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HIMax®

Safety Simulator Manual

SAFETY NONSTOP

HIMA

X-OTS

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1 Introduction

X-OTS - HIMax Safety Simulator allows one to simulate a HIMax or HIMatrix controller for structuring an OTS (Operator Training System).

X-OTS can be used for the following purposes:

- Training of operators and programmers of HIMA controllers
- Development and testing of user programs without the need to use a controller

The current manual describes how to install and use the X-OTS.

1.1 Structure and Use of this Manual

This manual is organized in the following main chapters:

- Introduction
- Safety
- Product Description
- Start-up
- Operation
- Maintenance
- Decommissioning
- Appendix
  - Application example
  - Glossary
  - Indexes

1.2 Target Audience

This document addresses system planners, configuration engineers, programmers of automation devices and personnel authorized to implement, operate and maintain the devices and systems. Specialized knowledge of safety-related automation systems is required.

1.3 Formatting Conventions

To ensure improved readability and comprehensibility, the following fonts are used in this document:

Bold:	To highlight important parts Names of buttons, menu functions and tabs that can be clicked and used in SILworX.
Italics:	System parameter and variables
`Courier`	Literal user inputs
RUN	Operating state are designated by capitals
Chapter 1.2.3	Cross references are hyperlinks even though they are not particularly marked. When the cursor hovers over a hyperlink, it changes its shape. Click the hyperlink to jump to the corresponding position.

Safety notes and operating tips are particularly marked.

1.3.1 Safety Notes

The safety notes are represented as described below.
These notes must absolutely be observed to reduce the risk to a minimum. The content is structured as follows:

- Signal word: danger, warning, caution, notice

- Type and source of danger
- Consequences arising from the danger
- Danger prevention

⚠ SIGNAL WORD

Type and source of danger!
Consequences arising from the danger
Danger prevention

The signal words have the following meanings:

- Danger indicates hazardous situation which, if not avoided, will result in death or serious injury.
- Warning indicates hazardous situation which, if not avoided, could result in death or serious injury.
- Warning indicates hazardous situation which, if not avoided, could result in minor or modest injury.
- Notice indicates a hazardous situation which, if not avoided, could result in property damage.

NOTICE

Type and source of damage!
Damage prevention

1.3.2 Operating Tips

Additional information is structured as presented in the following example:

i The text corresponding to the additional information is located here.

Useful tips and tricks appear as follows:

TIP The tip text is located here.

2 Safety

X-OTS must not be used for safety-related operation!

2.1 Intended Use

X-OTS is suitable for the following uses:

- Structuring simulators for training operators, designers and programmers..
- Testing of user programs

3 Product Description

X-OTS is the simulation of a HIMax or HIMatrix controller. It is used to train operators, planners and programmers, and test user programs.

X-OTS can be used for structuring simulators for plants operated with one or multiple HIMax or HIMatrix controllers. The OPC interface of X-OTS allows the connection of control and visualization systems, as well as of process simulators.

3.1 Features

The major features of X-OTS are:

- Processor module simulation
- Simulation of inputs and outputs
- Simulation and user program start and stop
- Simulation repeated for a given number of user program cycles or a given time period
- Simulation state storage and load

The OPC interface of X-OTS is suitable for data access (DA). An X-OPC server is necessary for reading alarms and events (A&E).

3.1.1 Processor Module Simulation

SILworX considers the X-OTS as an OTS resource allowing the following functions:

- Load by performing a download
- Cold start
- Warm start
- Stop

3.1.2 Simulation of Inputs and Outputs

X-OTS allocates all the global variables of the SILworX projects as OPC tags. One or multiple OPC clients can write to the tags used as inputs and read tags used as outputs.

The tags assigned to the global variables can only be read in the following cases:

- If the *Constant* attribute is set for the variables.
- If the global variables are written by the user program.
- If the global variables are written through safe**ethernet**.

3.1.3 Starting and Stopping the Resource

The entire simulation behaves like a processor module:

- Starting and stopping the resource and the individual programs in SILworX is allowed.
- The X-OTS service behavior can be configured when starting the PC:
  - During the installation, one can select whether the X-OTS should start when starting the PC.
  - This behavior can be modified using the service-specific settings.
- When starting or restarting the X-OTS, the simulation behaves in accordance with the value of the *Autostart* system variable.

The simulation interface can be used to switch the simulation to a pause or run state. The run state corresponds to the RUN state of the processor module, the pause state to the TEST state of the processor module.

3.1.4 OPC Interface

The OPC tags are classified in the following groups:

- Simulation interface
- Global variable
- System variable

The groups are identified with a node name, see Table 1.

Node name	Tag function
OTS simulation	Simulation control and monitoring
«Resource name».Global_Vars	Global variables that can be written and read such that the input and output can be simulated. Variables that were set to constant in the SILworX declaration can only be read.
«Resource name».System	System variable

Table 1: Groups of OPC Tags

3.1.4.1 Simulation Interface

The simulation interface is composed of OPC tags that can be used to control the simulation. The simulation has two states, *Pause* and *Run*. The current state is displayed by the *SimulationState* OPC tag. Setting *SimulationState* to another value changes the simulation state. Other simulation interface tags also affect the state. They are described in Table 7.

3.1.4.2 Global Variable

The global variables defined in SILworX for the resource are available as OPC tags.

3.1.4.3 System Variable

The resource's system variables are available as OPC tags. Refer to the System Manual (HI 801 001 E) for details.

3.1.5 Saving and Loading the Simulation States (Snapshot)

In *Pause*, the simulation interface (see Table 7, *SnapshotFile*...Tags) can be used to save the copy of the complete simulation in the file system and to load it again to a later point in time. The copy contains the names and values of the variables.

When the saved copy is loaded, X-OTS adjusts it to the current simulation:

- Variables are identified through their name.
- Variables from the current simulation are allocated with the current value from the copy.
- Variables contained in the copy, but no longer present in the current simulation are ignored.
- Variables present in the simulation, but not in the copy, are allocated with their initial value.
- Values of time elements and statistical data are replaced by the values from the copy.

3.2 Equipment, Scope of Delivery

X-OTS is included within scope of delivery and is provided with the HIMA DVD.

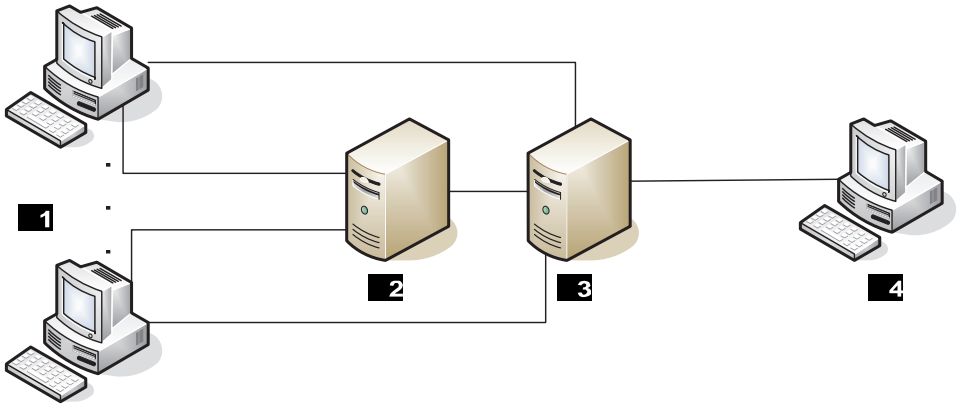
Hardware and software requirements:

- PC with the following features:
  - Core Duo
  - 3 GB RAM
  - approx. 20 MB hard disk space available
  - Windows XP Professional, SP2 (32-bit) or higher, or
  - Windows Server 2003, SP1 (32-bit) or higher, or
  - Windows 7 Ultimate / Professional (32-bit or 64-bit), or
  - Windows Server 2008 R2 (64-bit)

- A SILworX full version 4.116 (or beyond) is necessary for operating and programming the X-OTS.
- OPC client

The X-OPC server is required if alarms and events should be read out.

3.3 Structure



1 One or Multiple OPC Clients for Operating and Monitoring the OPC Tags
2 X-OPC Server for Alarms&Events (Optional)
3 X-OTS
4 SILworX

Figure 1: Structure of an X-OTS Installation

X-OTS 3 is a service running under the Windows operating system.

SILworX 4 configures and operates X-OTS as *OTS resource*.

One or multiple OPC clients 1 operate and monitor the OPC tags:

- Simulation interface
- Global variable, e.g., inputs and outputs
- System variable

An optional X-OPC server 2 reads the alarms and events.

As an example, X-OTS, OPC server, and SILworX can run on the same PC and operating system.

The following table describes the connection of the systems to X-OTS as well as the type of exchanged data.

System	Connection via	Exchanged data
Trainer PC (process simulator)	OPC	Simulation interface. Additionally, as needed: ▪ Input and output data (global variables) ▪ System variable
X-OPC server	OPC	Alarm and events (optional)
SILworX	PADT interface	PADT data
Control and visualization system	OPC	Input and output data (global variables), if needed also other

Table 2: Exchange of Data between X-OTS and Other Systems

3.4 Product Data

Data	Value
Number of OTS Installations per PC	10
Number of resources per installation	Not limited (dependent on the PC performance)
Number of OPC tags per resource	Not limited (dependent on the PC performance)

Table 3: Product Data

The following restrictions apply for X-OTS:

- X-OTS does not support unicode. All the texts are written and expected in ASCII, e.g., object names.
- Since the Windows® operating system is not real-time capable, the timing behavior of a controller's X-OTS simulation differs from the timing behavior of a real controller.

4 Start-up

The start-up process includes the following phases:

1. Installation of X-OTS on a Windows PC
2. Configuration of an OTS resource using SILworX
3. Creation of the programs, code generation and load

Depending on the requirements, installation of the software needed, e.g., an OPC client:

4.1 Installation

Installation notes:

- Administrator rights are required to perform the installation.
- Prior to install the current X-OTS version, HIMA recommends to uninstall all the previous versions.
- The installation language can be defined during the installation. The default language is German.
- During installation, the parameters described in Table 4 must be specified.

Parameter	Description
System ID	System ID assigned to the OTS resource. This must be specified during the SILworX configuration.
PADT Port	Number of the port that establishes the connection between X-OTS and SILworX. This port number must be greater than 1024 to prevent problems with other programs. Port numbers that were manually allocated to other installed programs must also be avoided. If there are firewalls in the connection between X-OTS and PADT, this port numer must be enabled in the firewall.
Service name	Name of the X-OTS service to differentiate the X-OTS services running on the same computer.
CLSID	CLSID (class identifier) for OPC-DA functionality of X-OTS is a unique identifier for the installed X-OTS, i.e., instance. In this field, one can choose whether the CLSID should be specified manually or automatically. If the manual option is selected, the CLSID must be typed.

Table 4: Parameters Required for the Installation

To install X-OTS on a PC

1. Insert the HIMA DVD. The set-up routine automatically starts after few minutes.
   Alternatively, manually call the `start.exe` file located on the DVD's root directory.
2. Open the X-OTS installation page.
   Select **X-OTS Installation** from the menu.
3. Start the X-OTS installation and follow the instructions.
   Specify the installation language (German or English) and the parameters in accordance with Table 4.

X-OTS is installed and able to run.

Up to 10 X-OTS instances can be installed on a PC.

Use `regedit.exe` to verify the parameters from Table 5. Each installed instance has a key with the corresponding *service name* that is located under HKEY\LOCAL_MACHINE\SOFTWARE\HIMA\X-OTS. Each of these keys contains the parameters.

A change to the parameter *System ID* or *PADT Port* is only effective after restarting the X-OTS service.

A change to the remaining parameters may affect the X-OTS functionality and should therefore not be performed!

4.2 Configuration

To configure an OTS resource, SILworX must be licensed for X-OTS. Licensing is done using a dongle provided by HIMA.

If SILworX is licensed for X-OTS, X-OTS can be added as new resource in a configuration.

To create an OTS resource

1. Choose the configuration and select **New** from the context menu or the action bar.
   ☑ The *New Object* dialog box is displayed.
2. Click **Operator Training System**.
3. Enter the name of the new OTS resource in the *Name* field.
4. Click **OK**.

An OTS resource is created as sub-element of configuration.

Also an OTS resource must be licensed to operate. To do so, an activation code must be created on the HIMA website (`http://www.hima.com`) using the license number and system ID. The activation code must then be specified in the SILworX license management.

4.2.1 System Parameters of the OTS Resource

The system parameters of an OTS resource are different from those of another resource, see the following table:

Parameter / switch	Description	Default value	Recommended settings
Name	Name of the OTS resource. This name may only contain ASCII characters.	-	-
System ID [SRS]	System ID of the OTS resource 1...65 535 The value assigned to the system ID must differ to the default value, otherwise the project is not able to run! The system ID value must be identical to the value set when installing the corresponding X-OTS instance.	60 000	Unique value within the resource network.
Safety Time [ms]	Safety time of the resource.	20 000 ms	Application-specific
Watchdog Time [ms]	Watchdog time for the OTS resource ≤ ½**safety time [ms]*	10 000 ms	Application-specific
Main Enable	Enable for the following parameters applying to the online change: ▪ *System ID* ▪ *Resource Watchdog Time* ▪ *Safety Time* ▪ *Target Cycle Time* ▪ *Target Cycle Time Mode* ▪ *Autostart* ▪ *Global Forcing Allowed* ▪ *Global Force Timeout Reaction* ▪ *Load Allowed* ▪ *Start Allowed*	ON	Application-specific
Autostart	ON Resource and user programs start when X-OTS is started OFF No automatic start	ON	Application-specific
Start Allowed	ON The user programs can be started using the PADT OFF No cold start allowed	ON	Application-specific

Load Allowed	ON A configuration can be loaded OFF Load not allowed	ON	Application-specific
Global Forcing Allowed	ON Global variables can be forced OFF Global variables cannot be forced	ON	Application-specific
Global Force Timeout Reaction	Specifies how the resource should behave when the global force time-out has expired: ▪ Stop Forcing ▪ Stop the Resource	Stop Forcing Only	Application-specific
Max.Com. Time Slice ASYNC [ms]	Highest value in ms for the time slice used for communication during a resource cycle, see the Communication Manual (HI 801 101 E), 2...5000 ms	500 ms	Application-specific
Target Cycle Time [ms]	Targeted or maximum cycle time, see *Target Cycle Time Mode*, 0...7500 ms. The maximum target cycle time value may not exceed the defined watchdog time (-1 000 ms); otherwise it is rejected by OTS.	50 ms	Application-specific
Multitasking Mode	Mode 1 The duration of a CPU cycle is based on the required execution time of all user programs. Mode 2 The processor provides user programs with a higher priority the execution time not needed by user programs with a lower priority. Operation mode for high availability. Mode 3 The processor waits during the unneeded execution time of user programs to expire and thus increases the cycle.	Mode 1	Application-specific
Target Cycle Time Mode	Use of *Target Cycle Time [ms]*. Fixed The X-OTS maintains the target cycle time and extends the cycle if necessary. This does not apply if the processing time of the user programs exceeds the target cycle time. Fixed-tolerant Similar to *Fixed*, but the target cycle time is not taken into account during the first reload activation cycle. Dynamic-tolerant Similar to *Dynamic*, but the target cycle time is not taken into account during the first reload activation cycle. Dynamic X-OTS tries to maintain the target cycle time, but executes the cycle as quickly as possible.	Fixed-tolerant	-
Namespace Prefix	Additional identifier for the resource, e.g., if multiple resources contain global variables with the same name.	„“ (empty)	Application-specific
Namespace Separator	Dot . Slash / Colon : Back slash \	Dot .	Application-specific
Namespace Type	Setting according to the OPC client requirement: ▪ Hierarchical Namespace ▪ Flat Namespace	Hierarchical Namespace	Application-specific
Changeless Update	Setting according to the OPC client requirement: ON Cyclically, X-OTS always provides all the items to the OPC client. OFF X-OTS only provides changed values to the OPC client.	OFF	Application-specific
Cycle Delay [ms]	The cycle delay limits the CPU load of the PC due to the X-OPC server to allow other programs to be run. Range of values: 1...100 ms	5 ms	Application-specific

Short Tag Names for DA	This parameter can only be activated if *Flat Name Space* is activated. It is an option in which data and events are offered to the OPC client without any further context (path name).	OFF	Application-specific

Table 5: System Parameters of an OTS Resource

4.2.2 OTS Host Set-Up

The OTS host is a sub-element of the OTS resource and contains parameters of the computer on which the X-OTS is running.

A parameter is the PADT port. It must contain a value specified during the X-OTS installation.

The remaining parameters describe the Ethernet connections to the computer. The following parameters are available for each connection:

Parameter	
Name	Name of the Ethernet connection
IP Address	IP address, as set in the computer
Standard Interface	If multiple IP connections are configured, this one is the standard interface for communicating with SILworX.
HH Port	Port for process data connections to the following partners: ▪ Other X-OTS instances ▪ Controllers ▪ OPC server If multiple X-OTS instances are installed on a resource, a unique port number must be assigned to each instance!

Table 6: Parameters for an Ethernet Connections

4.3 Creating Programs, Generating and Loading the Code

Like in a controller, the user programs and the corresponding global variables need be created. It is possible to copy programs from another resource.

To complete the OTS resource start-up

1. Generate the code for the resource and user program(s)
2. Load the generated code into the OTS resource.
3. Start the resource. Depending on the configuraton, the user programs start.
4. If required, start the user programs.

The resource starts operation. The OPC tags of the simulation interface are available.

4.4 Variants

In addition to OTS resources, an OTS project can also contain resources of type HIMax and/or HIMatrix. The OTS resources are connected to one another and to the other resources via safe**ethernet**. In doing so, the following points must be observed:

- OTS resources must not assume any safety-related tasks!
- The safe**ethernet** connections to the OTS resources are not safely-related!

5 Operation

During operation, X-OTS operates as a service and runs under the Windows operating system.

To start the simulation, the OPTS resource must be started with SILworX. SILworX can start and stop individual programs, and run them in test mode.

An OPC client can switch the simulation, i.e., all the user programs together, to the *Pause* state and restart then in the following modes:

- For a number of milliseconds.

  In this mode of operation, the programs run until the specified time has expired, and once again enter then *Pause* state.
- For a number of cycles.

  In this mode of operation, the programs run until the specified number of user program cycles is achieved, and once again enter then *Pause* state. During this period, test mode is displayed in SILworX.
- Continuous operation.

  In this mode of operation, the programs run with no limits.

The simulation interface is used to switch among these modes.

The OPC tags of an OTS resource are only available if the resource is in RUN. In the STOP state, they are 'out of service'.

5.1 Handling

The OTS resource is operated using SILworX and one or multiple OPC clients.

5.1.1 SILworX

SILworX can be used to start and stop the OTS resource and thus the simulation.

Like in a controller, the following actions are possible:

- Download
- Start and stop individual user programs
- Online test
- Forcing
- Online change of parameters

5.1.2 OPC Clients

The following tag groups are displayed in an OPC client:

- Simulation interface tags. These are identified with the node name *OTS Simulation*.
- Tags for global variables. These are identified with the node name 'Resource Name', followed by *Global Vars.*
- Tags for the system variables and system parameters. These are identified with the node name 'Resource Name', followed by *System.*
- If a namespace prefix was specified in the system parameters of the OTS resource (see Table 5), it is displayed as individual node before the specified name.

The simulation interface tags are described in the following table:

OPC tag name	Description	Writable in the state	Access
ColdStart	It performs a cold start of the user programs. -1 = Invalid, 0 = PAUSE, 1 = Running	Pause	W
LastFileOperationMsg	Event message of last snapshot file operation	-	R
RealTimeFactor	Required ratio between simulation time and time actually passed. This parameter affects all the user programs. 10^{-6}...10	Both	W
RealTimeFactorReached	Value actually reached by the RealTimeFactor, depending on the computer performance and other factors. It is only calculated if the target cycle time is greater than 0.	-	R
RunForCycles	Entering a value *n* greater than 0 starts the user programs for the duration of *n* cycles.	Both	W
RunForMs	Entering a value *n* greater than 0 starts the user programs for the duration of *n* milliseconds. Each of the user programs run until the end of its cycle. This can cause the specified time to be exceeded.	Both	W
SimTicks	Revolving millisecond counter: *TimerTicks* multiplied by *RealTimeFactorReached* If *RealTimeFactor* is changed, this relation no longer applies!	-	R
SimulationState	State of the simulation and user programs: ▪ 0 = Pause ▪ 1 = Run: The user programs are running *SimulationState* has the value 1 even after starting the user programs using *RunForCycles* and *RunForMs*.	Both	W
SnapshotFileDelete	Entering a valid name for a snapshot file deletes this file, if it contains an OTS snapshot. The result is displayed in *LastFileOperationMsg*.	Both	W
SnapshotFileLoad	It loads the snapshot from the specified file into the OTS. The result is displayed in *LastFileOperationMsg*.	Pause	W
SnapshotFileSave	It saves the current OTS state in the specified file of the file system. Files with identical names are not overwritten. The result is displayed in *LastFileOperationMsg*.	Pause	W
TimerTicks	Revolving millisecond counter	-	R
WarmStart	It performs a warm start of the user programs. -1 = Invalid, 0 = PAUSE, 1 = Running	Pause	W

Table 7: Simulation Interface - OPC Tags for Operating the X-OTS

5.2 Diagnosis

X-OTS maintains a diagnostic history about the occurred faults and other events. The events are stored in the history in chronological order. The history is organized as a ring buffer.

The diagnostic history is composed of short term diagnosis and long term diagnosis.

- Short term diagnosis
  If the maximum number of entries has been reached, each new entry deletes the oldest one.
- Long term diagnosis
  The long term diagnosis essentially stores actions and configuration changes performed by the user.
  If the maximum number of entries has been reached, each new entry deletes the oldest entry if this is older than three days.

The new entry is rejected if the existing entries are not older than three days. The rejection is marked by a special entry.

Number of events that can be stored:

- In the short term diagnosis: 10 000 entries
- In the long term diagnosis: 10 000 entries

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i In the following cases, the diagnostic entries can be lost before they could be saved into the non-volatile memory:
- A power outage occurs
- The OTS service is improperly terminated, e.g., by manually aborting the process.

- SILworX offers the opportunity to read the histories of the individual resource and represent them so that the information required to analyze a problem is available.

For additional functions of the diagnostic history, see the SILworX online help.

6 Maintenance

The maintenance actions for the X-OTS are the same as for each Windows PC:

- Operating system update

  HIMA recommends to install the latest updates available for Windows operating system version on a regular basis.
- Backup on a corresponding removable device, in particular of the snapshot files.

7 Decommissioning

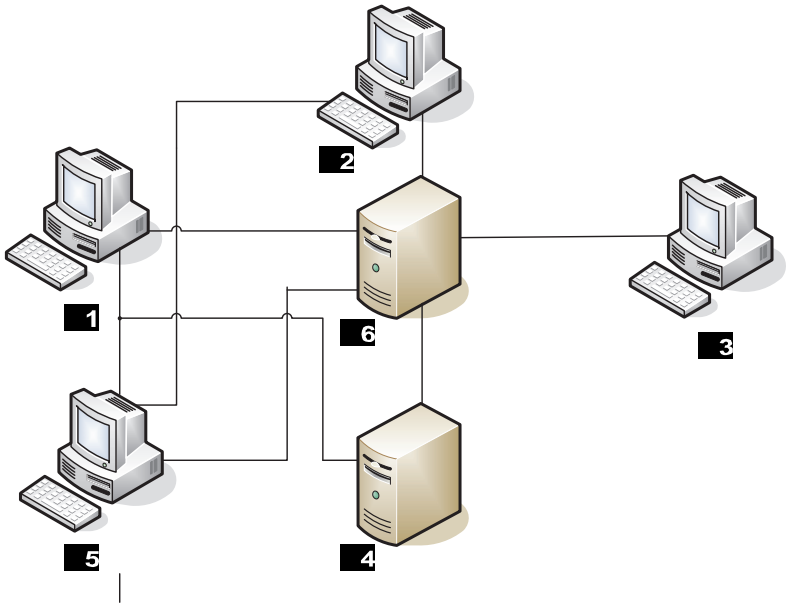
To decommission the X-OTS, use SILworX to stop the OTS resource.

Afterwards, the X-OTS can be uninstalled.

Appendix

Application Example

Structuring a typical application of X-OTS:



1 Trainer PC
2 X-OPC Server for Alarms and Events, Event Recording (optional)
3 SILworX
4 Process Simulator
5 Control/Visualization System or Simulator
6 X-OTS

Figure 2: Typical Application of X-OTS

The trainer PC is used by the trainer to control the following simulators:

- X-OTS through the simulation interface using an OPC client
- Process simulator
- Control system simulator

The operator to be trained uses the control system to operate the simulated plant, and, if required, SILworX.

The process simulator simulates the process to be controlled and communicates with X-OTS via the OPC tags of the global variables. The process simulator processes the output data created by X-OTS and provides the input data.

In contrast to Figure 2, several of these software packages can be installed on a common computer, e.g., X-OTS and SILworX.

Glossary

Term	Description
ARP	Address Resolution Protocol: Network protocol for assigning the network addresses to hardware addresses
AI	Analog Input
Connector Board	Connector board for the HIMax module
COM	Communication module
CRC	Cyclic Redundancy Check
DI	Digital Input
DO	Digital Output
EMC	Electromagnetic Compatibility
EN	European Norm
ESD	ElectroStatic Discharge
FB	Fieldbus
FBD	Function Block Diagram
FTT	Fault Tolerance Time
ICMP	Internet Control Message Protocol: Network protocol for status or error messages
IEC	International Electrotechnical Commission
MAC address	Hardware address of one network connection (Media Access Control)
PADT	Programming And Debugging Tool (in accordance with IEC 61131-3), PC with SILworX
PE	Protective Earth
PELV	Protective Extra Low Voltage
PES	Programmable Electronic System
PFD	Probability of Failure on Demand, probability of failure on demand of a safety function
PFH	Probability of Failure per Hour, probability of a dangerous failure per hour
R	Read
Rack ID	Base plate identification (number)
Non-reactive	Supposing that two input circuits are connected to the same source (e.g., a transmitter). An input circuit is termed "non-reactive" if it does not distort the signals of the other input circuit.
R/W	Read/Write
SB	System Bus (Module)
SELV	Safety Extra Low Voltage
SFF	Safe Failure Fraction, portion of safely manageable faults
SIL	Safety Integrity Level (in accordance with IEC 61508)
SILworX	Programming tool for HIMax
SNTP	Simple Network Time Protocol (RFC 1769)
SRS	System.Rack.Slot addressing of a module
SW	Software
TMO	TiMeOut
TMR	Triple Module Redundancy
W	Write
r_P	Peak value of a total AC component
Watchdog (WD)	Time monitoring for modules or programs. If the watchdog time is exceeded, the module or program enters the ERROR STOP state.
WDT	WatchDog Time

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SAFETY
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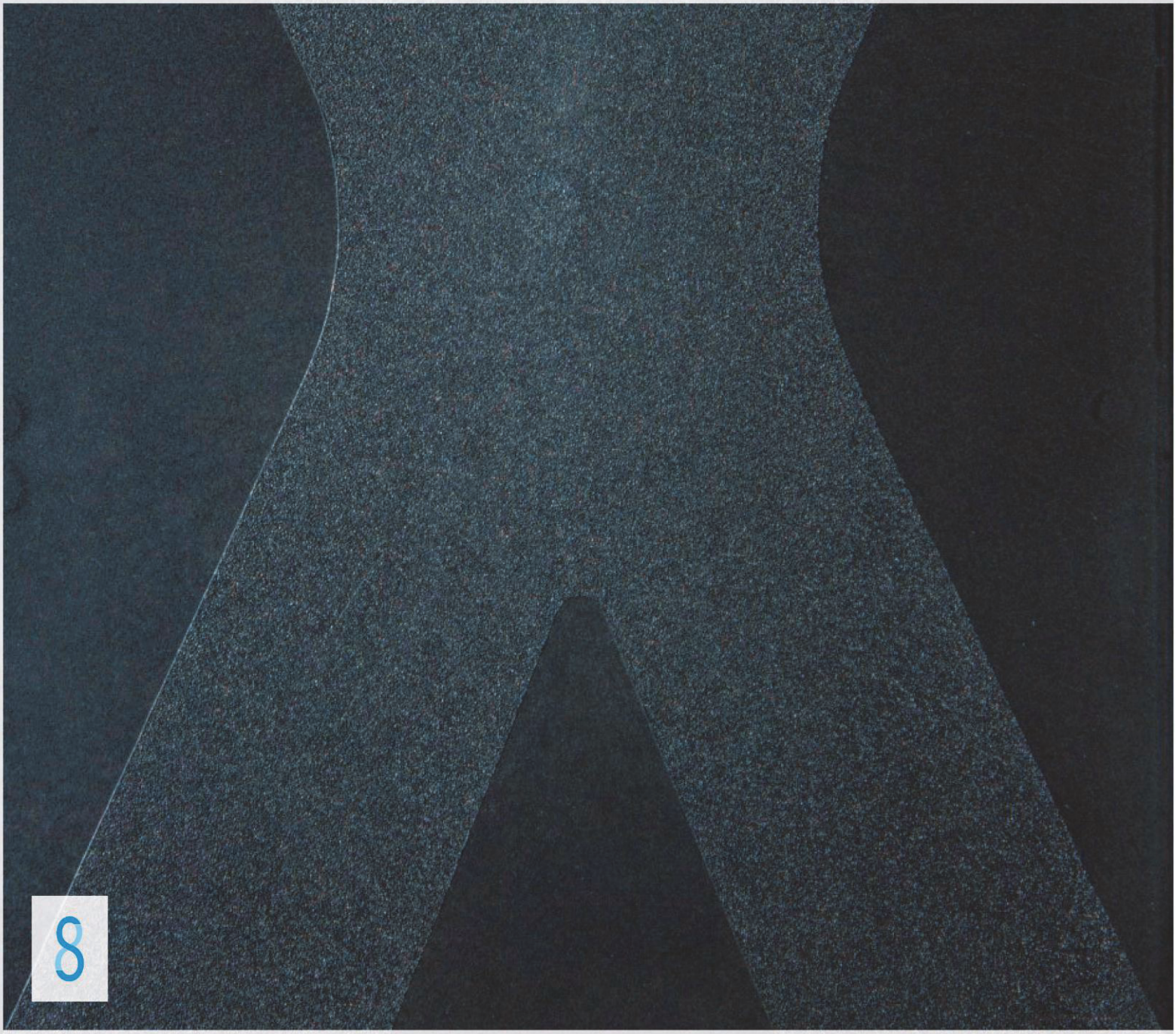

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