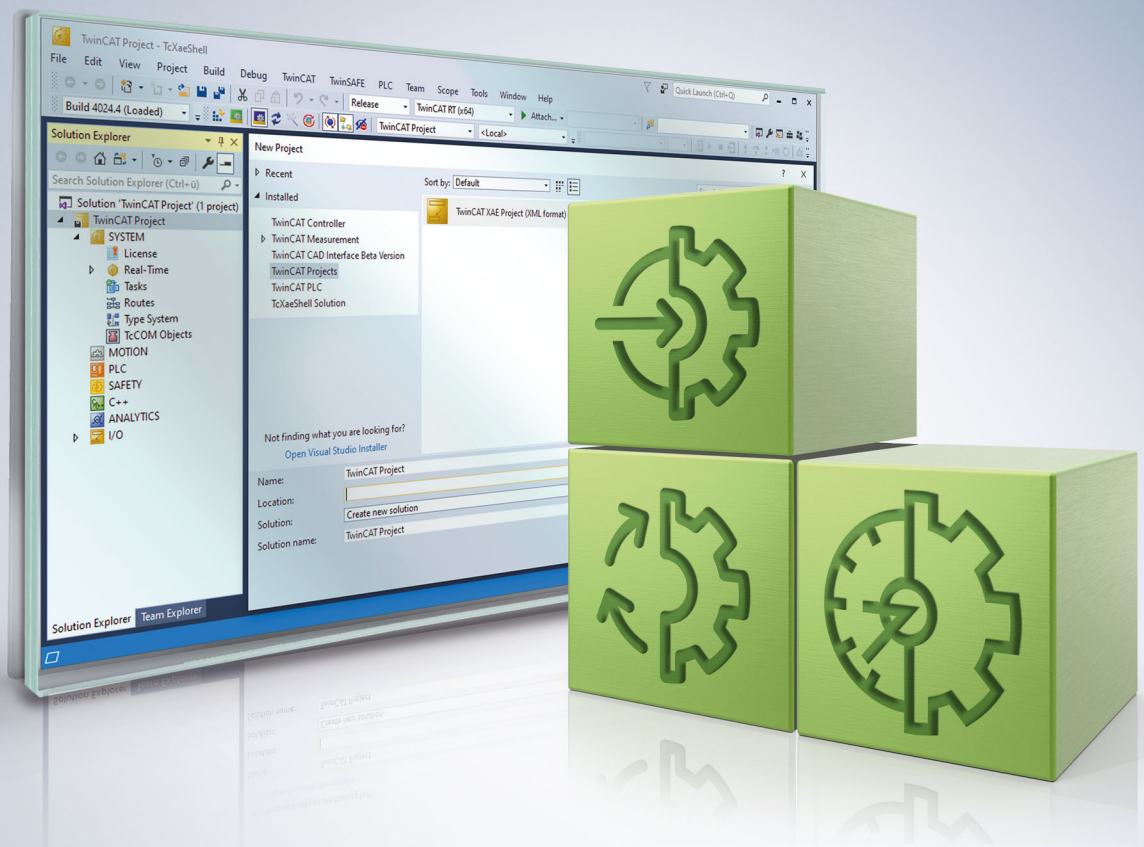
BECKHOFF New Automation Technology

Manual | EN

TC170x

TwinCAT 3 | Usermode Runtime



2025-07-09 | Version: 1.1.0

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1 Foreword

1.1 Notes on the documentation

This description is intended exclusively for trained specialists in control and automation technology who are familiar with the applicable national standards.
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

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

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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.

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1.4 Documentation issue status

Version	Changes
1.0.0	First public issue

2 Overview

This component is available from version TwinCAT 3.1 Build 4026.

The TwinCAT 3 Usermode Runtime enables the customer to execute a TwinCAT program without the deep TwinCAT operating system integration that would be necessary to ensure real-time execution.

The same program code of the customer project is executed but without meeting the real-time requirements.

The TwinCAT 3 Usermode Runtime provides functionality for three scenarios in particular:

- **Engineering (TC1700 - free of license costs)**: During the basic development of machine control systems, the focus is not yet on compliance with or measurement of real-time properties. The TwinCAT 3 Usermode Runtime can be used directly on the engineering system to execute, test or debug the program code as long as real-time properties are not required.
- **External Control (TC1701):** In some applications it makes sense to control the TwinCAT program from an external program. This enables synchronous integration of the execution, as is necessary, for example, when synchronous intermediate values are required in applications. The TwinCAT 3 Usermode Runtime offers an interface for this, whereby the ticks of the real-time are specified externally.
- **FastAsPossible (TC1702):** In particular for simulation aspects, it makes sense to execute the TwinCAT program code on a CPU as quickly as possible independently of real I/O and, for example, to calculate a preview of the result or the sequence. TwinCAT 3 Usermode Runtime offers an interface for this, so that instead of waiting for the next clock pulse, the real-time continues to calculate as quickly as possible.

3 Installation

The TwinCAT 3 Usermode Runtime is available as a workload in the TwinCAT package management workload

- TC170x | TwinCAT 3 Usermode Runtime

or as a package

- TwinCAT.XAR.UserModeRuntime.

System requirements

Technical data	Description
Operating system	Windows 10
Target platform	PC architecture (x64)
Minimum TwinCAT version	TwinCAT 3.1.4026
Required TwinCAT license	TC1700: no separate license required, only licenses used elsewhere in the project TC1701: License "TC3 UserMode Runtime - ExternalControl" in addition to the licenses used elsewhere in the project TC1702: License "TC3 UserMode Runtime - FastAsPossible" in addition to the licenses used elsewhere in the project

It is recommended to provide at least two cores for the operating system - otherwise communication may be interrupted if the computing time within the Usermode Runtime is heavily used.

TwinCAT Package Manager: Installation (TwinCAT 3.1 Build 4026)

Detailed instructions on installing products can be found in the chapter Installing workloads in the TwinCAT 3.1 Build 4026 installation instructions.

Install the following workload to be able to use the product:

- TC170x | TwinCAT 3 Usermode Runtime

Licensing

The TwinCAT 3 Usermode Runtime is used in different scenarios, which are licensed differently.

In principle, the licenses required for execution, such as TC1200 for the PLC, are also required for the device with TwinCAT 3 Usermode Runtime. This licensing takes place per device, so that mixed operation with real-time and Usermode Runtime is also possible with the same licenses.
The usual 7 days trial licenses can also be used in combination with the Usermode Runtime.

- **Engineering (TC1700):** No separate licensing requirement arises here. In combination with the 7 days trial licenses, this generally enables free test execution with the TwinCAT 3 Usermode Runtime as well as with the real-time runtime.
- **External Control (TC1701)**: This interface is additionally licensed for the device in the usual way. Irrespective of this, the normal licenses (such as TC1200 PLC) are required for the device.
- **Fast As Possible (TC1702):** This interface is additionally licensed for the device in the usual way. Irrespective of this, the normal licenses (such as TC1200 PLC) are required for the device.

3.1 Revision control

The revision control of the Usermode Runtime is based on the TwinCAT.Standard Workload, e.g. version 4026.42.
This is intended to indicate that the behavior is similar to that of the corresponding TwinCAT.Standard Workload.

The version number of the package referenced in the TwinCAT.UsermodeRuntime.XAR workload is different because this package is built and tested independently.

4 Limitations

The TwinCAT 3 Usermode Runtime provides an execution environment for the same program code that is executed in the real-time runtime.

- The TwinCAT 3 Usermode Runtime has no guaranteed deterministic execution properties. The operating system is able to interrupt the Usermode Runtime at any time.
- The TwinCAT 3 Usermode Runtime has no access to EtherCAT. The I/O part of the configuration is therefore normally "disabled".
- Components that are based on the real-time Ethernet driver can be executed. The execution times and the jitter can affect the function due to the principle.
- CCAT-based network cards cannot be used.
- TwinCAT 3 Usermode Runtime cannot access USB, i.e. the license key USB stick cannot be used.
- In principle, it does not make sense to use all TwinCAT functions under a TwinCAT 3 Usermode Runtime. For example, some TwinCAT functions require a constant real-time tick.
  If appropriate, TwinCAT 3 functions are extended to work with the TwinCAT 3 Usermode Runtime. In particular, if something has to be observed for the TwinCAT 3 Usermode Runtime with regard to the configuration, this is documented for the respective products.
- The execution order between the tasks may differ from the behavior in the real-time runtime due to the principle [▶ 11].
  For this reason, it also makes sense not to make the execution order dependent on the task priorities.

5 Technical introduction

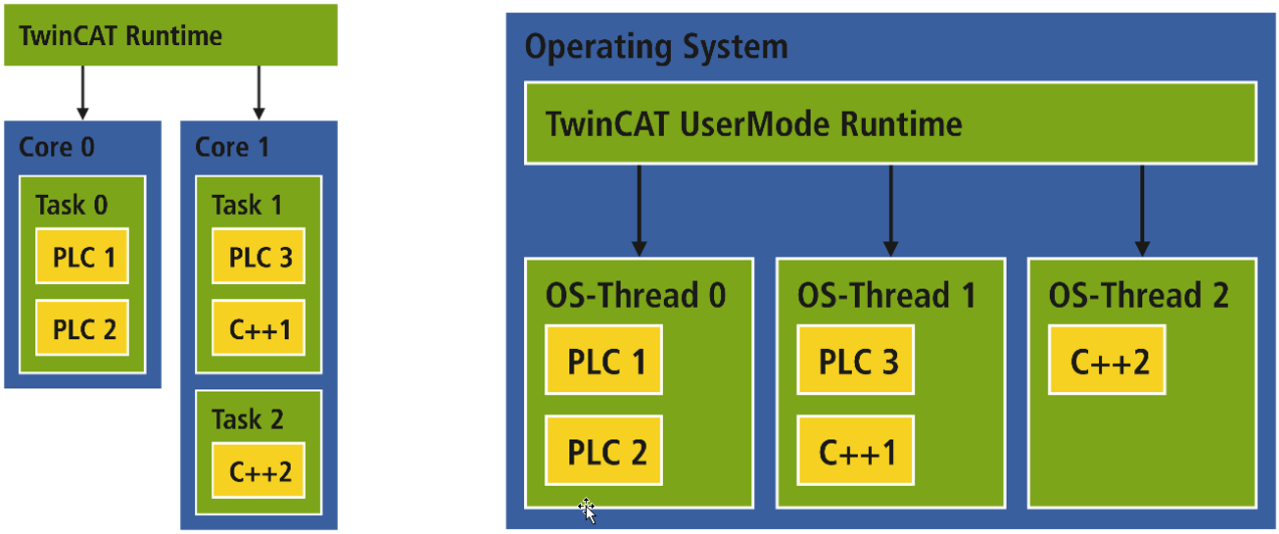
The TwinCAT 3 Usermode Runtime executes an engineering program as the same binary - but not under the usual real-time conditions. As a result, deviating system behavior must be expected, particularly with regard to time.

Separate configurations or behaviors must be taken into account for the use of further TwinCAT functions; these are described at Integration TwinCAT Functions [▶ 14].

The necessary parameterization is carried out via command line parameters [▶ 16] on the one hand and a configuration file [▶ 16] on the other.

5.1 Illustration Multi Core

While the real-time runtime has direct access to the hardware and can therefore use cores in a dedicated and possibly isolated manner, the TwinCAT Usermode Runtime does not have this option.
TwinCAT 3 Usermode Runtime therefore maps a task to an operating system thread. The assignment of tasks to CPU cores, on the other hand, is accepted by the Usermode Runtime but technically not taken into account, as the operating system manages these threads.



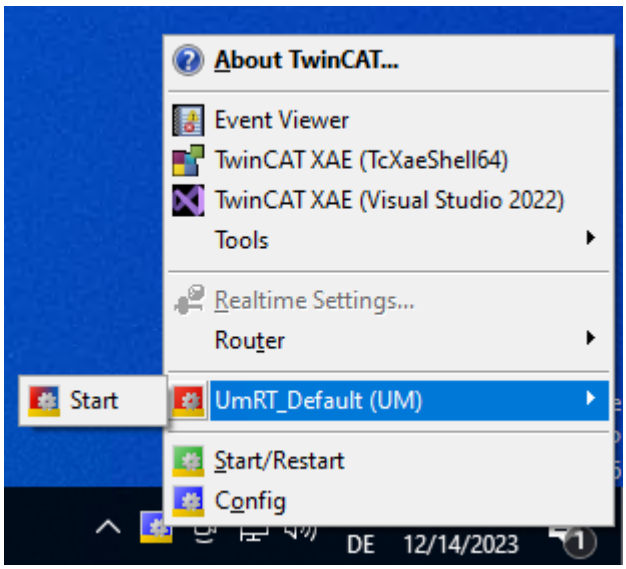
5.2 File storage

After installation, TwinCAT 3 Usermode Runtime files are located in two places:

- C:**Program Files (x86)**\Beckhoff\TwinCAT\3.1\Runtimes
  Contains the TwinCAT 3 Usermode Runtime itself as well as a copy template ("UmRT_Template") for the *ProgramData* directories of the TwinCAT 3 Usermode Runtime
- C:**ProgramData**\Beckhoff\TwinCAT\3.1\Runtimes
  Contains a directory "UmRT_Default" after installation.
  In addition to this directory, the copy template can be copied from the *Program Files (x86)* and thus several TwinCAT 3 Usermode Runtimes can be provided in parallel.
  This directory essentially contains a *start.bat*, which can be used to start the respective instance.
  The subdirectory *3.1/* contains the boot directory as well as a *TcRegistry.xml*, which serves as a configuration interface [▶ 16].

5.3 Starting the TwinCAT 3 Usermode Runtime

The TwinCAT 3 Usermode Runtime can be started via the TcSysUI:



The TwinCAT 3 Usermode Runtime starts in the background.
The router status can then be queried and changed via the same menu.

A minimized window provides additional interaction:

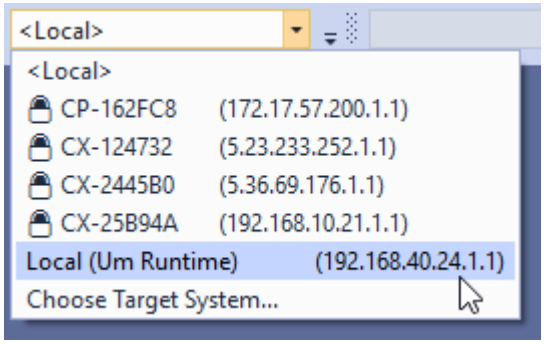
```
heap memory allocated 000002514EB00000 size=536870912
TcSysSrvUm state: Config [8896]
AmsNetId: 199.4.42.250.1.1
TcSysSrvUm state: Config [8896]

Press 'c' for Reconfig TwinCAT System.
Press 'r' for Restart TwinCAT system.
Press 's' to view current state.
Press 'x' to exit TwinCAT system service.
Press 'd' to detach the exception handler.
```

- 'c': Sets the Usermode Runtime to CONFIG - if it is already in CONFIG, a ReCONFIG is executed.
- 'r': Sets the Usermode Runtime to RUN - if it is already in RUN, it is restarted.
- 's': Sows the current state of the Usermode Runtime.
- 'x': Exits Usermode Runtime.
- 'd': A debugger is usually started with the Usermode Runtime, which is necessary for debugging a PLC, for example. This debugger can be terminated with 'd' if external debugging tools are to be used.

5.4 Using the TwinCAT 3 Usermode Runtime

Like the real-time runtime, the TwinCAT 3 Usermode Runtime can be addressed via an AmsNetId. This is defined when TwinCAT 3 Usermode Runtime is started for the first time and saved afterwards.



5.5 Using External Control (TC1701)

The "External Control" interface allows external applications to control the cycle tick. The advantage of specifying the cycle tick here is that the program can be simulated more quickly if the complexity of the model allows it. Conversely, the TwinCAT application can also be executed more slowly if the calculation of a model in the external application takes longer than the set cycle time.

On the other hand, this also means that the overall system does not execute - and therefore does not process - any code if no corresponding instruction has been issued.
The application can automatically switch back to normal cyclic execution in the code.

Use

The TwinCAT 3 Usermode Runtime must be called with the command line parameter "-f 0x4". The easiest way to achieve this is to extend the corresponding Start.bat in the ProgramData [▶ 11]:

```
start "%TC_INST_NAME%" /min "%TWINCAT3DIR%Runtimes\bin\TcSystemServiceUm.exe" -t bin -i path -n %TC_INST_NAME% -c .\3.1 -f 0x4
```

This enables the functionality of switching between the modes described below.

If this mode is set to the value `RtMode_Externaltick` in a real-time program by the PLC or a C++ module using the ITcRTimeSimulation [▶ 18] interface, the execution of the code is stopped.

In the following, the ADS interface External Control [▶ 18] can be used to control the execution by specifying 1..n cycle steps.

The application can return to cyclic execution by setting the value `RtMode_Cyclic` using `ITcRTimeSimulation->ChangeTickMode`.

The documentation for this is shown in the chapter API [▶ 18] as well as in the sample [▶ 21].

5.6 Using Fast As Possible (TC1702)

If the TwinCAT 3 Usermode Runtime is configured accordingly, the "Fast As Possible" interface can be used to instruct the execution environment not to use delays in order to map a real execution speed. Instead, the next cycle is started immediately after the program has been processed.

In return, this also means that the computer is loaded accordingly. To ensure that this remains available, it is recommended to have at least one more core than there are tasks in the project.

Use

The TwinCAT 3 Usermode Runtime must be called with the command line parameter "-f 0x4". The easiest way to achieve this is to extend the corresponding Start.bat in the ProgramData [▶ 11]:

```
start "%TC_INST_NAME%" /min "%TWINCAT3DIR%Runtimes\bin\TcSystemServiceUm.exe" -t bin -i path -n %TC_INST_NAME% -c .\3.1 -f 0x4
```

This enables the functionality of switching between the modes described below.

If this mode is set to the value `RtMode_FastAsPossible` via the ITcRTimeSimulation [▶ 18] interface, the code is executed as quickly as possible without delays.

The application can return to cyclic execution by setting the value `RtMode_Cyclic` using `ITcRTimeSimulation->ChangeTickMode`.

The documentation for this is shown in the chapter API [▶ 18] as well as in the sample [▶ 21].

5.7 Several TwinCAT 3 Usermode Runtimes on one system

Several TwinCAT 3 Usermode Runtimes can be started on one system.

The starting point for the scenario is copying the template from *Program Files (x86)* to *ProgramData*, as documented in File storage [▶ 11].

The following aspects must be taken into account:

- The AmsNetIds (command line parameter "-i") [▶ 16] must be unique in an entire AMS network. This means that the TwinCAT 3 Usermode Runtimes must have different AmsNetIds.
- Different configuration folders (command line parameter "-c" [▶ 16]) must be specified.
- It is not possible to connect several TwinCAT 3 Usermode Runtimes from one system to another external system, as the router on the external system cannot distinguish between the TwinCAT 3 Usermode Runtimes.
  In such a scenario, ADS-over-MQTT with a broker as intermediary should be evaluated.

5.8 Integration TwinCAT Functions

TwinCAT Functions must be partially upgraded to work with the TwinCAT 3 Usermode Runtime.

The information required to commission the functions with the TwinCAT 3 Usermode Runtime is provided here.

5.8.1 TF5100 | TwinCAT 3 NCI (GST interpreter)

The TF5100 TwinCAT 3 NCI function is partially supported (GST interpreter, PLC interpolation) by the TwinCAT 3 Usermode Runtime. The Classic interpreter is not supported.

GST interpreter

In addition to the general user mode runtime installation [▶ 9], the following packages must also be installed on the Usermode Runtime system in order to use the GST interpreter:

- TwinCAT.XARUM.NCPTP
- TwinCAT.XAR.NCI.GST

The GST interpreter is an ADS server which is started by the Usermode Runtime. To do this, the StartManConfig.xml file with the following content must be set up in the 3.1\Target directory of the Usermode Runtime (for example: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Runtimes\UmRT_Default\3.1\Target*) once the function has been installed.

```
<StartMan>
    <TwinCATServers>
        <TwinCATServer Enabled="1">
            <Name>TcMcGst</Name>
            <Path>C:\Program Files (x86)\Beckhoff\TwinCAT\3.1\Components\Mc\Nci\TcMcGst.exe</Path>
        </TwinCATServer>
    </TwinCATServers>
</StartMan>
```

Each Usermode Runtime instance has its own registry: TcRegistry.xml. This defines the default directories for the GST interpreter. If the TcRegistry.xml file needs to be edited, the associated Usermode Runtime instance must not be started.

```
<TcRegistry>
   <Key Name="HKLM">
      <Key Name="Software">
         <Key Name="Beckhoff">
            <Key Name="TwinCAT3">

               <Key Name="Nc">
                  <Key Name="TcMcGst">
                     <Value Name="searchpath" Type="SZ">C:\ProgramData\Beckhoff\TwinCAT\Mc\Nci\</
Value>
                     <Value Name="workingdirectory" Type="SZ">C:
\ProgramData\Beckhoff\TwinCAT\Mc\Nci\UmRT_Default\</Value>
                  </Key>
               </Key>

            </Key>
         </Key>
```

```
      </Key>
   </Key>
</TcRegistry>
```

GST interpreter and Fast As Possible mode

The GST interpreter is an ADS server outside the runtime in the Windows context. This means that the state of the GST interpreter is not taken into account when the cycle tick is presented in the Fast As Possible modes of the Usermode Runtime. This can result in the NC executing the Motion commands faster than the interpreter sends the commands to the NC. This results in unrealistic dynamic progressions and a lack of smoothing. To prevent this, when using the Fast As Possible mode in conjunction with the GST interpreter, the lookahead of the NC should be monitored and switched to cyclic mode if the value falls below a threshold so that the interpreter has the chance to fill the lookahead again.

```
IF fbSetRtMode.bExecute = FALSE THEN
    IF io_X.NcToPlc.SafEntries > nSafEntriesThreshold THEN
        IF fbSetRtMode.rtMode <> E_RtMode.RtMode_FastAsPossible THEN
            fbSetRtMode.rtMode := E_RtMode.RtMode_FastAsPossible;
            fbSetRtMode.bExecute := TRUE;
        END_IF
    ELSIF fbSetRtMode.rtMode <> E_RtMode.RtMode_Cyclic THEN
        fbSetRtMode.rtMode := E_RtMode.RtMode_Cyclic;
        fbSetRtMode.bExecute := TRUE;
    END_IF
ELSIF NOT fbSetRtMode.bBusy THEN
    fbSetRtMode.bExecute := FALSE;
END_IF

fbSetRtMode();
```

5.8.2 TF6310 | TwinCAT 3 TCP/IP

The function TF6310 TwinCAT 3 TCP/IP is based on an ADS Server, which is started by the TwinCAT 3 Usermode Runtime.

To do this - after the function has been installed - a *StartManConfig.xml* file with the following content must be created in the 3.1\Target directory of the Usermode Runtime (for example: *C:\ProgramData\Beckhoff\TwinCAT\3.1\Runtimes\UmRT_Default\3.1\Target*)

```
<StartMan>
                <TwinCATServers>
                                <TwinCATServer Enabled="1">
                                                <Name>TcpIpServer</Name>
                                                <Path>C:\Program Files
(x86)\Beckhoff\TwinCAT\Functions\TF6310-TCP-IP\Win32\Server\TcpIpServer.exe</Path>
                                </TwinCATServer>
                </TwinCATServers>
</StartMan>
```

5.8.3 TF7xxx | TwinCAT 3 Vision

A few configurations must be taken into account to use TwinCAT 3 Vision with the Usermode Runtime. These are described in the TwinCAT 3 Vision documentation in the chapter Using the TwinCAT 3 Usermode Runtime.

6 Reference

6.1 Command line parameters & commands

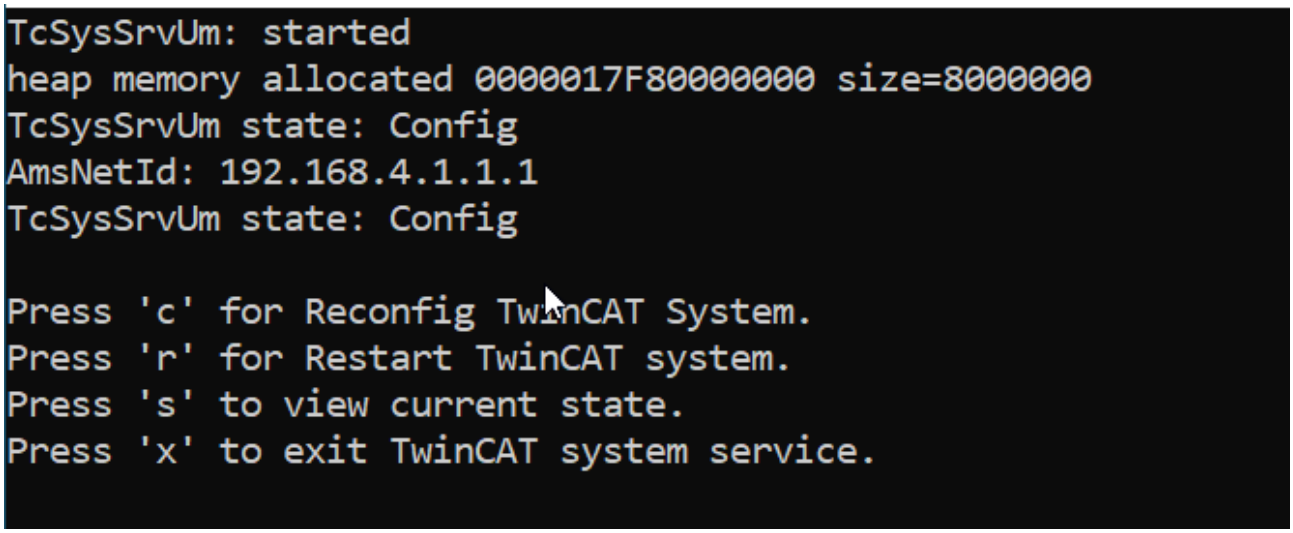
The TwinCAT 3 Usermode Runtime is implemented by the program *TcSystemServiceUm.exe*. This program can also be called up or used directly, which is why parameters and commands are described here.

Parameter

- -i: Specifies the AmsNetId to be used. Example "-i 192.168.4.1.1.1"
- -n: Name of the TwinCAT 3 Usermode Runtime. Example "-n MyUmRuntime"
- -c: Path to the configuration folder. Example "-c ..\3.1"
- -f 0x4: Mode to use External Control [▶ 13] or Fast As Possible [▶ 13].

Commands

If the TwinCAT 3 Usermode Runtime is started on the command line, the following output appears:



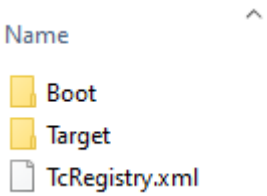
- "c" switches to Config mode
- "r" switches to Run mode
- "s" queries the current state
- "x" exits the TwinCAT 3 Usermode Runtime

6.2 Configuration

The entire configuration of the TwinCAT 3 Usermode Runtime is carried out in the *\3.1* directory. The structure of the directories is described at File storage [▶ 11].

Here you will find the usual files that are also used for the real-time runtime. On the one hand, this concerns the boot directory, which contains the program to be executed by enabling a configuration. On the other hand, the target directory, which for example also contains the route information via StaticRoutes.xml for the Usermode Runtime.

Under Windows, TwinCAT saves a number of settings in the system-wide Windows registry. Because the Usermode Runtime may have different settings than the real-time runtime, the *TcRegistry.xml* file is provided locally in the *\3.1* directory for this purpose.



The following XML entries in the TcRegistry.xml are of particular interest for the TwinCAT 3 Usermode Runtime:

- The structure used is similar to the Windows registry, so that adaptations can also be derived for other components.
- **HeapMemSizeMB** (see example below): Total size of the memory used.
  In real-time runtime, it corresponds to the nonpaged pool of Windows, but in Usermode Runtime, it is allocated completely at startup. The memory must be sufficient for
  - Router memory: Is defined via the Engineering Realtime-Tab->Settings->Router Memory. This value is stored as `LockedMemSize` (in bytes) in the TcRegistry.xml.
  - Application memory: Memory that is allocated by the runtime itself, the PLC, TMX modules or also dynamically by the application.

```
<?xml version="1.0"?>
<TcRegistry>
    <Key Name="HKLM">
        <Key Name="Software">
            <Key Name="Beckhoff">
                <Key Name="TwinCAT3">
                    <Value Name="CurrentVersion" Type="SZ">3.1</Value>
                    <Key Name="System">
                        <Value Name="RunAsDevice" Type="DW">1</Value>
                        <Value Name="AmsNetId" Type="BIN">C0A804010101</Value>
                        <Value Name="HeapMemSizeMB" Type="DW">512</Value>
                    </Key>
[…]
```

7 API

7.1 External Control (ADS)

An interface is available for TwinCAT 3 Usermode Runtime - External Control to enable access from external programs via ADS.

This interface consists of several parts:

Query the state

The current state can be queried via this interface.

ADS Port	Index Group	Index Offset	Access	Data type	Description	Note
200	0x00000001 (RTADSGRP_SYSDATA)	0x00000032 (RTADSOFFS_SYSDATA_TICK_MODE)	R	ULONG	Returns the current RtMode. If the value is 3 (RtMode_Externaltick), the calculation can be triggered by starting the tick.	

Values of the RtMode:

```
enum RtMode
{
        RtMode_None = 0,
        RtMode_Normal = 1,
        RtMode_Simulation = 2,
        RtMode_ExternalTick = 3,
        RtMode_Invalid = -1
}
```

Starting the ticks

This interface can be used to specify a number of ticks that the TwinCAT 3 Usermode Runtime should execute.

ADS Port	Index Group	Index Offset	Access	Data type	Description	Note
200	0x00000001 (RTADSGRP_SYSDATA)	0x00000031 (RTADSOFFS_SYSDATA_TICKNOW)	W	Int	Number of ticks that the Usermode Runtime should execute. Return value indicates whether the command can be processed, then ADSERR_NOERR.	

7.2 Interface ITcRTimeSimulation

The ITcRTimeSimulation interface provides the interface for accessing the TwinCAT 3 Usermode Runtime from the real-time program (in PLC / C++). This can be used to query and change the status.

Syntax

```
TCOM_DECL_INTERFACE("460AD091-0352-4002-9C5E-C8AE7A1AFE56", ITcRTimeSimulation)
```

Methods

Name	Description
ChangeTickMode [▶ 19]	Change the mode of the Usermode Runtime.
GetTickMode [▶ 19]	Query the mode of the Usermode Runtime.
AdvanceTick [▶ 19]	Execution of real-time ticks for the Usermode Runtime.

7.2.1 Method ITcRTimeSimulation:ChangeTickMode

Change the mode of the Usermode Runtime.

Syntax

```
virtual HRESULT TCOMAPI ChangeTickMode(ULONG rtTickMode) = 0;
```

Parameter

Name	Type	Description

rtTickMode	ULONG	Sets the mode of the Usermode Runtime.
		`RtMode_FastAsPossible := 2`
		`RtMode_Externaltick := 3`
		`RtMode_Cyclic := 4`

Return value

If successful, S_OK ("0") or another positive value will be returned, cf. Return values [▶ 22]. Extended messages refer in particular to the column HRESULT in ADS Return Codes [▶ 24].

7.2.2 Method ITcRTimeSimulation:GetTickMode

Query the mode of the Usermode Runtime.

Syntax

```
virtual HRESULT TCOMAPI GetTickMode(ULONG& rtTickMode) = 0;
```

Parameter

Name	Type	Description

rtTickMode	ULONG&	Query the advanced mode of the Usermode Runtime
		`RtMode_None := 0`
		`RtMode_Normal := 1`
		`RtMode_FastAsPossible := 2`
		`RtMode_Externaltick := 3`
		`RtMode_Cyclic := 4`
		`RtMode_Invalid := -1`

Return value

If successful, S_OK ("0") or another positive value will be returned, cf. Return values [▶ 22]. Extended messages refer in particular to the column HRESULT in ADS Return Codes [▶ 24].

7.2.3 Method ITcRTimeSimulation:AdvanceTick

Execution of real-time ticks for the Usermode Runtime.

Syntax

```
virtual HRESULT TCOMAPI ChangeTickMode(ULONG rtTickMode) = 0;
```

Parameter

Name	Type	Description
nTicks	ULONG	Execution of the number of ticks.

Return value

If successful, S_OK ("0") or another positive value will be returned, cf. Return values [▶ 22]. Extended messages refer in particular to the column HRESULT in ADS Return Codes [▶ 24].

7.3 Runtime type (ADS)

A runtime provides an interface via ADS with which an ADS client can query the type.

Platform type

The platform type can be queried via this interface.

ADS Port	Index Group	Index Offset	Access	Data type	Description	Note
200	0x00000700 (SYSTEMSERVICE_TARGETINFO)	0x00000004 (TARGETINFO_PLATFORM)	R	String	A string with the platform as selected in TwinCAT XAE Engineering. For example, a "TwinCAT OS (x64)" for a TwinCAT Usermode Runtime or a TwinCAT/BSD® system.	

Runtime type

The runtime type can be queried via this interface - i.e. the information whether it is a real-time runtime or the TwinCAT 3 Usermode Runtime.

ADS Port	Index Group	Index Offset	Access	Data type	Description	Note
200	0x00000700 (SYSTEMSERVICE_TARGETINFO)	0x00000002 (TARGETINFO_TARGETTYPE)	R	ULONG	1 = Usermode Runtime 0 = no Usermode Runtime	

8 Sample

This sample shows the different ways in which the TwinCAT 3 Usermode Runtime can be used.

Sample code for these products can be obtained from the corresponding repository on GitHub: https://github.com/Beckhoff/TC170x_Samples.
There you have the option to clone the repository or download a ZIP file containing the sample.

The sample assumes that a TwinCAT 3 Usermode Runtime has been started for execution and that this has also been started with -f 0x4 to switch between different modes, as described [▶ 13].

There are two projects in the repository:

- TcRtSimulationExternalTick provides external control of the TwinCAT 3 Usermode Runtime. A command is sent that leads to the execution of 100 real-time ticks.
  The program can be easily compiled in a Visual Studio with C++ support. Please note that you may need to adjust the AmsNetId.
- TestTcOsUmRtSimulation_SelfTick is a TwinCAT solution that provides a corresponding sample to demonstrate the use of the products.

External Control (TC1701): MAIN_ExternalTick

A counter `value` is counted down from 100 to 0 in normal cyclic mode. Meanwhile, "...cycling..." is displayed in a "hint" variable. The system then waits for the external ticks, which you can send using the TcRtSimulationExternalTick program

The three variants of MAIN_ExternalTick show different ways to use the same interface:
Via ADS (MAIN_ExternalTick),
as a Functions call (MAIN_ExternalTick_F),
or as a TcCOM object (MAIN_ExternalTick_ITc).

Fast As Possible (TC1702): MAIN_FastAsPossible

A counter `value` is counted down from 100 to 0 in normal cyclic mode. The system then switches to RtMode_FastAsPossible and counts from 100,000 to 0. The process is repeated, which is counted in the counter Iteration.

The three variants of MAIN_FastAsPossible show different ways to use the same interface: Via ADS (MAIN_FastAsPossible); as a Functions call (MAIN_FastAsPossible_F); or as a TcCOM object (MAIN_FastAsPossible_ITc).

9 Appendix

9.1 Return values

ITc interfaces methods generally return an HRESULT.

The following return values can be returned in the case of ITc interfaces:

Name	HRESULT
S_OK	0x0000 0000
S_FALSE	0x0000 0001
E_NOTIMPL	0x8000 4001
E_NOINTERFACE	0x8000 4002
E_POINTER	0x8000 4003
E_ABORT	0x8000 4004
E_FAIL	0x8000 4005
E_UNEXPECTED	0x8000 FFFF
E_ACCESSDENIED	0x8007 0005
E_HANDLE	0x8007 0006
E_OUTOFMEMORY	0x8007 000E
E_INVALIDARG	0x8007 0057

In addition, there is a possibility for ADS Return Codes [▶ 24] to be returned as HRESULT. These are also available as macros in the SDK, where they are known, for example, as ADS_E_BUSY for the ADS Error Code ADSERR_DEVICE_BUSY.

9.2 FAQ - frequently asked questions and answers

In this section frequently asked questions are answered, in order to facilitate your work with the TwinCAT Usermode Runtime. If you have any further questions, please contact our support team at support@beckhoff.com.

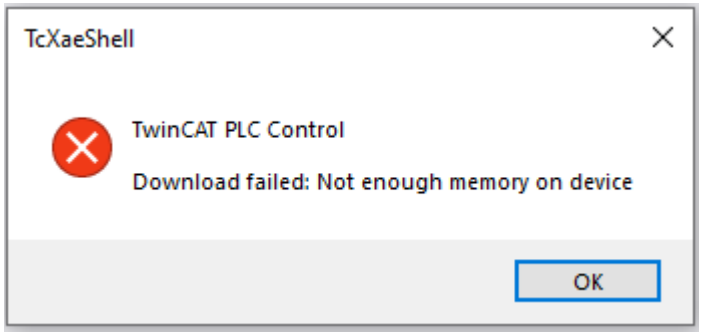
1. How do I start the TwinCAT Usermode Runtime? [▶ 22]
2. What does the error message mean: too little memory when using the PLC? [▶ 22]
3. How can I access the Usermode Runtime remotely? [▶ 23]
4. How is a collision of the AmsNetId prevented? [▶ 23]
5. Is TwinCAT C++ and CriticalSections available in the Windows context? [▶ 23]

How do I start the TwinCAT Usermode Runtime?

You can start the Usermode Runtime via the "start.bat" in your respective ProgramData [▶ 11] folder. It can then be selected as a target system via the Automation Interface and can be used in the same way as other systems in terms of Activate Configuration and changing the state.

What does the error message mean: too little memory when using the PLC?

If you get this error when logging in (or through the autostart):



your application requires more memory than the Usermode Runtime provides by default.
A file 3.1/TcRegistry.xml is available in the ProgramData directory of the Usermode Runtime, which you can use to change this configuration. Insert a value "HeapMemSizeMB", which specifies a value in megabytes. Here it is 512 MB:

```
<Key Name="TwinCAT3">
    <Value Name="CurrentVersion" Type="SZ">3.1</Value>
    <Key Name="System">
        <Value Name="RunAsDevice" Type="DW">1</Value>
        <Value Name="AmsNetId" Type="BIN">C7042AFA0101</Value>
        <Value Name="HeapMemSizeMB" Type="DW">512</Value>
```

How can I access the Usermode Runtime remotely?

The Usermode Runtime has its own router component and its own AmsNetId. The Usermode Runtime logs on to the system router component so that it can be reached locally via its own AmsNetId.

If the Usermode Runtime is to be accessible from another system, the file 3.1\StaticRoutes.xml can be extended in its ProgramData directory, as described in the documentation TwinCAT 3 ADS-over-MQTT.

How is a collision of the AmsNetId prevented?

A Usermode Runtime requires a unique AmsNetId on the system. This is saved in the configuration in your ProgramData directory 3.1\TcRegistry.xml.

If a Usermode Runtime has already occupied this AmsNetId at startup, the 2nd byte is incremented: 199.**4**.42.250.1.1 thus becomes 199.**5**.42.250.1.1.

Is TwinCAT C++ and CriticalSections available in the Windows context?

The CriticalSections synchronization mechanism is not available in the Windows context for TwinCAT C++. It is not required if the state machine is used correctly. The EnterCriticalSection call is therefore ignored in these transitions. However, in Usermode Runtime, the call terminates the process via an exception to improve understanding. The following code queries this explicitly:

```
if ( !InWindows() )
    m_cs.EnterCriticalSection();
m_counter = 0x00u;

if (!InWindows() )
    m_cs.LeaveCriticalSection();
```

However, it is important to familiarize yourself with the state machine of the C++ modules and to use it appropriately. Critical sections can be omitted in these steps.

9.3 ADS Return Codes

Grouping of error codes:
Global error codes: 0x0000 [▶ 24]... (0x9811_0000 ...)
Router error codes: 0x500 [▶ 24]... (0x9811_0500 ...)
General ADS errors: 0x700 [▶ 25]... (0x9811_0700 ...)
RTime error codes: 0x1000 [▶ 27]... (0x9811_1000 ...)

Global error codes

Hex	Dec	HRESULT	Name	Description
0x0	0	0x98110000	ERR_NOERROR	No error.
0x1	1	0x98110001	ERR_INTERNAL	Internal error.
0x2	2	0x98110002	ERR_NORTIME	No real time.
0x3	3	0x98110003	ERR_ALLOCLOCKEDMEM	Allocation locked – memory error.
0x4	4	0x98110004	ERR_INSERTMAILBOX	Mailbox full – the ADS message could not be sent. Reducing the number of ADS messages per cycle will help.
0x5	5	0x98110005	ERR_WRONGRECEIVEHMSG	Wrong HMSG.
0x6	6	0x98110006	ERR_TARGETPORTNOTFOUND	Target port not found – ADS server is not started, not reachable or not installed.
0x7	7	0x98110007	ERR_TARGETMACHINENOTFOUND	Target computer not found – AMS route was not found.
0x8	8	0x98110008	ERR_UNKNOWNCMDID	Unknown command ID.
0x9	9	0x98110009	ERR_BADTASKID	Invalid task ID.
0xA	10	0x9811000A	ERR_NOIO	No IO.
0xB	11	0x9811000B	ERR_UNKNOWNAMSCMD	Unknown AMS command.
0xC	12	0x9811000C	ERR_WIN32ERROR	Win32 error.
0xD	13	0x9811000D	ERR_PORTNOTCONNECTED	Port not connected.
0xE	14	0x9811000E	ERR_INVALIDAMSLENGTH	Invalid AMS length.
0xF	15	0x9811000F	ERR_INVALIDAMSNETID	Invalid AMS Net ID.
0x10	16	0x98110010	ERR_LOWINSTLEVEL	Installation level is too low –TwinCAT 2 license error.
0x11	17	0x98110011	ERR_NODEBUGINTAVAILABLE	No debugging available.
0x12	18	0x98110012	ERR_PORTDISABLED	Port disabled – TwinCAT system service not started.
0x13	19	0x98110013	ERR_PORTALREADYCONNECTED	Port already connected.
0x14	20	0x98110014	ERR_AMSSYNC_W32ERROR	AMS Sync Win32 error.
0x15	21	0x98110015	ERR_AMSSYNC_TIMEOUT	AMS Sync Timeout.
0x16	22	0x98110016	ERR_AMSSYNC_AMSERROR	AMS Sync error.
0x17	23	0x98110017	ERR_AMSSYNC_NOINDEXINMAP	No index map for AMS Sync available.
0x18	24	0x98110018	ERR_INVALIDAMSPORT	Invalid AMS port.
0x19	25	0x98110019	ERR_NOMEMORY	No memory.
0x1A	26	0x9811001A	ERR_TCPSEND	TCP send error.
0x1B	27	0x9811001B	ERR_HOSTUNREACHABLE	Host unreachable.
0x1C	28	0x9811001C	ERR_INVALIDAMSFRAGMENT	Invalid AMS fragment.
0x1D	29	0x9811001D	ERR_TLSSEND	TLS send error – secure ADS connection failed.
0x1E	30	0x9811001E	ERR_ACCESSDENIED	Access denied – secure ADS access denied.

Router error codes

Hex	Dec	HRESULT	Name	Description
0x500	1280	0x98110500	ROUTERERR_NOLOCKEDMEMORY	Locked memory cannot be allocated.
0x501	1281	0x98110501	ROUTERERR_RESIZEMEMORY	The router memory size could not be changed.
0x502	1282	0x98110502	ROUTERERR_MAILBOXFULL	The mailbox has reached the maximum number of possible messages.
0x503	1283	0x98110503	ROUTERERR_DEBUGBOXFULL	The Debug mailbox has reached the maximum number of possible messages.
0x504	1284	0x98110504	ROUTERERR_UNKNOWNPORTTYPE	The port type is unknown.
0x505	1285	0x98110505	ROUTERERR_NOTINITIALIZED	The router is not initialized.
0x506	1286	0x98110506	ROUTERERR_PORTALREADYINUSE	The port number is already assigned.
0x507	1287	0x98110507	ROUTERERR_NOTREGISTERED	The port is not registered.
0x508	1288	0x98110508	ROUTERERR_NOMOREQUEUES	The maximum number of ports has been reached.
0x509	1289	0x98110509	ROUTERERR_INVALIDPORT	The port is invalid.
0x50A	1290	0x9811050A	ROUTERERR_NOTACTIVATED	The router is not active.
0x50B	1291	0x9811050B	ROUTERERR_FRAGMENTBOXFULL	The mailbox has reached the maximum number for fragmented messages.
0x50C	1292	0x9811050C	ROUTERERR_FRAGMENTTIMEOUT	A fragment timeout has occurred.
0x50D	1293	0x9811050D	ROUTERERR_TOBEREMOVED	The port is removed.

General ADS error codes

Hex	Dec	HRESULT	Name	Description
0x700	1792	0x98110700	ADSERR_DEVICE_ERROR	General device error.
0x701	1793	0x98110701	ADSERR_DEVICE_SRVNOTSUPP	Service is not supported by the server.
0x702	1794	0x98110702	ADSERR_DEVICE_INVALIDGRP	Invalid index group.
0x703	1795	0x98110703	ADSERR_DEVICE_INVALIDOFFSET	Invalid index offset.
0x704	1796	0x98110704	ADSERR_DEVICE_INVALIDACCESS	Reading or writing not permitted. Several causes are possible. For example, an incorrect password was entered when creating routes.
0x705	1797	0x98110705	ADSERR_DEVICE_INVALIDSIZE	Parameter size not correct.
0x706	1798	0x98110706	ADSERR_DEVICE_INVALIDDATA	Invalid data values.
0x707	1799	0x98110707	ADSERR_DEVICE_NOTREADY	Device is not ready to operate.
0x708	1800	0x98110708	ADSERR_DEVICE_BUSY	Device is busy.
0x709	1801	0x98110709	ADSERR_DEVICE_INVALIDCONTEXT	Invalid operating system context. This can result from use of ADS blocks in different tasks. It may be possible to resolve this through multitasking synchronization in the PLC.
0x70A	1802	0x9811070A	ADSERR_DEVICE_NOMEMORY	Insufficient memory.
0x70B	1803	0x9811070B	ADSERR_DEVICE_INVALIDPARM	Invalid parameter values.
0x70C	1804	0x9811070C	ADSERR_DEVICE_NOTFOUND	Not found (files, ...).
0x70D	1805	0x9811070D	ADSERR_DEVICE_SYNTAX	Syntax error in file or command.
0x70E	1806	0x9811070E	ADSERR_DEVICE_INCOMPATIBLE	Objects do not match.
0x70F	1807	0x9811070F	ADSERR_DEVICE_EXISTS	Object already exists.
0x710	1808	0x98110710	ADSERR_DEVICE_SYMBOLNOTFOUND	Symbol not found.
0x711	1809	0x98110711	ADSERR_DEVICE_SYMBOLVERSIONINVALID	Invalid symbol version. This can occur due to an online change. Create a new handle.
0x712	1810	0x98110712	ADSERR_DEVICE_INVALIDSTATE	Device (server) is in invalid state.
0x713	1811	0x98110713	ADSERR_DEVICE_TRANSMODENOTSUPP	AdsTransMode not supported.
0x714	1812	0x98110714	ADSERR_DEVICE_NOTIFYHNDINVALID	Notification handle is invalid.
0x715	1813	0x98110715	ADSERR_DEVICE_CLIENTUNKNOWN	Notification client not registered.
0x716	1814	0x98110716	ADSERR_DEVICE_NOMOREHDLS	No further handle available.
0x717	1815	0x98110717	ADSERR_DEVICE_INVALIDWATCHSIZE	Notification size too large.
0x718	1816	0x98110718	ADSERR_DEVICE_NOTINIT	Device not initialized.
0x719	1817	0x98110719	ADSERR_DEVICE_TIMEOUT	Device has a timeout.
0x71A	1818	0x9811071A	ADSERR_DEVICE_NOINTERFACE	Interface query failed.
0x71B	1819	0x9811071B	ADSERR_DEVICE_INVALIDINTERFACE	Wrong interface requested.
0x71C	1820	0x9811071C	ADSERR_DEVICE_INVALIDCLSID	Class ID is invalid.
0x71D	1821	0x9811071D	ADSERR_DEVICE_INVALIDOBJID	Object ID is invalid.
0x71E	1822	0x9811071E	ADSERR_DEVICE_PENDING	Request pending.
0x71F	1823	0x9811071F	ADSERR_DEVICE_ABORTED	Request is aborted.
0x720	1824	0x98110720	ADSERR_DEVICE_WARNING	Signal warning.
0x721	1825	0x98110721	ADSERR_DEVICE_INVALIDARRAYIDX	Invalid array index.
0x722	1826	0x98110722	ADSERR_DEVICE_SYMBOLNOTACTIVE	Symbol not active.
0x723	1827	0x98110723	ADSERR_DEVICE_ACCESSDENIED	Access denied. Several causes are possible. For example, a unidirectional ADS route is used in the opposite direction.
0x724	1828	0x98110724	ADSERR_DEVICE_LICENSENOTFOUND	Missing license.
0x725	1829	0x98110725	ADSERR_DEVICE_LICENSEEXPIRED	License expired.
0x726	1830	0x98110726	ADSERR_DEVICE_LICENSEEXCEEDED	License exceeded.
0x727	1831	0x98110727	ADSERR_DEVICE_LICENSEINVALID	Invalid license.
0x728	1832	0x98110728	ADSERR_DEVICE_LICENSESYSTEMID	License problem: System ID is invalid.
0x729	1833	0x98110729	ADSERR_DEVICE_LICENSENOTIMELIMIT	License not limited in time.
0x72A	1834	0x9811072A	ADSERR_DEVICE_LICENSEFUTUREISSUE	Licensing problem: time in the future.
0x72B	1835	0x9811072B	ADSERR_DEVICE_LICENSETIMETOLONG	License period too long.
0x72C	1836	0x9811072C	ADSERR_DEVICE_EXCEPTION	Exception at system startup.
0x72D	1837	0x9811072D	ADSERR_DEVICE_LICENSEDUPLICATED	License file read twice.
0x72E	1838	0x9811072E	ADSERR_DEVICE_SIGNATUREINVALID	Invalid signature.
0x72F	1839	0x9811072F	ADSERR_DEVICE_CERTIFICATEINVALID	Invalid certificate.
0x730	1840	0x98110730	ADSERR_DEVICE_LICENSEOEMNOTFOUND	Public key not known from OEM.
0x731	1841	0x98110731	ADSERR_DEVICE_LICENSERESTRICTED	License not valid for this system ID.

Hex	Dec	HRESULT	Name	Description
0x732	1842	0x98110732	ADSERR_DEVICE_LICENSEDEMODENIED	Demo license prohibited.
0x733	1843	0x98110733	ADSERR_DEVICE_INVALIDFNCID	Invalid function ID.
0x734	1844	0x98110734	ADSERR_DEVICE_OUTOFRANGE	Outside the valid range.
0x735	1845	0x98110735	ADSERR_DEVICE_INVALIDALIGNMENT	Invalid alignment.
0x736	1846	0x98110736	ADSERR_DEVICE_LICENSEPLATFORM	Invalid platform level.
0x737	1847	0x98110737	ADSERR_DEVICE_FORWARD_PL	Context – forward to passive level.
0x738	1848	0x98110738	ADSERR_DEVICE_FORWARD_DL	Context – forward to dispatch level.
0x739	1849	0x98110739	ADSERR_DEVICE_FORWARD_RT	Context – forward to real-time.
0x740	1856	0x98110740	ADSERR_CLIENT_ERROR	Client error.
0x741	1857	0x98110741	ADSERR_CLIENT_INVALIDPARM	Service contains an invalid parameter.
0x742	1858	0x98110742	ADSERR_CLIENT_LISTEMPTY	Polling list is empty.
0x743	1859	0x98110743	ADSERR_CLIENT_VARUSED	Var connection already in use.
0x744	1860	0x98110744	ADSERR_CLIENT_DUPLINVOKEID	The called ID is already in use.
0x745	1861	0x98110745	ADSERR_CLIENT_SYNCTIMEOUT	Timeout has occurred – the remote terminal is not responding in the specified ADS timeout. The route setting of the remote terminal may be configured incorrectly.
0x746	1862	0x98110746	ADSERR_CLIENT_W32ERROR	Error in Win32 subsystem.
0x747	1863	0x98110747	ADSERR_CLIENT_TIMEOUTINVALID	Invalid client timeout value.
0x748	1864	0x98110748	ADSERR_CLIENT_PORTNOTOPEN	Port not open.
0x749	1865	0x98110749	ADSERR_CLIENT_NOAMSADDR	No AMS address.
0x750	1872	0x98110750	ADSERR_CLIENT_SYNCINTERNAL	Internal error in Ads sync.
0x751	1873	0x98110751	ADSERR_CLIENT_ADDHASH	Hash table overflow.
0x752	1874	0x98110752	ADSERR_CLIENT_REMOVEHASH	Key not found in the table.
0x753	1875	0x98110753	ADSERR_CLIENT_NOMORESYM	No symbols in the cache.
0x754	1876	0x98110754	ADSERR_CLIENT_SYNCRESINVALID	Invalid response received.
0x755	1877	0x98110755	ADSERR_CLIENT_SYNCPORTLOCKED	Sync Port is locked.
0x756	1878	0x98110756	ADSERR_CLIENT_REQUESTCANCELLED	The request was canceled.

RTime error codes

Hex	Dec	HRESULT	Name	Description
0x1000	4096	0x98111000	RTERR_INTERNAL	Internal error in the real-time system.
0x1001	4097	0x98111001	RTERR_BADTIMERPERIODS	Timer value is not valid.
0x1002	4098	0x98111002	RTERR_INVALIDTASKPTR	Task pointer has the invalid value 0 (zero).
0x1003	4099	0x98111003	RTERR_INVALIDSTACKPTR	Stack pointer has the invalid value 0 (zero).
0x1004	4100	0x98111004	RTERR_PRIOEXISTS	The request task priority is already assigned.
0x1005	4101	0x98111005	RTERR_NOMORETCB	No free TCB (Task Control Block) available. The maximum number of TCBs is 64.
0x1006	4102	0x98111006	RTERR_NOMORESEMAS	No free semaphores available. The maximum number of semaphores is 64.
0x1007	4103	0x98111007	RTERR_NOMOREQUEUES	No free space available in the queue. The maximum number of positions in the queue is 64.
0x100D	4109	0x9811100D	RTERR_EXTIRQALREADYDEF	An external synchronization interrupt is already applied.
0x100E	4110	0x9811100E	RTERR_EXTIRQNOTDEF	No external sync interrupt applied.
0x100F	4111	0x9811100F	RTERR_EXTIRQINSTALLFAILED	Application of the external synchronization interrupt has failed.
0x1010	4112	0x98111010	RTERR_IRQLNOTLESSOREQUAL	Call of a service function in the wrong context
0x1017	4119	0x98111017	RTERR_VMXNOTSUPPORTED	Intel VT-x extension is not supported.
0x1018	4120	0x98111018	RTERR_VMXDISABLED	Intel VT-x extension is not enabled in the BIOS.
0x1019	4121	0x98111019	RTERR_VMXCONTROLSMISSING	Missing function in Intel VT-x extension.
0x101A	4122	0x9811101A	RTERR_VMXENABLEFAILS	Activation of Intel VT-x fails.

Specific positive HRESULT Return Codes:

HRESULT	Name	Description
0x0000_0000	S_OK	No error.
0x0000_0001	S_FALSE	No error. Example: successful processing, but with a negative or incomplete result.
0x0000_0203	S_PENDING	No error. Example: successful processing, but no result is available yet.
0x0000_0256	S_WATCHDOG_TIMEOUT	No error. Example: successful processing, but a timeout occurred.

TCP Winsock error codes

Hex	Dec	Name	Description
0x274C	10060	WSAETIMEDOUT	A connection timeout has occurred - error while establishing the connection, because the remote terminal did not respond properly after a certain period of time, or the established connection could not be maintained because the connected host did not respond.
0x274D	10061	WSAECONNREFUSED	Connection refused - no connection could be established because the target computer has explicitly rejected it. This error usually results from an attempt to connect to a service that is inactive on the external host, that is, a service for which no server application is running.
0x2751	10065	WSAEHOSTUNREACH	No route to host - a socket operation referred to an unavailable host.
More Winsock error codes: Win32 error codes			

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