TwinCAT

The Windows Control and Automation Technology

TwinCAT 3

Introduction

Introduction

eXtended Automation Architecture (XAA)

eXtended Automation Engineering (XAE)
eXtended Automation Runtime (XAR)

Product overview

TwinCAT 3 Engineering

TE1xxx

TwinCAT 3 Base

TC1xxx

TwinCAT 3 Functions

System TF1xxx
Measurement TF3xxx
Controller TF4xxx
Motion TF5xxx
Connectivity TF6xxx
Industry specific TF8xxx

TwinCAT 2

Product overview

TwinCAT 2 PLC TX1200
TwinCAT 2 NC PTP TX1250
TwinCAT 2 NC I TX1260
TwinCAT 2 CNC TX1270
TwinCAT 2 I/O TX1100
TwinCAT 2 CP TX1000

TwinCAT 2 Supplements

System TSxxxx
Controller TS4xxx
Motion TS5xxx
Communication TS6xxx
Building Automation TSxxxx
TwinCAT 3

- one engineering environment, based on Microsoft Visual Studio®
- IEC 61131, C/C++, MATLAB®/Simulink®
- integrated modules:
  - real-time
  - PLC, NC, CNC
  - robotics
  - measurement technology
  - Safety
- TwinCAT 3 modules:
  - standardised programming frame for modular programming
  - automatic code generation and project implementation with the TwinCAT Automation Interface

TwinCAT 3 runtime environment

- hard real-time for Windows
- one runtime for all modules
- IEC 61131, C/C++, MATLAB®/Simulink® objects in one runtime
- integrated TwinSAFE runtime
- extended real-time functionality:
  - min. 50 µs cycle time and low jitter
- better performance:
  - support of multi-core CPUs
- future-proof: support of 64-bit operating systems

See page 898

We reserve the right to make technical changes.
TwinCAT 2
- engineering and runtime
- IEC 61131-3 programming environment
- integrated modules:
  - real-time
  - PLC, NC, CNC
  - robotics
  - measurement technology
  - Safety

TwinCAT 2 runtime environment
- hard real-time for Windows
- real-time jitter < 5 µs
- cycle time adjustable from 50 µs
- pre-emptive multi-tasking

See page 838

➤ www.beckhoff.com/TwinCAT

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TwinCAT 3 | eXtended Automation Technology (XAT)
With TwinCAT 3 a PC-based control software is available which will expand the standard automation world considerably. In addition to the object-oriented IEC 61131-3 extensions, the languages of the IT world are available in C and C++. The integration of MATLAB®/Simulink® enables the application in scientific fields. And all of that in just one engineering environment. The modules run in different languages in a common runtime. The advantage of this modularity is the improved reuse of modules, once they have been written and tested. The runtime runs under harsh real-time conditions with the use of multi-core technology and the support of 32- or 64-bit operating systems.

TwinCAT 3 highlights

- only one software for programming and configuration
- Visual Studio® integration
- more freedom in selecting programming languages
- support for the object-oriented extension of IEC 61131-3
- use of C/C++ as the programming language for real-time applications
- link to MATLAB®/Simulink®
- open interfaces for expandability and adaptation to the tools landscape
- flexible runtime environment
- active support of multi-core and 64-bit systems
- migration of TwinCAT 2 projects
- automatic code generation and project implementation with the TwinCAT Automation Interface

► www.beckhoff.com/TwinCAT3
In addition to the possibilities of controller programming according to the 3rd edition of IEC 61131-3, the new TwinCAT 3 architecture allows the use of C and C++ as the programming language. This opens up completely new application possibilities, as well as the expansion of or integration in existing systems. The link to MATLAB®/Simulink® is just one example of this new openness.

TwinCAT 3 extends the standard automation world

**eXtended Automation Architecture**
- supports all main fieldbuses
- supports IEC 61131, C/C++, MATLAB®/Simulink®
- supports Motion Control: from point-to-point to CNC
- supports TwinSAFE configuration
- supports Scientific Automation: robotics, measurement technology, Condition Monitoring

**eXtended Automation Engineering**
- one tool – Microsoft Visual Studio®
- integrated: IEC 61131 – worldwide standard in automation

**eXtended Automation Runtime**
- IEC 61131, C/C++, MATLAB®/Simulink® objects in one runtime
- integrated TwinSAFE runtime
- extended real-time functionality: min. 50 µs cycle time and low jitter
- enhanced performance: support of multi-core CPUs
- future-proof: supports 64-bit operating systems
Integration in Microsoft Visual Studio® makes it possible to program automation objects in parallel with the aid of the 3rd edition of IEC 61131-3 and the C or C++ languages. The objects (modules) generated can exchange data with each other and call each other independently of the language they were written in. The TwinCAT System Manager has been integrated into the development environment. This way, only one software is required to configure, parameterise, program and to diagnose automation devices.

Visual Studio® integration can be accomplished in two different ways. TwinCAT Standard only uses the basic framework of Visual Studio® with all its benefits in terms of handling, connection to source code control software, etc., while TwinCAT Integrated, as the name implies, integrates itself into Visual Studio®. In this version, the C/C++, C#, VB.NET programming languages and link to MATLAB®/Simulink® are available.

Flexible use of programming languages

**C and C++ programming languages**
- standardised
- widely used programming languages
- very powerful programming languages
- run under the same runtime as PLC programs
- for the implementation of drivers

**Extended debugging of C++ programs**
- debugging of C++ programs that run in real-time
- use of breakpoints
- use of watch lists
- use of call stacks

**.NET programming languages**
- used for non-real-time programming (e.g.: HMI)
- source code management in the same project

**Link to MATLAB®/Simulink®**
- great variety of toolboxes
- possibilities for use:
  - building of control circuits
  - in simulation
  - in optimisation
  - automatic code generation
  - debug interface between MATLAB®/Simulink® and TwinCAT
Integration of Visual Studio®

Automation devices and application programming in one environment
- use of the most famous and best supported development suite
- future-proof
- editing of PLC programs and complex visualisations in one environment
- multi-language support
- modern look and feel
- context-sensitive online help

- automatic syntax checking
- IntelliSense
- syntax highlighting
- use of the well-known source code control tools
- open architecture
- extendable by plug-ins

Parallel use of the C++ and FBD programming languages

TwinCAT System Manager integrated into Visual Studio®

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For more efficient programming of automation devices, the editors for IEC 61131-3 programming in TwinCAT have been significantly improved. The operability in particular has been improved and the debugging options have been extended. The new options include improved inline monitoring, conditional break points and more.

In TwinCAT 3, the editors of the IEC 61131-3 have been integrated seamlessly into the Visual Studio® environment. As a result, the editors use the original Visual Studio® toolbox for the graphical languages, for example.

Improved inline monitoring for the Structured Text (ST) programming language
TwinCAT 3 completely supports the 3rd edition of the IEC 61131-3. It enables among other things the use of object-oriented techniques such as single inheritance, interfaces, methods and attributes, which significantly increase both the reusability and the quality of the control code.

Example of the use of polymorphism within an IEC 61131-3 POU (Program Organization Unit)

IEC 61131-3 programming

- supplier-independent programming standard
- PLCopen certification
- portable, reusable software
- 5 graphic and text-based programming languages:
  - Structured Text and Instruction List
  - Function Block Diagram and Ladder Diagram
  - Sequential Function Chart
- data encapsulation by user-defined data types

Extended options in TwinCAT 3

- improved ease of operation usability
  - auto-complete
  - marking of associated keywords
  - collapsing of programming structures
  - ...
- extended debugging
  - use of conditional break points
  - improved inline monitoring
  - ...
- object-oriented extensions
  - single inheritance
  - interfaces
  - methods
  - attributes
TwinCAT 3 offers the possibility to program TwinCAT runtime modules in C/C++ languages. For code generation, the C compiler integrated in Microsoft Visual Studio® 2010 is used. With TwinCAT 3 C++ libraries, functions for reading/writing files, starting threads, allocating memory or communicating with a database are provided. This corresponds to the IEC 61131-3 mechanism when using libraries.

Wizards for the creation of basic projects, classes and I/O variables make rapid engineering possible.

The routine “Cycle-Update” is cyclically processed. The internal variables are available for monitoring in the TwinCAT online watch window even without having to set a break-point.

C/C++ as programming languages in automation technology

- **C and C++ programming languages**
  - powerful, widely used programming languages
  - standardised, object-orientated programming languages
  - generation of efficient object code
  - run under the same runtime as PLC programs
  - for the implementation of drivers

- **Beckhoff C++ Libraries** for extended functionality in the real-time context

- **Extended debugging of C++ programs**
  - debugging of C++ programs that run in real-time
  - monitoring, watch lists also without the use of break points

- **.NET programming languages**
  - used for non-real-time programming (e.g.: HMI)
  - source control in the same project
The integration of MATLAB®/Simulink® enables execution of TwinCAT modules that were generated as models in the Simulink® simulation environment. The chosen interfacing type displays the parameters and variables in the graphic interface of TwinCAT 3 and enables viewing and modification in the real-time environment at runtime.

- standard tool in scientific and measuring applications
- wide range of toolboxes (e.g. Fuzzy Logic Toolbox)
- development, simulation and optimisation of complex control loops
- automatic code generation via Realtime Workshop
- debug interface between TwinCAT 3 and Simulink®, parameterisation of the generated module in TwinCAT 3
- download and execution of the module in TwinCAT 3 runtime
- multiple module instantiation possible
- Modules can be used without MATLAB®/Simulink®.
With eXtended Motion Control, TwinCAT automation software offers an integrated and scalable solution for Motion Control applications including simple point-to-point movements, CNC and robot control.

### Functionality

<table>
<thead>
<tr>
<th>NC PTP</th>
<th>NC I</th>
<th>CNC</th>
<th>Robotics</th>
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</thead>
<tbody>
<tr>
<td>Point-to-point movement</td>
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<tr>
<td>– gearing</td>
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<td>– camming</td>
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<td>– superposition</td>
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<td>– flying saw</td>
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<tr>
<td>Interpolated motion with 3 axes and 5 additional axes</td>
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<td></td>
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<tr>
<td>– programming according to DIN 66025</td>
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<td></td>
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<tr>
<td>– technological features</td>
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<tr>
<td>– straightforward utilisation through function blocks from the PLC</td>
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<td>Complete CNC functionality</td>
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<td>– interpolated movement for up to 32 axes per channel</td>
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<td>– various transformations</td>
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<tr>
<td>Interpolated motion for robotic control</td>
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<tr>
<td>– support for a wide range of kinematic systems</td>
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<td>– optional torque pre-control</td>
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### Interpolated motion for robotic control

**Advantages of the integration of robotic control in TwinCAT**

– configuration, parameterisation, diagnostics and programming in TwinCAT
– optimum synergy between PLC, Motion Control and robot control system

**Kinematic calculation process**

– forward transformation
– inverse transformation
– calculation of the dynamic model

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The Safety Editor integrated in TwinCAT 3 allows the creation of a safety application in a graphical environment. The user can program the desired logic directly with function blocks. The logic can initially be developed independently of the hardware configuration, leading to increased flexibility and portability. Additionally, the editor can automatically generate documentation for the application, making both the act of documenting and commissioning significantly easier.

For further information on TwinSAFE and the TwinSAFE products see page 966.
Current developments in computer technology, which offer CPUs with more and more cores, enable the distribution of tasks across different cores. The TwinCAT 3 runtime environment follows this concept. It can be used to distribute functional units such as HMI, PLC runtime or MC to dedicated cores. For each of the cores used by the runtime environment the maximum load as well as the base time and therefore the possible cycle times can be set separately.

Due to the use of multi-core systems, functional units (e.g. PLC and NC runtimes, HMI) are distributed to individual processor cores.

Dialog for the distribution of tasks to processor cores: Moreover, in the so-called “core isolation” mode it is possible to make individual cores exclusively available for the use of TwinCAT. The context change between TwinCAT and the Windows operating system is thus avoided for these cores, which increases the attainable performance still further.

Multi-core and multi-tasking support

<table>
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<tr>
<th>Support of multi-core systems</th>
<th>Support of multi-tasking</th>
<th>Support of 64-bit operating systems</th>
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<tbody>
<tr>
<td>distribution from applications to cores (e.g. PLC, NC and HMI can run on different cores)</td>
<td>preemptive multi-tasking</td>
<td>usage of more resources (memory)</td>
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<td>parallel processing of tasks</td>
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Standardised modules enable open and flexible design of the TwinCAT 3 runtime. It makes an environment available in which the TwinCAT 3 modules can run. Whether the modules are PLC, NC, CNC, RC (Robotic Control) or C/C++ code-based modules (e.g. created with MATLAB®/Simulink®) is irrelevant.

Modular design, openness, extendibility

**Open runtime interface**
- separation of complete functionality into modules
- use of services from system modules (e.g. real-time)
- defined interfaces
- extension of the runtime by own modules (e.g. bus drivers)
- Scalability: modules can contain simple functions; complex algorithms and real-time tasks.
TwinCAT 3 modules consist of a range of formally defined attributes and interfaces. They enable general application of the modules with each other and externally. The predefined interfaces enable cyclic calling of the internal module logic, for example. Each module implements a state machine that controls the initialisation, parameterisation and linking of the respective module.

In addition to user modules, a number of system modules are already available which provide basic runtime functionality (e.g. TwinCAT real-time). These modules have fixed object IDs and are therefore accessible from each module.

Fast communication, reusability

- Functionality of the modules is scalable.
- direct and therefore very fast communication between modules
- Modules are sealed.
- Modules can be developed, serviced and tested independent of each other.
- high reusability
TwinCAT 2
The Windows Control and Automation Technology

The Beckhoff TwinCAT software system transforms almost any compatible PC into a real-time controller with multi-PLC system, NC axis control, programming environment and operating station. At the same time, TwinCAT integrates the programming environment for all Beckhoff controllers: from high-end Industrial PC control to embedded controller.

TwinCAT architecture

TwinCAT consists of runtime systems for real-time execution of control programs and development environments for programming, configuration and diagnostics:

- TwinCAT I/O: versatile I/O interface for all common fieldbuses
- TwinCAT PLC: enables programming of up to four PLC runtimes on a single PC. The PLC program can optionally be written in one or several IEC 61131-3 languages (IL, LD, FBD, SFC, ST) or CFC.
- TwinCAT NC: enables simultaneous positioning of many axes. The levels NC PTP (point-to-point positioning), NC I (linear and circular interpolating movements of axis groups with up to eight drives) and CNC (extension of NC I with conventional CNC features for up to 32 interpolating axes per channel) are available for this purpose.

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