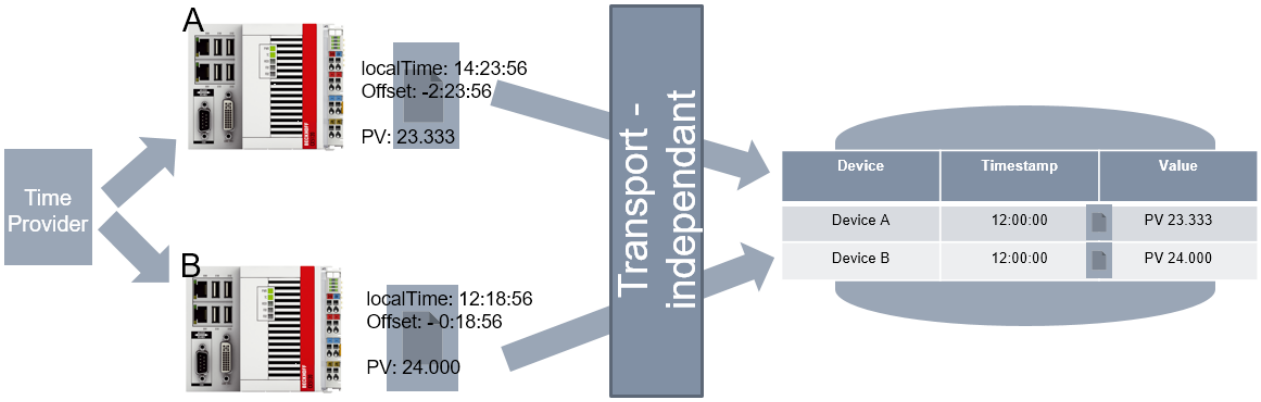
3.6 Corrected time stamps

3.6.1 Overview

Controllers generate data to be collected and linked in modern, distributed systems.
Since controllers start off as stand-alone devices, they have independent time bases. In a common database, it would not be possible to correlate data with respect to time.

In order to counter this problem, it has been possible for quite some time to synchronize controllers with each other, for example using the network protocol IEEE1588 or PTP.
However, in many scenarios it is sufficient to provide the data with a uniform timestamp. The controllers can be operated independently of each other, so that on the one hand the hardware costs associated with the

protocols mentioned above are reduced, while on the other hand there is no technical dependency between the controllers.
This chapter describes the TwinCAT components for adapting timestamps for storing time-synchronous data.



The figure illustrates the basic idea: independent controllers obtain the local timestamp and adjust it using an offset, which is then used to store the common data.

A central component, the external time interface, is available in TwinCAT real-time for this purpose. This component

- receives the offset to the corrected time from a configured source (external time provider).
- provides the external time consumer with a corrected time, depending on the current local time.

This corrected time can then be used by different components inside and outside the real-time.

The source is typically either an NTP server or a DC time signal based on EtherCAT, which is synchronized via EL6688 through PTP (IEEE1588), for example. However, a source can also be implemented by the customer, so that other time signals can be realized as a source.

In addition to the central component in the TwinCAT real-time described above, the concept thus comprises two types of components:

1. External time providers: provide an offset for adjusting timestamps of the central component.
   For example, a provider obtains a timestamp via NTP (Network Time Protocol, see RFC 4330), from which it calculates an offset to the local system time and makes this available.
2. External time consumers: use an offset that they obtain from the central component. Thus a timestamp can be used in the components that leads to comparable data on remote devices.
   All TwinCAT components that use timestamps can be consumers, and also customer applications.

3.6.2 System requirements

Technical data	Requirement
Operating system	Windows 10
Target platform	PC architecture (x86, x64)
TwinCAT version	TwinCAT 3.1 build 4024.0 or higher
Required TwinCAT setup level	TwinCAT 3 XAE, XAR
Required TwinCAT license	Any runtime license (PLC, C++)

3.6.3 Limitations

Some important limitations have to be taken into account:

- The TwinCAT system time is not changed by the external time interface described here
- The external time offsets are made available to the consumers as provided by the provider. It follows that
  - the offset must be calculated correctly by the provider.

- no monotony can be guaranteed in the timestamps.

- The external time offsets are not saved and subsequently made available for retrieval. This means that only the current offsets are managed in the TwinCAT system.

3.6.4 Technical introduction

TwinCAT offers different interfaces for the external time provider and the external time consumer in order to utilize the concept of corrected timestamps.

On the external time consumer side, different TwinCAT components are able to use the external timestamp. In addition, there are different access options for applications.

On the external time provider side, modules are provided that can calculate and provide an offset via NTP. In addition, there is a module that can use the offset via DC. The corresponding interface for providing the offset is also offered for TwinCAT C++, so that customers can create their own external time providers.

Timestamps for different use cases

It should be noted that TwinCAT differentiates between four types of timestamps in this concept:

1. None: Local system time and no correction
2. Soft: Recommended use e.g. for NTP
3. Medium: Recommended use e.g. for IEEE1588
4. Hard: Recommended use e.g. for hardware synchronization where no drift should occur

An external time provider provides one of the possible offsets; only one provider can be defined for each type.

An external time consumer can then use any offset; all four offset types can be used as required. Thus it is possible to use different timestamps in different ensembles or operation modes. For example, a local diagnosis can take place with the local system time, while at the same time aggregated data from different systems can be corrected with the offset type Soft and stored in a common database.

The interfaces of the corrected timestamps use data types with a length of 8 bytes and are counted from 1.1.1601 in 100 ns steps.

3.6.4.1 Consumers

External time consumers are components that can correct the local system time with an offset. For this purpose, the components must select or configure an offset of type Soft, Medium or Hard and query it accordingly.

3.6.4.1.1 TwinCAT components as offset consumers

The following TwinCAT components support the approach of corrected timestamps – the respective documentation describes how this functionality can be enabled:

- TwinCAT 3 EventLogger
- TwinCAT Scope

This list will be extended.

3.6.4.1.2 Application implementation

Applications can use the external time offsets in different components:

- Real-time PLC: The PLC can query an offset or have a local timestamp corrected accordingly.
- Real-time – C++: C++ TcCOM modules are able to query the offset and act accordingly.
- User mode – ADS device notifications: The timestamps sent with the ADS device notifications can be corrected.

- User mode – ADS Read: The corrected timestamp can be retrieved by an ADS Read. This can be used in ADS Sum commands to retrieve a timestamp along with data.

The interfaces are documented in the corresponding API chapters.

3.6.4.2 Provider

External time providers are components that determine an external time offset in relation to the local system time through an external information source and make it available in TwinCAT. This allows external time consumers to receive a corrected time, independent of the provider.

TwinCAT also supplies providers with:

- NTP providers: an implementation that queries and provides a time signal from an NTP server via (S)NTP.
- DC providers: An implementation that passes on the DC time from the EtherCAT master to TwinCAT as an offset (e.g. via IEEE1588 or PTP)
- In addition, the customer is able to provide his own providers.

3.6.4.2.1 NTP provider

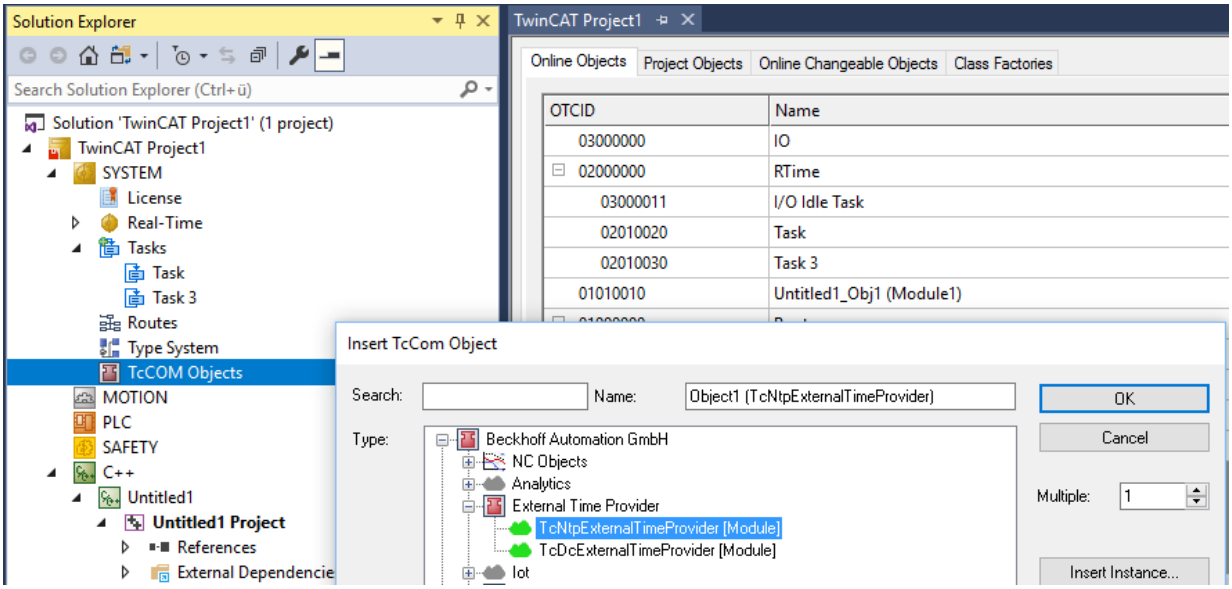
The NTP provider is an (S)NTP client that cyclically receives a time signal from an NTP server. This allows it to calculate an offset of the system time from the time signal of the NTP server and make it available accordingly.

Configuration

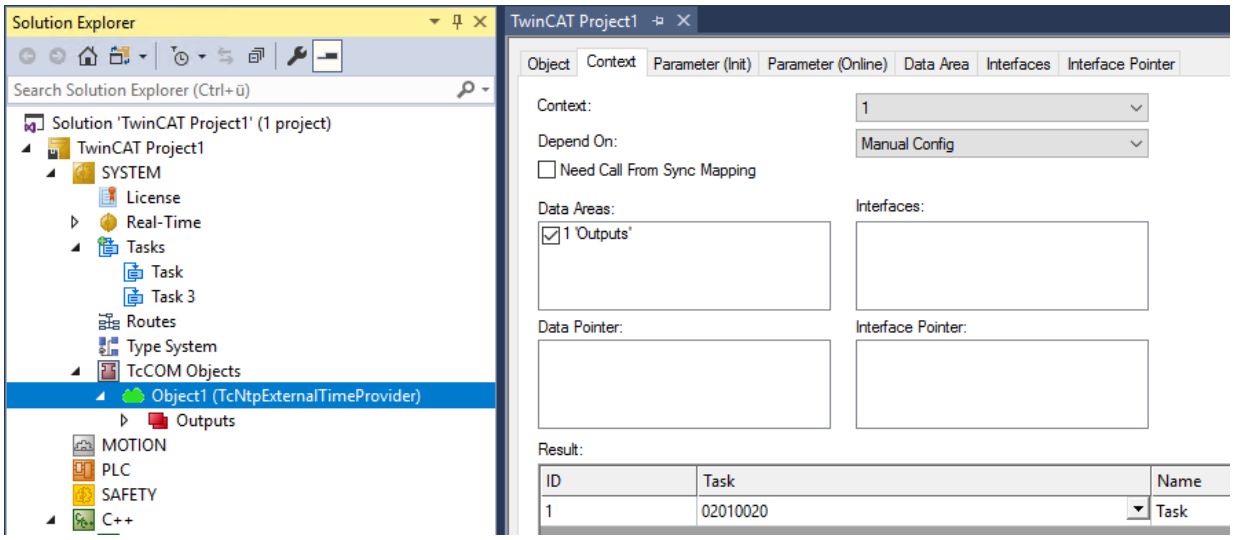
The NTP provider is implemented as TcCOM module TcNtpExternalTimeProvider. This module is commissioned as a TcCOM module as follows:

✓ TwinCAT project

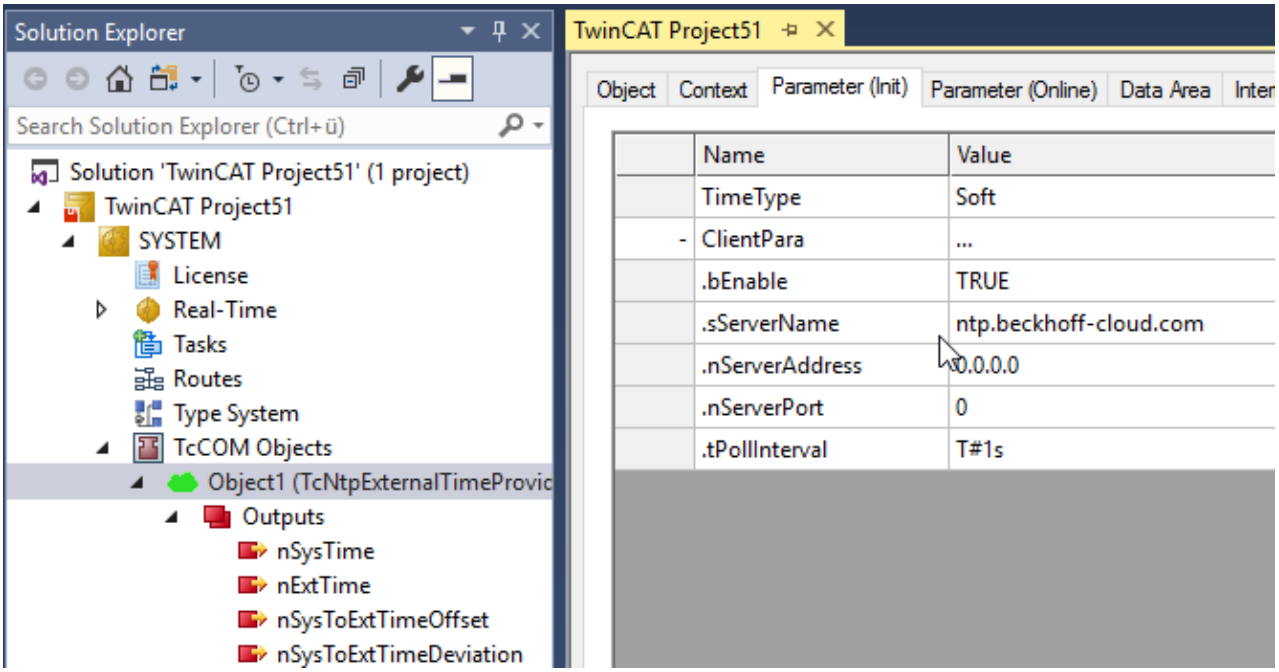
1. Insert a TcCOM module under System->TcCOM Objects and select type TcNtpExternalTimeProvider in the category External Time Provider.



2. The module requires a task from which it is called. This is parameterized via the **Context** tab of the module:



⇨ The TcCOM module can be parameterized:



The configuration takes place in the **Parameter (Init)** tab. The parameters have the following meanings:

- **TimeType:** The type of offset for which this module is to determine an offset.

Client Para:

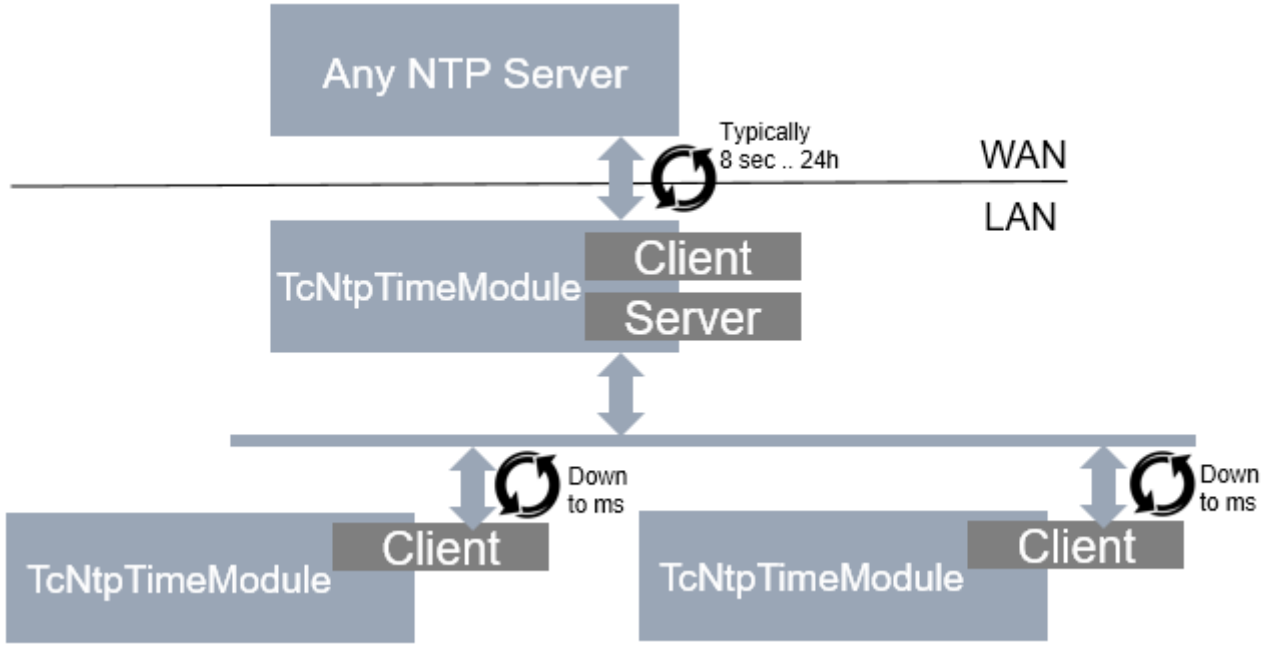
- **bEnable:** The module can be disabled to prevent NTP communication.
- **sServerName:** The name of the NTP server to be used as the source.
- **nServerAddress:** IP address of an NTP server (used if sServerName is empty).
- **nServerPort:** The UDP port of the NTP server to be used (default: 123).
- **tPollIntervall:** The interval in which the NTP queries are to be started. The maximum specified by the server is taken into account, which may slow down requests.

This module passes a determined offset to TwinCAT via the ITcSetExternalTime [▶ 227] interface. In addition, outputs are available for mapping.

NTP provider as NTP server

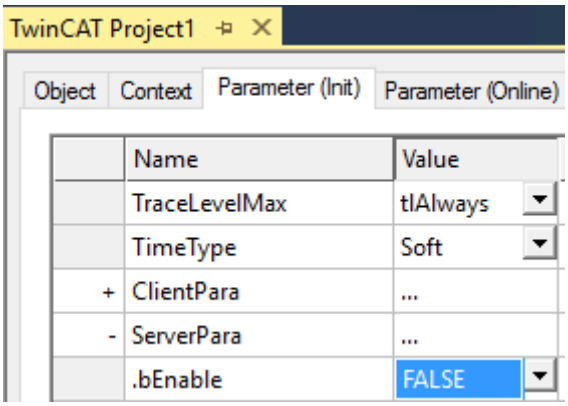
Optionally, the same module can also act as an NTP server. Thus, a time signal can be obtained from an external NTP server (as a client) and simultaneously provided to lower-level systems.

For the external server, the NTP protocol typically requires a minimum query time of 8 seconds or more. The NTP provider as NTP server, on the other hand, allows more frequent query intervals.



Server function

The server functionality is normally hidden. It can be displayed and configured via **Show Hidden Parameters**:



- **bEnable:** Enable NTP server functionality for this module. To do this, open the udp/123 port in the Windows firewall.
- **nPort:** The UDP port that is used to offer the server (default: 123).

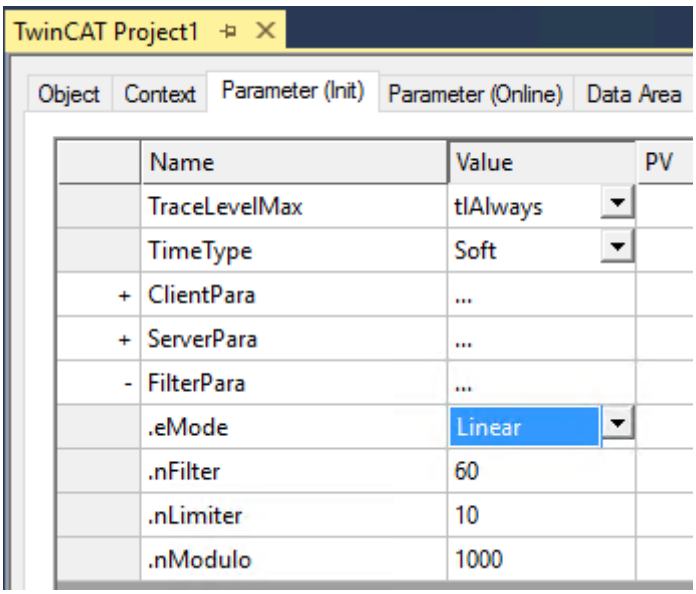
The following parameters are used to adjust the NTP information provided. By default, the parameters are set as specified in the protocol; they can be overwritten here:

- **nLeap:** Manual configuration of the Leap Indicator.
- **nStratum:** Manual configuration of the stratum.
- **nRoot:** Manual configuration of the root server information, as defined depending on the stratum.

Filter function

If offsets are determined by the NTP server query, the module can independently perform a transition from the old offset to the new offset.

This functionality is normally hidden. It can be displayed and configured via **Show Hidden Parameters**:



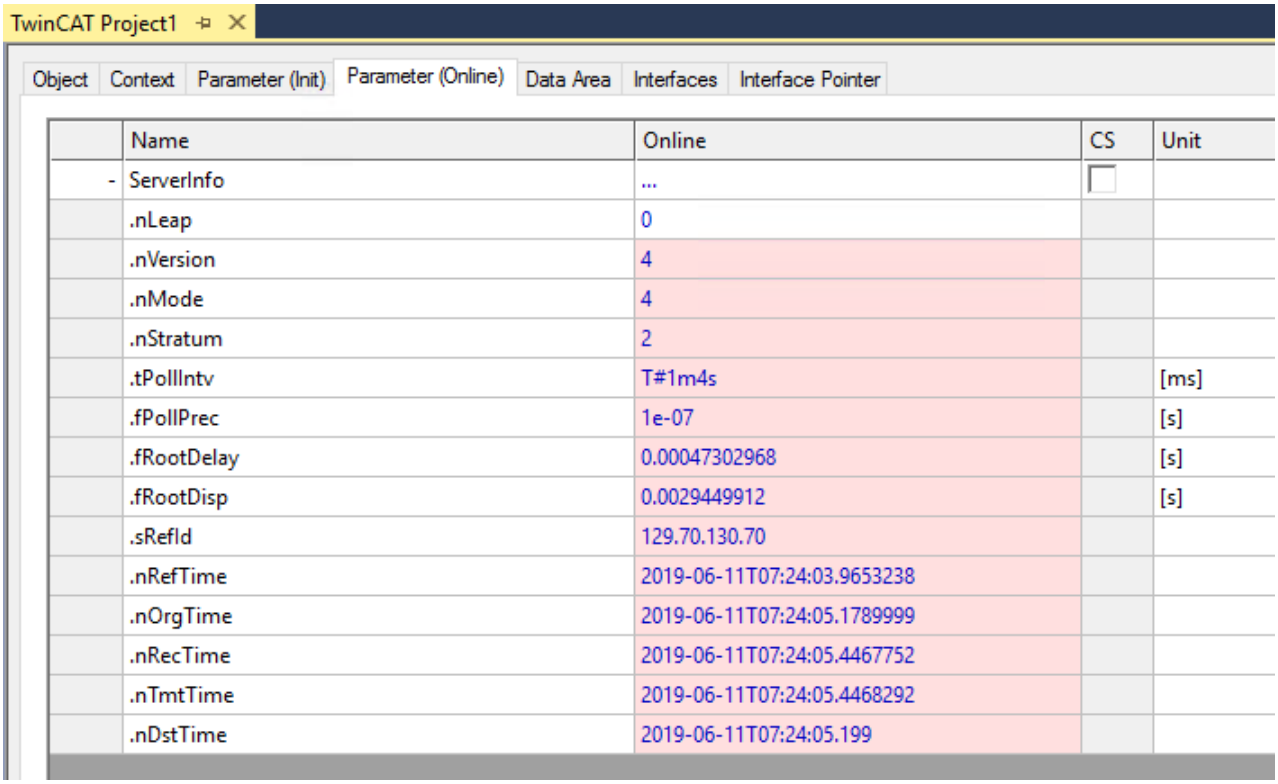
- **eMode**: A selection of modes. Currently, either no adjustment or a linear adjustment is made (default).

The following parameters apply if "Linear" is selected as eMode:

- **nFilter**: Number of values for which the average is taken, i.e. number of NTP responses. With a poll interval of 1 s, nFilter = 60 would effect a filter for one minute. (Default: 60).
- **nLimiter**: The offset is changed by this value at the most per cycle. If the difference between the local and external clocks were to be 100 ms and the cycle time 1 ms, it would thus take 100,000 cycles or 1.6 minutes at nLimiter = 10 until the offset has settled. (Default: 1 µs).
- **nModulo**: Rounding of the offset. Usually this should be chosen depending on the cycle time. The offset is adjusted via this modulo so that no "un-round" times are created. The DC Time will return the modulo of the cycle time; corrected with the offset, the timestamp thus remains "round". The offset/ timestamp changes as a result, but also with small jumps if an adjustment takes place. As described under nLimiter and with nModulo = 1000, the offset and thus the relative timestamp would increment every 100th cycle by 0.1 ms.

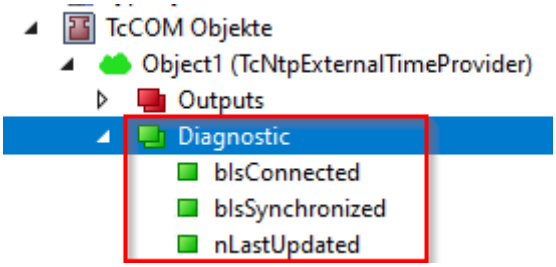
Diagnostics

Diagnostic information can be viewed under the **Parameters (Online)** tab.



For each line there is a corresponding description in the **Comment** column.

In addition, corresponding symbols are available for programmatic evaluation:



- **bIsConnected**: At least 8 successful responses were received from the server (TRUE) or at least 8 requests were not answered (FALSE).
- **bIsSynchronized**: The determined time of the client has been determined in the last 8 responses with a deviation smaller than the cycle time of the server.
- **nLastUpdate**: The time of the last evaluated response from the server.

3.6.4.2.2 DC provider

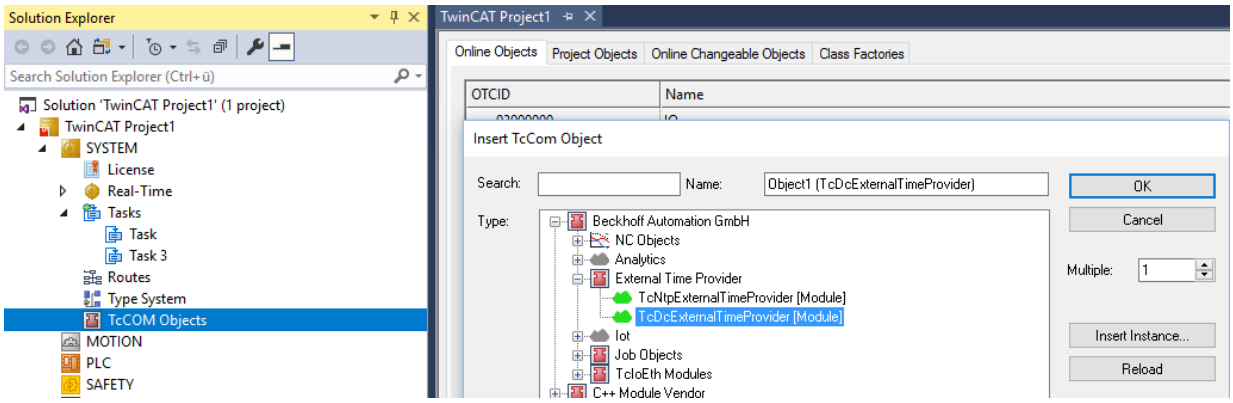
The DC provider obtains an offset through mapping from an EtherCAT master. It can be used to use time values from the I/O range as offset, such as those provided by the EtherCAT master (DC time) or an EL6695.

Configuration

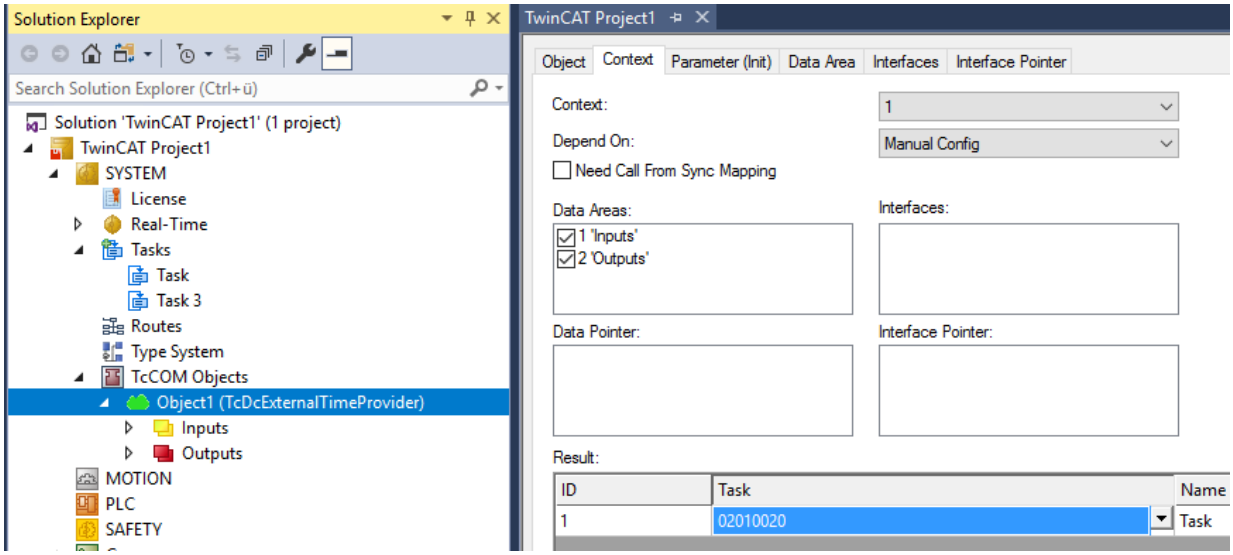
The DC provider is implemented as TcCOM module TcDcExternalTimeProvider. This module is commissioned as a TcCOM module as follows:

✓ TwinCAT project

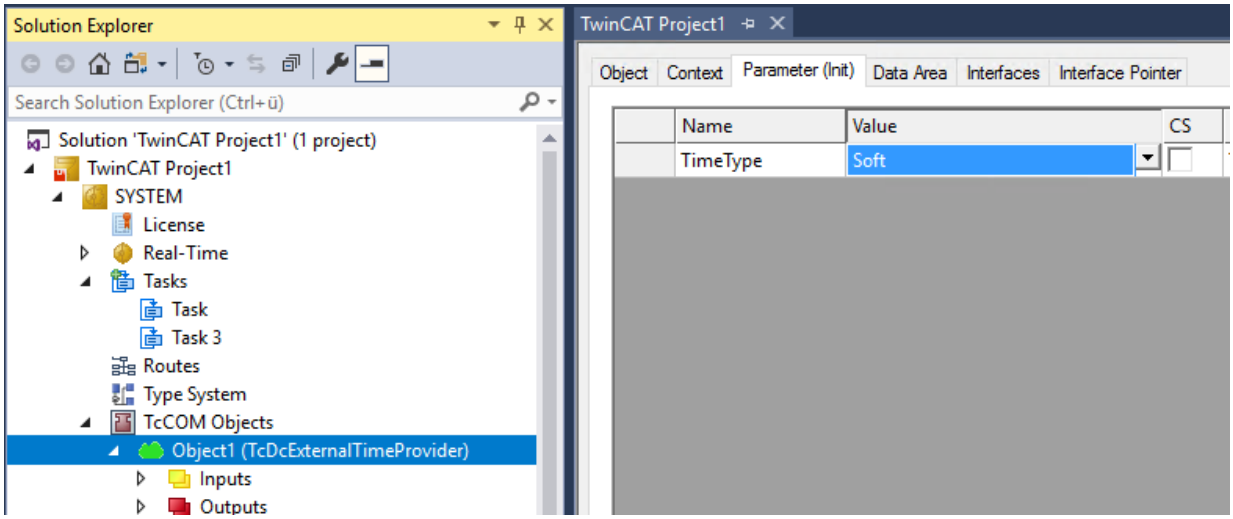
1. Insert a TcCOM module under System->TcCOM Objects and select type TcDcExternalTimeProvider in the category External Time Provider.



2. The module requires a task from which it is called. This is parameterized via the context tab of the module:



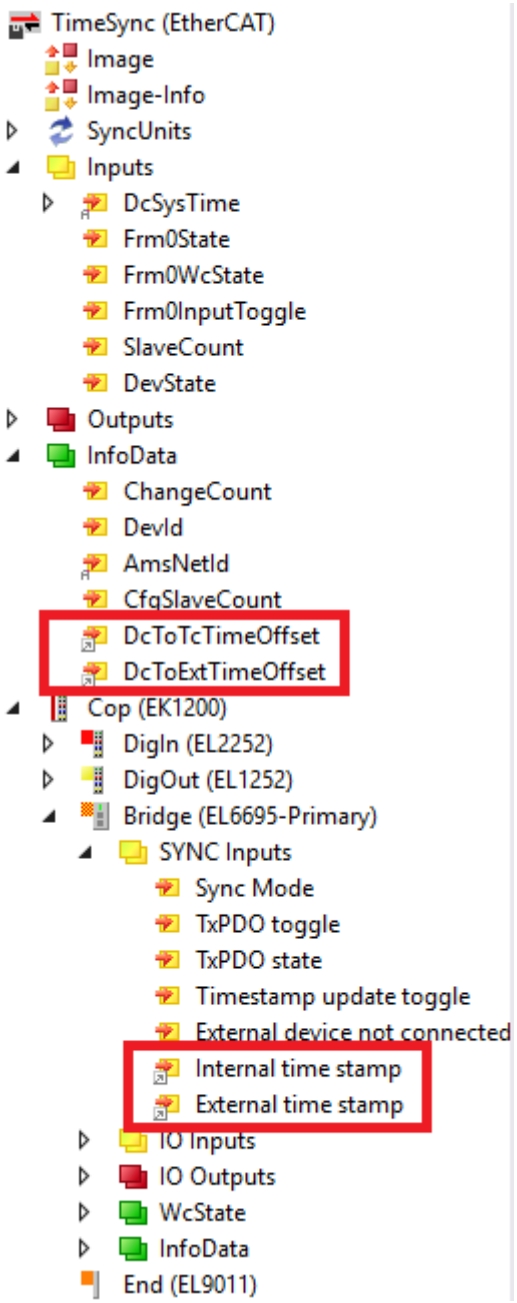
⇨ The module can be parameterized:



The configuration takes place in the Parameters (Init) tab. The parameters have the following meanings:

- TimeType: The type of offset for which this module is to determine an offset.

- This module obtains the offset itself through mapping:



This module passes a determined offset to TwinCAT via the ITcSetExternalTime [▶ 227] interface. In addition, outputs are available for mapping.

3.6.4.2.3 Application implementation

An application can provide its own TimeOffset provider by using the ITcSetExternalTime interface in TwinCAT C++.

This module provides a cyclic value for the respective offsets, if necessary.

Sequence

A module implements the following sequence

✓ A TcCOM module was instantiated

1. The module registers itself as provider of a certain type of offset (Soft/Medium/Hard) via RegisterExternalTimeProvider

2. SetExternalTimeOffset can be used to provide an offset cyclically, if necessary
3. The module logs off using UnregisterExternalTimeProvider

Registration ensures that an offset of only one module can be used at a time.

A more detailed description of the ITcSetExternalTime interface can be found in chapter ITcSetExternalTime interface [▶ 227].

3.6.5 Real-time API

At this point, interfaces and structures are documented to deal with the corrected timestamps from the real-time.

3.6.5.1 Structures

3.6.5.1.1 Enum TimeType

TwinCAT provides four different timestamps. The Enum TimeType is used to distinguish between them.

Syntax

```
enum TimeType {
SystemTime = 0,
ExternalTimeHard = 1,
ExternalTimeMedium = 2,
ExternalTimeSoft = 3, // e.g. NTP
};
```

Values

How the three external timestamp types are used in practice depends on application. The example below is merely a suggestion.

Name	Description
ExternalTimeHard	Suggested use for hard offsets that have no drift
ExternalTimeMedium	Suggested use for accurate offsets such as IEE1588
ExternalTimeSoft	Suggested use for general offsets, such as NTP

3.6.5.2 Interfaces

At this point the interfaces are described which are used for the corrected time stamps.

For the different time formats and representations there is a corresponding list in the C++ SDK.
See: Infosys C/C++

3.6.5.2.1 ITcSetExternalTime interface

The ITcSetExternalTime interface is implemented by the TcCOM object server. It can be used to provide an externally determined offset.

Syntax

```
TCOM_DECL_INTERFACE("00000067-0000-0000-e000-000000000064", ITcSetExternalTime)
struct __declspec(novtable) ITcSetExternalTime : public ITcExternalTime
```

Methods

Name	Description
RegisterExternalTimeProvider [▶ 228]	Registering a provider for an offset related to TimeType
UnregisterExternalTimeProvider [▶ 228]	Logging off a provider for an offset related to TimeType
SetExternalTimeOffset [▶ 228]	Provide a new offset for the registered TimeType

Comments

This interface is not available for the PLC.

3.6.5.2.1.1 RegisterExternalTimeProvider method

Registering a provider for an offset related to TimeType

Syntax

```
HRESULT TCOMAPI RegisterExternalTimeProvider(OTCID oidProvider, TimeType type) = 0;
```

Parameter

oidProvider: (type: OTCID) The object ID of the provider; normally the object ID of the calling party

type: (type: TimeType [▶ 227]) The TimeOffset type to be registered.

Return value

Type: HRESULT

Notifies the success of registration

Description

3.6.5.2.1.2 UnregisterExternalTimeProvider method

Logging off a provider for an offset related to TimeType

Syntax

```
HRESULT TCOMAPI UnregisterExternalTimeProvider(OTCID oidProvider, TimeType type) = 0;
```

Parameter

oidProvider: (type: OTCID) The object ID of the provider; normally the object ID of the calling party

type: (type: TimeType [▶ 227]) The TimeOffset type to be logged off.

Return value

Type: HRESULT

Notifies the success of the deregistration

Description

3.6.5.2.1.3 SetExternalTimeOffset method

Provide a new offset for the registered TimeType

Syntax

```
HRESULT TCOMAPI SetExternalTimeOffset(OTCID oidProvider, TimeType type, __int64 offset) = 0;
```

Parameter

oidProvider: (type: OTCID) The object ID of the provider; normally the object ID of the calling party

type: (type: TimeType [▶ 227]) The TimeOffset type

offset: (type: __int64) The new offset value.

Return value

Type: HRESULT

Notifies the success.

Description

It is valid for the offset ExternalTime = Internal Time + Offset. I.e. if the time in TwinCAT is in the past, the offset must be greater than 0.

3.6.5.2.2 ITcExternalTime interface

The ITcExternalTime interface is implemented by the TcCOM object server. This can be used to retrieve and use an externally determined offset.

Syntax

```
TCOM_DECL_INTERFACE("00000066-0000-0000-e000-000000000064", ITcExternalTime)
struct __declspec(novtable) ITcExternalTime : public ITcUnknown
```

Methods

Name	Description
SystemTimeToExternalTime [▶ 229]	Calculation of a corrected timestamp in relation to the system time
ExternalTimeToSystemTime [▶ 230]	Calculation of the system time in relation to a corrected timestamp
GetExternalTimeOffset [▶ 230]	Retrieving an offset in relation to the TimeType
GetExternalTimeProvider [▶ 230]	Queries the ObjectID of the current provider

3.6.5.2.2.1 SystemTimeToExternalTime method

Calculation of a corrected timestamp in relation to the system time

Syntax

```
HRESULT TCOMAPI SystemTimeToExternalTime(TimeType type, __int64& time) = 0;
```

Parameter

type: (type: TimeType [▶ 227]) The TimeOffset type to be used for the calculation

time: (type: __int64&) The timestamp to be corrected by offset

Return value

Type: HRESULT

Notifies the success.

Description

3.6.5.2.2.2 ExternalTimeToSystemTime method

Calculation of the system time in relation to a corrected timestamp

Syntax

```
HRESULT TCOMAPI ExternalTimeToSystemTime(TimeType type, __int64& time) = 0;
```

Parameter

Type: (type: TimeType [▶ 227]) The TimeOffset type to be used for the calculation

time: (type: __int64&) The corrected timestamp, adjusted by the offset.

Return value

Type: HRESULT

Notifies the success.

Description

The offset valid at the time of the call is used to determine the local system time.

3.6.5.2.2.3 GetExternalTimeOffset method

Retrieving an offset in relation to the TimeType

Syntax

```
HRESULT TCOMAPI GetExternalTimeOffset(TimeType type, __int64& offset) = 0;
```

Parameter

type: (type: TimeType [▶ 227]) The TimeOffset type to be retrieved

offset: (type: __int64&) The value set to the offset.

Return value

Type: HRESULT

Notifies the success.

Description

3.6.5.2.2.4 GetExternalTimeProvider method

Queries the ObjectID of the current provider

Syntax

```
HRESULT TCOMAPI GetExternalTimeProvider(TimeType type, OTCID& oidProvider) = 0;
```

Parameter

type: (type: TimeType [▶ 227]) The TimeOffset type whose provider is to be queried.

oidProvider: (type: OTCID&) The ObjectID that is set to the ObjectID of the provider.

Return value

Type: HRESULT

Notifies the success.

Description

3.6.6 ADS API

The TimeOffsets can also be queried via ADS. There are two ways to do this

1. ADS Notification: ADS notifications contain a time stamp that contains the time at which the data was changed.
   An ADS client sends an ADS command before the AddDeviceNotification. This causes the target system to register which type of corrected time stamp is required from this ADS client.
2. ADS Read: A corrected time stamp can be read out via ADS Read. This can be used to obtain a corrected time stamp in an ADS Sum command at the time when the ADS commands were executed.

Index group	Index offset	Access	Data type	Description	Note
ADSIGRP_EXTERNALTIME 0xF088					
	ADSIOFFS_EXTERNALTIME_SET 0x0000	R	LONG	Read the currently configured offset type for the respective ADS client (AmsNetAddr incl. client port).	The return value is type 0 = None, 1 = Hard, 2 = Medium, 3 = Soft
	ADSIOFFS_EXTERNALTIME_SET 0x00__	W		Set the offset type for the ADSDevice notifications of the respective ADS client (AmsNetAddr incl. client port).	__ is type 0 = None, 1 = Hard, 2 = Medium, 3 = Soft
	ADSIOFFS_EXTERNALTIME_OFFSET 0x01__	R	LONGLONG	Reading the current offset for a type.	__ is type: 0 = None, 1 = Hard, 2 = Medium, 3 = Soft
	ADSIOFFS_EXTERNALTIME_OFFSET 0x01__	W	LONGLONG	Setting the current offset for a type.	__ is type: 0 = None, 1 = Hard, 2 = Medium, 3 = Soft
	ADSIOFFS_EXTERNALTIME_ABSOLUTE 0x02__	R	LONGLONG	Reading the corrected time stamp.	__ is type: 0 = None, 1 = Hard, 2 = Medium, 3 = Soft
	ADSIOFFS_EXTERNALTIME_PROVIDER 0x03__	R	ULONG	Reading the object ID from the TimeOffset provider.	__ is type: 0 = None, 1 = Hard, 2 = Medium, 3 = Soft
	ADSIOFFS_EXTERNALTIME_SETALL 0x0400	R	LONG	Reads the type that is used if no other type is set.	The return value is type 0 = None, 1 = Hard, 2 = Medium, 3 = Soft
	ADSIOFFS_EXTERNALTIME_SETALL 0x04__	W		Sets the type that is used if no other type is set.	__ is type 0 = None, 1 = Hard, 2 = Medium, 3 = Soft

The Defines can be found in the file "Ads.h".

The ADS consumer sample [▶ 233] illustrates the application.

3.6.7 Samples

Various samples illustrating the use of the corrected timestamps are provided for the benefit of the user:

- PLC Consumer [▶ 233]: A PLC program accesses corrected timestamps.
- C++ Consumer [▶ 234]: A C++ TcCOM module accesses corrected timestamps.
- ADS Consumer [▶ 233]: An ADS client in user mode accesses the corrected timestamps.

- C++ Provider [▶ 234]: A C++ TcCOM module determines an offset and provides it.

The corrected timestamps are also used by other components of the TwinCAT system. A required configuration can be found with the respective components.

3.6.7.1 ADS consumer

The ADS Consumer sample retrieves corrected timestamps as described in the ADS API [▶ 231].

Download

Here you can access the https://infosys.beckhoff.com/content/1033/tc3_Grundlagen/Resources/7705550603.zip for this sample.

✓ Start the TwinCAT target system with which the ADS Consumer sample is to communicate. The PLC Consumer [▶ 233] sample can be used.

1. Unpack the downloaded ZIP file.
2. Open the included vcxproj file in Visual Studio.
3. Adjust the target AmsNetID. (TcExternalTimeAdsClient.cpp, line 119)

⇨ The sample is ready for operation.

Description

The sample code can be found in the CPP file TcExternalTimeAdsClient.cpp

Different UseCases for receiving corrected timestamps are illustrated in the Main() method:

- Reading of the provider, the offset and the corrected timestamp from the system service for the different offsets: uncorrected(0), soft(1), medium(2), hard(3), plus an invalid value (4) to illustrate the error behavior.
- Reading the corrected timestamps from a PLC program for the different offsets.
- Reading the provider used and all providers.
- Subscribing to a variable in the PLC; the time provided via notification has a corrected timestamp. The output takes place in the AdsNotificationCallback() method.

3.6.7.2 PLC Consumer

The PLC Consumer sample retrieves a corrected timestamp from the TwinCAT system and uses it.

Download

Here you can access the https://infosys.beckhoff.com/content/1033/tc3_Grundlagen/Resources/7705583115.zip for this sample.

1. Open the tszip file that it contains in TwinCAT 3 by clicking on **Open Project ….**
2. Select your target system.
3. Build the sample on your local machine (e.g. **Build->Build Solution**).
4. Activate the configuration by clicking on  .

⇨ The sample is ready for operation.

Description

The TcNtpExternalTimeProvider is configured under **System > TcCOMObjects**.
Here you can parameterize your own NTP server under **Parameter (Init)**, if the default pool.ntp.org cannot be reached.

The PLC program essentially consists of the function block FB_TcExternalTime. It provides functions for reading a corrected timestamp from the TwinCAT system. The variable _eTimeType represents the type (soft, medium, hard) and can be parameterized.

In MAIN, this function block is used for the eTimeType "Soft" to ensure that the corrected time set by NTP is used.

3.6.7.3 C++ consumer

The C++ Consumer sample retrieves a corrected timestamp from the TwinCAT system and uses it.

Download

Here you can access the https://infosys.beckhoff.com/content/1033/tc3_Grundlagen/Resources/7705552907.zip for this sample.

1. Open the zip file that it contains in TwinCAT 3 by clicking on **Open Project ….**
2. Select your target system.
3. Build the sample on your local machine (e.g. **Build->Build Solution**).
4. Activate the configuration by clicking on  .

⇨ The sample is ready for operation.

Description

The TcNtpExternalTimeProvider is configured under **System > TcCOMObjects**.

Here you can parameterize your own NTP server under **Parameter (Init)**, if the default pool.ntp.org cannot be reached.

The C++ module cyclically determines a local timestamp in the CycleUpdate() method and corrects it. It can be traced in the respective steps using the debugger. The corrected timestamp is provided as a parameter (online).

The type required for this can be configured as parameter "TimeType" in the TcCOM object.

3.6.7.4 C++ provider

The C++ provider sample determines an offset and stores it in the TwinCAT system so that it can be used by the consumers.

Download

Here you can access the https://infosys.beckhoff.com/content/1033/tc3_Grundlagen/Resources/7705555211.zip for this sample**.**

1. Unpack the downloaded .zip file.
2. Open the .zip file that it contains in TwinCAT 3 by clicking on **Open Project ….**
3. Select your target system.
4. Build the sample on your local machine (e.g. **Build->Build Solution**).
5. Activate the configuration by clicking on  .

⇨ The sample is ready for operation.

Description

The offset provider receives the offset to be provided as DataArea "ExternalTime.nOffset“. This is transferred to the TwinCAT system as a TimeType medium, which can also be configured at runtime under **Parameter (Init)**.

In the CycleUpdate() method, the SetExternalTimeOffset method is used for this after a corresponding register has been created using RegisterExternalTimeProvider for a TimeType.

3.6.8 FAQ

3.6.8.1 Windows as NTP client

Windows itself offers an NTP client for the system time. In addition, an NTP time can be retrieved using the following script, which is useful for debugging purposes:

```
@echo off
set /p Server=Server:
w32tm /stripchart /computer:%Server% /packetinfo /samples:10
pause
```

3.6.8.2 Windows as NTP server

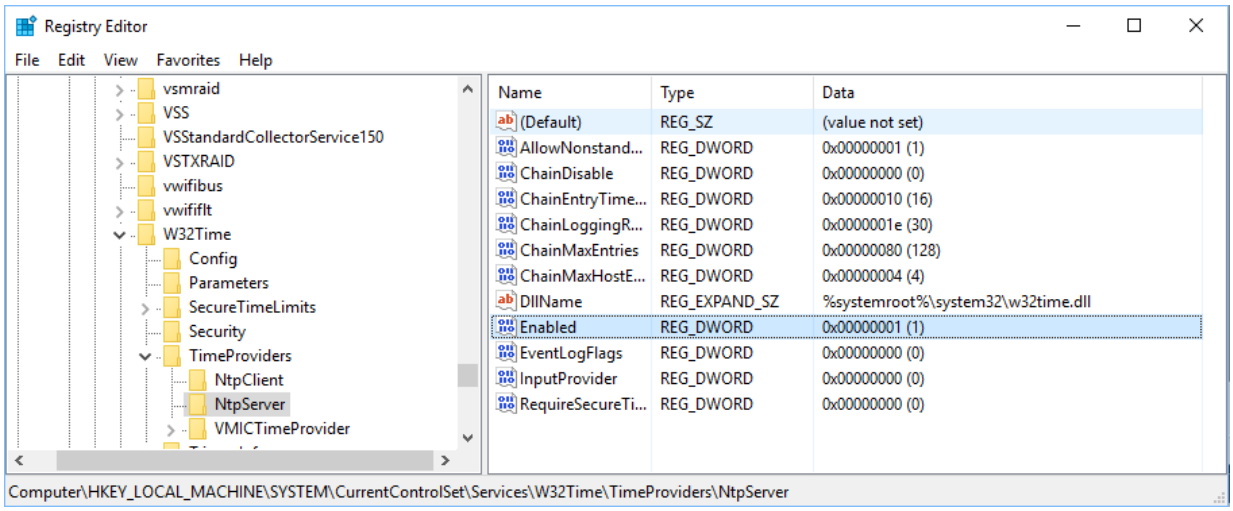
Windows itself offers an NTP server to provide timestamps.

Please note that only one component can use the port for NTP (udp/123). This means that either the TwinCAT NTP server functionality [▶ 220] or the Windows NTP server can be used.

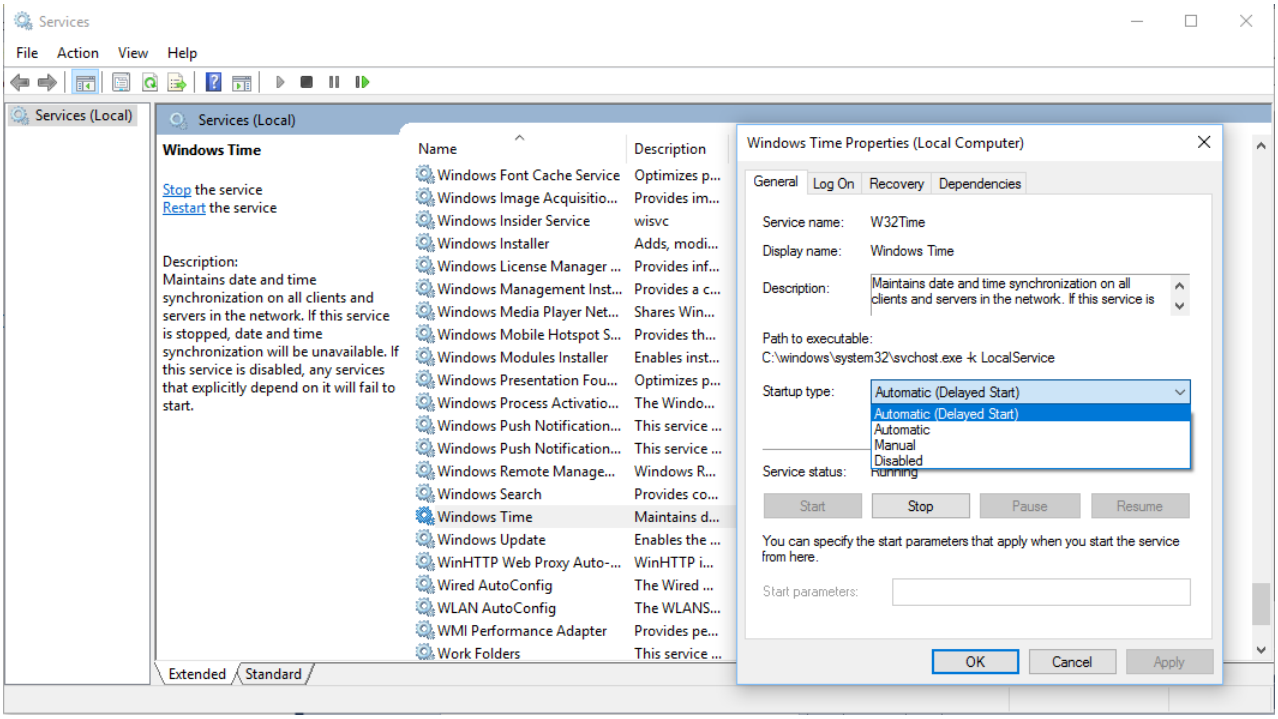
The Windows NTP server is disabled by default and can be activated later:

✓ Windows 10

1. The registry key is set:
   `HKLM\System\CurrentControlSet\Services\W32Time\TimeProviders\NtpServer`
   `Enabled = 1`



2. The Windows Time system service is started and set to Autostart, if appropriate.



3.7 TcRTeInstall

The TcRTeInstall tool manages real-time Ethernet compatible devices of the control system. This involves installing a real-time capable driver for the standard Ethernet connection of a control system.

TwinCAT 3 installation required

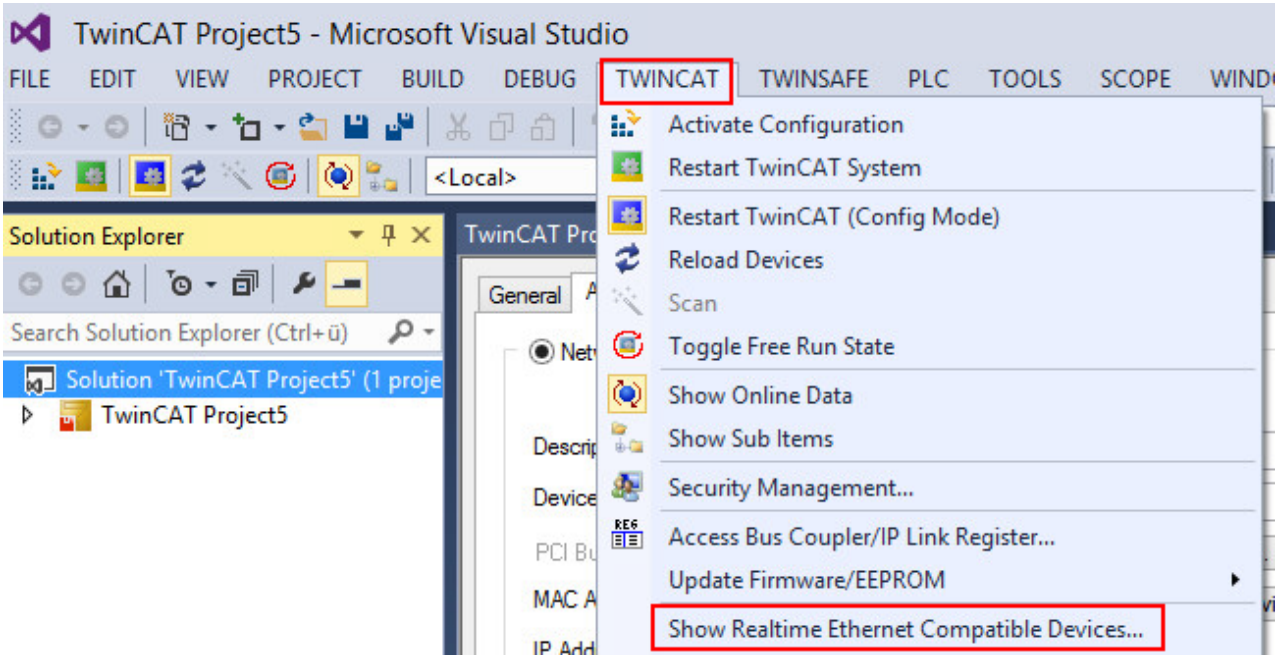
The TcRTeInstall application can only be used in combination with a complete installation of TwinCAT 3 (XAE, runtime environment, XAR).

Administrator rights required

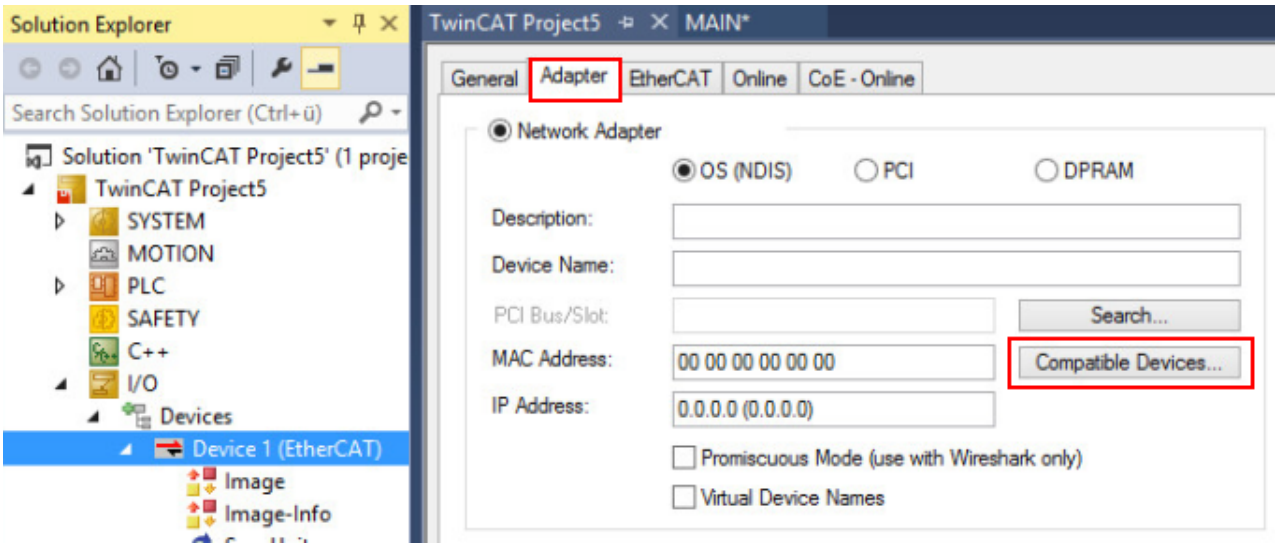
To run the TcRTeInstall application, you need administrator rights on the control system.

Call in TwinCAT 3 XAE

Call the driver via the menu **TWINCAT → Show Realtime Ethernet Compatible Devices...** .



Alternatively you can install the driver by adding a network capable device to the I/O configuration (e.g. EtherCAT). In the adapter dialog of the network capable device, call the TcRTeInstall application with the button **Compatible Devices...**:



Call in TwinCAT runtime environments

You can directly call the installation application for the TwinCAT RT Ethernet adapter on a TwinCAT 3 runtime system.

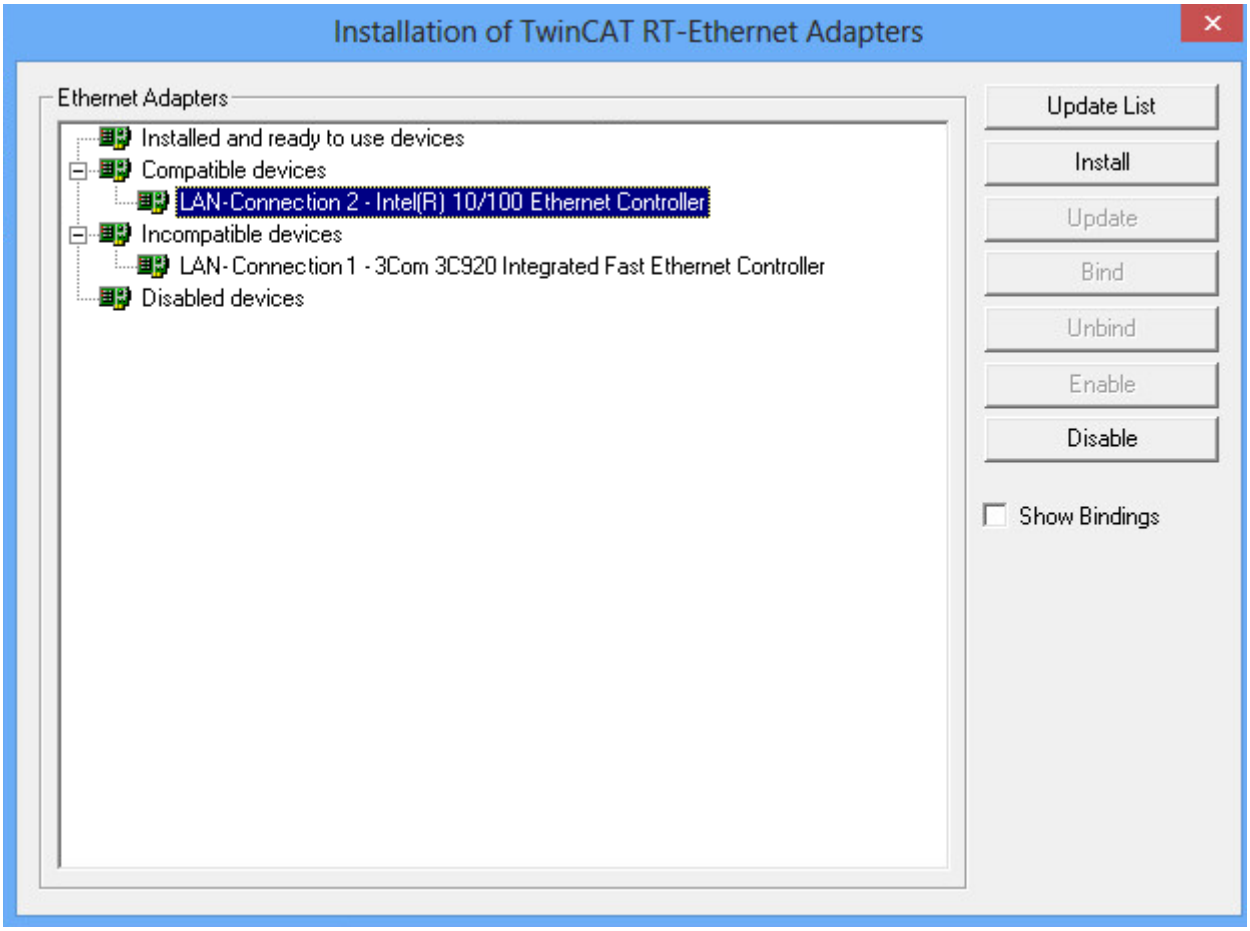
Location:

up to and including TwinCAT 3.1.4024: *c:\TwinCAT3.1\System\TcRteInstall.exe*

as of TwinCAT 3.1.4026: *c:\Program Files (x86)\Beckhoff\TwinCAT\3.1\System\TcRteInstall.exe*

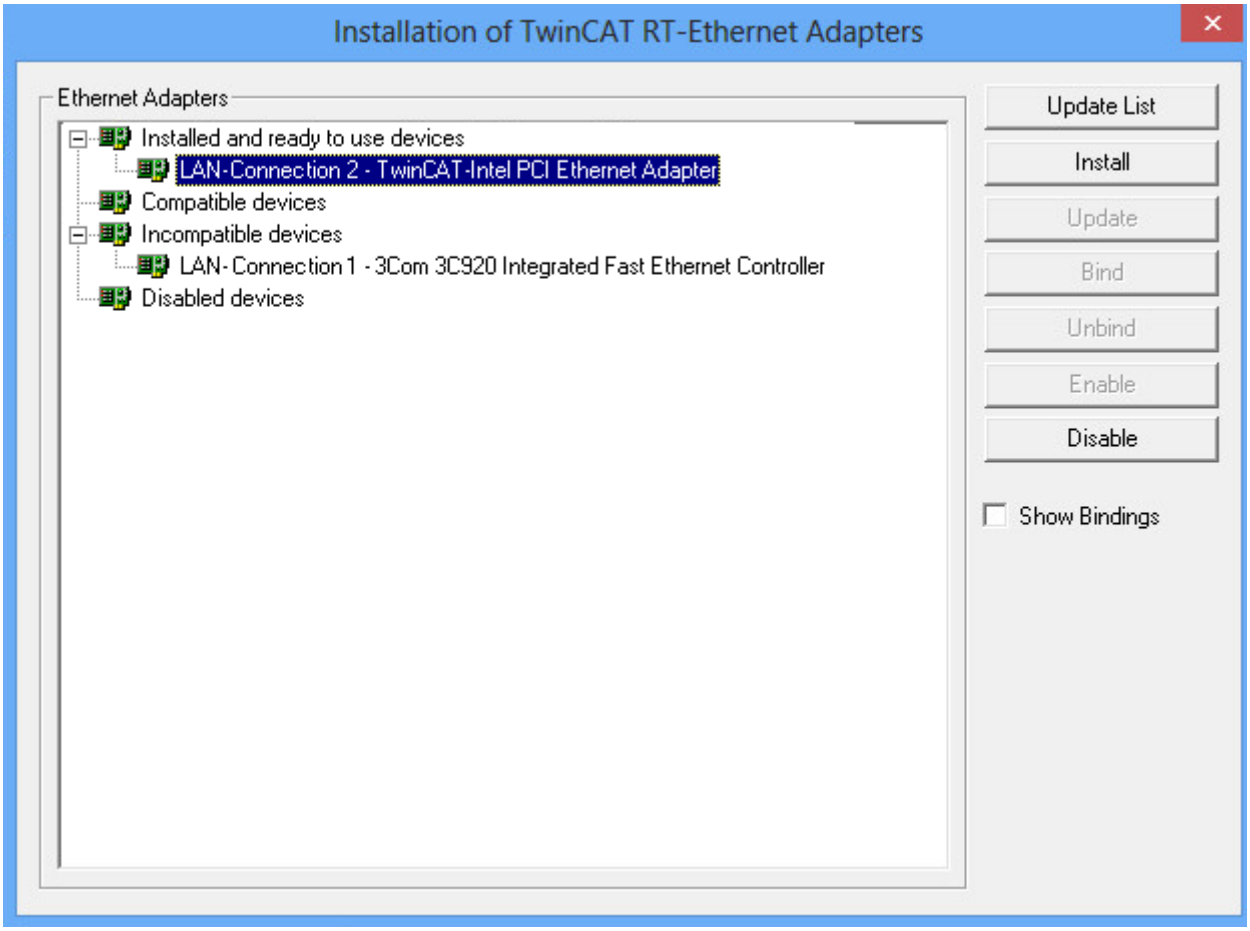
Manage network connections

TcRteInstall displays the real-time capable (Compatible devices) and non-real-time capable (Incompatible devices) network interface cards.

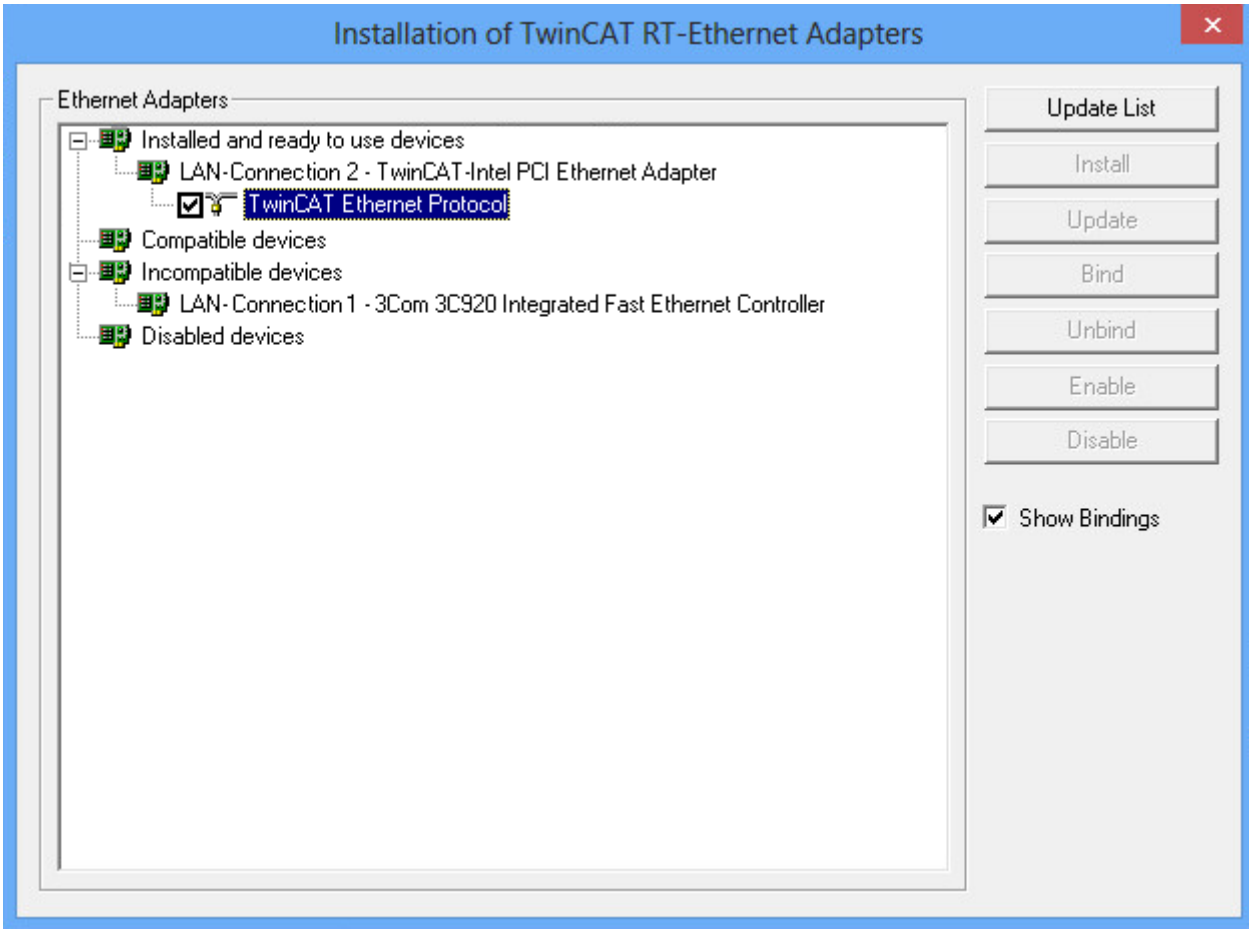


1. Select a real-time capable network interface card from the list of "compatible devices".
2. Click on the *Install* button.

⇨ The TwinCAT driver for real-time Ethernet and the TwinCAT Ethernet protocol are installed for the selected device.



The option **Show Bindings** shows the connected protocol of the installed RT Ethernet device.


Installation of TwinCAT RT-Ethernet Adapters
Ethernet Adapters
Installed and ready to use devices
LAN-Connection 2 - TwinCAT-Intel PCI Ethernet Adapter
TwinCAT Ethernet Protocol
Compatible devices
Incompatible devices
LAN-Connection 1 - 3Com 3C920 Integrated Fast Ethernet Controller
Disabled devices
Update List
Install
Update
Bind
Unbind
Enable
Disable
Show Bindings

4 Type system

TwinCAT 3 provides a type system for the management of data types. The type system consists of system basic types and can be extended by custom data types through the customer project.

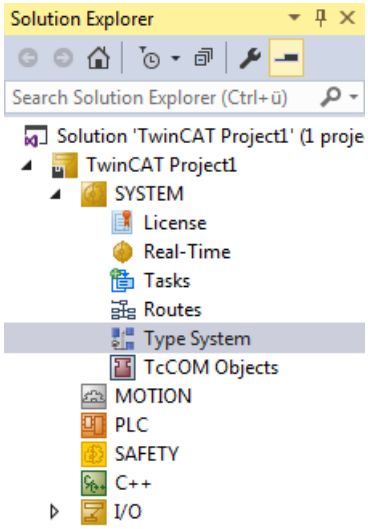
This documentation describes the TwinCAT 3 type system and the management of data types. The TMC editor, with which the data types are created and described, is described in the documentation entitled “C++” in the TwinCAT Module Class Editor (TMC) section.

4.1 Project-based type system

The TwinCAT 3 type system is project-specific; i.e. it is a fixed component of a TwinCAT 3 project in a Visual Studio solution.

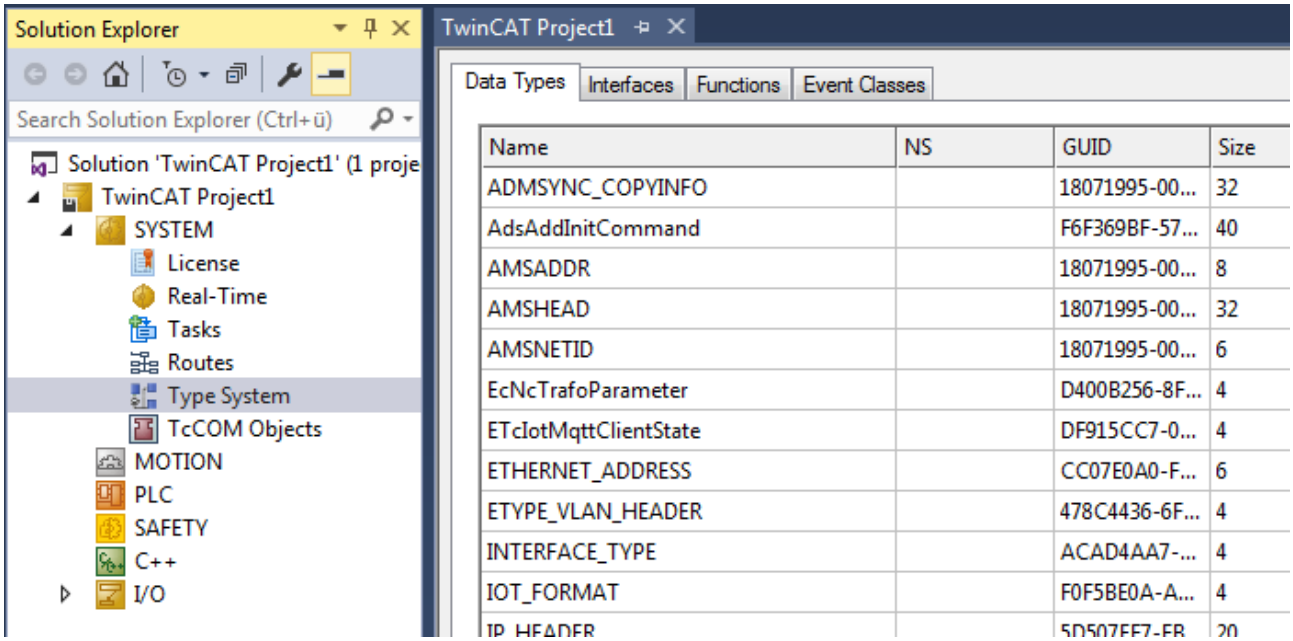
Data types can be defined at various points and transferred if necessary to the TwinCAT 3 type system. Thus, local data types can also exist that don't exist in the TwinCAT 3 type system.

You will find the type system in the TwinCAT 3 project tree as an object in the SYSTEM subtree.



4.2 Data types

The TwinCAT 3 type system displays the data types in an editor on four different tabs. The editor is opened by double-clicking on the "Type System" object in the TwinCAT 3 project tree.



The following data types (TMC editor: "Specifications") are displayed on the **Data Types** tab:

- Alias: these data types are simply synonyms for other data types. For example, a time range (duration) can be defined in a specific project as UINT.
- Struct: these data types are structures of other data types, which in turn can also be structures.
- Enum: these data types describe enumerations.
- Array: these data types are arrays with a defined number of dimensions as well as the respective length.

The interfaces are displayed on the **Interfaces** tab. This data type describes an interface that can be provided or used by different components such as function blocks or TcCOM modules. An interface consists of methods that have a respective signature.

The **Functions** tab shows PLC functions and PLC function blocks whose definition was read from in a TMC/TML file.

The **Event Classes** tab defines event classes that are used for the TwinCAT 3 EventLogger.

4.3 Handling of data types

In order to create or modify a data type via the TwinCAT 3 type system, select the **New** or **Edit** command from the context menu of the first table column on the appropriate tab of the type system editor. Both commands open the TMC editor in which you can edit the data type.

Data types from PLC projects

Data types (DUTs) can be created and saved in a PLC project. These data types initially exist locally in the PLC project and are not usable from the point of view of TwinCAT 3. If the data types are used in the input/output memory map (%I* / %Q*), they are imported into the TwinCAT 3 type system so that they can also be linked through the mapping.

With the **Convert to Global Type** command in the context menu of a DUT in the PLC project tree you can transfer the DUT to the type system of the higher-level TwinCAT project. Thereafter the data type is usable in the PLC via the external types and is managed in the TwinCAT 3 type system.

To transfer a data type from the TwinCAT 3 type system to a PLC project, you can use the source code in the “Data Types” dialog.

Data types from C++ projects

In C++ projects the data types are defined in the TMC editor in parallel with the modules. Like the internal DUTs in the PLC project, these data types are local and thus invisible in the TwinCAT 3 type system.

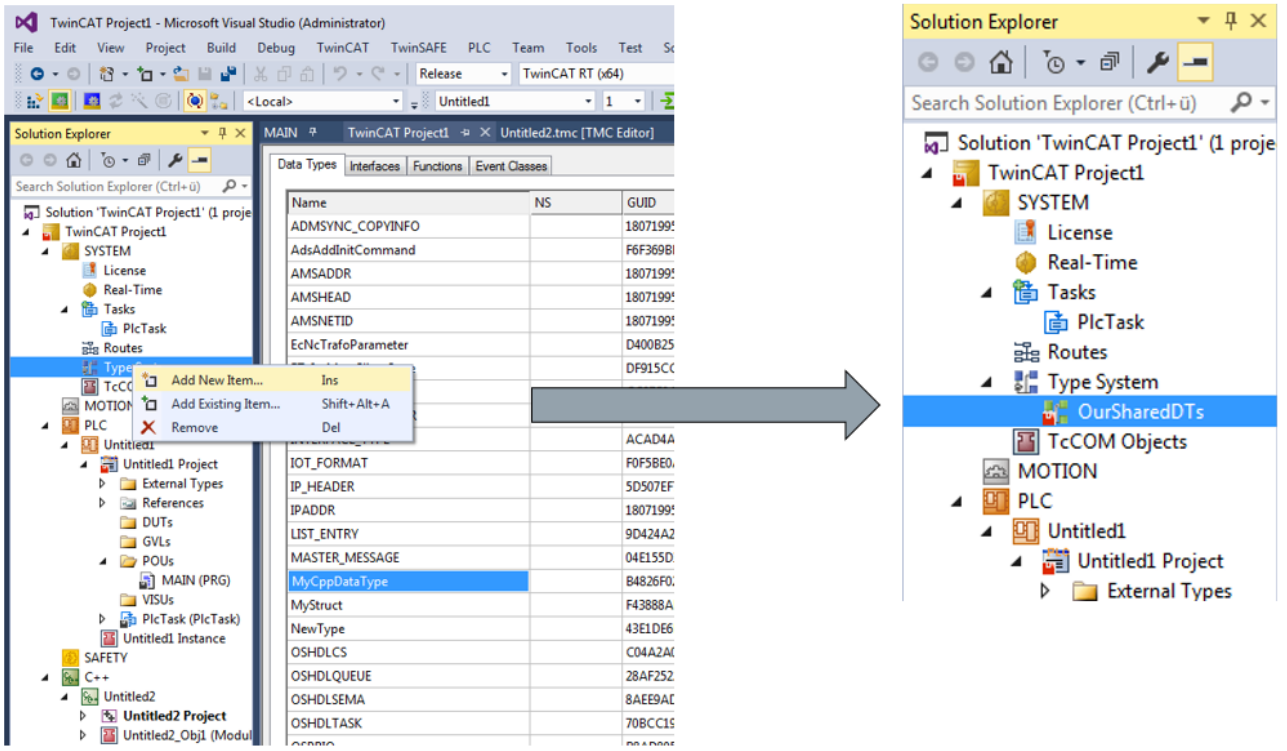
Through the use of the data types in a C++/Matlab module, which has also been instanced, the data types are inserted into the TwinCAT 3 type system.

You can also insert a data type into the TwinCAT 3 type system without using the data type in an instanced C++ module by activating the **Persistent (even if unused)** check box.

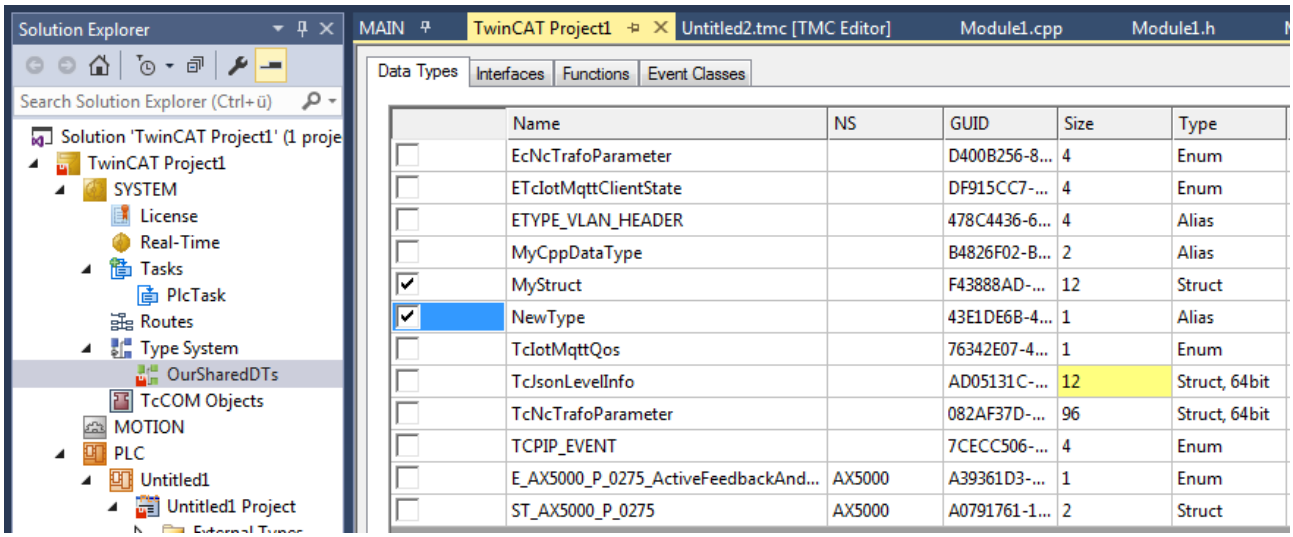
Use of data types in several projects

In some cases it may be useful to use data types in several projects. In particular for EAP/network variables it can be useful to use the same data type on both the publisher and subscriber side.

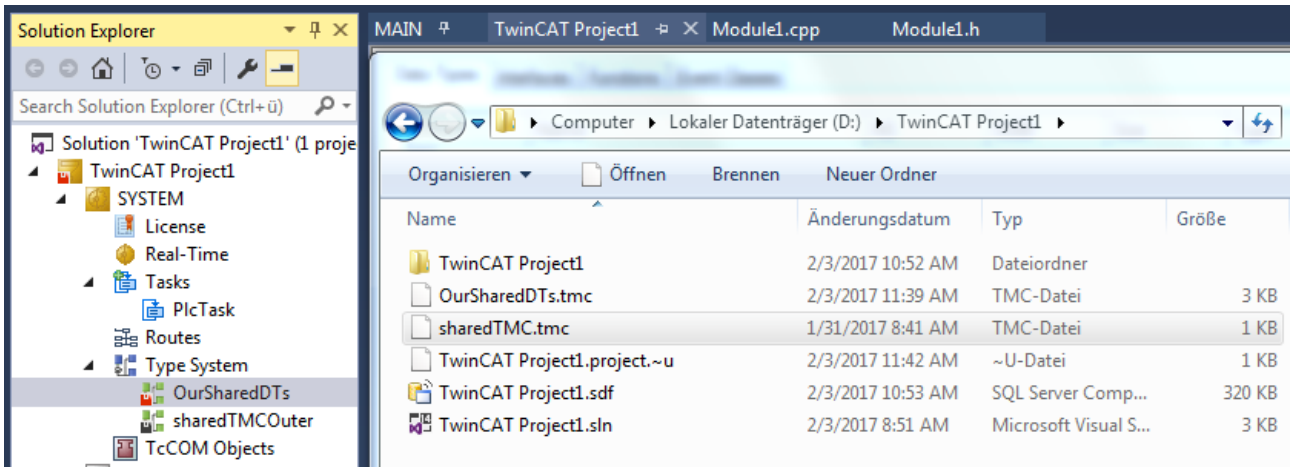
You can create individual TMC files for this under the "Type System" node.



A check box appears in front of every data type in the editor window of the TMC files. Using the check box you can specify which data type is to be deposited in the respective TMC file.



The data types are additionally deposited in the TMC files. You can use these files on different computers and in different projects, for example, by means of file exchange or version control.
However, the file itself must not be used by different projects at the same time, so that these are normally stored in the project directory and this project is then available as a copy on different computers, e.g. via version control.



Since the GUID is used to identify the data type, the type system recognizes this double deposition automatically.

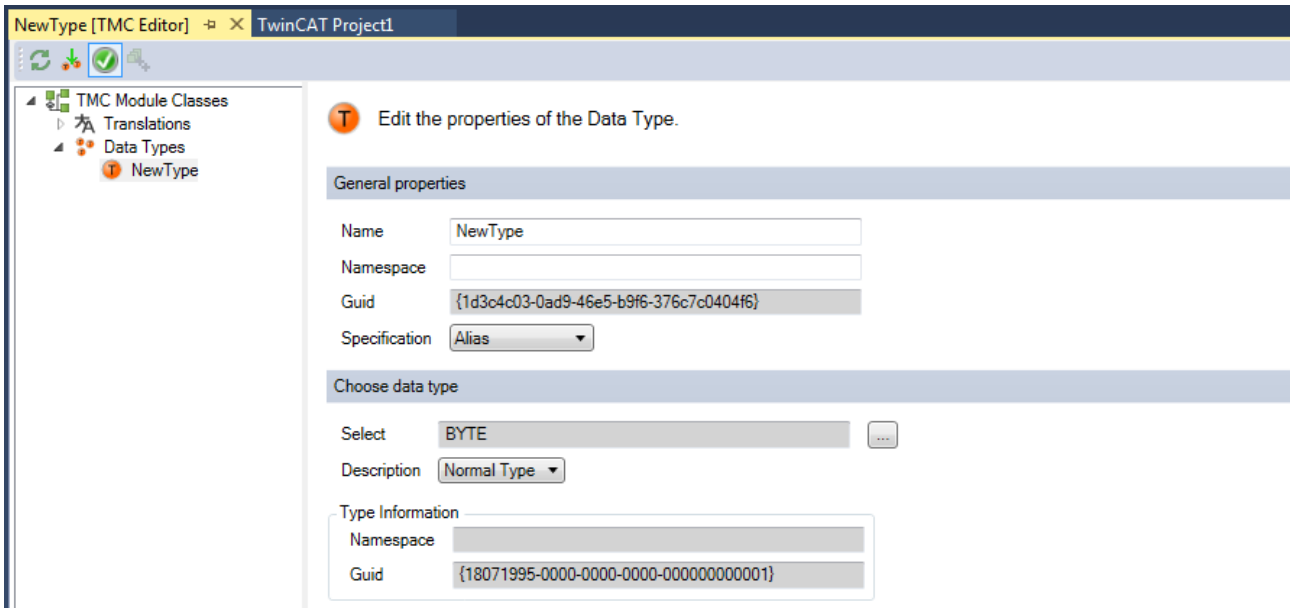
When using data types after they have been integrated in several projects, make sure that changes to the data types are made as far as possible only in one place. Otherwise the different variants can no longer be merged to a common version.

See also:

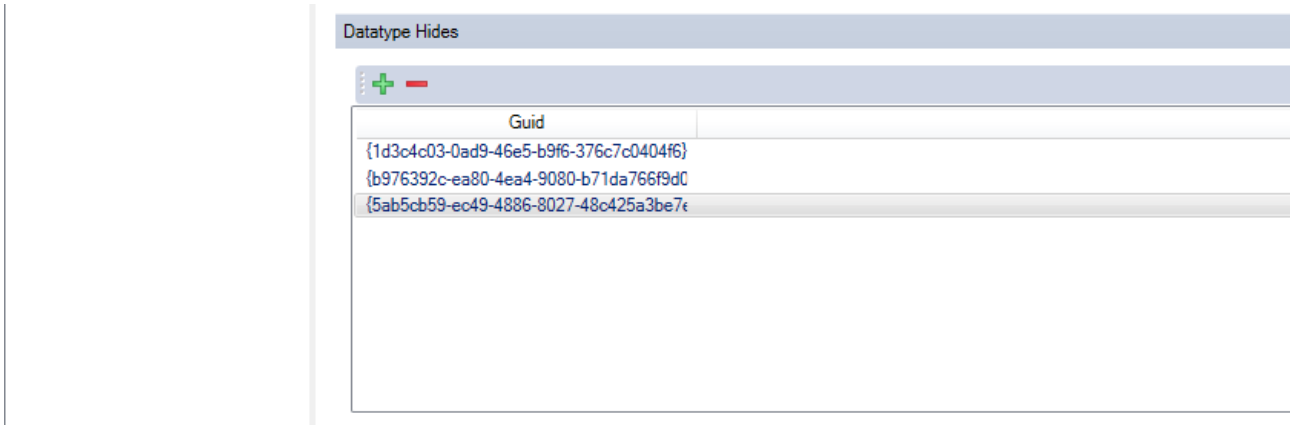
Management and identification of data types [▶ 244]

4.4 Management and identification of data types

Data types in the TwinCAT 3 type system are fundamentally identified on the basis of their GUID. Thus, several data types can exist with the same name. The same applies to different versions of a data type. Each version of a data type is assigned a new GUID.



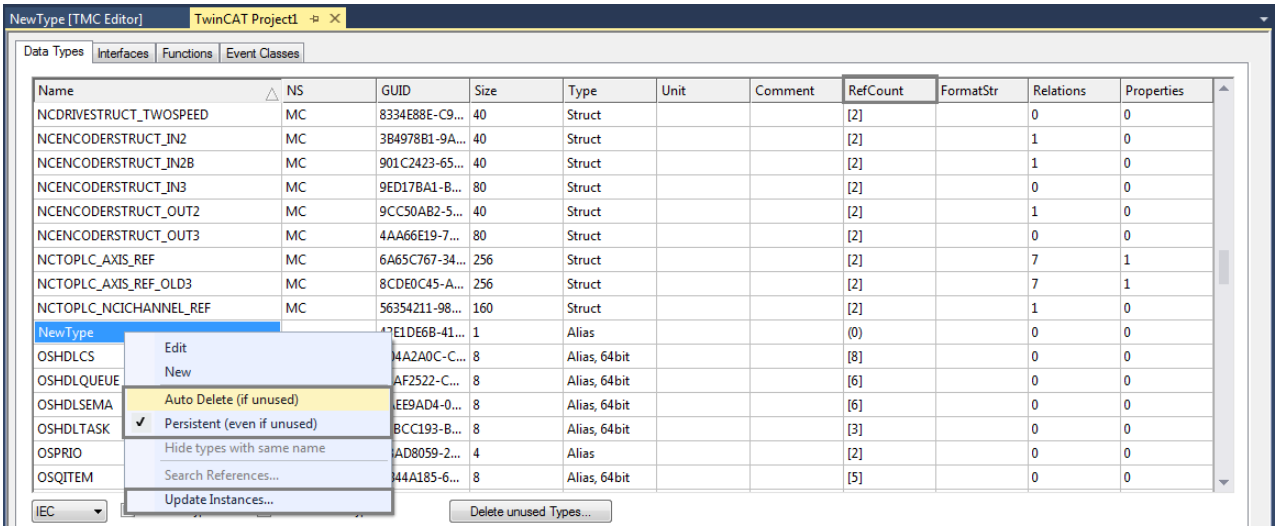
At the same time, each data type has a list of data types that it keeps hidden ("Datatype Hides").



This makes it possible to use different versions of a data type in the project at the same time.

The **Update Instances...** command in the context menu of a data type in the type system editor (**Data Types** tab) employs the respectively latest version for selected uses of a data type.

TwinCAT has a so-called reference counter for each data type. This counter can be seen in the **RefCount** column in the editor of the type system. Each use of the data type in a project, and also in an editor and so on, increments the counter. If a counter is at 0, the data type is no longer used and is discarded.



If the **Persistent (even if unused)** setting in the context menu of a data type is activated, the data type description will be saved in the TwinCAT project file (*.tsproj) even if the data type is not used in the TwinCAT project. The setting is activated by default with data types that are newly created directly via the type system editor. This ensures that the data types are not directly deleted if the TwinCAT project is saved before the new data types are used.

If a SharedTMC is used underneath the **Type System** object in the TwinCAT project tree, the setting should not be activated for data types in this file as the data types are saved both in the project and in the SharedTMC. The setting is deactivated by default with data types that are newly created directly via a SharedTMC editor.

The **Auto Delete (if unused)** setting should not be manually changed, but is shown for the sake of completeness. Data types for which this setting is activated are hidden for PLC projects and cannot be used there. The setting should not be used, for example, to automatically clean the type system. Unused data types are not automatically saved in the TwinCAT project and are then no longer in the type system after reloading the TwinCAT project.

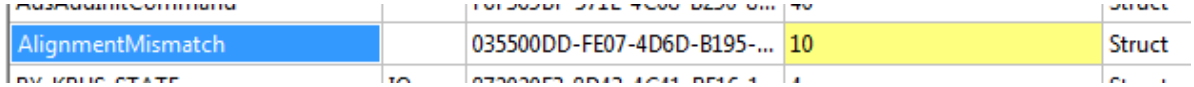
4.5 Alignment of data types

The memory layout of a data type is determined by the alignment. Further information on the alignment can be found in the “Alignment” section in the documentation entitled “PLC”.

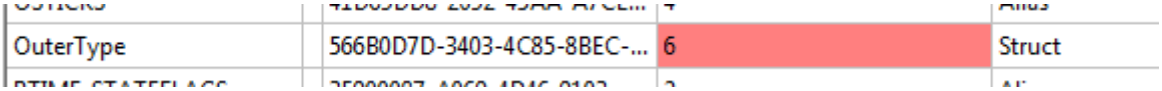
With the default alignment of 8 bytes it can be ensured that the access to data types functions optimally in terms of runtime and access on different platforms. Deviation from this should only take place in exceptional cases.

The TwinCAT 3 type system marks data types in color.

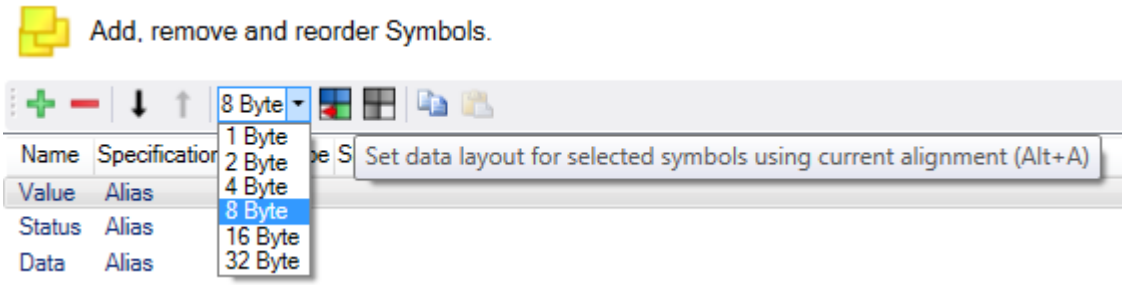
- Yellow if the length of the data type is not a multiple of the largest internal field (max. 8 bytes). As a result, the alignment no longer obeys the rules in the case of an array of such a data type.



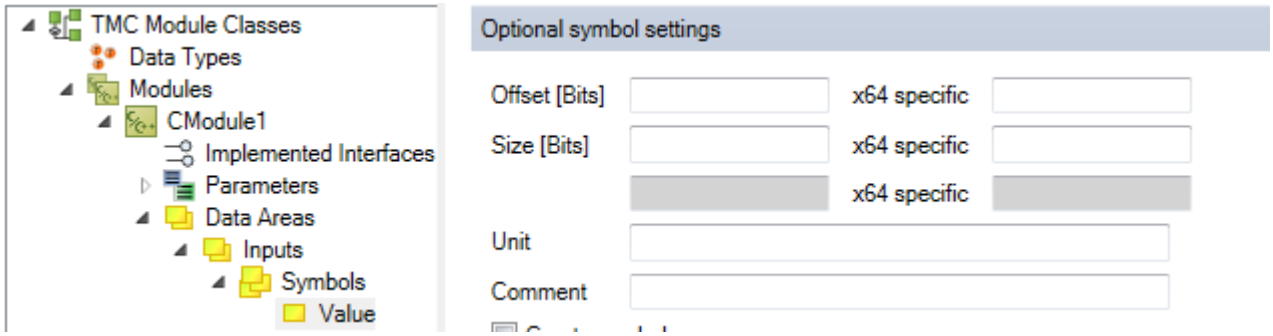
- Red if the alignment within the data type no longer obeys the rules.



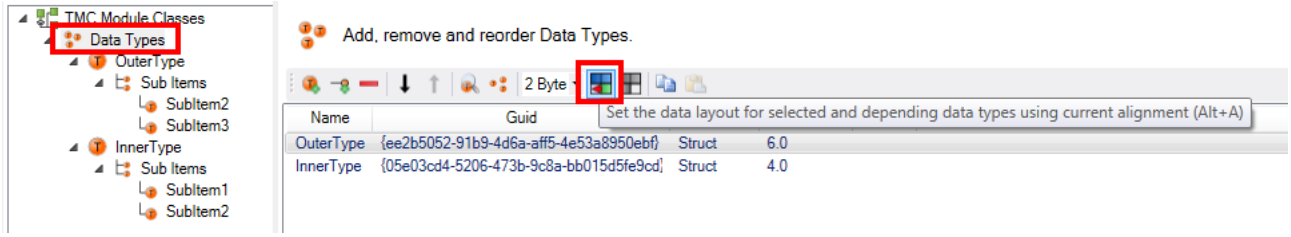
The TMC editor offers the possibility to specify the memory layout of a data type for a selected alignment.



Alternatively, the layout can be manually specified using offsets.



If the size of a data type that is used in another data type is changed, then this data type must also be adjusted. The TMC editor offers an appropriate recursive function for this at the data type overview level.



4.6 Files in connection with the type system

The TwinCAT 3 type system is formulated entirely in XML.

Depending on the field of application there are different files that contain the data types:

- .tsproj file – TwinCAT project
  This file contains the entire TwinCAT project, including the complete TwinCAT 3 type system.

- .tmc files – TwinCAT Module Class files
  These files are used to describe the TcCOM modules themselves. They include module class descriptions and the data types used. At the same time, these files are used to realize the exchange of data types between projects, as described above.
- .tmi files – TwinCAT Module Instance files
  These files describe the instance of a class. They are deposited on the destination by the TwinCAT 3 Engineering in order to describe an instance of a class. In addition, instance information can also be transferred from one project to another using a .tmi file.

5 TcCom modules

The TwinCAT Component Object Model defines the properties and behavior of the TwinCAT 3 Runtime modules and describes how different software components that have been developed and compiled independently of each other can work together. The following chapters explain the concept behind and handling of TcCOM modules.

5.1 The TwinCAT Component Object Model (TcCOM) concept

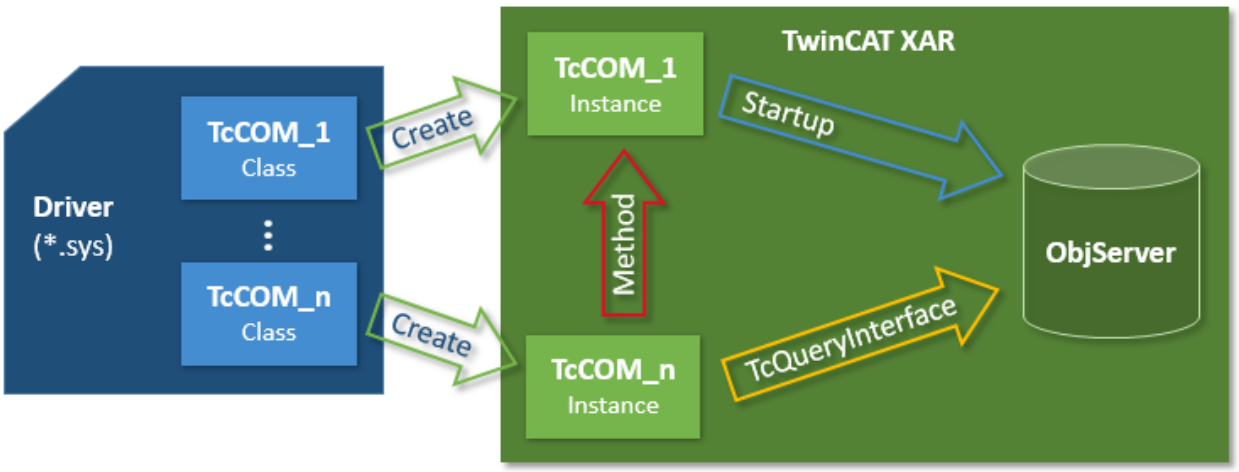
The TwinCAT Component Object Model defines the characteristics and the behavior of the modules. The model derived from the "Component Object Model" COM from Microsoft Windows describes the way in which various independently developed and compiled software components can co-operate with one another. To make that possible, a precisely defined mode of behavior and the observation of interfaces of the module must be defined, so that they can interact. Such an interface is also ideal for facilitating interaction between modules from different manufacturers, for example.

To some degree TcCOM is based on COM (Component Object Model of the Microsoft Windows world), although only a subset of COM is used. In comparison with COM, however, TcCOM contains additional definitions that go beyond COM, for example the state machine module.

Overview and application of TcCOM modules

This introductory overview is intended to make the individual topics easier to understand.

One or several TcCOM modules are consolidated in a driver. This driver is created by TwinCAT Engineering using the MSVC compiler. The modules and interfaces are described in a TMC (TwinCAT Module Class) file. The drivers and their TMC file can now be exchanged and combined between the engineering systems.



Instances of these modules are now created using the engineering facility. They are associated with a TMI file. The instances can be parameterized and linked with each other and with other modules to form the I/O. A corresponding configuration is transferred to the target system, where it is executed.

Corresponding modules are started, which register with the TwinCAT ObjectServer. The TwinCAT XAR also provides the process images. Modules can query the TwinCAT ObjectServer for a reference to another object with regard to a particular interface. If such a reference is available, the interface methods can be called on the module instance.

The following sections substantiate the individual topics.

ID Management

Different types of ID are used for the interaction of the modules with each other and also within the modules. TcCOM uses GUIDs (128-bit) and 32-bit long integers.

TcCOM uses

- GUIDs for: ModulIDs, ClassIDs and InterfaceIDs.
- 32-bit long integers are used for: ParameterIDs, ObjectIDs, ContextIDs, CategoryID.

Interfaces

An important component of COM, and therefore of TcCOM too, are interfaces.

Interfaces define a set of methods that are combined to perform a certain task. An interface is referenced with a unique ID (InterfaceID), which must never be modified as long as the interface does not change. This ID enables modules to determine whether they can cooperate with other modules. At the same time the development process can take place independently, if the interfaces are clearly defined. Modifications of interfaces therefore lead to different IDs. The TcCOM concept is designed such that InterfaceIDs can superpose other (older) InterfaceIDs ("Hides" in the TMC description / TMC editor). In this way, both versions of the interface are available, while on the other hand it is always clear which is the latest InterfaceID. The same concept also exists for the data types.

TcCOM itself already defines a whole series of interfaces that are prescribed in some cases (e.g. ITComObject), but are optional in most. Many interfaces only make sense in certain application areas. Other interfaces are so general that they can often be re-used. Provision is made for customer-defined interfaces, so that two third-party modules can interact with each other, for example.

- All interfaces are derived from the basic interface ItcUnknown which, like the corresponding interface of COM, provides the basic services for querying other interfaces of the module (TcQueryInterface) and for controlling the service life of the module (TcAddRef and TcRelease).
- The ITComObject interface, which must be implemented by each module, contains methods for accessing the name, ObjectID, ObjectID of the parent, parameters and state machine of the module.

Several general interfaces are used by many modules:

- ITcCyclic is implemented by modules, which are called cyclically ("CycleUpdate"). The module can register via the ITcCyclicCaller interface of a TwinCAT task to obtain cyclic calls.
- The ITcADI interface can be used to access data areas of a module.
- ITcWatchSource is implemented by default; it facilitates ADS DeviceNotifications and other features.
- The ITcTask interface, which is implemented by the tasks of the real-time system, provides information about the cycle time, the priority and other task information.
- The ITComObjectServer interface is implemented by the ObjectServer and referenced by all modules.

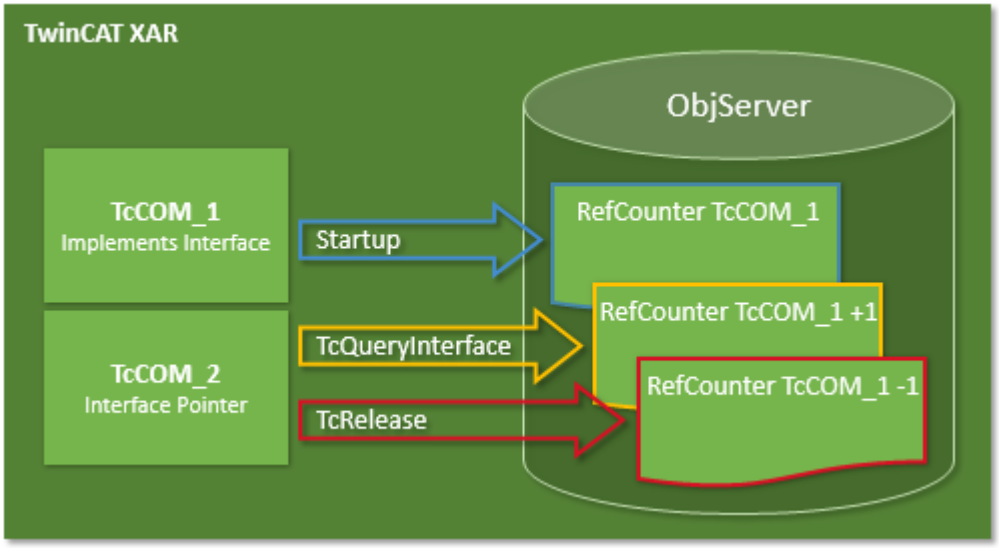
A whole series of general interfaces has already been defined. General interfaces have the advantage that their use supports the exchange and recycling of modules. Only if no suitable general interfaces exist should you define your own interfaces.

Class Factories

"Class Factories" are used for creating modules in C++. All modules contained in a driver have a common Class Factory. The Class Factory registers once with the ObjectServer and offers its services for the creation of certain module classes. The module classes are identified by the unique ClassID of the module. When the ObjectServer requests a new module (based on the initialization data of the configurator or through other modules at runtime), the module selects the right Class Factory based on the ClassID and triggers creation of the module via its ITcClassFactory interface.

Module service life

Similar to COM, the service life of a module is determined via a reference counter (RefCounter). The reference counter is incremented whenever a module interface is queried. The counter is decremented when the interface is released. An interface is also queried when a module logs into the ObjectServer (the ITComObject interface), so that the reference counter is at least 1. The counter is decremented on logout. When the counter reaches 0, the module deletes itself automatically, usually after logout from the ObjectServer. If another module already maintains a reference (has an interface pointer), the module continues to exist, and the interface pointer remains valid, until this pointer is released.



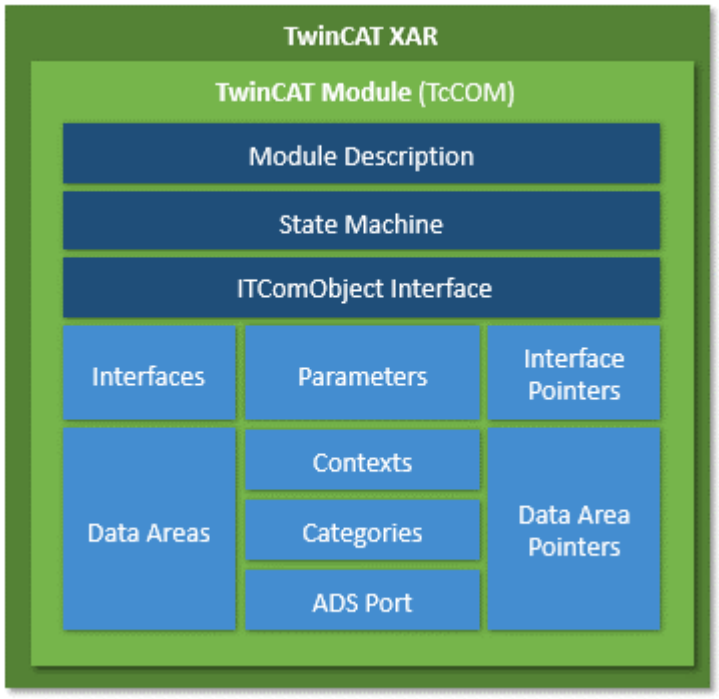
5.1.1 TwinCAT module properties

A TcCOM module has a number of formally defined, prescribed and optional properties. The properties are sufficiently formalized to enable interchangeable application. Each module has a module description, which describes the module properties. They are used for configuring the modules and their relationships with each other.

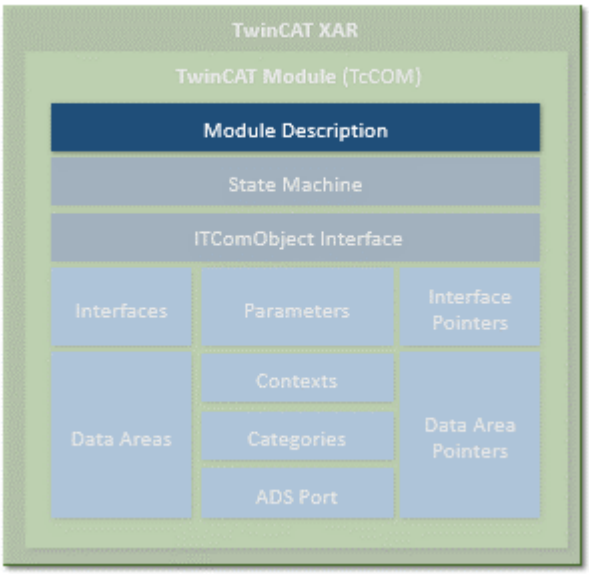
If a module is instantiated in the TwinCAT runtime, it registers itself with a central system instance, the ObjectServer. This makes it reachable and parameterizable for other modules and also for general tools. Modules can be compiled independently and can therefore also be developed, tested and updated independently. Modules can be very simple, e.g. they may only contain a basic function such as low-pass filter. Or they may be very complex internally and contain the whole control system for a machine subassembly.

There are a great many applications for modules; all tasks of an automation system can be specified in modules. Accordingly, no distinction is made between modules, which primarily represent the basic functions of an automation system, such as real-time tasks, fieldbus drivers or a PLC runtime system, and user- or application-specific algorithms for controlling a machine unit.

The diagram below shows a common TwinCAT module with his main properties. The dark blue blocks define prescribed properties, the light blue blocks optional properties.



Module description



Each TcCOM module has some general description parameters. These include a ClassID, which unambiguously references the module class. It is instantiated by the corresponding ClassFactory. Each module instance has an ObjectID, which is unique in the TwinCAT runtime. In addition there is a parent ObjectID, which refers to a possible logical parent.

The description, state machine and parameters of the module described below can be reached via the ITComObject interface (see "Interfaces").

Class description files (*.tmc)

The module classes are described in class description files (TwinCAT Module Class; *.tmc).

These files are used by developers to describe the module properties and interfaces, so that others can use and embed the module. In addition to general information (vendor data, module class ID etc.), optional module properties are described.

- Supported categories
- Implemented interfaces
- Data areas with corresponding symbols
- Parameter
- Interface pointers
- Data pointers, which can be set

The system configurator uses the class description files mainly as a basis for the integration of a module instance in the configuration, for specifying the parameters and for configuring the links with other modules.

They also include the description of all data types in the modules, which are then adopted by the configurator in its general data type system. In this way, all interfaces of the TMC descriptions present in the system can be used by all modules.

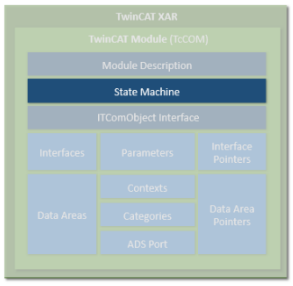
More complex configurations involving several modules can also be described in the class description files, which are preconfigured and linked for a specific application. Accordingly, a module for a complex machine unit, which internally consists of a number of submodules, can be defined and preconfigured as an entity during the development phase.

Instance description files (*.tmi)

An instance of a certain module is described in the instance description file (TwinCAT Module Instance; *.tmi). The instance descriptions are based on a similar format, although in contrast to the class description files they already contain concrete specifications for the parameters, interface pointers etc. for the special module instance within a project.

The instance description files are created by TwinCAT Engineering (XAE), when an instance of a class description is created for a specific project. They are mainly used for the exchange of data between all tools involved in the configuration. However, the instance descriptions can also be used cross-project, for example if a specially parameterized module is to be used again in a new project.

State machine

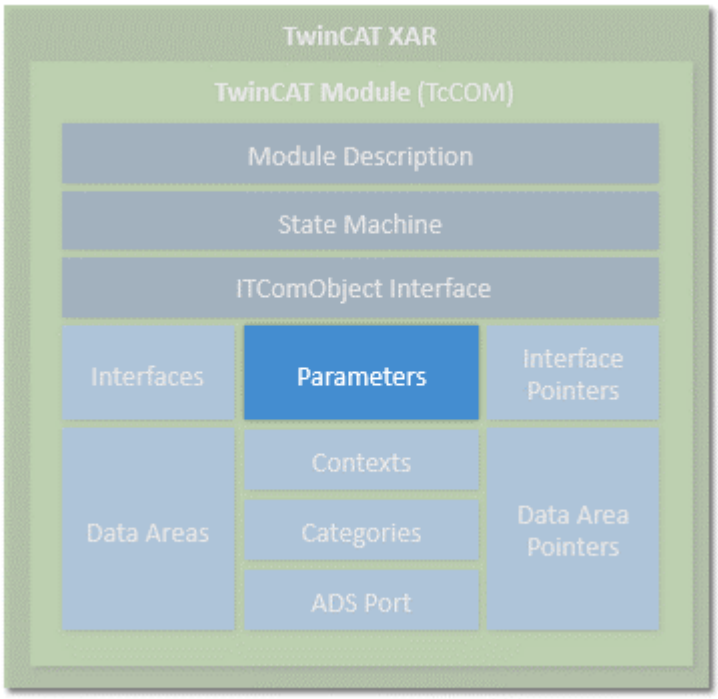


Each module contains a state machine, which describes the initialization state of the module and the means with which this state can be modified from outside. The state machine describes the states, which occur during starting and stopping of the module. This relates to module creation, parameterization and production in conjunction with the other modules.

Application-specific states (e.g. of the fieldbus or driver) can be described in their own state machines. The state machine of the TcCOM modules defines the states INIT, PREOP, SAFEOP and OP. Although the state designations are the same as under EtherCAT fieldbus, the actual states differ. When the TcCOM module implements a fieldbus driver for EtherCAT, it has two state machines (module and fieldbus state machine), which are passed through sequentially. The module state machine must have reached the operating state (OP) before the fieldbus state machine can start.

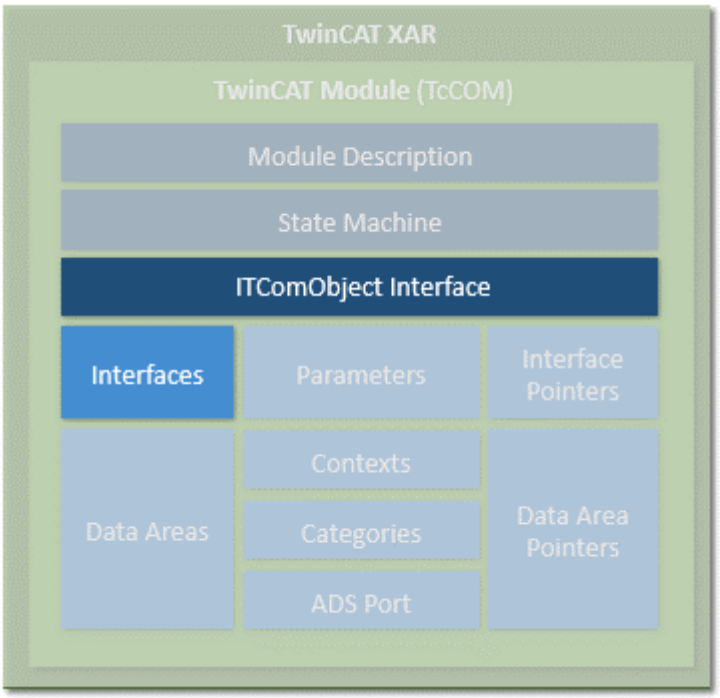
The state machine is described [▶ 257] in detail separately.

Parameter



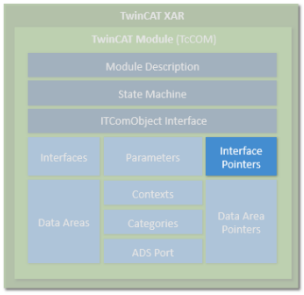
Modules can have parameters, which can be read or written during initialization or later at runtime (OP state). Each parameter is designated by a parameter ID. The uniqueness of the parameter ID can be global, limited global or module-specific. Further details can be found in the "ID Management" section. In addition to the parameter ID, the parameter contains the current data; the data type depends on the parameter and is defined unambiguously for the respective parameter ID.

Interfaces



Interfaces consist of a defined set of methods (functions), which offer modules through which they can be contacted by other modules. Interfaces are characterized by a unique ID, as described above. A module must support at least the ITComObject interface and may in addition contain as many interfaces as required. An interface reference can be queried by calling the method "TcQueryInterface" with specification of the corresponding interface ID.

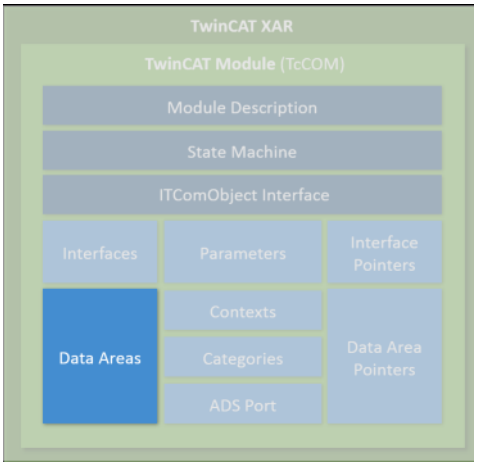
Interface pointers



Interface pointers behave like the counterpart of interfaces. If a module wants to use an interface of another module, it must have an interface pointer of the corresponding interface type and ensure that it points to the other module. The methods of the other module can then be used.

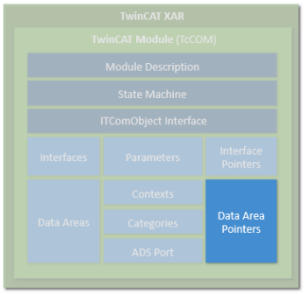
Interface pointers are usually set on startup of the state machine. During the transition from INIT to PREOP (IP), the module receives the object ID of the other modules with the corresponding interface; during the transition from PREOP to SAFEOP (PS) or SAFEOP to OP (SO), the instance of the other modules is searched with the ObjectServer, and the corresponding interface is set with the Method Query interface. During the state transition in the opposite direction, i.e. from SAFEOP to PREOP (SP) or OP to SAFEOP (OS), the interface must be enabled again.

Data areas



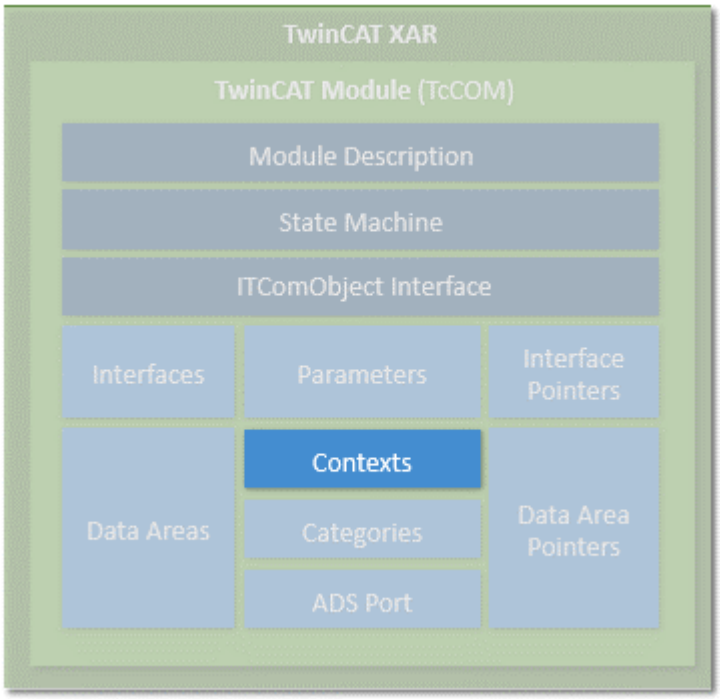
Modules can contain data areas, which can be used by the environment (e.g. by other modules or the IO area of TwinCAT). These data areas can contain any data. They are often used for process image data (inputs and outputs). The structure of the data areas is defined in the device description of the module. If a module has data areas, which it wants to make accessible for other modules, it implements the ITcADI interface to enable access to the data. Data areas can contain symbol information, which describes the structure of the respective data area in more detail.

Data area pointer



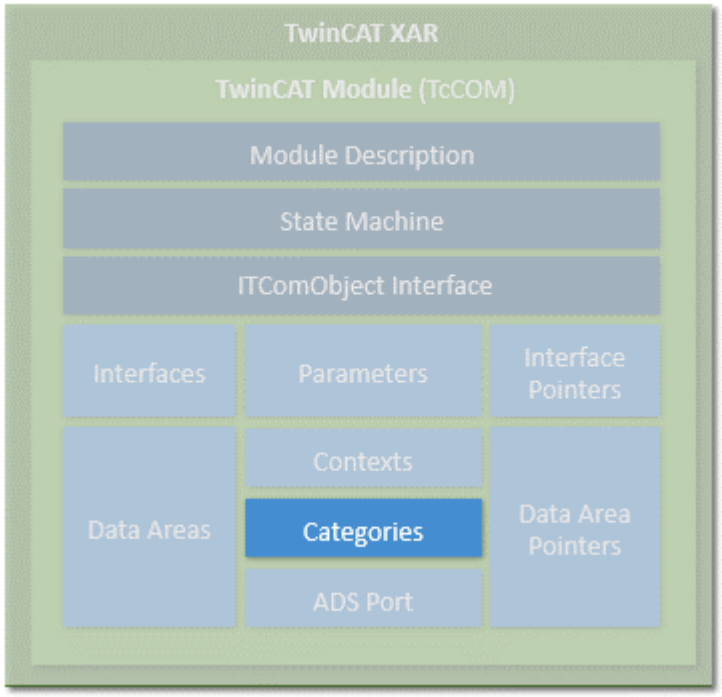
If a module wants to access the data area of other modules, it can contain data area pointers. These are normally set during initialization of the state machine to data areas or data area sections of other modules. The access is directly to the memory area, so that corresponding protection mechanisms for competing access operations have to be implemented, if necessary. In many cases it is preferable to use a corresponding interface.

Context



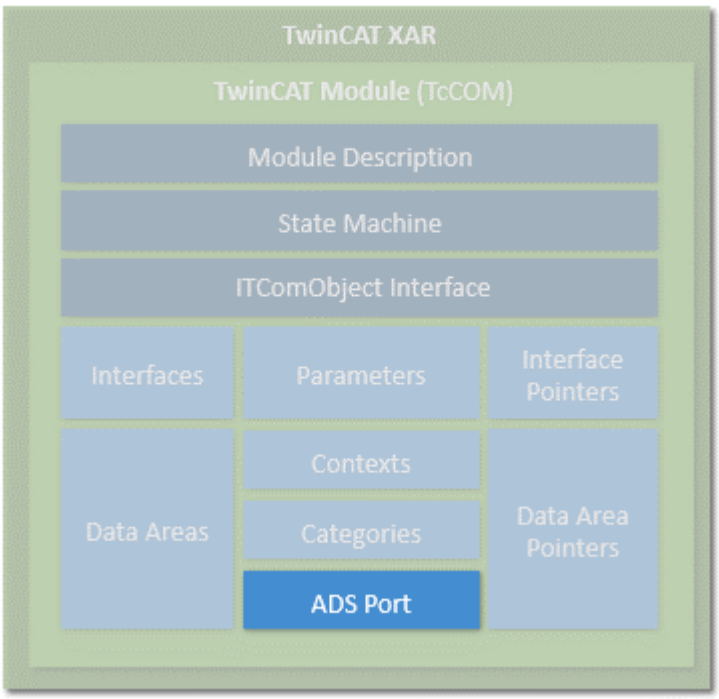
The context should be regarded as real-time task context. Context is required for the configuration of the modules, for example. Simple modules usually operate in a single time context, which therefore requires no detailed specification. Other modules may partly be active in several contexts (e.g. an EtherCAT master can support several independent real-time tasks, or a control loop can process control loops of the layer below in another cycle time). If a module has more than one time-dependent context, this must be specified the in the module description.

Categories



Modules can offer categories by implementing the interface ITComObjectCategory. Categories are enumerated by the ObjectServer, and objects, which use this to associated themselves with categories, can be queried by the ObjectServer (ITComObjectEnumPtr).

ADS



Each module that is entered in the ObjectServer can be reached via ADS. The ObjectServer uses the ITComObject interface of the modules in order to read or write parameters or to access the state machine, for example. In addition, a dedicated ADS port can be implemented, through which dedicated ADS commands can be received.

System module

In addition, the TwinCAT runtime provides a number of system modules, which make the basic runtime services available for other modules. These system modules have a fixed, constant ObjectID, through which the other modules can access it. An example for such a system module is the real-time system, which makes the basic real-time system services, i.e. generation of real-time tasks, available via the ITcRTime interface. The ADS router is also implemented as a system module, so that other modules can register their ADS port here.

Creation of modules

Modules can be created both in C++ and in IEC 61131-3. The object-oriented extensions of the TwinCAT PLC are used for this purpose. Modules from both worlds can interact via interfaces in the same way as pure C++ modules. The object-oriented extension makes the same interfaces available as in C++.

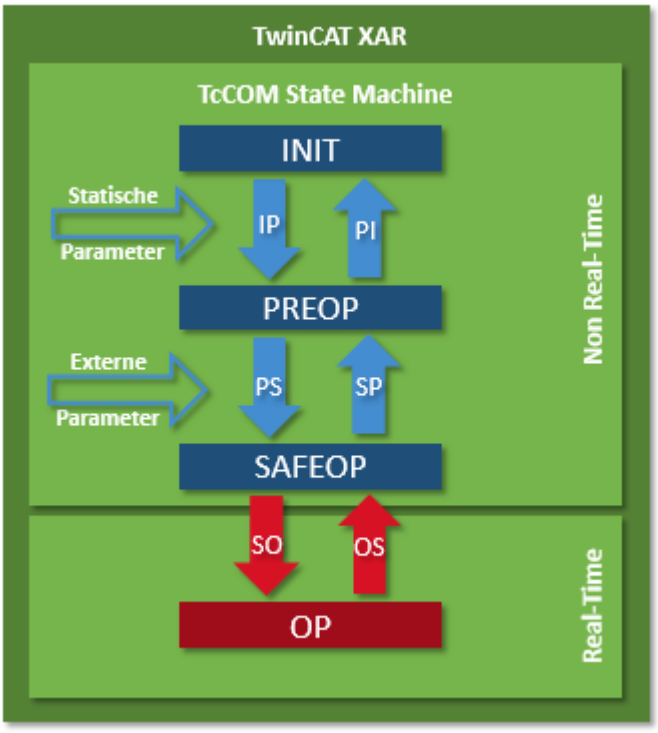
The PLC modules also register via the ObjectServer and can therefore be reached through it. PLC modules vary in terms of complexity. It makes no difference whether only a small filter module is generated or a complete PLC program is packed into a module. Due to the automation, each PLC program is a module within the meaning of TwinCAT modules. Each conventional PLC program is automatically packed into a module and registers itself with the ObjectServer and one or several task modules. Access to the process data of a PLC module (e.g. mapping with regard to a fieldbus driver) is also controlled via the defined data areas and ITcADI.

This behavior remains transparent and invisible for PLC programmers, as long as they decide to explicitly define parts of the PLC program as TwinCAT modules, so that they can be used with suitable flexibility.

5.1.2 TwinCAT module state machine

In addition to the states (INIT, PREOP, SAFEOP and OP), there are corresponding state transitions, within which general or module-specific actions have to be executed or can be executed. The design of the state machine is very simple. In any case, there are only transitions to the next or previous step.

This results in the state transitions: INIT to PREOP (IP), PREOP to SAFEOP (PS) and SAFEOP to OP (SO). In the opposite direction, the following state transitions exist: OP to SAFEOP (OS), SAFEOP to PREOP (SP) and PREOP to INIT (PI). Up to and including the SAFEOP state, all states and state transitions take place within the non-real-time context. Only the transition from SAFEOP to OP, the OP state and the transition from OP to SAFEOP take place in the real-time context. This differentiation is relevant when resources are allocated or enabled, or when modules register or deregister with other modules.



State: INIT

The INIT state is only a virtual state. Immediately after creation of a module, the module changes from INIT to PREOP, i.e. the IP state transition is executed. The instantiation and the IP state transition always take place together, so that the module never remains in INIT state. Only when the module is removed does it remain in INIT state for a short time.

Transition: INIT to PREOP (IP)

During the IP state transition, the module registers with the ObjectServer with its unique ObjectID. The initialization parameters, which are also allocated during object creation, are transferred to the module. During this transition the module cannot establish connections to other modules, because it is not clear whether the other modules already exist and are registered with the ObjectServer. When the module requires system resources (e.g. memory), these can be allocated during the state transition. All allocated resources have to be released again during the transition from PREOP to INIT (PI).

State: PREOP

In PREOP state, module creation is complete and the module is usually fully parameterized, even if further parameters may be added during the transition from PREOP to SAFEOP. The module is registered in the ObjectServer, although no connections with other modules have been created yet.

Transition: PREOP to SAFEOP (PS)

In this state transition the module can establish connections with other modules. To this end it has usually received, among other things, ObjectIDs of other modules with the initialization data, which are now converted to actual connections with these modules via the ObjectServer.

The transition can generally be triggered by the system according to the configurator, or by another module (e.g. the parent module). During this state transition further parameters can be transferred. For example, the parent module can transfer its own parameters to the child module.

State: SAFEOP

The module is still in the non-real-time context and is waiting to be switched to OP state by the system or by other modules.

Transition: SAFEOP to OP (SO)

The state transition from SAFEOP to OP, the state OP, and the transition from OP to SAFEOP take place in the real-time context. System resources may no longer be allocated. On the other hand, resources can now be requested by other modules, and modules can register with other modules, e.g. in order to obtain a cyclic call during tasks.

This transition should not be used for long-running tasks. For example, file operations should be executed during PS.

State: OP

In OP state the module starts working and is fully active in the meaning of the TwinCAT system.

Transition: OP to SAFEOP (OS)

This state transition takes place in the real-time context. All actions from the SO transition are reversed, and all resources requested during the SO transition are released again.

Transition: SAFEOP to PREOP (SP)

All actions from the PS transition are reversed, and all resources requested during the PS transition are released again.

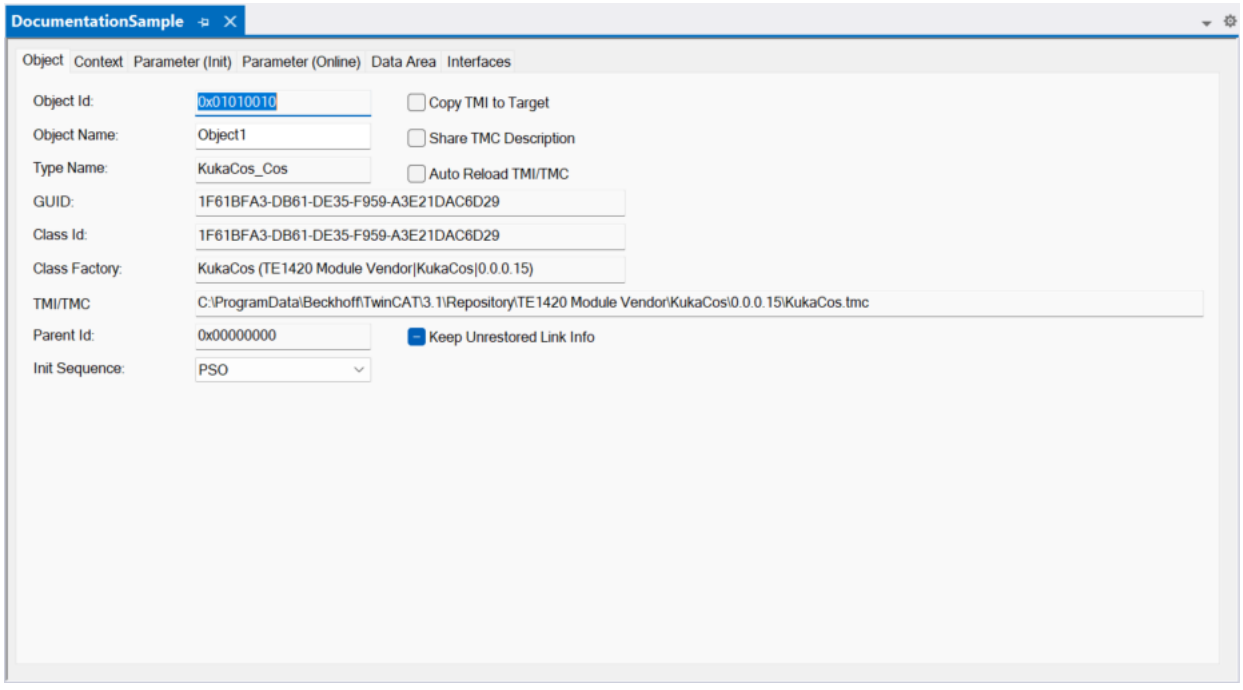
Transition: PREOP to INIT (PI)

All actions from the IP transition are reversed, and all resources requested during the IP transition are released again. The module signs off from the ObjectServer and usually deletes itself (see "Service life").

5.2 Handling TcCom modules

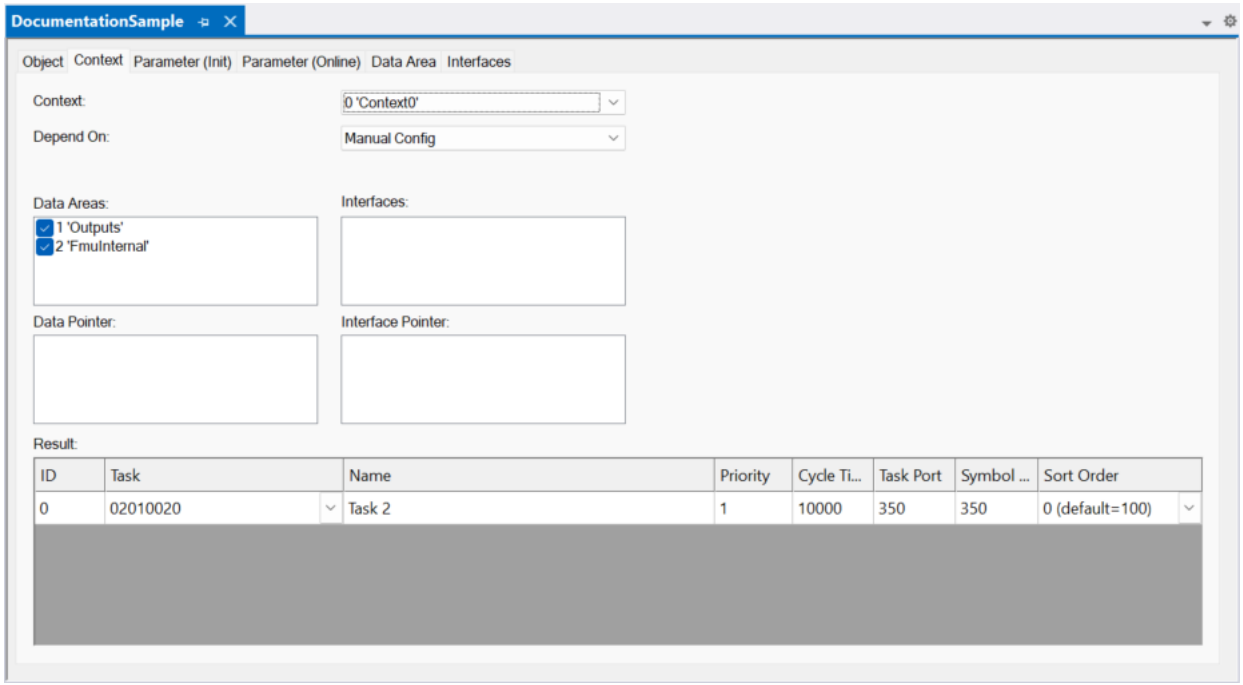
The following chapter deals with the handling of TcCom modules. For this purpose, both the mapping of the properties defined in the chapter TwinCAT module properties [▶ 250] in the various tabs of a TcCom module and the storage or use of the modules in a TwinCAT project are described.

5.2.1 Object tab



Object Id	Internal Id of the TcCom object instance in a TwinCAT project
Object Name	Name of the TcCom object instance
Type Name	Name of the TcCom object type
GUID	GUID of the module class
Class Id	GUID of the class that implements the module class.
Class Factory	Name of the TwinCAT driver
TMI/TMC	Path to the TMI/TMC file
Parent Id	Internal Id of the parent object in a TwinCAT project
Init Sequence	Init sequence up to which state the TcCom object should start.
Copy TMI to Target	Setting as to whether the instance information of the TcCom object should also be written to the target system.
Share TMC Description	Setting whether the TMC description should be shared for several module instances of the same class.
Auto Reload TMI/TMC	Automatically reloads the linked TMI/TMC file when it is rewritten to the hard disk.
Keep Unrestored Link Info	Setting as to whether link information that cannot be restored when reloading is saved for the module.

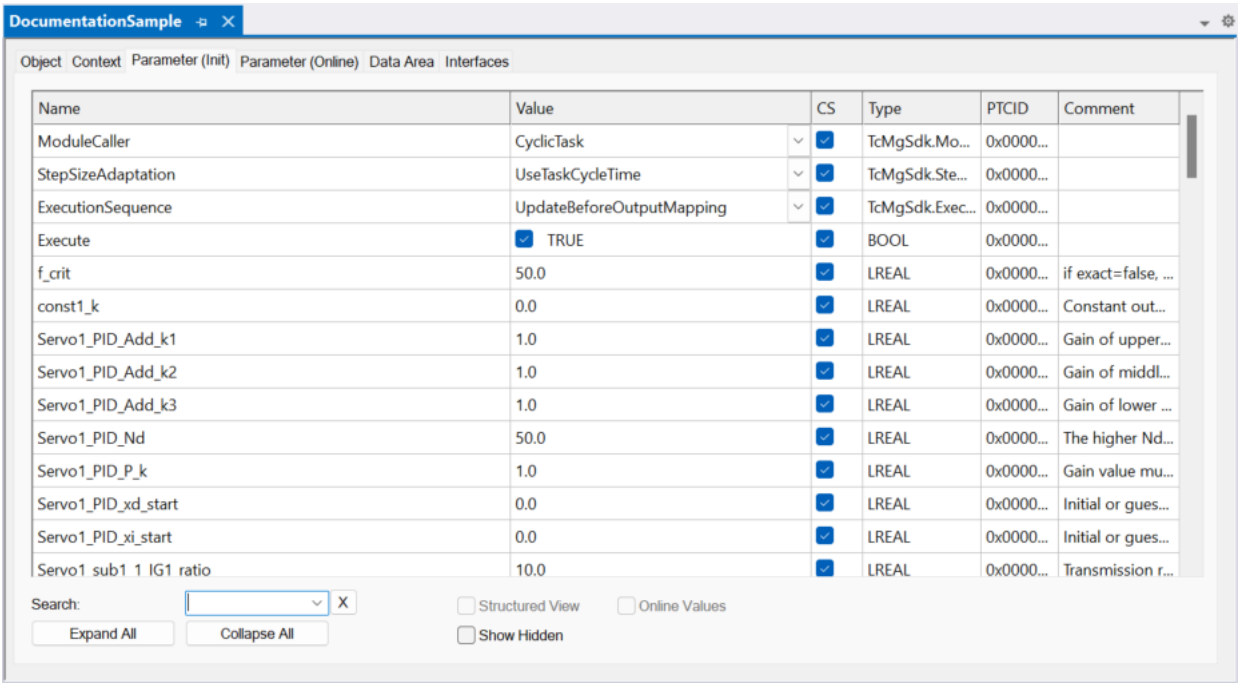
5.2.2 Context tab



Context	Choice of context for the settings to be changed (using the ID from the table below).
Depend On	Setting how this context is called up. (Manual setting, based on the parent object, based on the data areas, based on the task settings)
Data Areas	Choice of which data area is to be updated from the selected context.
ID	ID of the context
Task	ID of the tasks assigned to the context
Name	Name of the assigned tasks
Priority	Priority of the assigned tasks
Cycle Time	Cycle time of the assigned tasks
Task Port	Tasks port of the assigned tasks
Symbol Port	ADS symbol port of the selected tasks
Sort Order	Sort order with which the module logs on to the task. (The smaller the number, the more likely it is to be called up in the list of registered modules.)

5.2.3 Parameter (Init) tab

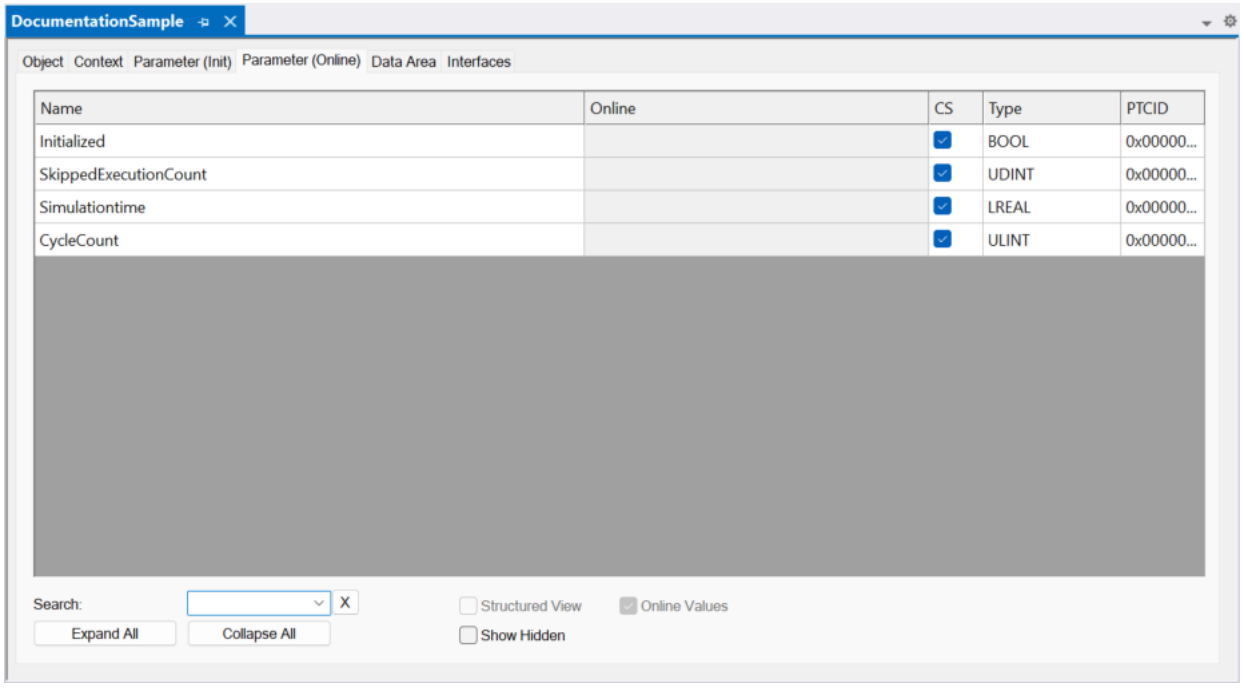
The initial parameters of the TcCom module are listed in this controller card.



Name	Name of the parameter
Value	Value of the parameter
CS	If the check mark is set, an ADS symbol is generated for the respective parameter.
Type	Data type of the parameter
PTCID	Parameter ID
Comment	Comment

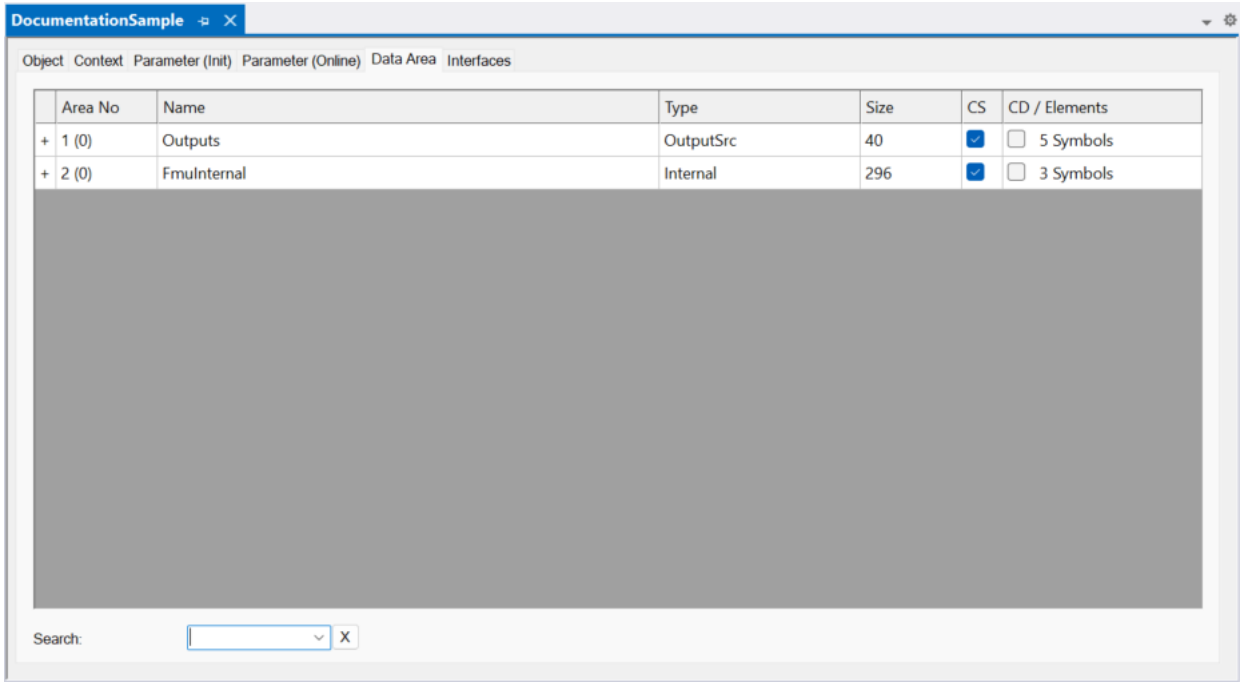
5.2.4 Parameter (Online) tab

The online values of the current TcCom module are displayed in this tab.



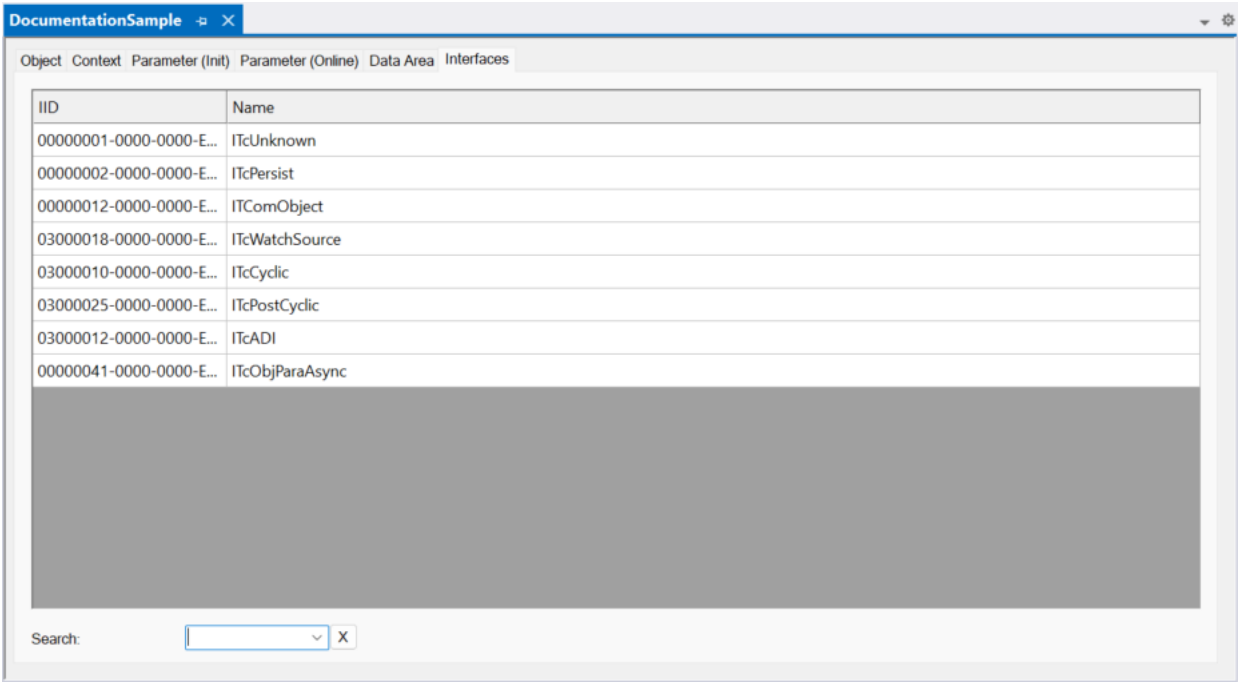
Name	Name of the parameter
Value	Value of the parameter
CS	If the check mark is set, an ADS symbol is generated for the respective parameter.
Type	Data type of the parameter
PTCID	Parameter ID

5.2.5 Data Area tab



Area No	ID of the data area
Name	Name of the data area
Type	Type of the data area or variable
Size	Size of the data area or variable
CS	Option to create the ADS symbols for the data area
CD / Elements	Option to create the data types on the runtime system so that they are available for the symbols.

5.2.6 Interfaces tab



IID	Interface ID
Name	Interface name

6 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Download finder

Our download finder contains all the files that we offer you for downloading. You will find application reports, technical documentation, technical drawings, configuration files and much more.

The downloads are available in various formats.

Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for local support and service on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on our internet page: www.beckhoff.com

You will also find further documentation for Beckhoff components there.

Beckhoff Support

Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

- support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

Hotline:	+49 5246 963-157
e-mail:	support@beckhoff.com

Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

Hotline:	+49 5246 963-460
e-mail:	service@beckhoff.com

Beckhoff Headquarters

Beckhoff Automation GmbH & Co. KG

Huelshorstweg 20
33415 Verl
Germany

Phone:	+49 5246 963-0
e-mail:	info@beckhoff.com
web:	www.beckhoff.com

Trademark statements

Beckhoff®, ATRO®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, MX-System®, Safety over EtherCAT®, TC/BSD®, TwinCAT®, TwinCAT/BSD®, TwinSAFE®, XFC®, XPlanar® and XTS® are registered and licensed trademarks of Beckhoff Automation GmbH.

Third-party trademark statements

Arm, Arm9 and Cortex are trademarks or registered trademarks of Arm Limited (or its subsidiaries or affiliates) in the US and/or elsewhere.

BiSS is a trademark of IC Haus GmbH.

Intel, the Intel logo, Intel Core, Xeon, Intel Atom, Celeron and Pentium are trademarks of Intel Corporation or its subsidiaries.

The registered trademark Linux® is used pursuant to a sublicense from the Linux Foundation, the exclusive licensee of Linus Torvalds, owner of the mark on a worldwide basis.

Microsoft, Microsoft Azure, Microsoft Edge, PowerShell, Visual Studio, Windows and Xbox are trademarks of the Microsoft group of companies.

More Information:
www.beckhoff.com/automation

Beckhoff Automation GmbH & Co. KG
Hülshorstweg 20
33415 Verl
Germany
Phone: +49 5246 9630
info@beckhoff.com
www.beckhoff.com